

# **Carbon Valuation in UK Policy Appraisal: A Revised Approach**

## **Response of Government Economists to Peer Reviewers Comments**

### **Climate Change Economics, Department of Energy and Climate Change (DECC)**

The UK Government recently reviewed its methodology to value greenhouse gas emissions in policy appraisal. The Review implemented a move away from the previous approach, which used estimates of marginal social damage costs ('the social cost of carbon') to value changes in emissions, to one in which valuation is based on the marginal abatement costs that will need to be incurred to meet specific emissions reduction targets. This change was also suggested by several peer reviewers of the 2007 Defra paper on the Shadow Price of Carbon (SPC).<sup>1</sup>

As part of the process of reviewing its carbon valuation methodology, DECC invited comments from expert academics in this area. DECC received seven sets of peer review comments on an early draft of the explanatory note describing the proposed revision to the carbon valuation approach. The purpose of the peer review was to help Government economists finalise the appropriate methodology for valuing carbon in UK policy appraisal, by considering the practical implications and potential risks of the proposed revised approach, the current SPC and other possible alternatives. Within this context, peer reviewers were asked for their thoughts on the document as a whole or on any issues arising.

DECC would like to thank all those who took part in the peer review process for their constructive comments, which have helped us to explain the new approach more clearly and to clarify our thoughts on how the methodology needed to be developed. The paper that has now been published has been amended to take on board many of the comments received.

This document summarises the major points raised by reviewers and outlines the response of Government economists, indicating where they have and have not been incorporated in the new guidance. The first part focuses on the comments received on the overall approach; the second part of the document assesses the peer reviewers' responses to some specific issues highlighted during the process of internal Government review; and the third part of the document discusses some of the other issues raised by peer reviewers.

---

<sup>1</sup> "The Social Cost Of Carbon And The Shadow Price Of Carbon: What They Are, And How To Use Them In Economic Appraisal In The UK" (Defra,2007). Available online at: <http://defra.gov.uk/environment/climatechange/research/carboncost/pdf/background.pdf>.

## **Part I: Overall Approach**

- 1. Most peer reviewers strongly supported (and none was against) the recommended move away from the current approach based on damage cost towards a marginal abatement approach:**

*“I support the general approach taken to the cost of carbon; the arguments for primary reliance on marginal abatement costs are persuasive, and stated well in the draft. Estimates of the social cost of carbon are sufficiently problematical and incomplete that they should play little or no role in policy appraisal.” (F.Ackerman)*

*“In short, the use of SPC in policy appraisal was counter-productive for either informing or steering policy, and was of very limited utility in terms of getting feedback as to its effectiveness in moving towards its targets. It is therefore greatly to be welcomed that the Government is planning to move away from this methodology that is theoretically unsound in relation to climate change, and that encouraged both excessive optimism about mitigation of climate change and activities that made such mitigation more difficult to achieve.”(P. Ekins)*

*“The move to marginal abatement costs, and to a framework of cost-effectiveness, is a reasonable and pragmatic choice...I understand and accept the logic for moving to a MAC based approach...”(P.Watkiss)*

*“I agree with the general thrust of the paper which is to encourage policy makers to factor in higher carbon prices into their decision taking than the current assumptions imply.” (A. Sentance)*

*“ [The paper’s] overall conclusion that some measure of the marginal abatement cost should be used in policy appraisal seems right. It correctly identifies the issues in possibly setting different prices in the traded and non traded sectors and considers the long and the short run.” (P. Johnson)*

*“The appropriateness of a target-consistent approach depends upon the policy questions being addressed. If the question is: “what is the mix of policies which meets the target at least cost?”, then it is the correct approach. However, the SCC is relevant if policy makers are interested in the efficiency of the targets. The practical implications is that both are required.” (D. Helm)*

One reviewer (Ackerman) noted that estimates of the social cost of carbon are “sufficiently problematical and incomplete that they should play little or no role in policy appraisal” and therefore he believes it is appropriate to turn to a target consistent approach driven by science based policy deliberation on sensible targets for emissions reduction.

Other reviewers (Johnson and Watkiss) stressed that a damage cost approach would not necessarily guarantee a carbon price consistent with a given emission reduction target. One reviewer (Watkiss) highlighted that policy targets for the short and long term are not set on the basis of the social cost of carbon, implying a risk of under- or over-achieving targets if the Government continues to use the social cost of carbon.

### **Response of Government economists**

It is reassuring that most reviewers strongly supported the recommended decision to move away from the current approach based on damage cost towards a marginal abatement approach. Most notably, most reviewers supported the arguments in the paper that the SCC is likely to be inconsistent with emissions reductions targets and international agreements, whereas a target consistent approach would help ensure that the targets are met.

#### **2. There was a divergence of views as to whether we should continue to use the SCC to inform the process for setting targets for emission reductions:**

*“The SCC is important as a check on the targets...SCC estimates are however even more susceptible to uncertainty, since they include the damage side as well as the costs. There is a fierce debate on whether damages can be viewed within the framework of cost benefit analysis, and if so how the “fat tail” issue can be taken into account. For these reasons, the range of possible numbers is correspondingly even larger than for the abatement cost and targets measures.” (D.Helm)*

*“I agree with the broad proposal that IAMs and the SCC have a role as an input to long term policy targets, but should not determine it (e.g. through optimisation analysis). However, I found that the current proposal considerably overstates the confidence in the IAMs, and attaches too great an importance to the SCC numbers alone. ” (P. Watkiss)*

*“I really do not think this paper needs to take any view on whether estimates of the SCC are useful in target setting.” (P. Johnson)*

*“... The problems with SCC calculations, however, are insurmountable. As a result, even the limited uses of the SCC proposed in the draft are problematical. [...]The determination of overall targets for greenhouse gases reduction should be, and often is in practice, based on a precautionary response to catastrophic worst case risks, not calculations of the social cost of carbon.” (F. Ackerman)*

*“SPC (based on SCC) is a marginal concept: the cost imposed by the marginal tonne of carbon. Such a concept is inappropriate for a damage function that is suspected to have gross discontinuities, i.e. when a small increase in emissions can lead to a step-change*

*increase in damages, especially when this is accompanied by gross uncertainty as to the level of carbon emissions that will lead to them.” (P. Ekins)*

One reviewer (Watkiss) agreed with the recommended approach of using the SCC as an input in the long term targeting process but highlighted that the review put too much weight on the role of the SCC in the process of target setting, and not enough on other more important factors (i.e. scientific evidence). He also noted that only one integrated assessment model (i.e. PAGE) was used to derive the social cost estimates despite several models already being available.

Another reviewer (Ackerman) was very concerned over the suitability of the SCC to provide support to the target setting process, suggesting that the role proposed for the SCC is “no more defensible than its detailed use in policy appraisal”, principally because the SCC “does not provide a stable, reliable basis for decision making”. He also pointed out that climate change is known to cause damages to economic activity, human health and the natural environment but there is significant uncertainty over the exact timing and extent of these damages. Moreover, estimates of the social cost of carbon are based on scenario modelling and tend to cover only a small set of possible damages. The reviewer also highlighted the difficulties in meaningfully pricing some of the most important damages such as loss of human life, extinction of species and destruction of ecosystems. It follows that SCC estimates are likely to underestimate the most likely climate impacts.

### ***Response of Government economists***

We recognise that Social Cost of Carbon (SCC) estimates remain very uncertain and this is one of the most important factors for the recommended move to a target consistent approach in policy appraisal. There is, of course, uncertainty in abatement cost estimates as well, but the uncertainty is far lower, as recognised by most reviewers.

Despite the significant uncertainty surrounding damage cost estimates, we believe that the most robust evidence available from Integrated Assessment Models (IAMs) should be taken into account in the process of target setting. Without any assessment of the damages of climate change, it would not be possible to reach a view on whether overall stabilisation goals and emissions reductions targets are appropriate. The so-called precautionary principle does not provide a method for doing so, nor does reliance on the “science alone”. However, the comments of the peer reviewers do raise two important questions:

- *How* should damage costs be integrated into the assessment of the appropriateness of overall targets? Should we use the social cost of carbon alone or draw more broadly on IAMs and other evidence?
- Is the evidence on damage costs that we currently use, from the Stern Review, up to date?

In relation to the first question, Paul Ekins makes the point that it is not likely to be appropriate to use the social cost of carbon – a marginal concept – for assessing damages that are likely to be highly non-linear and subject to significant discontinuities. Similarly, Paul Watkiss considers that the paper does not fully capture the necessary role for other inputs, including scientific evidence and risk-based assessments. As set out in the paper, Government economists agree with most reviewers that the SCC should not be the only input in the process of target setting. The latter should be supplemented by scientific information to account for possible lags in the climate system but also by other judgements regarding the acceptable level of risk that we wish to bear of potentially catastrophic events owing to extreme or rapid temperature rises.

In response to this comment it was concluded that, for appraisals of the adequacy of overarching targets and goals, we should not rely on estimates of the SCC alone in quantifying the benefits from action, but use a more integrated approach, drawing on IAMs, evidence about individual impacts and assessments of risks. In practice, this might mean downplaying the role of the SCC in producing a single value for benefits in Impact Assessments assessing the adequacy of targets.

In relation to the second point, to date we have used SCC values drawn from the Stern Review. This is a pragmatic choice, but it is worth noting that Stern has recently suggested that the costs of inaction could be significantly higher than originally estimated in the Stern Review. It is very important that our assessment of damage costs reflects the latest scientific and economic evidence on climate change impacts. For this reason, DECC has commissioned the update of PAGE, a leading Integrated Assessment Model used in the Stern Review that is likely to be completed later in summer 2009.

### **3. Most reviewers thought that the recommended dual approach for valuing carbon in policy appraisal was theoretically sound:**

*“The gap between the price in the traded and non traded sectors seem logical in theory... “  
(F. Ackerman)*

*“The paper recommends using different values for appraisal in traded and non traded sectors. The basic logic is clear. In the EU ETS if we operate policies which involve different carbon valuations than those at which carbon is traded then we will be getting the opportunity cost wrong. The outcome is a price applied in the non traded sector which is much higher than that in the traded sector.” (P. Johnson)*

*“I do not agree with the differential approach to the pricing of carbon emissions in the non traded and traded sectors of the economy.” (A. Sentance)*

*“There is no single unique target for CO<sub>2</sub> reductions – and as new information becomes available, they are likely to change. There is the EU and a number of CCC targets according*

*to time frame. Thus the paper needs to provide estimates for each of these targets, not a single number. Furthermore when the targets change, so should the least cost estimate change too.” (D. Helm)*

Despite describing as “clear” the underlying rationale for the proposed dual approach, one reviewer (Johnson) highlighted that the paper could further explore the possible economic costs of the inefficiencies following a two prices approach. And another reviewer (Watkiss) noted that the paper should pay more attention to the impacts of the recommended carbon valuation approach in the presence of policies that affect both the traded and non traded sectors.

A third reviewer (Sentance) noted that prices could be too low following “market imperfections” but he thought that the recommended dual approach could potentially exacerbate these imperfections by imposing different prices in different sectors of the economy. The reviewer also highlighted that UK policy decisions should be based on the “right shadow price of carbon” in order to ensure a consistent carbon valuation across all sectors of the economy. Moreover, the reviewer noted that policy decisions have a relatively long time horizon therefore they should not reflect possible inefficiencies that might be captured in private prices.

#### ***Response of Government economists***

We welcome the fact that most reviewers thought that the recommended dual approach to valuing carbon in policy appraisal is theoretically sound. As discussed in the paper, this approach aims to ensure that the policies developed are consistent with domestic and international emission reduction targets.

One reviewer (Sentance) was concerned that the recommended approach would institutionalize inefficiencies in the economy. However, it is worth noting that the recommended traded and non traded prices of carbon are for economic appraisal only; they do not represent a policy instrument themselves. As further discussed in the published paper, the main objective of the proposed approach is to encourage Government to seek the most cost effective opportunities to reduce carbon emissions across policies and projects in order to achieve prevailing climate change targets. It is not an endorsement of the current split between the traded and non traded sectors in the UK.

- 4. Most reviewers supported the recommended approach to setting carbon values in the long term (post 2030) based on global abatement costs but some reviewers suggested the policy regime from which they were derived implied action was taking place later than would be optimal:**

*“Yes, this seems like the appropriate way to set long term prices, consistent with the MAC based approach to pricing.” (F. Ackerman)*

*“On the long term marginal abatement costs, there has been considerable work since the IPCC on intermodel comparisons (e.g. within the Energy Modelling Forum, which has standardised inter-comparisons and within the EC’s ADAM project, which has looked at comparison of stabilisation runs). This includes a wider suite of models and it would be useful to compare the existing comparison against this literature.” (P.Watkiss)*

*“...You might consider whether you have the right profile for prices.”(A. Sentance)*

One reviewer (Watkiss) was particularly concerned by the major mismatch between the short term traded price of carbon in 2020 (£26) and the global carbon price in 2030 (£70). He suggested that this significant difference could mean a disconnection between the current political commitments and the realistic level of action required to achieve the long term target. The reviewer also pointed out that the current recommended price profile for the traded sector would make it very difficult for the UK to achieve future deeper cuts if required, for example, in response to new scientific evidence. In other words, the reviewer thought that the large price gap between the short and long run recommended price profile would imply a loss of option value for the UK associated with early action.

Another reviewer (Sentance) thought that the recommended price profile over the 2008-2030 period should be steeper than suggested to reflect the strong price signal required to drive most significant shifts in technology and economic behaviour to occur over the next 50-100 years. More precisely, the reviewer recommended a more sudden rise to £100 by 2025 to send a clear signal to policy makers and businesses in support of the low carbon economy. By contrast, he was concerned that the relatively high recommended price in 2050 could signal that action could be delayed and also wondered whether it would be politically feasible given its relatively high level.

A third reviewer (Helm) stressed the role of technological shocks in shifting the marginal abatement cost curve raising the question of whether abatement costs will be rising in the future to the extent suggested by the recommended approach.

### ***Response of Government economists***

We welcome the support from most reviewers for the recommended approach to setting carbon values in the long term (post 2030) based on global abatement costs.

In relation to the point that prices should be higher earlier on, to avoid lock in, this is again a question about the policy regime rather than the appraisal approach. If there is a strong view that carbon constraints are too weak in the early years, the correct approach would be for Government to respond by increasing the level of constraint, not by changing the value used in appraisal.

As for the suggested comparison between the recommended long term modelling approach based on GLOCAF (and other modelling approaches) and the recent Energy Modelling Forum (EMF), the paper (Annex 3) does already discuss some of the models used in the Forum. More precisely, we looked at Gemini E3 and POLES (both used in the VTC); Merge and Minicam (both used in the USCCSP). However the USCCSP was excluded from the final assessment because its modelling features were inconsistent with those of GLOCAF (i.e. a very generous trajectory until after 2050 implying a relatively low carbon price.).

## **Part II: Specific Issues**

### **5. Most reviewers agreed with the recommended choice of using a model based value to estimate the short term traded price of carbon:**

*"This seems reasonable." (F. Ackerman)*

*"In the traded sector the choice of a modelled value for the traded price of carbon seems inescapable." (P. Johnson)*

*"I felt the analysis only drew on a very small subset of modelling estimates for future prices." (P. Watkiss)*

One reviewer (Watkiss) highlighted that the short term traded carbon price was derived from a small subset of modelling estimates (i.e. EC's model and DECC's model) and suggested that a much wider review of the evidence base was needed. He also noted that there was no price range around the central short term traded carbon price estimate whereas the non traded and the global carbon price estimates were provided within a range.

### ***Response of Government economists***

Following requests from peer reviewers, four additional model based forecasts of EUA prices in 2020 were considered. Two of these forecasts fall within the range produced by the DECC carbon price model, but are above the central estimate, whereas the other two are well above the range. Several modelling assumptions are at the core of the differences between DECC and other estimates. However, in comparison with the DECC model, we have limited information on the structural assumptions underlying these additional forecasts. Therefore, it would be very difficult to achieve a carbon price that is consistent with other assumptions (e.g. fossil fuel price, GDP growth etc) used across Government if these alternative modelling approaches were to be used. For this reason, it was concluded to continue to use the DECC carbon price model to inform the traded carbon price value.

As for the sensitivity of the short term traded carbon price to fossil fuel price assumptions, the published paper clarified how the low and high price range have been derived from fossil fuel price sensitivity.



**6. Most reviewers broadly agreed with the approach taken to dealing with uncertainty but highlighted the need to account for some additional sensitivity analyses:**

*“While the range of sensitivity analysis on the MAC curve could be expanded to address oil price uncertainty and discount rate effects, some other uncertainties could be reduced.” (F. Ackerman)*

*“...much is made of the uncertainty over what might be achieved from the transport sector and from non CO2 GHGs. But almost nothing is made of uncertainty regarding other aspects of the MAC curve.” (P. Johnson)*

Despite broadly agreeing with the approach taken in the review to dealing with uncertainty, one reviewer (Ackerman) noted that some additional uncertainties should have been considered. The reviewer suggested that non traded sector carbon price estimates should be accompanied by a fossil fuel prices sensitivity. He thought that the MAC might be very sensitive to fossil fuel price assumptions because fossil fuel prices influence the opportunity costs of cutting emissions, especially on the negative cost options. Also a sensitivity of the MAC to different discount rates was recommended, although it was considered less important than in the social cost of carbon approach. In contrast, the reviewer considered the concerns discussed in the paper regarding uncertainty surrounding non CO2 estimates to be overstated.

Another reviewer (Johnson) was concerned about the sensitivity of the final non traded price estimates to small changes in the underlying assumptions and he highlighted that the paper does not account for uncertainty regarding other important drivers of the marginal abatement costs such as BAU emissions. He also thought that further discussion of the sensitivity of the non traded carbon price to policy costs was required as well.

Another reviewer (Helm) stressed that abatement cost estimates are inherently uncertain; thus there was the risk that the paper could give a spurious impression of certainty about the numbers. He also mentioned evidence that ex ante abatement costs have proved to be widely inaccurate ex post.

***Response of Government economists***

Following the peer reviews, a number of sensitivities were undertaken and have been presented in Annex 1 to Carbon Valuation in the UK: A Revised Approach.

We also believe that improving our understanding of the abatement available in non CO2 sectors (especially in agriculture and waste) must be a priority for Government research and policy development. Further analysis is being undertaken in this area.

**7. Most reviewers agreed that the significant disparity between traded and non traded estimates reflect broadly robust modelling but potentially inefficient policy targets:**

*“In a sense it is robust only because there are apparently inconsistent assumptions about carbon reduction goals in the ETS cap versus the targets for the UK that drive the non traded sector price. With consistent carbon reduction goals, the disparity should largely or entirely disappear. The inconsistency of goals, not the modelling techniques, is the important problem.”(F. Ackerman)*

*“As this paper demonstrates the result [of inconsistent policy targets] is very different prices in the two sectors. There are obvious potential economic inefficiencies that could be created when operating a dual system like this. Given this dual system it is probably inevitable that different prices need to be used. The analysis exposes the inefficiency that is created by this approach bringing in to sharp relief the lack of coherence of the current policy framework in which half of emissions are within, and half outside, the ETS.” (P. Johnson)*

One reviewer (Ackerman) also noted that the “disturbingly large” gap between the traded and the non traded carbon price might lead to practical political problems (e.g. the need to tighten the cap in order to rebalance the costs between traded and non traded sector).

***Response of Government economists***

As most reviewers noted, the identified gap between the traded and non traded carbon price suggests there may be an argument for revisiting the split between traded and non traded sectors at any future negotiations. However, this option would need to be analysed at length and the paper was not felt to be the right place to discuss this issue.

**8. There was some agreement that policy costs should be included but there was no consensus on whether they are likely to have a significant impact:**

*“I am not sure why this is thought to be unique. It seems consistent with many cost benefit analyses of new policies and technologies. I suspect that analogues could be found in US EPA analyses of the costs and benefits of the Clean Air Act, for instance. In theory policy costs should be included; however, as suggested by the McKinsey report quoted in the draft, policy costs are probably small, and very difficult to estimate. It is important to avoid the inference made by some economists that policy costs must exist, and must be large, because negative cost savings are known to be impossible a priori.”(F. Ackerman)*

*“Policy costs are an inherent component of climate change policy approach. This paper should distinguish between two questions in providing estimates of abatement costs: what the cheapest way of achieving the target is in theory; and what it is likely to cost in practice.” (D. Helm)*

*“It is not obvious to the reviewer that that is the right choice. The technical potential may not be easily unlocked. Some idea of using policy MAC would be helpful...The discussion suggests that such costs are likely to be high particularly for negative cost abatement potential where barriers to behaviour are high. I agree. ....This is another area where an analysis of sensitivity to the assumption would be useful.”(P. Johnson)*

### **Response of Government economists**

We agree with most peer reviewers that the policy costs should be included but there is little robust evidence to inform our analyses. In order to reflect such costs in the analyses, the published paper reflects some initial evidence provided by McKinsey but adjusted to reflect the fact that policy costs are likely to be higher for negative costs options than otherwise. However, it is worth noting that this inclusion did not influence the marginal technology although it would affect decisions on policies that increase carbon emissions.

#### **9. Most peer reviewers agreed with the recommended approach of including air quality impacts and other ancillary impacts if available:**

*“Yes, if robust estimates of other air quality impacts are available, they should be included.”  
(F. Ackerman)*

*“I support the view that policy needs to assess the economic costs or benefits of ancillary effects including air quality.. .”(P. Watkiss)*

Despite agreeing that ancillary effects should be included in the recommended approach, one reviewer (Watkiss) highlighted two most important problems with the approach followed in the paper. First, the reviewer thought that the recommended approach was inconsistent because it combines target consistent estimates of the marginal abatement costs with social damage cost estimates for air quality. Second, it was highlighted that the recommended approach was missing other important factors (e.g. noise level, congestion for transport etc) that could still influence the final rank of the options.

Another reviewer (Ackerman) suggested that so called “co benefits”- benefits associated with the reduction of certain type of emissions induced by the reduction of other type of emissions (for instance due to fossil fuel combustion) - should be included in the calculation of the marginal abatement costs if monetary values were also available.

### **Response of Government economists**

DECC agrees that marginal abatement cost estimates should be adjusted for all the ancillary effects that we can quantify. In practice these are limited to air quality costs and congestion. Further ancillary costs and benefits could be included in future iterations of the work as they become available.

**10. Some reviewers noted the paper should provide clearer practical guidance on how the recommended price profile should be used in different policy contexts:**

*“The overall review is a little light on practical aspects. I suspect this will come with further guidance...(P. Watkiss)*

*“The paper focuses very heavily on the technical discussion of various approaches to valuation, but the application of carbon pricing within the overall carbon reduction strategy is as important if not more so. The paper needs an introductory section which explains the role of carbon pricing in the nation's carbon reduction strategy.” (A. Sentance)*

*“The use of different carbon values estimated by this method need further explanation...no doubt that can be done separately.” (P. Johnson)*

**Response of Government economists**

In the published paper, the role of carbon valuation in economic appraisal is further clarified, in the context of Government's overall strategy for tackling climate change. More precisely, we explain that carbon values are used in the framework of broader cost benefit analyses to assess whether, taking into account all relevant costs and benefits (including impacts on climate change), a particular policy may be expected to improve or reduce the overall welfare of society.

Practical guidance on how to apply the new carbon values in policy appraisal is being published alongside the new approach. And later in 2009, revised guidance on greenhouse as policy evaluation and appraisal in Government Departments will be published. This guidance will explain in detail how the new carbon values should be used in economic appraisal across Government along with revised guidance on the use fossil fuel price assumptions, carbon emissions factors etc.

**11. One reviewer noted that the UK and EU targets are based upon production and not consumption therefore they are not clearly related to global CO2 ppm concentration and do not guarantee that global emissions remains under control:**

*“The UK and EU targets are all based upon production and not consumption. They therefore do not link in any clear way to the CO2 ppm concentrations at the global level. Hence the abatement cost measures are not strictly carbon ones, but rather domestic production based. It is important therefore not to confuse the numbers produced in this exercise with climate change abatement: it is possible to hit the domestic production targets whilst at the same time increasing global emissions.” (D. Helm)*

### ***Response of Government economists***

This is an argument about the international regime for accounting for emissions and making commitments, not the adequacy of the appraisal methodology. The current system of commitments under the Kyoto Protocol is for developed countries (including the UK and other EU Member States) to limit and reduce greenhouse gas emissions, based on national boundaries. This includes emissions from production in developed countries, which covers emissions from production to meet domestic consumption, and emissions associated with the production of goods exported from developed countries for consumption in other countries. Developing countries do not currently have targets, so the current system of commitments does not (for example) include emissions associated with the production of goods exported from developing countries to developed countries, and these emissions are increasing, as research by Government and others has shown.

In the Government's view the way forward is for the future climate agreement being negotiated in Copenhagen later this year to include commitments for developed and developing countries so that total anthropogenic emissions are on track to keep the human induced temperature increase to 2C or less, which is consistent with atmospheric concentrations below about 450 ppm CO<sub>2</sub> equivalent.

#### **12. One reviewer mistakenly thought that the carbon price profile were derived using the MARKAL modelling:**

*"These errors are manifest in the DTI's 2003 white paper and in particular its use of the MARKAL model. This is a "garbage in – garbage out model", essentially taking a priori exogenous cost estimates and plugging them into the input-output framework. It is notable that the paper provides no critical assessment at all of the past use of the model and especially the numbers that resulted in the 2003 White Paper. No reliance should be placed on figures 7.1 – 7.4 and 8.4." (D. Helm)*

### ***Response of Government economists***

The MARKAL model was not used for the carbon valuation paper. The reviewer appears not to have realised this. The non traded price of carbon used to derive figure 7.1 – 7.4 was obtained using the CCC UK MAC curve, as amended by further Government analysis. There is no Figure 8.4 in the paper.

#### **13. The role of the cost of carry in the derivation of the price profile was not entirely clear:**

*"I am unclear why a real cost of carry of 1.5% has been used. My instinctive inclination would have been to use the same real discount rate (3.5%) as elsewhere." (P. Johnson)*

### ***Response of Government economists***

The paper that has now been published clarifies that the same cost of carry has been applied for the traded and non traded carbon price estimates. In the traded sector, the aim of the cost of carry is to reflect the opportunity cost of investing in EUAs as opposed to holding the money in cash. More precisely, this is the risk free rate that makes installations indifferent between abating now and selling EUAs tomorrow or abating tomorrow and using EUAs today. The EURIBOR rate (3.5%) was used as a proxy of the risk free rate in the traded sector. For consistency, the same rate has been used in the non traded sector to derive the non traded price profile.

**14. One reviewer highlighted the importance of timely revision of the guidance:**

*“Given the speed of change in this area, a two year review period seems too long, at least in the immediate future” (P. Watkiss)*

***Response of Government economists***

The published document set out the approach for amending and reviewing carbon values. As noted in the document, there is a trade-off to be struck between having the most up-to-date carbon valuation figures, and ensuring some consistency in application - we would not want a situation where the carbon price used in appraisal changed too often, as this would mean that policy options were being assessed against different criteria.

The published paper recommends that the short term traded carbon price will be revised alongside periodic updates to the fossil fuel price assumptions (usually once a year). However, further revision will be undertaken if there is a major change in the cap (for instance due to the achievement of a global deal on climate change).

As for the non traded carbon values, the published paper recommended a further revision of the value after the setting of the fourth carbon budget (by end of June 2011). Further reviews of the non traded carbon values will occur every five years (starting in 2011). Similarly, the long term traded values will be revised every five years beginning in 2011.