

## PEER REVIEW BY PAUL EKINS OF DEFRA'S PAPER

### 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

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#### General

The purpose of this DEFRA paper is to arrive at a price of carbon that can be applied in policy appraisal across Government. That is an important objective. The issue is how to arrive at such a price in a way that is both defensible and supports the Government's climate change policy.

The traditional economic means of arriving at such a price is through estimating the optimal price of carbon – the price at which the marginal damage cost of carbon to the climate (also called the social cost of carbon [SCC]) equals the marginal carbon abatement cost (MAC). Both my and DEFRA's earlier work on estimating SCC has convinced me that, unfortunately, this approach is infeasible in the case of climate change.

An alternative approach would be to seek to estimate the MAC required to reduce carbon emissions to achieve the desired UK contribution to a global goal of stabilising carbon concentrations in the atmosphere at a level thought to avoid unacceptably dangerous climate change. The Stern Review suggested that such a concentration should be in the range of 450-550ppm.

The DEFRA paper under review chooses the route of optimality, but with the Shadow Price of Carbon (SPC) replacing the SCC. In the review that follows I set out why I do not think that this resolves the problems associated with trying to use the SCC, and put forward in more detail the approach based on MAC which I prefer.

#### Definitions

There are a number of quite different, but related, concepts concerning the cost of carbon. Previous efforts by DEFRA/Treasury to clarify these for practical policy purposes (Watkiss 2004) were, in my view, not successful, because they failed to distinguish rigorously and consistently between the concepts, and confusion and inconsistency were the results. My peer reviews for DEFRA of this paper and the scientific paper that accompanied it (Downing et al. 2005) are presumably still extant and cover much of the relevant general ground, which I will try not to repeat here, except where absolutely necessary

This paper introduces a new concept, the Shadow Price of Carbon (SCP). However, it is not clear that this gets round the problems of SCC which were so evident in the earlier review. Definitions of the relevant concepts are as follows:

*Social cost of carbon (SCC):* This is the damage done by a tonne of carbon when it is emitted, because of its effect on the climate. Conceptually it is therefore quite simple. Practically, it is far from simple, as the scientific paper commissioned by DEFRA

(Downing et al. 2005) some time ago made clear. Because of uncertainties over impacts (which different estimates have assessed over a range from mildly positive to catastrophically negative) the Downing et al. paper considered that SCC could range from 0 to £1,000/tC, but it was not possible to give an upper estimate (because of uncertainties over possible catastrophe), nor a best estimate (because of more general uncertainties over impacts). When combined with the deeply contested basis of monetary valuations of the impacts, together with some issues with a deeply ethical element, such as discount rates, the chances of arriving at the necessary consensus on a number for the SCC for it to be useful for policy purposes are, in my view, effectively zero. The difficulties are compounded, as the paper under review makes clear, by the fact that the SCC varies according to eventual concentration of CO<sub>2</sub>-e in the atmosphere, and therefore according to any stabilisation goal and the emissions trajectory that may be adopted to achieve it.

*Marginal Abatement Cost (MAC)*: This is the cost of reducing carbon emissions by one tonne. It has the advantage over the SCC of being related to existing activities and technologies, and of therefore of being empirically observable in the present time, although it varies over sector, with technology, over time and with the degree of abatement being undertaken. It is normally assumed the MAC increases with the level of abatement, but over time that might not be true as new abating technologies come on stream, or learning effects and economies of scale reduce the costs of existing abatement technologies.

In neo-classical economic theory, optimal abatement, or the optimal degree of climate change, is achieved when, at a certain level of emissions/atmospheric concentration of carbon and emissions abatement,  $SCC=MAC$ . Because of the problems with computing SCC, it is practically impossible to estimate this theoretical optimum. A condition for cost-effective (as opposed to optimal) abatement is that MAC is equal across the different sectors of the economy. This is theoretically achieved by economic instruments such as taxes and trading, but the political reality of the policy landscape is that MACs vary widely across sectors. It is a useful exercise to understand the nature and extent of this variation, either to see whether there is any justification for it (e.g. does it serve another policy purpose, such as industrial policy?) or to seek to reduce it over time, to move towards cost-effectiveness. The DEFRA approach in this paper is partly along these lines.

*Shadow Price of Carbon (SCP)*: This is a theoretically complex concept, relating to the welfare gain of relaxing a constraint at some optimal state. In this paper, SCP is not defined, but in a short DEFRA guidance paper clearly related to that under review it is defined thus: “the SPC captures the damage costs of climate change caused by each additional tonne of greenhouse gas emitted .... The SPC is different from the previously used social cost of carbon (SCC) in that it takes more account of uncertainty, is based on a stabilisation trajectory, and is in line with the marginal abatement costs of reaching the stabilisation goal.”<sup>1</sup> The guidance paper makes it clear that it is intended that SCP should be used instead of SCC in policy appraisal, and that the theoretical basis for SCP will be explained in this paper. However, what is not clear to this reviewer from this paper is either how SCP “takes more account of

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<sup>1</sup> See ‘How to use the Shadow Price of Carbon in policy appraisal: Interim Guidance’, <http://www.defra.gov.uk/environment/climatechange/research/carboncost/pdf/HowtouseSPC.pdf>

uncertainty, is based on a stabilisation trajectory, and is in line with the marginal abatement costs of reaching the stabilisation goal”, or how SCP avoids the overcomes the insuperable difficulties faced by SCC is capturing “the damage costs of climate change caused by each additional tonne of greenhouse gas emitted”. In other words, SCP seems a more complex concept than SCC, but under this definition has the same fundamental drawbacks in terms of its policy usefulness, as noted above<sup>2</sup>.

This point is illustrated in some of the detailed comments on the paper.

### **Detailed Comments**

p. 2

**Top bullet points:** it might be useful to make clear that the market price of carbon (MPC) will equal the MAC if the carbon market is competitive.

**The sentence beginning** ‘Under certain restrictive assumptions ...’ is not helpful. It would be better to say, as per the above:

For cost-effective policy: MAC is equal across emitters to reach a given carbon reduction target, and  $MAC=MPC$  if the carbon market is competitive.

For optimal policy (which is also cost-effective) in addition:  $SCC=MAC$ . Because SCC is unknown within a very wide range, it will not be possible to know what optimal policy is. The ‘restrictive assumptions’ referred to in the text are, in fact, just hypothetical constructions without any possibility of empirical verification, and are therefore not useful for policy.

**Para. beginning ‘Given the number of uncertainties ....’** The key point here is that, because of the uncertainties concerning possible climate change damages, how they vary with different emission trajectories and within the 450-550ppm range, it is not possible to calculate SCC and therefore calculate a stabilisation goal according to the desirable criterion of optimality. There is no way that we can know whether SCC is more or less than the global MAC. It is therefore desirable to decide to try to choose a stabilisation goal, and a means of appraisal of policy measures to achieve it on some other basis.

**Note 4:** the Stern Review also says “There is up to a one-in-five chance that the world would experience a warming in excess of 3°C ... even if GHG concentrations were stabilised at today’s level of 430ppm CO<sub>2e</sub>.” (Stern 2006, p.12) This seems to suggest that there is a significant probability that the SCC could be very high even at today’s concentrations of CO<sub>2-e</sub>, suggesting that unless abatement costs increase very greatly over the 450-550ppm range, the stabilisation goal should be towards the lower end of the Stern range.

pp.2/3

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<sup>2</sup> It may be noted in passing that shadow prices are also used, rather confusingly, to compare the implicit prices of carbon with different abatement options, see pp.251-2 and 259 of Lesser, J., Dodds, D. & Zerbe, R. 1997 *Environmental Economics and Policy*, Addison-Wesley, Reading MA/Harlow UK, i.e. SCP is thereby related to abatement costs rather than the SCC.

**Para. beginning ‘The distinct definitions ....’** As noted above, the definitional difference between SCC and SCP is important, but it is not true to say that SCC is exogenous, because it varies with abatement policy: the more abatement, the less climate change and the lower the SCC (as the paper makes clear later). Also it is not clear that the SCP “can adjust to reflect the policy and technological environment”. This sentence needs further clarification.

p.3

**Para. beginning ‘As argued above ...’** I would argue against even using the term ‘optimum stabilisation goal’, because we cannot know what this is. Rather I would refer to the science that suggests that the damages from climate change above 550ppm could be very high indeed, which argues strongly for a goal that is well below this. It may also be worth noting in this context that the ‘optimum stabilisation goal’ rises over time for as long as there is no emissions abatement, because any given goal becomes more expensive to reach the less time there is to achieve it (see Note 4 for Stern saying that the 450 goal is not optimal, and may not even be achievable, because of past failure to take strong action).

**Para. beginning ‘The tighter the emissions target ....’** This is a really confusing paragraph, because it introduces all four variables (SCC, SPC, MAC, stabilisation goal) in a way that fails to distinguish carefully between them. Thus in line 3 it talks about “selecting the SCC”, but surely it is the stabilisation goal that is being selected (firstly because this determines the SCC and secondly, as argued above, because the SCC is essentially unknowable). The SPC is then selected in order to achieve the stabilisation goal. The sentence “So long as the SCC continues ... target.”, and that after it, completely mis-characterises the process of policy choice, because there is no way that policy makers or anyone else will know whether or not SCC is below or above the MAC. What the first of these sentences appears to be saying is that if the target (whether SCC, SPC or stabilisation goal is not clear) is such that the SCC is or is implied to be above it, and the MAC is set to be equal to the SCC, then the MAC will be higher than that required to reach the target and the target will be overshot.

Surely a simpler and more convincing argument than this and the subsequent two paragraphs would be:

1. The science suggests a stabilisation goal of 450-550ppm (it is possible to justify this in terms of limiting the temperature rise rather than trying to resort to SCC or SCP calculations).
2. Even 450ppm runs a significant risk (as per the quote from Stern above) of very damaging climate change.
3. It therefore makes sense to adopt a price of carbon related to MACs that will bring about enough mitigation of emissions to move towards the lower end of the Stern range, without doing unacceptable damage to the UK economy.
4. This damage to the UK economy will depend on whether other countries adopt a similar stance. It is only worth adopting a stringent mitigation target (and therefore incurring a relatively high MAC) if it is believed that at some point (perhaps some years after the UK) other countries will follow suit.

p.4

**Para. beginning “The Stern Review ...”** The Stern Review may claim to know the SCC for 550ppm, but certainly I would not believe this. Later in the paragraph it should be made clear that the ‘uprating convention’ discussed later includes increasing the SCC over time, because Note 8 suggests that it is only adjusted for inflation.

This whole section gives the impression of having gone into the most convoluted argumentation to avoid picking a stabilisation goal but picking an SCC that is centred on 550ppm. Despite its protestations to the contrary (on p.3 and in Note 9) that picking an SCC consistent with 550ppm does not imply picking a stabilisation goal of 550ppm, that is how it will be interpreted if there is no explicit stabilisation goal to refute it. That is why the argument above, that involves choosing an MAC that will achieve emissions reduction towards the bottom of the Stern range, would be less confusing and more credible than the arguments presented in the paper.

p.5

The sentence in the fourth bullet point “Likewise the SPC ... to be desirable.” seems to be at variance with the argument of the previous section that bases SPC on SCC in line with the DEFRA definition given at the beginning. It is however entirely in line with the arguments presented above that the most coherent and comprehensible policy approach is to set a UK emissions target that will contribute to global mitigation to achieve a stabilisation concentration towards the bottom of the Stern range, and then to set an MAC that will achieve this. This is a quite different approach to that based on some notional optimality arguments, and it is not consistent to introduce it here in this way. For example, who will decide what UK contribution is “agreed to be desirable”, and if this can be agreed, than why is it not the basis for mitigation policy, implying a certain level of MAC, in the first place, without all this spurious (in my view) argument based on an unknowable optimality?

p.6

**Third sub-bullet of third bullet, “to reflect an assessment ...”** The ‘SPC profile’ is said to be ‘based on the SCC in conjunction with evidence on the marginal abatement costs curve’, but actually it is very unclear how the SPC is derived from SCC plus evidence on MAC, and then it is expected to “generate abatement consistent with the the UK’s commitments”, but where do such commitments come from if not from the SPC itself? There is an unresolved circularity of argument here. The SPC based on SCC is expected to provide the rationale for abatement, but then the SPC is to be regularly reviewed in order to ensure that the abatement is in line with UK commitments, which themselves derive from perceptions of the climate damages of not abating, i.e. the SCC and SCP. Again, it looks as if the authors of the paper are trying to follow two inconsistent approaches: that of optimality, where the SCC/SCP drives abatement action such that  $SCC=MAC$ ; and that of reaching a stabilisation target derived from the science, where MAC is set in order to reach the target. The latter approach is suggested in this third sub-bullet, but it is at odds with the paper’s dominant approach based on optimality.

**Para. beginning “Recognising that this ...”** The inconsistency of approach is evident in this paragraph too. The “uncertainties ... around the relationship between

the SPC and the MAC” actually seem to derive from DEFRA’s uncertainty as to whether its policy should be driven by SPC (based on SCC) in the quest for optimality, or by MAC set at a level to achieve a robust UK contribution to a global stabilisation target derived from a desire to limit global warming.

**Para. beginning “The SPC should be incorporated ...”** This is theoretically absolutely right. The practical question is what value of SCP should be used for this purpose. The dominant approach of the paper seems to be that SCP should be based on SCC; I would argue that it should be based on the MAC thought necessary to reach the UK contribution to the global stabilisation goal.

pp.7/8

This introduces the three market failures that characterise climate change:

- The unpriced nature of the emissions that cause it, arguing for policy to give emissions a price. Most of the paper is about how this price should be derived and therefore what it should be. The paper mainly argues for an SCP based on SCC (which this reviewer thinks is unknowable), but occasionally seems to recommend an MAC which will reach a stabilisation goal derived from the science (which this reviewer recommends).
- The positive externality associated with innovation, which means *inter alia* that there is less low-carbon innovation than is socially desirable.
- The market failures that inhibit behaviour change in response to climate change policies.

Annex 3 argues that these market failures should be tackled separately, but in reality of course the policies for one market failure interact with the others. Thus policy to internalise the carbon externality, by raising the price of activities associated with it, will stimulate innovation. Other policies to stimulate innovation will reduce the MAC and therefore increase the abatement associated with a given SCP (thereby potentially reducing the SCC and SCP in the future). Policies to stimulate behaviour change may increase the response to carbon prices, again thereby increasing abatement. While it undoubtedly helps clarity to separate these market failures conceptually, in reality there will be multiple interactions between policies to address them.

**Para. beginning “Subject to this ...”** Again it is stressed that SCP is not the same as MAC, but is in fact “a measure of our willingness to pay (WTP) for carbon abatement”, but that is one definition of SCC, because such WTP is derived directly from the perceived benefits of carbon abatement, i.e. damages avoided. This is the basis of contingent valuation. Again, the distinction between SCC and SCP is far from clear, although it was stressed earlier on.

The injunction to choose the ‘least cost options first’ is surely uncontroversial and can be justified on cost effectiveness grounds to reach a given target without recourse to arguments on SCP. It could be recognised that the market failures to tackle innovation and behaviour change have rather different implications: the former justify MACs in those areas where innovation is thought likely to occur that are higher in the short term than those required to reach a carbon reduction target (because the innovation will reduce the MAC in the long term); while the latter implies an inadequate

response to an MAC that should result in the target being reached, but because of this response will fail to do so.

p.10

**Last line:** 'low' (not 'law') carbon technologies

p.11

**First line:** Note 16 not printing (i.e. not visible) in my version

**Note 18:** e-address is different from that in Note 14

## **Conclusion**

This paper appears to indicate that DEFRA has moved away from a desire to base carbon policy on the SCC in favour of the SCP. In the opinion of this reviewer this move is neither desirable, nor has it been successful. This is because:

1. SCP is a more complex concept than SCC and therefore more difficult too explain;
2. SCP has all the disadvantages of SCC in terms of the uncertainties relating to climate change damages and how they should be valued;
3. It is very unclear how SCP is derived from SCC such that "it takes more account of uncertainty, is based on a stabilisation trajectory, and is in line with the marginal abatement costs of reaching the stabilisation goal."

In short, therefore, SCP seems to have all the disadvantages of SCC and to be more complex and less comprehensible as well.

An alternative would be to derive policy as follows:

1. Use climate science to derive a physical target that will avoid dangerous climate change. Such a target that has already been adopted is to keep average global warming below 2°C.
2. Choose a stabilisation goal that makes it unlikely that this warming target will be exceeded. As per the Stern quote cited earlier, this argues for a stabilisation goal towards 450ppm in the Stern range.
3. Estimate the contribution to the stabilisation goal that the UK should seek to achieve consistent with its status as a major industrial nation that desires to be a leader on climate change mitigation, and as a member of the EU which has adopted a 20% CO<sub>2</sub> reduction policy by 2020.
4. Estimate from the UK MAC curve the MAC that will generate the amount of abatement that will reduce emissions to the extent required to achieve the UK contribution to the stabilisation goal (distinguishing clearly between abatement that is to take place in the UK, to stimulate moves towards a low-carbon economy there, and abatement that will be paid for by the UK but will take place in other countries, which will do nothing to stimulate a low-carbon economy in the UK).
5. Seek to generate through policy a price of carbon across the UK economy that is consistent with this MAC (to achieve cost-effective carbon reductions), and use this price in policy appraisal of policies whether they are related to

- abatement or not (as noted in Note 2 above, some textbooks use the different in MACs across different options as a form of shadow price).
6. Be prepared to adopt policies with a higher short-term MAC of carbon where it is believed that innovation can be achieved which will reduce the MAC in the future, or where there are ancillary benefits to carbon reduction which justify the higher MAC.
  7. Seek to overcome obstacles to behaviour change such that the response to the MAC is higher than it would otherwise be, because of an increased take up of abatement options with a MAC below that set, take up of which these obstacles are currently preventing.

## **REFERENCES**

Downing, T. et al. 'Scoping Uncertainty in the Social Cost of Carbon', Final Project Report, Review Draft (December 2004). In what follows this report is referred to as TD05.

Watkiss, P. 'The Social Costs of Carbon (SCC) Review – Methodological Approaches for Using SCC Estimates in Policy Assessment', Draft Final Report (December 2004). In what follows this report is referred to as PW05.

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