National Audit Office

# COST-EFFECTIVENESS ANALYSIS IN THE 2006 CLIMATE CHANGE PROGRAMME REVIEW

A REVIEW BY THE NATIONAL AUDIT OFFICE

JANUARY 2007

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# CONTENTS


| | |
|---|---|
| EXECUTIVE SUMMARY | 4 |
| PART ONE | 8 |
| INTRODUCTION | 8 |
| This briefing responds to a request from the Environmental Audit Committee | 8 |
| Climate change could bring significant costs, but Government expects it will be cheaper to address the problem than to deal with the consequences | 8 |
| The 2006 Review was based on a coordinated programme of work across government | 10 |
| COST-EFFECTIVENESS ANALYSIS IS AN APPROPRIATE TOOL TO APPRAISE POLICIES | 12 |
| Cost-effectiveness analysis was used in the 2006 Climate Change Programme Review | 12 |
| Cost-effectiveness analysis is a widely used policy appraisal tool | 12 |
| Cost-effectiveness indicators used in 2006 sensibly excluded the social cost of carbon | 13 |
| THE COST-EFFECTIVENESS INDICATORS IN THE 2006 REVIEW WERE RELIABLE ENOUGH TO COMPARE POLICIES | 15 |
| Analysis in 2006 was more comprehensive and consistent than that which supported the original climate change programme | 15 |
| Appropriate costs and benefits were analysed | 15 |
| Analysis was based on reasonable assumptions | 17 |
| Analysts considered sensitivity and risk but inherent uncertainties remain | 17 |
| Quality assurance processes ensured analyses were reasonably consistent and well-founded | 19 |

NOT ALL POLICIES OR POLICY OPTIONS WERE COVERED BY COST-EFFECTIVENESS ANALYSIS 21

Some policy ideas were not considered for the Review and were not analysed 21

Analyses did not explore different ways to implement each policy 22

POLICY SELECTION WAS BROADLY IN LINE WITH THE RESULTS OF COST-EFFECTIVENESS ANALYSIS 23

Most existing policies were considered to be cost effective 24

Most new policy ideas were thought to be cost-ineffective 24

APPENDICES

1 Government spend on climate change policies 30

2 Policy appraisal techniques 31

ENDNOTES 33

# EXECUTIVE SUMMARY

**1** Climate change and policies to address it involve huge sums of money for taxpayers, industry and citizens. The Stern review of the economics of climate change, published in October 2006[1], estimated that climate change impacts could cost between five and 20 per cent of world GDP per capita, each year (through natural disasters, population displacement and the damage to agriculture, for example); in contrast, policies to avoid or reduce these problems might cost just one per cent of GDP each year. Policies to adapt to climate change could also cost tens of £billions in developing countries alone. Earlier work suggested that the implications for the UK are broadly consistent with these estimates.

**2** In view of the large sums at stake, it is vital that policy makers should take full account of cost and cost-effectiveness in framing policy. This briefing examines the analysis used in the UK's most recent Climate Change Programme Review (the '2006 Review'), carried out between September 2004 and March 2006. Our briefing responds to a request from the Environmental Audit Committee.

**3** The focus of the 2006 Review was the Government's 2010 domestic target for reducing carbon dioxide emissions by 20 per cent below 1990 levels. Departments involved in the 2006 Review used a technique known as cost-effectiveness analysis to evaluate existing measures and appraise possible new policies. This analysis produced a series of indicators which, alongside other considerations such as impacts on security of supply, fuel poverty and innovation, informed policy decisions. The aim of this briefing is to help the Committee understand:

- whether cost-effectiveness analysis was an appropriate method to appraise policies;
- what the results mean and whether they are reliable;
- whether the analysis covered all relevant policy choices; and
- how policy makers used the analysis to inform the selection of policies for the 2006 Climate Change Programme.

To answer these questions we looked at the analytical methods used by policy makers; examined key papers and interviewed officials; and we looked in more detail at the evaluations or appraisals for the 10 policies expected to deliver the biggest carbon savings in 2010.

# The main points from our examination

**4** The main findings from our review are as follows.

## Cost-effectiveness analysis was used to identify the net cost or benefit, per tonne of carbon saved, for each policy

- The results of cost-effectiveness analysis in the 2006 Review were expressed in £ per tonne of carbon saved for each existing or new policy. To do this, analysts identified the costs and benefits over the life of a policy. These values, excluding the social cost of carbon (for which, see next section) were discounted to present values and divided by the volume of carbon savings expected.

## Cost-effectiveness analysis is an appropriate tool to appraise policies

- Departments considered alternatives ways of appraising or evaluating policies on a common basis. Each policy was subject to a number of analyses. Cost-effectiveness analysis was selected as the primary method to assist policy making because it focused attention on the least cost (or most benefit) way of meeting the 2010 emission targets, and because (unlike methods which seek to quantify all benefits) it is not reliant on a firm valuation of the social cost of carbon.
- The social cost of carbon is a value which aims to quantify the damage to health, environment and the economy caused by each tonne of carbon emitted. Earlier government analysis suggested that this figure was £70 per tonne, within a range of £35 to £140; the recent Stern review has suggested £60 to £200 per tonne. All analyses recognise that the value is very uncertain. In practice, the 2006 Review placed little reliance on the social cost of carbon to inform policy choices; the data was just part of the information available to policy makers. However, new ideas to reduce emissions which came at very significant cost were rejected.
- Cost-effectiveness analysis has some limitations. For example, the £ per tonne calculation results in an indicator which does not reflect the potential scale or timing of a policy effect. We found no evidence, however, that analysts and policy makers had used the indicators uncritically.

## Cost-effectiveness analysis produced results which were reliable enough to compare policies

- Analysis in 2006 was carried out on a more consistent basis than that which supported the original climate change programme in 2000.
- Officials analysed an appropriate range of costs and benefits for each policy, including a wider set of costs and benefits than had been assessed in 2000.

- Cost-effectiveness indicators were dependent on key assumptions and subject to significant uncertainties – an inherent feature of this sort of analysis. We were satisfied that the evaluations we examined were based on reasonable assumptions and a fair consideration of uncertainty. Assumptions and risk profiles were reinforced by novel quality assurance processes. However, whilst much of the work was conducted by independent consultants, we saw little systematic or explicit consideration of whether evaluations and appraisals were subject to optimism or pessimism bias.
- Fiscal measures were not subject to the same quality assurance processes as other policies.

## Not all policies or policy options were covered by cost-effectiveness analysis

- Analysts evaluated nearly 40 existing policies and appraised nearly 70 new or expanded policies – including most of those thought likely to contribute towards the government's domestic target of a 20 per cent reduction in carbon dioxide emissions, below 1990 levels, by 2010.
- Some potential policies were not considered on the grounds of impracticality or because they were thought to make an insignificant contribution to carbon saving. A small number could not be appraised within the timescale of the Review.
- The focus on the 2010 target meant that policies whose impact was expected to occur after 2010 were not analysed. This meant that appraisal or serious consideration of some major new policies, more likely to be relevant to meeting the longer-term targets, was deferred.
- Most appraisals of new ideas or ways to expand policies were based on a single scenario of policy scale and impact; there was no systematic attention to different scales of policy intervention. This may have denied policy-makers the ability to determine the optimal level of intervention for each policy.

## Policy selection was broadly in line with the results of cost-effectiveness analysis

- The principal driver of policy choice in the 2006 Review was the early recognition that the UK was very unlikely to meet its 2010 domestic target – achievement of the Kyoto target was never in much doubt. Cost effectiveness data was just part of policy-makers' consideration of the right policy mix to achieve the national target.
- Existing policies were continued, and some expanded. Data suggested that two significant policies (the Renewables Obligation, and Voluntary Agreements with car manufacturers) were not cost-effective in terms of carbon reduction, but these policies were continued (and the

latter extended) because policy-makers believed that the quantitative analysis did not capture their full impact or their value in assisting other government objectives.

- The majority of new policy ideas were forecast to produce minimal carbon savings and be non cost-effective. As a result, few were selected for the new Programme, and the final selection of existing and new policies will still leave the UK short of its 2010 domestic target.

## Issues for Committee scrutiny

**5** On the basis of our findings, the Committee may wish to pursue the following lines of inquiry:

- Given the inherent uncertainties associated with the social cost of carbon, will it ever be an appropriate basis of future policy appraisal? How will policy change in the wake of Stern's new estimation of this cost (and thus the value of carbon savings)?
- Did the 2006 Review explore or analyse enough policy ideas and options for intervention to fill the carbon gap?
- Why were most analyses based on a single scenario rather than exploring different scales of policy intervention? How can the government be sure that the most cost-effective option or mix of policies has been selected? Had different scales of policy intervention been considered, might greater carbon savings have been possible?
- Was enough done to counter "optimism bias" – the risk that evaluators may take too rosy a view of the future impact or costs?
- How regularly will the cost-effectiveness of the Programme be evaluated? What will be the role of the Interdepartmental Analysts Group and the new Office for Climate Change?
- Was the remit of the 2006 Review appropriate? Was it sensible for it to be focused on achieving the 2010 domestic target, with little attention to achieving longer-term targets? Will the next round of appraisal focus on 2020 targets or 2050? When will longer term policies be considered, if every review is focused on the next short-term target?
- Was it reasonable to exclude some ideas because they could not be appraised in the timescale of the Review?
- The analysis of many new policy ideas found them to be small in impact but large in cost. Analyses in other countries have had similar results. Should the focus be on expanding and improving existing policies such as the Climate Change Levy, Climate Change Agreements, and emissions trading schemes, rather than thinking up new interventions?[2]
- What lessons have been learned from the conduct of the 2006 Review? How will practice be improved in future reviews?

# PART 1

# 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 cost-effectiveness indicators that informed the Climate Change Programme Review carried out between September 2004 and March 2006 (hereafter referred to as the 2006 Review). This briefing responds to the Committee's request.

**2** A separate briefing being prepared for the Committee examines the projections of carbon emissions in the 2006 Review. At a detailed technical level, the preparation of projections and data on cost-effectiveness are closely connected **(see Figure 1)**, but for the purposes of these two briefings we can treat projections and cost-effectiveness as two distinct topics.

**1** 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 existing and proposed policy instruments as part of the 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 mostly 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 Review's aggregate modelling and consideration of costs.

*Source: National Audit Office*

**3** The focus of this briefing is to help the Committee understand the method by which the cost-effectiveness indicators were calculated, their meaning and reliability, and how they influenced the choice of policies in the 2006 Review. We used a variety of methods **(see Figure 2)** and were assisted by consultants Frontier Economics.

## Climate change could bring significant costs, but Government expects it will be cheaper to address the problem than to deal with the consequences

### Global estimates

**4** A growing body of opinion has estimated that the worldwide cost of mitigating climate change (that is, stabilising greenhouse gas emissions at a safe level) at between one to 4.5 per cent of annual GDP for the next 50 years.[3] Recent work by PwC is in line with these estimates.[4] And the international body of experts convened to address climate change issues, the Intergovernmental Panel on Climate Change, has put

**2** Our methodology

We interviewed analysts from several departments who were involved in the Review. We examined Review minutes, working papers and consultants' reports. We employed consultants from Frontier Economics to conduct a review of ten papers produced during the Review which evaluated or appraised policy ideas. The ten policies selected were those that are forecast to contribute the greatest carbon savings. We have not conducted a full audit of the figures; rather, our focus was to provide to the Committee a greater understanding of the technical aspects of cost-effectiveness.

We have also conducted a brief international comparison. This was based on 4th National Communication reports to the United Nations Framework Convention on Climate Change (UNFCCC). (Signatory nations are required to submit an annual communications report to the UNFCCC, in which each nation should include a description of its domestic Climate Change measures and an evaluation of how these contribute to meeting its commitment.) Denmark, Sweden and the Netherlands gave sufficient information to enable comparison with the UK cost-effectiveness methodology.

*Source: National Audit Office*

the cost of achieving an atmospheric target of 550ppm at between US$78 and US$1141 billion per annum (equivalent to 0.2 to 3.2 per cent of current annual GNP). [5] The recent Stern Review[6] estimated the cost of mitigation at around one per cent of global GDP (within a range of –1 to 3.5 per cent or –2 to five per cent according to the different modelling used).

**5** There are also likely to be significant costs associated with policies to adapt to climate change – for example in flood defences or agricultural protection. Quantitative information on the costs and benefits of economy-wide adaptation is currently limited. However, Stern estimated that the additional costs of making infrastructure and buildings more resilient to climate change in OECD countries could range from US$15-150 billion each year (0.05-0.5 per cent of GDP).

**6** But the costs of dealing with climate change are far less than the costs of not dealing with it. Recent reports have suggested that the costs of failing to take action on climate change may be significantly greater than the costs of mitigation, perhaps in the order of six to eight per cent of global GDP by 2100.[7] The Stern Review estimated that climate change consequences could be equivalent to a loss of between 5 and 20 per cent of world GDP per capita.

## UK implications

**7** Although climate change will affect countries differently, with developing countries likely to suffer most and earliest, the UK is not immune to these consequences and costs. The UK picture of costs and benefits is not very different from the global outlook.

**8** In terms of the costs of mitigation, modelling carried out by DTI has estimated the annual economic cost of reducing UK emissions by 60 per cent from 1990 levels to be between 0.5 to two per cent of GDP over the period to 2050.[8] A later review found that these estimates were reasonable when compared with studies elsewhere.[9]

**9** UK policy on climate change is a mixture of direct government expenditures (on grants and educational campaigns, for example); economic instruments such as the climate change levy; regulation and voluntary agreements. There are no conclusive data readily available on the direct taxpayer cost of climate change policy but our own estimate, set out in Appendix 1, is that there are direct expenditures of around £600 million a year, together with tax foregone (in return for climate change agreements) of around £300 million a year. These are conservative estimates – actual spending figures are likely to be higher. There are also significant amounts of taxation – primarily duties on petrol and diesel (£23 billion in 2005) – which influence carbon emissions.

**10** Despite the costs of dealing with climate change, current policies are nonetheless expected to bring a net benefit to the UK. This is because the costs of policies are expected to be less than the cost of damage that would otherwise be caused to the environment, to health and the economy. The analysis conducted during the 2006 Review suggested that this net benefit may be in the region of £86.5 billion[10] over the lifetimes of the policies. Assuming an average lifetime of five to 10 years, this represents roughly one per cent of GDP per annum. This net benefit is shared between taxpayers, industry and consumers.

- The Exchequer expects to incur a net cost of £20.9 billion[11], though this figure does not include fuel duty receipts.
- Businesses are estimated to incur a net cost of £18.0 billion.[12] This figure includes only direct costs and benefits brought about by government policy, such as changes in tax rates or efficiencies from new technologies. Wider macro-economic impacts have not been quantified by the government, though a recent independent study suggested that new business opportunities worth £30 billion over ten years would be created by the Government's Programme.[13]
- Consumers are estimated to receive a net benefit of £87.1 billion.[14] The reason this is a positive figure is because consumers are deemed to be the beneficiaries of the reduction in climate change damages.

## The 2006 Review was based on a coordinated programme of work across government

**11** The 2006 Review involved Ministers and officials:

- The Review was steered by and reported to a Sustainable Energy Policy Network (SEPN) Ministerial group. A Cabinet Committee on Energy and the Environment (EE) chaired by the Prime Minister was responsible for approval of the final policy package.
- At official level, a Project Board oversaw the Review and advised Ministers. The Board comprised officials from Defra, DTI, DfT, No. 10, the then ODPM, HM Treasury and the devolved administrations. It was chaired by the head of the Climate, Energy and Environment Risk directorate within Defra. The National Climate Change Policy (NCCP) Division within Defra acted as Secretariat to the Board and co-ordinated the production of the final report.
- Analytical work was overseen by the Interdepartmental Analysts Group (IAG), which had been convened to provide analytical support during the development of the Energy White Paper in 2003. This cross-departmental group of around fifty analysts was expanded to include representatives from the Energy Saving Trust, Carbon Trust, Environment Agency and Sustainable Development Commission. Sub-groups of the IAG were established to commission, scrutinise and run the day-to-day co-ordination of methodological and cross-cutting issues.
- The review was split into eight work strands **(see Figure 3)** with a relevant government body taking ownership of each. In some cases work strands were already part of, or overlapped with, projects ongoing in their own right (notably the implementation of the Energy Efficiency Action Plan, the Climate Change Communications Campaign and the implementation of the EU Emissions Trading Scheme). Fiscal policies were excluded from the work strands and were instead considered by the Treasury.
- Consultants were engaged in support of the Review, mainly to conduct evaluations. This was in line with the good practice that those responsible for a policy do not also evaluate it. Appraisal work was more often carried out by departments themselves **(see Figure 4)**.

**3** Work strands within the Climate Change Programme Review

| Work strand | Owner | Other bodies with inputs |
|---|---|---|
| Energy Supply | DTI | Defra, Ofgem, HMRC, HMT |
| Business | Defra | HMT, HMRC, DTI, ODPM, Carbon Trust |
| Transport | DfT | DTI, HMT, HMRC, Defra, Energy Saving Trust |
| Energy efficiency and Combined Heat and Power (CHP) | Defra | Energy Saving Trust, Carbon Trust, ODPM, HMRC, DTI, HMT, Ofgem |
| Agriculture, forestry and land use | Defra | |
| Public sector | Defra | ODPM, DfES, NHS |
| Climate change | Defra | DTI |

The Devolved Administrations had an input into all work strands.

*Source: Interdepartmental Analysts Group*

**4** Use of consultants within the Climate Change Programme Review

In many cases external consultants were used by work strands to estimate potential carbon savings and costs and benefits. Some key pieces of consultancy work that informed the Review included the following:

- AEA evaluated the whole package of energy efficiency measures and assessed the energy price implications of the policy package.
- Oxera collated the synthesis reports on the evaluations of existing policies and the appraisals of new ones.
- AEA assessed the air quality impacts of the policy package.

*Source: Interdepartmental Analysts Group*

**12** The Review included a public consultation, launched In December 2004. This ran until March 2005 and received some 300 responses. In addition, three meetings (in January, April and June 2005) were held with some fifty external stakeholders, including representatives from industry and NGOs. Comments on existing policies and ideas for new measures were considered by the IAG. A full list of the policies being appraised, along with the results of the analytical work, was made available to these stakeholders. However, they were not shown the final policy package before publication.

**13** To ensure a consistent analytical approach, the IAG produced guidance for analysts. These specified templates which Review work strands were required to complete and send to the IAG. The templates facilitated peer review, consideration of overlaps, and consolidation into papers for the Project Board and Ministers. Each evaluation and some appraisals 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 itself. Some appraisals were reviewed by consultants Oxera rather than the IAG.

# COST-EFFECTIVENESS ANALYSIS IS AN APPROPRIATE TOOL TO APPRAISE POLICIES

## Cost-effectiveness analysis was used in the 2006 Climate Change Programme Review

**14** The Climate Change Programme 2006 states that cost effectiveness is one of the key principles upon which policies for the programme were selected.[15] Cost-effectiveness analysis was carried out for both the evaluation of existing measures and the appraisal of possible new policies. The purpose of the analysis was to help:

- rank the best policies;
- rule out the worst policies; and
- put together a new programme of policies which would achieve the Government's target to reduce carbon dioxide emissions by 20 per cent below 1990 levels by 2010.

**15** The results of this analysis were not set out in the published Climate Change Programme itself, but were brought together in two synthesis reports for existing measures and new policies respectively.[16]

## Cost-effectiveness analysis is a widely used policy appraisal tool

**16** A wide variety of techniques are available to policy makers to assess the potential costs and benefits of a policy (see Appendix 2). The choice of technique depends upon the question the policy maker is asking or the types of costs or benefits to be measured. For the 2006 Review, departments considered alternative ways by which existing policies could be evaluated or new policies appraised on a common basis. Each policy was subjected to several analyses. A technique known as cost-effectiveness analysis (CEA) was selected as the primary metric for presenting the outcome of analysis to ministers.

**17** CEA is discussed in a broad range of published guidelines on policy appraisal, such as EFTEC (1999)[17], OECD (2006)[18] and HM Treasury's Green Book. It is used widely to appraise health policies and in environmental policy. CEA was used to support the Climate Change Programme 2000 and the 2001 Intergovernmental Panel on Climate Change report on Climate Change Mitigation. As such, it was an appropriate technique for the 2006 Review to use.

**18** As its name suggests, CEA summarises the costs (and benefits) associated with achieving a key policy goal. All costs and benefits are brought to present day values using standard discounting techniques. To allow comparison between policies, a common unit of effectiveness must be chosen (for example, in health the number of lives saved, or in climate change tonnes of carbon emissions saved). Cost-effectiveness is then expressed as the net benefit or cost per unit of effectiveness (in this case, benefit or cost per tonne of carbon emissions saved):

$$\text{Indicator} = \frac{\text{benefits} - \text{costs}}{\text{unit of effectiveness}}$$

Positive indicators represent a net benefit, negative ones a net cost.[19]

**19** **Figure 5** shows a typical set of figures, for some of the main policy instruments affecting the domestic sector, with a column showing the cost-effectiveness indicator. The Figure is an extract from a similar table included in our earlier briefing to the Committee, and is in turn drawn from the synthesis of climate change policy evaluations produced as part of the 2006 Review. For example, in Figure 5 the Warm Front scheme has a net benefit of £420 per tonne; in contrast community heating systems have a net cost of £20 per tonne.

**20** Departments considered alternative ways of appraising or evaluating policies on a common basis. Cost-effectiveness analysis was selected because it focused attention on the least cost (or most benefit) way of meeting emission targets, and because (unlike methods which seek to quantify all benefits) it is not reliant on a firm valuation of the social cost of carbon – explained in the next section.

**5** The principal policy instruments for the domestic sector

| Key policy instruments | Cost effectiveness indicator (£/tC) | Planned impact in million tonnes carbon equivalent (MtCe) | Latest projections: emissions reductions (MtCe in 2010) |
|---|---|---|---|
| Energy Efficiency Commitment including Decent Homes | 270 | 1.8 – 3.7 MtCe in 2010 | 1.6 |
| Community heating | -20 | 0.1 – 0.9 MtCe in 2010 | Less than 0.05 |
| Building regulations (domestic) 2002 | 540 | 1.0 MtCe in 2010 | 0.7 |
| Building regulations (domestic) 2005-06 | Data not available | 0.8 MtCe in 2010 | 0.8 |
| Appliance standards and labelling (e.g. Market Transformation Programme) | 570 | 0.2 – 0.4 MtCe in 2010 | 0.2 |
| Warm Front (England) and devolved administration equivalents; Decent Homes programmes | 420 | 0.2 – 0.3 MtCe in 2010 | 0.4 |

*Source: Defra*

## Cost-effectiveness indicators used in 2006 sensibly excluded the social cost of carbon

**21** The social cost of carbon is a value which aims to quantify the damage to health, environment and the economy caused by each tonne of carbon emitted – for example through poorer health outcomes, loss or damage to biodiversity, and economic impacts on agricultural, timber, water and energy industries as well as the loss or damage to coastal resources. The key point about these costs are that they are not felt by the immediate parties to any economic transaction – they are "externalities" in economists' terminology – but are borne by wider society.

**22** We explained that the cost-effectiveness indicator excludes the primary benefit of each tonne of emissions reductions – that is, avoiding the social cost of carbon. Alternative methods such as cost-benefit analysis do take account of all costs and benefits. However, in the case of climate change, the primary benefit – a reduction in carbon emissions – cannot be monetised with any certainty. There are significant uncertainties surrounding this value, with estimates ranging from zero to over £1000/tC:[20]

- Since 2002, government has relied on earlier analysis which suggested that this figure was £70 per tonne within a range of £35 to £140.
- The recent Stern Review suggested £60 to £200[21] per tonne, depending on different emissions trajectories. Stern states that his estimate is higher because his model incorporates explicit modelling of the risk of catastrophe and non-market costs in a way that his predecessors did not.

All analyses recognised that the value is very uncertain.

**23** In theory, at least, the indicator could be used to assess whether society will be better off if the policy is undertaken (if the cost per tonne is lower than the primary benefit – i.e. the social cost of carbon). So if a social cost of carbon of £70 per tonne is accepted, a policy that reduces emissions by one tonne at a cost of more than £70 would be rejected. However, the social cost of carbon has been criticised as being too uncertain to provide the basis of policy decision-making.[22] It has been argued that monetisation of climate change damage, such as loss of ecosystems and large-scale population displacement, cannot be assessed because an upper limit of the cost is so difficult to establish. Recent research carried out on

behalf of Defra concluded that a single monetary estimate of the social cost of carbon should be avoided for policy decision-making.[23] In practice, the 2006 Review placed little outright or explicit reliance on the social cost of carbon to inform policy choices: the data was just part of the information available to policy makers. Policies were not selected purely by comparison with the social cost of carbon, although policies which came at very significant cost were rejected.

**24** Three further limitations must be considered when using CEA:

- By reporting the average cost per unit of benefit over the lifetime of the policy, the single indicator conceals the fact that costs may increase over time as the most efficient ways of meeting the goal are achieved, or may decrease over time as technological know-how increases. Policy makers should recognise this when interpreting the results.
- Policies can be ranked by cost-effectiveness, but policy makers should keep in mind the fact that this ranking will change over time. The relative costs and benefits of policies will rise or fall over time; thus at some point the choice between interventions will switch as their cost-effectiveness alters in rank order.
- CEA does not reflect the potential scale or timing of a policy effect (ie. the total amount of carbon saved or when carbon reductions could be made). For this reason, the results of CEA should be reviewed alongside forecasts of each policy's total potential to reduce emissions and the time in which these reductions could be achieved.

From our review of individual appraisals and of the work done by officials on the programme as a whole, we were satisfied that departments did take account of these limitations, and that their use of the cost-effectiveness indicators was appropriate.

# THE COST-EFFECTIVENESS INDICATORS IN THE 2006 REVIEW WERE RELIABLE ENOUGH TO COMPARE POLICIES

## Analysis in 2006 was more comprehensive and consistent than that which supported the original climate change programme

**25** The Inter-departmental Analysts Group (IAG) provided guidance[24] to policy makers for conducting CEA. The guidance was drawn up during the early stages of the 2006 Review to ensure that policy evaluations and appraisals were carried out in a more comprehensive and consistent manner than in 2000. The CEA that informed the 2000 Programme had only considered sub-sets of total costs and benefits – see **Figure 6**. The analysis performed for the 2006 Review was more comprehensive because it considered and quantified more costs and benefits.

## Appropriate costs and benefits were analysed

**26** The guidelines recommended that:

- Real and direct resource **costs** should be measured for the lifetime of the policy. Wherever possible, all costs should be expressed as monetary values. Where this was not possible, costs should be listed and described qualitatively.
- **Benefits**, excluding the social cost of carbon, should be quantified wherever possible. Guidance was provided on how some common benefits should be measured.
- Certain **other non-quantifiable factors** such as security of energy supply should be taken into account.
- **Distributional impacts**, that is the net cost or benefit to the exchequer, firms and consumer over the lifetime of the policy, should be assessed.

**Figure 7 on page 16** shows these considerations in more detail.

**6** Cost-effectiveness analysis as used in 2000

The 2000 Climate Change Programme relied on a variety of CEA methods to estimate the potential for achieving carbon dioxide emission reductions.

**For the energy sector** the cost-effectiveness of a range of carbon saving technologies up to a 50 year horizon was estimated. A partial CEA approach was used, taking into account investment and operation costs for the energy system, including end users. (By 2006 the model had been updated to include price responses and technological learning, facilitating a more comprehensive approach).

**In the commercial and public buildings sector** the Building Research Establishment surveyed 90 carbon saving measures, such as loft insulation, to assess cost-effectiveness. Here a less standard measure of cost-effectiveness, known as Net Annual Cost (£/annum), was used. This enabled measures to be appraised against each other. However, the analysis did not extend to comparing household policies as a whole against policies from other sectors.

**Recommendations for the transport sector** were informed by a 10-year plan which was partly based on CEA of options to reduce greenhouse gas emissions.[25]

**Recommendations for the domestic sector** were based on partial CEA of Energy Efficiency options.[26]

In each case the measure of effectiveness was the quantity of mitigated carbon emissions. However, the approaches differ quite significantly in terms of how costs were defined. This appears largely to be due to data and modelling constraints at the time.

*Source: Frontier Economics*

**27** Our review of ten evaluations and appraisals found that, where data were available, the costs and benefits of policies were quantified in line with IAG guidelines. In general, the selection of costs and benefits seemed appropriate. As an illustration, **Figure 8 on page 17** shows the estimated costs and benefits of one of the policies appraised during the 2006 Review. In general, analysts also identified non-monetary impacts. They assigned a positive, negative or neutral rating for air quality, competitiveness, security of supply and fuel poverty, in order that the Project Board and Ministers could better assess the effect of each policy.

## 7 Costs and benefits outlined in IAG guidelines

**Direct costs**

Real resource costs might include

- the up-front costs associated with new investment;
- the ongoing running costs (including marketing);
- administrative costs incurred by government and its agencies; and
- costs incurred by other firms and individuals affected by the policy.

**Ancillary impacts (costs or benefits)**[27]

Examples of quantifiable ancillary impacts are:

- comfort taking, e.g. where consumers who have installed improved insulation will keep their house warmer rather than using less energy;
- air quality impacts; and
- changes in traffic congestion.

Examples of non-quantifiable ancillary impacts are:

- Security of supply: In assessing this analysts should note whether the policy results in a significant reduction in energy consumption and which fuels are affected; whether it has a significant impact on the UK fuel mix; whether it has a significant regional impact; or whether it affects the short-run security of supply.
- Fuel Poverty: To assess this, analysts should take into account whether the policy affects domestic electricity and gas prices; whether it reduces heating needs for vulnerable groups; what the impact is on the number of fuel poor.[28]
- Competitiveness and innovation within British industry.
- Impacts on biodiversity.
- Regeneration.

**Distributional impacts**

Impacts should be assessed for:

- the **Exchequer**, defined as expenditure net of revenues;
- **businesses**, defined as the one-off and ongoing costs to businesses, plus any tax liability, net of any payments from government, assuming no changes in prices to customers; and
- **consumers**, including movement in the price of goods as a result of firms changing prices, net of any changes in taxes on consumers. In addition, monetary values for greenhouse gas emissions (calculated via the social cost of carbon) and air quality benefits are attributed to consumers.

*Source: Interdepartmental Analysts Group*

**8** Costs and benefits of a successor to the Voluntary Agreement package

In the late 1990s, the European Commission secured Voluntary Agreements with car manufacturer associations which set a target to reduce new car $CO_2$ emissions to 140g/km by 2008-09. This represents a 25 per cent improvement over 1995 levels. The 2006 Review looked at a successor to these Voluntary Agreements which would sustain fuel efficiency improvements to 2020. The appraisal highlighted the following costs and benefits.

**Costs**

- Costs to business of adopting new technologies (£9.67 billion).
- Costs to business and consumers of increased congestion, caused by the fact that consumers are expected to drive more as driving becomes cheaper (£7.96 billion).
- Costs of accidents, which will rise in number along with increased congestion.
- Air quality will worsen marginally, because consumers are expected to drive more as the cost per km of driving falls.

**Benefits**

- Value of the carbon saved, based on the social cost of carbon (£1.32 billion).
- Savings to consumers, because they will be purchasing less fuel (£3.82 billion). This figure takes account of the fact that consumers are expected to drive more as driving becomes cheaper.
- The benefit society receives from driving more (£0.69 billion).
- The benefit society receives from increased use of in-car appliances such as air conditioning (£0.17 billion).

*Source: Department for Transport (2005)*

NOTE

Figures are net present values calculated over the lifetime of the policy.

**28** All costs and benefits were brought to present day values through the use of discounting techniques. Discounting is a tool used commonly by both business and government to appraise projects or investments: it converts future cash or resource flows into today's terms by discounting them at a percentage rate which aims to reflect the fact that £1 today is worth more than £1 tomorrow, even after taking inflation out of the equation. For the 2006 Review analysts used a discount rate of 3.5 per cent for impacts that occur in the next 30 years, and lower rates thereafter, in line with Treasury guidelines.

## Analysis was based on reasonable assumptions

**29** Forecasting inevitably relies on significant assumptions about the future. In the case of climate change, the reliability of the expected carbon savings and cost-effectiveness indicators depends a great deal on the reasonableness of key assumptions such as:

- future fossil fuel prices;
- the take up of energy efficiency measures;
- the costs of new low carbon technology options;
- the scale of adoption of new technologies; and
- what level of improved efficiency new technologies will bring.

Our review of ten evaluations and appraisals found that in general these key assumptions were reasonable. The IAG provided guidance on how to make assumptions on energy prices to promote consistency. Elsewhere, work strands or their consultants had to make assumptions based on market or industry data.

## Analysts considered sensitivity and risk but inherent uncertainties remain

### Uncertainties in cost-effectiveness

**30** Even where all assumptions appear to be reasonable, significant uncertainties remain because:

- estimations are open to bias;
- there are always uncertainties in predicting the future;
- there are additional uncertainties when non-monetary costs and benefits are quantified; and
- there is usually a greater degree of uncertainty about new policies compared with existing ones.

**31** Many evaluations and appraisals in the 2006 Review shared similar uncertainties about:

- the scale of future costs including capital costs and energy costs;
- the user response to initiatives (e.g. take-up of energy efficiency measures);
- statistical or econometric forecasts based on past trends; and
- what would have happened without the measure in place (the "counterfactual").

**32** If uncertainties are not well handled, cost-effectiveness indicators may be inaccurate and policy decisions based on those indicators flawed. The risk can be reduced by consciously considering bias. The scale of risk can be identified by performing sensitivity analysis.

## Optimism and pessimism bias

**33** Policy appraisal is often at risk from over-optimism or pessimism. For example, in appraisals the pace of technology adoption is often underestimated and the cost of businesses complying with regulation is overestimated.[29] The IAG guidelines follow the Treasury's Green Book, which recommends that adjustments for bias should be empirically based: where there is robust evidence of bias, this evidence should be used. Otherwise data from past or similar projects can be used and adjusted for the unique characteristics of the project in hand.[30]

**34** Our review of ten evaluations and appraisals found that only a few explicitly considered optimism or pessimism bias. In some cases analysts explained that this was due to a lack of past or similar projects for comparison. We also found no evidence of peer reviewers systematically or explicitly considering the risk of optimism (or indeed pessimism) bias in evaluations or appraisals, although they did implicitly do this by questioning key assumptions that seemed unreasonable.

## Sensitivity analysis

**35** Sensitivity analysis is a technique which determines how much the outcomes of an evaluation or appraisal will change if key variables are changed. The IAG guidelines state that sensitivity analyses should be carried out for key variables such as fuel prices and the rate of adoption of new technologies. In the 2006 Review analysts estimated high, central and low cost-effectiveness indicators for each policy, based on changes to key variables. **Figure 9** gives examples of the kinds of variables considered. Of the 10 evaluations and appraisals we examined in more detail, the evaluation of Climate Change Agreements was the only one which did not include sensitivity analysis.

**36** Sensitivity analysis was performed only on variables outside the control of policy makers. Controllable variables such as the level of funding, the scale of the policy or the type of intervention were not analysed in this way. Instead, sensitivity analysis looked at uncertainties of outcome around an assumed scale or type of policy intervention.

**37** For existing policies, there remains considerable inherent uncertainty attaching to cost-effectiveness indicators, as described in **Figure 10**. Whilst there is considerable uncertainty, it is not so significant as to fundamentally alter views about most policies' cost-effectiveness or worth.

**9** Examples of sensitivity analysis in use

- For the EU Emissions Trading Scheme, costs were estimated for a wide range of carbon prices. On the basis of historic prices and underlying uncertainties, the range seemed reasonable.
- For the evaluation and appraisal of an extension to the Renewables Obligation, consultants carried out sensitivity to a range of factors when modelling the resource costs of renewable technologies. For example, the costs of on-shore wind power were checked for sensitivity to changes in capacity and wind speeds.

*Source: Frontier Economics*

**10** The extent of uncertainty in the evaluations of existing policies

**Net Present Value**

Future costs and benefits were identified, and discounted to present value using standard discount rates. The net sum of benefits minus costs is referred to as the Net Present Value or NPV. High, low and central estimates for NPVs were estimated for a majority of policies. On average, the range from high to low is 91 per cent of the value of the central estimate. On average, the high estimate is 60 per cent higher than the central estimate; the low estimate is 31 per cent lower than the central estimate. Though the actual figure may be subject to a range, all policies clearly result in a positive or negative result.

Though these are only mean figures, and do not include all existing policies, they do illustrate considerable uncertainty in the value of the costs and benefits expected.

**Cost-Effectiveness Indicator**

When the uncertainty in the costs and benefits is combined with uncertainty in the projected carbon savings, there is also a considerable degree of uncertainty in the resulting cost-effectiveness indicator.

On average, the range from high to low is 48 per cent of the value of the central estimate. On average, the high estimate is 30 per cent higher than the central estimate; the low estimate is 18 per cent lower than the central estimate.

*Source: National Audit Office*

**38** The appraisals of new policies were subject to greater uncertainty. In one sector the consultants performing the appraisals felt that given the uncertainties in the figures, *'simple comparisons between specific policies could be highly misleading'*.[31] They suggested further analysis and appraisal to improve the reliability of the figures. Oxera's peer review of appraisals also highlighted areas of significant uncertainty and stated that further investigation might lead to different results. For most new policies, only central estimates of NPVs (excluding the social cost of carbon) were produced. Ranges of carbon savings were produced for every policy.

## Quality assurance processes ensured analyses were reasonably consistent and well-founded

**39** Our review of the minutes of IAG meetings suggests that peer reviewers were active in questioning the work done by analysts. Comments included:

- data were not always sufficient to verify all of the analysis provided;
- overlaps with other policies had not been fully considered;
- some assumptions were questionable;
- there was a lack of sensitivity analysis relating to certain variables; and
- some impacts had not been accounted for.

**40** Oxera were employed to produce a synthesis of the evaluations. Whilst collecting the information, they checked that evaluation criteria had been complied with, and ran a simple sense check of the figures.

**41** Oxera were also asked to perform the peer review of many of the new policy appraisals, as deadlines were approaching and the IAG did not have the resources to do the peer review themselves. Oxera found that:

- appraisals were produced in a variety of formats;
- some appraisals had no supporting documentation whilst others had clear calculations and layouts;
- most appraisals adhered well to the IAG guidance;
- there were overlaps between some policies that would have to be taken into account when consolidated;
- some appraisals had failed to identify delivery mechanisms; and
- some appraisals were missing important information on costs, such that they only reported the carbon savings and the value of benefits thereof.[32]

We saw that analysts performed more work to resolve issues highlighted by peer review, such as running models with different variables, revisiting baseline assumptions and correcting numerical errors.

**42** The IAG guidelines state that costs and benefits of a policy must only relate to the unique elements of that policy. If a policy overlaps with another, this must be taken into account. Where there are clear overlaps, the guidelines recommend considering the combined impact of the policies. The same approach could be followed for policies which are substitutes. During the 2006 Review, a sub-group of the IAG was established to consider areas of overlap and synergies between work strands. Oxera also provided some analysis of where they thought policy overlaps occurred. Our review of ten evaluations and appraisals found that in general overlaps had been taken into account in the cost-effectiveness calculations. Some examples of overlaps are described in **Figure 11.**

**43** As far as the existing documentation allows us to tell, it appears that quality assurance was mostly successful in addressing overlaps, issues of consistency and comparability, and improving the sensitivity analysis. It was less able to address weaknesses in the methodology relating to missing or out of date data, and where appraisals required more time and resource than was available to the Review. This was not a significant problem, but full analysis was not completed for all appraisals.

**44** Fiscal measures were not subject to the same quality assurance processes. They were appraised by analysts working within HMT and HMRC, and the IAG did not have sight of them. IAG analysts were therefore uncertain of the carbon saving that would be achieved by fiscal measures until a late stage in the Review.

**45** Officials expressed confidence in the reliability of the cost-effectiveness figures produced by the 2006 Review: the processes described above are at least as rigorous as that used in policy-making elsewhere in government. The use of guidelines, external consultants, sensitivity analysis and quality assurance all add weight to this view. The UK methodology also compares favourably with other countries we looked at.

**11** Examples of policy overlaps that were considered

**Transport**

Graduated Vehicle Excise Duty, Company Car Tax and EU Voluntary Agreements on new car fuel efficiency were considered as a package because they all contribute to the same outcome: improved fuel efficiency.

**Domestic**

Several policies are aimed at improving domestic energy efficiency. Defra counted benefits from only a small number of polices, whilst treating all other policies as 'supporting'. Costs of all policies were included.

*Source: Interdepartmental Analysts Group*

**Comparisons with Sweden, Denmark and the Netherlands**

The UK Government's methodology compares favourably in terms of consistency of approach.

In Sweden different climate change policy instruments are evaluated using different measures, making comparison across sectors difficult. Like the UK, qualitative and quantitative methods are used. The government of the Netherlands examines the cost-effectiveness of the programme as a whole, rather than attempting to assess individual measures. The Danes analyse each policy separately but do not consider overlaps.

Like the UK, the Swedish government attempts to split out costs for public bodies, companies and households; in the Netherlands they distinguish between government costs and end-user costs.

The UK is not alone in having difficulty quantifying ancillary impacts. In Denmark no attempt was made to quantify the monetary value of the ancillary effects such as improved security of supply, technological and commercial development nor all environmental impacts. Sweden attempt to make estimates, but note the difficulties involved.

*Source: 4th National Communication reports to the UNFCCC*

# NOT ALL POLICIES OR POLICY OPTIONS WERE COVERED BY COST-EFFECTIVENESS ANALYSIS

## Some policy ideas were not considered for the Review and were not analysed

**46** During the course of the 2006 Review, departmental analysts and consultants evaluated nearly 40 existing policies and appraised nearly 70 new or expanded policies. Although some existing policies had been evaluated or appraised for or since the 2000 Review, all such previous work was updated to reflect the latest data and evaluative work. This was a major exercise, unusual in its scale and intensity within government, to ensure that policy makers were armed with up to date information on policy cost and effectiveness.

**47** Although all existing policies were evaluated, analysts did not have the ability to investigate all new policy options. Potential new policies included changes agreed and announced in 2004, such as additional funding for the Carbon Trust, other ideas from government departments, and the results of IAG brainstorming. Departments also agreed to consider every idea raised as part of the consultation exercise, but did not fully appraise a significant proportion of them for the following reasons:

- Some ideas for new fiscal policies were ruled out by ministers at an early stage, such as linking stamp duty to energy efficiency in homes.[33]
- Ideas that were deemed beyond the scope of the Review or were beyond the scope of normal government activity. These included ideas for long-term research and development, areas under EU jurisdiction and ideas for regulators to consider rather than government.
- Ideas that would not be in place in time to contribute towards the 2010 target, even though they could contribute to cuts in emissions by 2020 or 2050. These included the proposal to establish a supply network of hydrogen fuel stations.
- Ideas that would be too difficult to quantify, or could not be appraised within the expected timeframe of the review. These included suggestions to promote local food economies and curtail long-distance transportation of food.
- Ideas that would be technically or administratively impractical, such as legislation preventing businesses leaving lights or appliances on 24 hours a day.
- Ideas that would probably contribute minimal or no carbon savings such that it would not be sensible to spend resources appraising them. These included the suggestion to exempt nuclear energy and large scale hydro power from the Climate Change Levy.

Almost all other new ideas underwent a full appraisal. However, there were some which were abandoned because initial work suggested they were ineffective, or because the appraisal work could not be completed within the timeframe of the Review.

**48** Phase II of the EU Emissions Trading Scheme (2008-2012) was not appraised by the IAG because a series of separate consultations were running at the same time **(see Figure 12)**.

**12** Appraisal of Phase II of the EU Emissions Trading Scheme

With the National Allocation Plan due to be announced in June of 2006, the Government held a series of consultations during 2005 to establish how the next phase of the EU Emissions Trading Scheme would work in the UK. This considered the overall cap, the industrial sectors to be included and other variables.

Options initially considered would have resulted in a range of carbon savings of 0–10 MtC. This was revised to 3–8 MtC on the basis of consultation with industry and ministerial discussion.

Some analysis of costs to industry was conducted on the basis of a range of estimated future carbon prices. Impacts on air quality, energy prices and security of supply were also considered. Estimated costs are extremely uncertain due to the difficulty in predicting future market prices for carbon. A net cost of £10 to £40 per tonne was calculated on the basis of this analysis, but it is more uncertain than most indicators due to the underlying uncertainties.

In the event, this indicator does not seem to have played an important role in the policy choice process. By June 2006 it was clear that maximum carbon savings were required from the Emissions Trading Scheme to help close the carbon gap left by the rest of the new Climate Change Programme; the cap was therefore set to achieve savings of 8MtC.[34]

*Source: National Audit Office*

## Analyses did not explore different ways to implement each policy

**49** Most analyses did not explore different ways to implement each policy; appraisals did not in general demonstrate that the best cost-effectiveness or carbon saving potential had been selected. For most polices certain variables (the scale of the policy, amount of funding or the type of intervention) were set or assumed before the bulk of the analysis was performed. As a result, one carbon saving figure and cost-effectiveness indicator was produced for each policy (with a high and low value reflecting uncertainties in the analysis). Few work strands seem to have fully analysed whether a particular policy would be more or less cost-effective if variables such as the scale of intervention were changed. Evaluations of existing policies were based on the current policy arrangement; however there was not always full consideration of how the policy might be changed. Likewise, most appraisals of new policies were based on a single set of assumptions. For example:

- Evaluation of Climate Change Agreements was based on the existing energy saving targets and industrial sectors covered by the policy.
- Evaluation of the Carbon Trust's work assumed current levels of funding. The corresponding appraisal produced one indicator for a certain level of additional funding, rather than a range of indicators for different scales of funding.
- Appraisal of a successor to the current Voluntary Agreements assumed that annual improvements in average new car fuel economy of 1.5 per cent would be achieved by car manufacturers.

**50** In theory, analysis of a range of variables should enable a comparison of the cost-effectiveness of policy options to be better informed. Another advantage is that it enables a policy to be set at a level which will complement other policies.

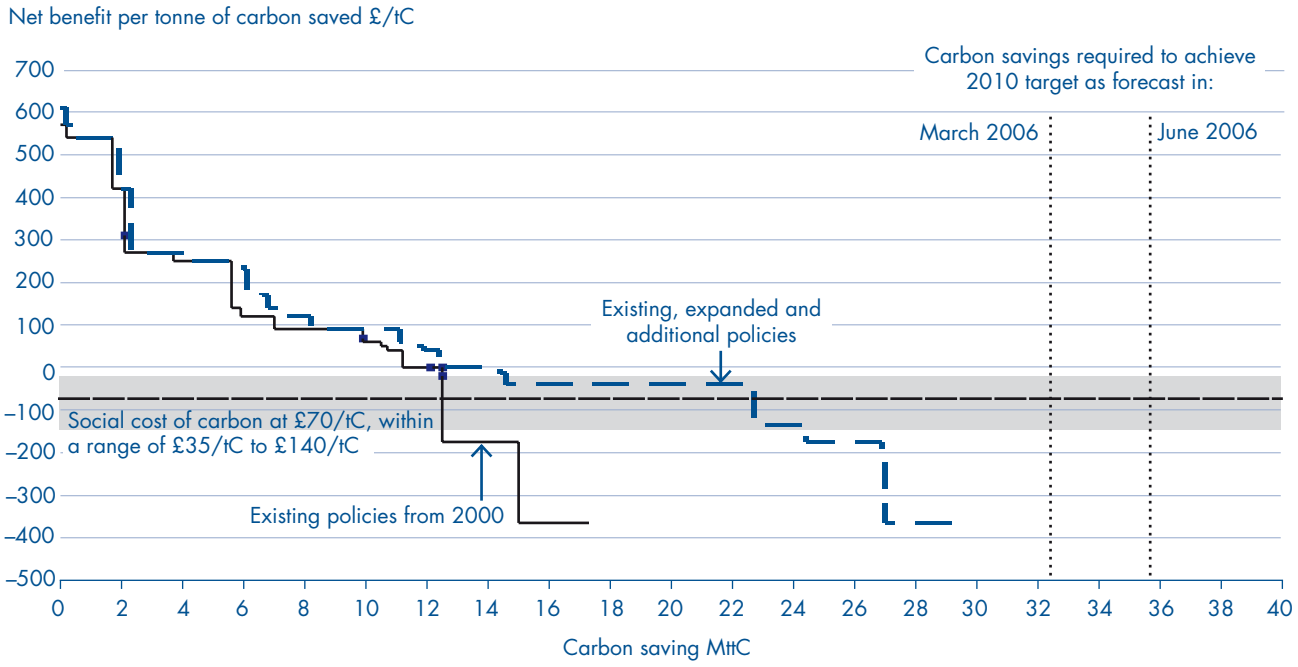
# POLICY SELECTION WAS BROADLY IN LINE WITH THE RESULTS OF COST-EFFECTIVENESS ANALYSIS

**51** The result of the analysis described and evaluated in the preceding sections was a series of cost-effectiveness indicators. Working papers of the Project Board show that these indicators did have an influence on the final policy programme. However, the principal driver of policy choice in the 2006 Review was the early recognition that the UK would fall well short of its 2010 domestic target – achievement of the Kyoto target was never in much doubt. Cost effectiveness data was just part of policy-makers' consideration of the right policy mix to achieve the national target.

**52** **Figure 13** shows the mix of policies at the start and the end of the 2006 Review. The two lines show policies in the order of their cost-effectiveness, with the most beneficial at the left and the least at the right. The main points from the figure are:

- Both the start and end position fell short of the 36MtC of reductions needed to meet the UK's 2010 domestic target, although the Review resulted in an additional 12MtC towards this target, leaving a carbon gap of around 6MtC.

**13** Carbon dioxide abatement curves for the 2000 and 2006 programmes, as assessed in 2006




*Source: National Audit Office*

NOTES

1 Each 'step' shows a policy within the Climate Change Programme, for both the original programme and 2006 programme. If £70/tC were an undisputed measure of the social cost of carbon, no policies below that line would have been selected.

2 At the time of the publication of the 2006 Programme it was estimated that carbon savings would fall 3.2MtC short of the 2010 target. In June 2006 the carbon gap increased to 6.3 MtC, based on revised projections.

3 Not all impacts can be quantified and included in the cost-effectiveness indicators (see Figure 7). Impacts on such things as security of energy supply, competitiveness and innovation were considered but will not be represented in the graphs, as they were not given monetary weightings.

- Both start and end positions included policies with a wide range of cost-effectiveness indicators. Most policies chosen were estimated to bring a net benefit, but some policies with a net cost were selected as well, including some policies which fell below the then estimate of the social cost of carbon (£70 per tonne).

**53** Initially, it had been assumed that when aggregated, the results of analysis would produce several options by which the 2010 target could be achieved and that only those that were most cost-effective would be chosen. This did not turn out to be the case. Policy-makers commissioned further analysis late on in the Review to try to locate further carbon savings. Policies that were expanded, and new policies selected, during the course of the 2006 Review were spread across the range of cost-effectiveness.

**54** The following sections explore the policy selection process in more detail.

## Most existing policies were considered to be cost effective

**55** All existing policies were continued. We found that almost all decisions to continue or expand existing policies were consistent with the results of the cost-effectiveness analysis, shown in the top half of **Figure 14 on pages 26 and 27**. The analysis found all existing policies to bring net benefit, with two significant exceptions, which policy makers decided to continue because non-monetary impacts were taken into account:

- The Renewables Obligation (net cost £175 per tonne) was continued because of its wider benefit in supporting the UK's security of energy supply. No monetary value was placed on security of supply, and DTI considered that the policy was more cost-effective than its indicator suggested.
- The Voluntary Agreements Package with car manufacturers (net cost £365 per tonne) was continued and will be extended because it is a policy where technology costs were expected to decline over time, bringing the lifetime cost down. It was considered to promote innovation in low-carbon transport technology: an impact which could not be quantified.

**56** It was decided to expand some existing measures – shown in the bottom half of Figure 15. Most of these were policies which analysis had shown to be highly cost-effective, such as the extension of the Energy Efficiency Commitment, Warm Front programmes and Market Transformation and consumer information programmes.

## Most new policy ideas were thought to be cost-ineffective

**57** The new policy ideas included in the new Climate Change Programme are listed in **Figure 15 on page 28.** Where cost-effectiveness data was compiled, their indicators range from a net benefit of £610 per tonne to a net cost of £140 per tonne. Despite having low cost-effective indicators the Renewable Transport Fuel Obligation and subsidy for biomass heat do have positive non-quantified impacts on innovation and energy security.

**58** The results of the appraisals of new policies suggested that many were simply not cost-effective. **Figure 16 on page 29** shows some of the policy proposals which were considered and not taken forward. The finding that most new ideas are not cost-effective is in line with similar work in other countries.

**International Comparisons: Sweden, Denmark and the Netherlands**

Both Sweden and Denmark stated that their analysis shows that the more general and more flexible policies, such as emissions trading schemes, have a higher cost-effectiveness than more specific and targeted policies. The Danish communication states that unlike the EU Emissions Trading Scheme, there are few domestic policies with significant potential for abatement that are also cost effective. This seems very similar to the results of the UK's analysis.

The Swedish communication agrees that targeted instruments have generally been found to be less cost-effective but notes that they can create an awareness of new carbon abatement opportunities. The Swedes argue that it has been useful combining general (highly cost-effective) instruments with more targeted (lower cost-effectiveness) instruments.

*Source: 4th National Communication reports to the UNFCCC*

**59** Some policy ideas were rejected because they required further analysis that was not possible within the resource and time provided to the Review. These included measures to enhance the energy performance of buildings and extensions to the Smarter Choices and Sustainable Distribution transport programmes. A new mandatory UK Emissions Trading Scheme is still under review. Regulations on the energy efficiency of house extensions have not been ruled out.

**60** The focus of the 2006 Review was the 2010 target, rather than longer-term objectives. Two policies were predicted to have a greater effect by 2020, but were not taken up:

- a new mandatory UK Emissions Trading Scheme, as suggested by the Carbon Trust, was estimated to contribute annual savings of 2.4–3.3 MtC by 2020. Work on this policy is ongoing.
- the idea to provide organisations with a temporary relief on their business rates as a reward for investments in energy efficiency was estimated to contribute annual savings of 1.4 MtCe by 2020. However, there were concerns over the cost to the Exchequer, and further work was needed to resolve uncertainties about the response by businesses.

## 14 Cost-effectiveness data for existing policies

| | Policy | | Carbon saved (MtC) | | Lifetime net present value[4] (£m) | Cost-effectiveness indicator (£/tC) | Distribution of net present value over lifetime (£m)[5] | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | 2010 | 2020 | | | Exchequer | Businesses | Consumers |
| **Existing policies unchanged** | | | | | | | | | |
| Energy supply | Renewables Obligation | | 2.5 | 3.5 | (11,400) | (175) | 1,200 | (11,100) | (16,900) |
| Business | Climate Change Levy[7] | | *3.7*[2] | *3.7*[2] | 11,600 | 100 | | | |
| | Climate Change Agreements[7] | | 2.9 | 0.3 | 5,500 | 90 | | | |
| | F-gas Integrated Pollution Prevention and Control | | *1.4*[3] | *1.3*[3] | 3,500 | 70 | 0 | (105) | 3,504 |
| | Carbon Trust | | 1.1 | 2.2 | 3,400 | 120 | (331) | 1,756 | 1,986 |
| | Building Regulations 2002 and 2005 | | 0.6 | 1.9 | 3,800 | 60 | (70) | 1,893 | 1,965 |
| | UK Emissions Trading Scheme | (effect on other greenhouse gases) | *0.5*[3] | | 256 | (10) | (66) | (6) | 328 |
| | | (effect on $CO_2$) | 0.3 | 0.0 | 837 | 140 | (114) | 591 | 360 |
| | Voluntary Agreements F-gas | | *0.1*[3] | *0.1*[3] | 84 | 50 | 0 | (5) | 84 |
| | Loan Action Scotland | | 0.0 | 0.0 | *7* | 310 | 0 | *7* | 2 |
| Transport | Voluntary Agreements package, including reform of company car tax and graduated Vehicle Excise Duty | | 2.3 | 3.5 | (6,700) | (365) | (9,100) | (4,300) | 6,600 |
| | Fuel Duty Escalator[7] | | 1.9 | 1.5 | 17,000 | 250 | | | |
| | Wider transport measures | | 0.8 | | | | | | |
| | Sustainable distribution in Scotland and Wales | | 0.1 | | | | | | |
| Domestic | Energy Efficiency Commitment (EEC) (2002-11) | | 1.6 | 1.6 | 15,700 | 270 | (829) | (2,637) | 16,526 |
| | Building Regulations 2002 and 2006 (including condensing boilers update 2005) | | 1.5 | 4.5 | 34,700 | 540 | (13) | 0 | 34,731 |
| | Warm Front and fuel poverty programmes | | 0.4 | 0.3 | 5,500 | 420 | (3,094) | 0 | 8,624 |
| | Market Transformation including appliance standards and labelling | | 0.2 | 1.0 | 6,700 | 570 | (18) | 0 | 6,712 |
| | Grants for solar panels | | 0.0 | 0.0 | 0 | 68 | (2) | 1 | 1 |
| | Community Energy | | 0.0 | 0.0 | 30 | (20) | (70) | 0 | 101 |
| Agriculture | Woodlands planting since 1990 (Scotland) | | 0.5 | 0.7 | 392 | 40 | | | |
| | Woodlands Grants Scheme (England) | | 0.2 | 0.3 | 161 | 50 | | | |
| | Energy Crops Scheme | | 0.0 | | | | | | |
| Public Sector | Central Government, NHS, UK universities and English schools including Carbon Trust activities, plus regional Central Energy Efficiency Funds | | 0.2 | 0.5 | | | | | |
| Waste | Waste strategies saving $CO_2$ | | 0.2 | 0.2 | | | | | |
| | Waste strategies saving other greenhouse gases | | *2.7*[3] | *3.3*[3] | | | | | |
| **Total** | | | **17.3** | **22.0** | **91,067** | | **(12,507)** | **(13,905)** | **64,624** |

## 14 Cost-effectiveness data for existing policies *continued*

| | Policy | Carbon saved (MtC) | | Lifetime net present value[4] (£m) | Cost-effectiveness indicator (£/tC) | Distribution of net present value over lifetime (£m)[5] | | |
|---|---|---|---|---|---|---|---|---|
| | | 2010 | 2020 | | | Exchequer | Businesses | Consumers |
| **Expansions of existing policies** | | | | | | | | |
| Energy supply | Second phase for the EU Emissions Trading Scheme | 8.0 | 8.0 | | (10)–(40) | | | |
| Business | Carbon Trust support for investment in energy efficiency in SMEs | 0.1 | 0.1 | 630 | 220–230 | | | |
| Transport | Future voluntary agreement with car manufacturers | 0.1 | 2.0 | (5,000)[6] | (220)[6] | (8,000)[6] | (3,300)[6] | 7,800[6] |
| Domestic | Increased activity in Energy Efficiency Commitment (EEC) (2008-11) | 0.5 | 0.5 | 3,100 | 180 | (240) | (500) | 3,300 |
| | Market Transformation/Products Policy: consumer information and standards for lights and other energy-using products (EUPs) | 0.2 | 0.6 | | 610 | | | 9,100 |
| | Expansion of Warm Front | 0.0 | 0.1 | | 270 | 0 | (770) | 2,200 |
| **Total** | | **8.9** | **11.3** | **(1,270)** | | **(8,240)** | **(4,570)** | **22,400** |
| **Total existing and expanded policies** | | **26.2** | **33.3** | **89,797** | | **(20,747)** | **(18,475)** | **87,024** |

*Source: Defra/Oxera*

NOTES

1 Data derives from synthesis reports produced by Oxera on behalf of Defra and underlying working papers. Figures therefore represent expectations at the time of the Review and may not be an accurate reflection of current expectations of policy impact. Where data was not compiled, cells have been left blank; total figures may not therefore include all policies and are a guide only. Figures in italics are excluded from the carbon saved totals.

2 An independent evaluation by Cambridge Econometrics concluded that the Climate Change Levy would deliver annual carbon savings of 3.7MtC. The actual projections that informed the Review assumed a lower level of saving from this policy measure, which are partly included in baseline projections and partly within the Climate Change Agreements estimate. This was because the Cambridge Econometrics analysis included an announcement effect, which is not replicated in the DTI model. Nevertheless, the 3.7MtC figure has been published in the Climate Change Programme 2006, though not included in total carbon savings figures.

3 F-Gas and waste policies are mostly aimed at cutting greenhouse gases other than $CO_2$. As the Government's domestic targets are based on a target reduction of $CO_2$ emissions, these policies are excluded from the total savings figures.

4 Positive figures represent a total net benefit over the lifetime of the policy. Negative figures, shown in brackets, represent a total net cost.

5 Distributional impacts do not sum to the total net present value because costs passed through to consumers by businesses are treated as a cost to both. Distributional impacts to firms are therefore likely to be considerably overstated.

6 Excludes ancillary benefits.

7 The Fuel Duty Escalator was scrapped in 2000 so is not, strictly speaking, an existing policy. But because fuel duty has since remained higher than it would have been had the policy never been implemented, it is still considered to be contributing to carbon reduction targets. Distributional impact figures for the Climate Change Levy, Climate Change Agreements and the Fuel Duty Escalator were not included in the published Review documents which means that they were not subject to the same level of scrutiny as other figures. They are, therefore, not included here because there is less certainty about their accuracy.

**15** Cost-effectiveness data for new policies taken into the 2006 Programme

| Policy | | Carbon saved (MtC) | | Lifetime net present value[4] (£m) | Cost-effectiveness indicator (£/tC) | Distribution of net present value over lifetime (£m)[5] | | |
|---|---|---|---|---|---|---|---|---|
| | | 2010 | 2020 | | | Exchequer | Businesses | Consumers |
| **Expansion of existing policies** | | | | | | | | |
| Energy supply | Subsidy for biomass heat | 0.1 | 0.2 | (550) | (140) | (60) | 430 | 180 |
| Business | Measures to encourage or assist SMEs to take up energy saving opportunities | 0.1 | 0.1 | | | | | |
| Transport | Renewable Transport Fuel Obligation (RTFO) | 1.6 | 1.6 | (2,700)[4] | (135)[4] | | | |
| Domestic | Provision of advice to stimulate early replacement of inefficient boilers and implementation of the Energy Performance of Building Directive | 0.2 | 0.2 | (4) | (14) | (5) | 0 | (150) |
| | Better billing and metering | 0.2 | 0.5 | | 0–170 | | | |
| | Package of measures to improve energy efficiency in buildings | 0.1 | 0.1 | | | | | |
| Agriculture | Strategy for non-food crops | 0.1 | 0.1 | | (45) | (50) | | 80 |
| Public Sector | Action by devolved administrations | 0.3 | | | | | | |
| | Additional effort by local authorities | 0.2 | 0.2 | | 270 | | | |
| | Revolving loan fund for the public sector | 0.1 | 0.5 | | | | | |
| Other measures | | 0.1 | | | | | | |
| **Total** | | **3.1** | **3.5** | **(3,254)** | | **(115)** | **430** | **110** |
| **Total existing, expanded and additional policies (from Figure 14)** | | **29.3** | **36.8** | **86,543** | | **(20,862)** | **(18,045)** | **87,134** |

*Source: Defra/Oxera*

NOTES

1 Data derives from synthesis reports produced by Oxera on behalf of Defra and underlying working papers. Where data was not compiled, cells have been left blank; total figures may not therefore include all policies and are a guide only. Figures in italics are excluded from the carbon saved totals.

2 Positive figures represent a total net benefit over the lifetime of the policy. Negative figures, shown in brackets, represent a total net cost.

3 Distributional impacts do not sum to the total net present value because costs passed through to consumers by businesses are treated as a cost to both. Distributional impacts to firms are therefore likely to be considerably overstated.

4 Excludes ancillary benefits.

## 16 Examples of policy ideas which were dropped following analysis

We have not sought to provide a comprehensive list of all policies appraised and abandoned. The policies listed below indicate the range of ideas across several sectors, and the range of estimated carbon savings and cost effectiveness indicators. All of the other abandoned policies covered by our work were forecast to reduce carbon emissions by less than 1MtC per annum, where information was available.

| Policy proposal | Estimated carbon saving per annum in 2010 (MtCe) | Cost effectiveness indicator (£/tC) | Reason the proposal was dropped |
|---|---|---|---|
| Domestic sector | | | |
| Revising Building Regulations for 2010 and 2015 | 0.1 | 2010: 50<br>2020: (430) | Achieving buy-in from industry would be problematic, as would enforcement. |
| Obliging home-owners to install energy efficiency measures when undertaking extensions | 0.1 | 100 | This may be considered at a later stage, possibly in conjunction with a wider review of sustainability in existing buildings by ODPM. |
| Encouraging Green Roofs (installation of vegetation on rooftops) | 0.02 | (1,000) | Minimal carbon savings, with very high costs. |
| Business sector | | | |
| New Mandatory UK Emissions Trading Scheme | 0.3–0.7 | 427 | The policy was not abandoned but further work was required on the implications for certain sectors, including regulatory burden and competitiveness. |
| Temporary Business Rates relief | 0.4 | (210) | Concerns about the cost to the Exchequer and uncertainty about behavioural responses. |
| Transport sector | | | |
| Strict enforcement of road speed limits | 0.57 | (180) | Carbon would be saved as a result of cars travelling at a more fuel-efficient speed but the cost of ensuring 100 per cent compliance would be high. |
| Reducing speed limits from 70 to 60 mph | 0.86 | (1,900) | Cars travelling at a reduced speed would reduce emissions, but high costs would result from increased enforcement activity and longer journey times. |
| Increased provision of public transport | Negligible | N/A | Evidence suggested that a major expansion of existing public transport schemes would not save substantial amounts of carbon, at least in the short run and would be likely to be extremely expensive |
| High Speed Rail Links | Uncertain, likely to be small | N/A | Estimated carbon savings were very uncertain, and the policy would probably not deliver before 2010. |

*Source: Defra/Oxera*

# APPENDIX ONE

## GOVERNMENT SPEND ON CLIMATE CHANGE POLICIES

**1** The Government does not recognise a single precise figure for spending on climate change. One reason for this is that many policies which contribute towards climate change targets are primarily targeted at other government objectives, such as on energy, fuel poverty or pollution. However, spend on individual programmes is known and can be quoted. **Figure 17** shows the significant areas of spend by type of intervention.

**17** Government spend on climate change

Significant areas of spend have been quantified, but detailed spending figures for all policies were unavailable. Figures for each type of intervention should therefore be treated as a reasonable estimate of spending but true figures will be higher.

| Type of intervention | Spend in 2005-06 | Notes (all figures relate to spend in 2005-06) |
|---|---|---|
| Research and development | At least £250 million | Government funding for a variety of climate change related projects currently stands at around £250 million per annum. This includes research carried out by the Natural Environmental Research Council (£97 million) and the Engineering and Physical Sciences Research Council (£14 million). The cost-effectiveness of these programmes was not evaluated by the 2006 Review because it is difficult to estimate the level of carbon savings that may result from them.<br><br>Research and development of several different renewables technologies are due to receive £500 million over 2002–2008. Some of this figure is in addition to the £250 million spend quoted above.<br><br>Specific grant schemes include:<br>■ New and renewables capital grant £10 million<br>■ Photovoltaic grant scheme £4 million<br>■ Sustainable energy capital grant £28 million |
| Subsidies | At least £197 million | Subsidies reduce the price of goods which promote emissions reductions.<br><br>Specific schemes include:<br>■ Warm Front and fuel poverty programmes £192 million<br>■ Community Energy £5 million |
| Information provision | At least £88 million | These policies seek to enhance information to businesses and consumers to enable them to reduce their emissions.<br><br>Specific schemes include:<br>■ The Carbon Trust £61 million<br>■ Energy Saving Trust £27 million |
| Market creation | At least £41 million | These policies fix a quantity and allow the newly created market to determine the appropriate price. Government spend on the UK Emissions Trading Scheme was up to £41 million. |
| Regulation and voluntary agreements | – | Regulations and voluntary agreements set standards or prescribe particular technologies to be employed. Though there will be costs associated with ensuring compliance, there is no significant spend by central government. |
| Fiscal charges | Around £300 million tax foregone | Environmental levies, charges and taxes bring receipts to the Exchequer rather than an expense. The main explicit climate change tax is the Climate Change Levy, which is intended to be revenue neutral because businesses which pay the levy incur reduced national insurance contributions. This brought in £744 million in 2004-05. A further £300 million of levy was waived for those companies participating in Climate Change Agreements. There are also significant amounts of other taxation – primarily duties on petrol and diesel (£23 billion in 2005) – which influence carbon emissions. |
| **Total** | **Around £600 million of spend, and £300 million tax foregone** | |

*Source: National Audit Office*

# POLICY APPRAISAL TECHNIQUES

## The policy appraisal toolkit

**1** **Comprehensive techniques** take into account all the costs and benefits that are expected to accrue to all individuals as a result of policy implementation. These are the most thorough and so time and resource intensive ways to appraise policies. They are most commonly employed for key policy decisions – for example as a final stage before policy implementation.

**18** Policy appraisal techniques

**Comprehensive appraisal techniques**

- Cost-Benefit Analysis
- Cost-effectiveness analysis (multiple benefits)
- Multi Criteria Analysis

**Partial appraisal techniques**

- Cost-effectiveness analysis (single benefit)
- Environmental Impact Assessment
- Strategic Environmental Assessment
- Life Cycle Analysis
- Risk Assessment
- Comparative Risk Assessment
- Risk – Benefit Analysis
- Risk – Risk Analysis
- Health – Health Analysis

*Source: Frontier Economics*

**2** **Partial appraisal techniques** only consider a subset of total costs and benefits. These are usually used to answer a narrower policy question than comprehensive techniques and are easier to carry out. They rarely replace a full assessment of the costs and benefits of policies but may be used as a substitute in the early stages of policy design, or as a complement in the final assessment.

## Cost-effectiveness analysis

**3** The term 'cost-effectiveness' can be interpreted in a number of ways and can be a partial or comprehensive tool. It is therefore important that CEA is well-defined to avoid misinterpretation. See **Figure 19**.

## Defining costs in cost-effectiveness analysis

**4** A key issue in CEA is how to define costs. In the case of partial policy appraisal, decision makers may choose only to consider the costs that are directly associated with implementing a policy. Comprehensive analysis must take into account a wider set of costs, including social as well as direct costs.

**5** Which costs are included has obvious bearings on the results. It is important that the costs that are taken into account adequately reflect the stakeholders for whom the policy decision is important.

## 19 Cost-effectiveness analysis as partial or comprehensive appraisal tools

**Partial**

$$\text{Cost-effectiveness indicator} = \frac{\text{£ Cost}}{\text{Unit of effectiveness}}$$

Only one measure of effectiveness is used. This must be quantified, but not converted into a monetary expression. On the cost side, all direct policy costs must be identified and expressed in monetary terms.

**Comprehensive**

$$\text{Cost-effectiveness indicator} = \frac{\text{£ (costs – ancillary benefits)}}{\text{Unit of effectiveness}}$$

The cost element of the analysis includes all the costs and all the benefits (excluding the primary measure of effectiveness) arising over the lifetime of the policy. The ancillary (secondary) benefits are included as negative costs.

**Examples of use**

Various analyses supporting the **Climate Change Programme 2000** used partial appraisal.

The **Intergovernmental Panel on Climate Change** report on **Climate Change Mitigation (2001)** used both partial[35] and comprehensive[36] analyses. This included CEA conducted by Manne and Richels (1997)[37] and Edmonds et al. (1997)[38] to present a global benchmark for the least cost way of stabilising carbon dioxide emissions.

Partial CEA fed into the 2003 Energy White Paper, such as ranking renewable sources by cost.[39]

Comprehensive CEA was conducted as part of the **2006 Climate Change Programme Review**.

*Source: Frontier Economics*

# END NOTES

1 http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/stern_review_report.cfm

2 Note the opinion given by the CBI to the Environmental Audit Committee in July 2006: 'there needs to be a streamlining of policy measures (the climate change space is busy with measures)' – http://www.publications.parliament.uk/pa/cm200506/cmselect/cmenvaud/uc1452-i/uc145202.htm

3 Anderson, D and Leach, M (2005), 'The Costs of Mitigating Climate Change', *World Economics*, Vol. 6, No. 3, July–September 2005, p. 78 – http://www.hm-treasury.gov.uk/media/F72/E9/The_costs_of_mitigating_climate_change_(world_economics).pdf

4 PwC, *The World in 2050: Implications of global growth for carbon emissions and climate change policy*, September 2006 - http://www.pwcglobal.com/extweb/pwcpublications.nsf/docid/DFB54C8AAD6742DB852571F5006DD532

5 House of Lords Select Committee on Economic Affairs, *The Economics of Climate Change*, July 2005 – http://www.publications.parliament.uk/pa/ld200506/ldselect/ldeconaf/12/12i.pdf

6 http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/stern_review_report.cfm

7 http://www.foe.co.uk/resource/press_releases/economists_warn_climate_ch_13102006.html

8 http://www.dti.gov.uk/files/file21348.pdf#search=%22MARKAL%22

9 Imperial College London Centre for Energy Policy and Technology and Future Energy Solutions on behalf of Defra, *Options for Low Carbon Future: Review of Modelling Activities and an Update*, September 2005 – http://www.dti.gov.uk/files/file14792.pdf

10 Figure does not include all policies and is a guide only. Distributional impacts do not sum to the total net present value because costs passed through to consumers by businesses are treated as a cost to both. Distributional impacts to firms are therefore likely to be considerably overstated. See Figure 15.

11 Figure does not include all policies and is a guide only. See Figure 15.

12 Figure does not include all policies and is a guide only. See Figure 15.

13 Vivid Economics on behalf of Shell Springboard, *Opportunities for innovation: The business opportunities for SMEs in tackling the causes of climate change*, October 2006 – http://www.shellspringboard.org/downloads/news/Q65_Springboard_Doc_V4.pdf

14 Figure does not include all policies and is a guide only. See Figure 15.

15 HM Government, *Climate Change – The UK Programme 2006*, March 2006, pp 30 and 190 – http://www.defra.gov.uk/ENVIRONMENT/climatechange/uk/ukccp/pdf/ukccp06-all.pdf

16 Defra, *Synthesis of Climate Change Policy Evaluations*, April 2006, and *Synthesis of climate change policy appraisals*, August 2006 – http://www.defra.gov.uk/environment/climatechange/pubs/ukccp/index.htm

17 DETR, *Review of Technical Guidance on Environmental Appraisal*, April 1999 – http://www.defra.gov.uk/environment/economics/rtgea/index.htm

18 Organisation for Economic Co-operation and Development, *Cost-Benefit Analysis and the Environment – Recent Developments*, February 2006 – http://www.oecd.org/document/39/0,2340,en_2649_37465_36144679_1_1_1_37465,00.html

19 Note: in many analyses in other spheres, costs are treated as positive and benefits treated as negative – the higher the resultant figure, the more costly. This is because CEA is often about costs alone, or about minimising costs.

20 http://www.defra.gov.uk/ENVIRONMENT/climatechange/carboncost/index.htm

21 The Stern Review quotes a figure of US$85/tCO$_2$ (year 2000 prices). Using the PPP conversion rate adopted by the Review (of £1 = $1.6), this equates to around £200/tC. This figure relates to a business-as-usual emissions trajectory: if atmospheric carbon is stabilised at 450ppm-550ppm CO$_2$e, the social cost of carbon is estimated to be around $25-30/tCO$_2$ (£60-70/tC).

22 http://www.defra.gov.uk/environment/climatechange/carboncost/pdf/scc-peerreviewcomments.pdf

23 AEA Technology on behalf of Defra, *Methodological Approaches for using SCC Estimates in policy assessment*, December 2005, pp. v-vii.

24 Defra, *Greenhouse Gas Policy Evaluation and Appraisal in Government Departments*, April 2006 – http://www.defra.gov.uk/environment/climatechange/uk/ukccp/pdf/greengas-policyevaluation.pdf

25 DTI, *Cleaner Vehicles Task Force, Technology and Testing*: working-group report, 2000 – http://www.autoindustry.co.uk/docs/74288.pdf

26 http://www.defra.gov.uk/environment/consult/climatechange/31.htm

27 The Intergovernmental Panel on Climate Change define ancillary benefits as follows: *"the term ancillary benefits connotes those secondary or side effects of climate change mitigation policies on problems that arise subsequent to any proposed GHG mitigation policies. These include reductions in local and regional air pollution associated with the reduction of fossil fuels, and indirect effects on issues such as transportation, agriculture, land use practices, employment, and fuel security. Sometimes these benefits are referred to as "ancillary impacts", to reflect that in some cases the benefits may be negative."* – http://www.grida.no/climate/ipcc_tar/wg3/273.htm

28 The guidelines state that the definition and measurement of the fuel poor should be carried out using the definitions and methodologies provided by the DTI.

29 Optimism and pessimism bias and these examples are discussed in more depth in section 5.2 of Organisation of Economic Cooperation and Development (2006), *Cost Benefit Analysis and the Environment – Recent Developments* – http://www.oecd.org/document/39/0,2340,en_2649_37465_36144679_1_1_1_37465,00.html

30 http://www.hm-treasury.gov.uk/media/05553/Green_Book_03.pdf#search=%22hm%20treasury%20guidelines%20optimism%20bias%20uk%22

31 AEA Technology on behalf of Defra, *Evaluation of the Government's Energy Efficiency Policies and Programmes*, April 2005.

32 Oxera, working papers to Defra, August – September 2005.

33 This particular idea has since been accepted and was announced in the December 2006 Pre-Budget Report.

34 Oral Statement by David Miliband, Secretary of State for Environment, Food and Rural Affairs, on EU Emissions Trading: phase II cap – Thursday 29 June 2006 – http://www.defra.gov.uk/corporate/ministers/statements/dm060629.htm

35 Intergovernmental Panel on Climate Change (2001), Section 10.1.4.2 – http://www.grida.no/climate/ipcc_tar/wg3/391.htm

36 Intergovernmental Panel on Climate Change (2001), Section 7.2.2.1 – http://www.grida.no/climate/ipcc_tar/wg3/272.htm

37 Manne, A. S., and R. G. Richels (1997), 'On Stabilizing CO$_2$ Concentrations – Cost-Effective Emission Reduction Strategies', *Environmental Modelling & Assessment*, 2(4), 251-266.

38 Edmonds, J., M. Wise, and J. Dooley (1996), 'Atmospheric Stabilization and the Role of Energy Technology', *Climate Change Policy, Risk Prioritization and U.S. Economic Growth*, American Council for Capital Formation – http://www.accf.org/publications/reports/sr-atmosstab1996.html

39 Energy Technology Support Unit (ETSU)'s 1999 report. See Energy – the changing climate, Royal Commission on Environmental Pollution, June 2000, Chapter 7, table 7.1 – http://www.rcep.org.uk/pdf/chp7.pdf