

Daylight falls on the shadow price of carbon

The government claims its new cost figure for the harm done by each tonne of CO₂ will be a powerful tool in helping to cut greenhouse gases. **Nicholas Schoon** explains how the Environment Department (DEFRA) devised it and plans to use it

How much should polluters be charged for the damage done by a tonne of carbon dioxide as it alters the earth's climate? It is the ultimate 'how long is a piece of string' question, one that has been keeping a growing number of economists, scientists and powerful computers busy – and one for which the answer really matters.

Already there are plenty of answers, but are any of them right? Any kind of tax, duty or regulation aimed at cutting CO₂ emissions implies a price per tonne for the chief greenhouse gas. There are more and more of these carbon charges and regulations.

The EU's Emissions Trading Scheme (EUETS) also puts a price on emissions. So, too, does the burgeoning international trade in carbon offsets under the Kyoto Protocol.

Just before 2007 closed, the UK government took a prominent and – it may eventually prove – decisive stance in the debate by announcing a new 'shadow price of carbon': £26.50 per tonne in 2008 and rising by 2% per year even before inflation is factored in.

That is rather higher than any current market price of CO₂ (see table). Even more striking is the precision that the government attaches to this new carbon price. The stipulated uncertainty range is plus 20% to minus 10% (£31.80 to £23.85), which is much narrower than what had gone before: plus 100% to minus 50%.

The new shadow price is being adopted across government, not just to weigh up policies aimed at curbing CO₂ and other greenhouse gases, but for decision-making on all projects, programmes and policies with significant implications for emissions, from forestry and agriculture through to transport, industry and construction.

The Environment Department (DEFRA), whose economics team devised it, says it must be used by the energy and water regulators Ofgem and Ofwat. Local councils are also encouraged

to adopt it. DEFRA says it knows of no other nation which has taken carbon pricing so seriously in government.

The shadow price will "ensure that lower-carbon options are recommended whenever they are economically and socially justified," claims DEFRA.¹ It could cause some policies which would increase emissions to be dropped altogether.

Government departments are asked to use the shadow price in all cost-benefit analyses of projects and policies. Any increase in total tonnages of emissions should be calculated as a cost, any decrease as a benefit.

DEFRA's economists point out that impact assessments must now be carried out for any proposed government policy affecting the private, public or voluntary sector. These must contain a summary setting out the rationale, costs and benefits, and include the value of changes in greenhouse gas emissions, which must be signed off by the sponsoring department's chief economist. The new shadow price of carbon will figure in this.²

The right price?

However, controversy came hard on the heels of the announcement. It emerged that the new CO₂ price had already been used in the cost-benefit analysis for the proposed massive expansion of Heathrow airport, with a new terminal and runway (ENDS Report 395, pp 30-33).

The projected increase in flights from the development will add an extra 2.6 million tonnes of CO₂ to the atmosphere each year. After applying the shadow price to that surge in emissions, the project still washed its face, so it could be justified as an overall benefit to the nation. Environmental economist Professor Paul Ekins, told the ENDS Report he found this "lacking in policy consistency and environmental credibility."

Friends of the Earth director Tony Juniper said the shadow price "could be an extremely important approach in efforts to develop a low-carbon economy, but the price of carbon must be much higher than that proposed".

So is the price right? Any judgment requires an understanding of how DEFRA's economists arrived at £26.50 per tonne.

The story begins around 1990 when a handful of economists started using computer models to estimate how much the damage caused by climate change would cost humanity in future. Their aim was to figure how much it might be worth spending now and in the coming decades to curb emissions and limit the damage, achieving the right balance.

PRICES OF CARBON*

Market	£/tCO ₂
UK Shadow Price of Carbon	26.50
UK Social Cost of Carbon, year 2000 prices	19.00
EU Emissions Trading Scheme	17.76
Kyoto Clean Development Mechanism**	13.30
Chicago Climate Exchange	1.09

* as at January 15, ** secondary CERs



Carbon sink: the shadow CO₂ price should be used in assessing policies and projects for forests like this one near Stirling, Scotland

This is not easy. The first difficulty is the uncertainty about how much climate change there will be, what form it will take and how it will be distributed across the planet.

Dealing with uncertainty

Computer modelling of climate change under different greenhouse gas emissions scenarios has seen major advances since the early 1990s. But we are still far from knowing precisely what any particular global emissions scenario – of which there are many – means for greenhouse gas levels in the atmosphere.

We are also a long way from knowing exactly how climate will change in each country for any given level of greenhouse gases.

We know most about average temperature rises, less about changes in rainfall and still less about changes in the intensity and frequency of storms. And the further we look into the future, the murkier the picture becomes.

The next big problem is working out the costs and benefits which flow from this uncertain change across the planet. Crop and timber production could fall or rise, depending on location. Heating bills will drop, cooling bills increase. If rainfall declines or becomes more erratic, more money will have to be spent on water capture and storage. Cold weather deaths should fall but deaths and sickness caused by high temperatures may grow and further health costs are likely as tropical diseases spread north and south.

As sea levels rise, large sums will have to be spent on coastal defences. Storm and hurricane damage might increase. There is uncertainty about the costs of adapting to changing climate and

rising sea levels, and what the costs of a failure to adapt will be. Much depends on how wealthy the affected society is.

Economists apply monetary values to costs, benefits and human welfare. Yet there is no market value for some highly valued resources which climate change will damage such as nature reserves and wildlife species, many of which will become locally

“The shadow price will ensure lower-carbon options are recommended whenever they are economically and socially justified” DEFRA

or globally extinct. The experts have to use various clever but contentious ways of valuing these, and the damage to them.

Spreading the cost

One of the most controversial issues in climate change economics is equity. How do we deal with the fact that conventional economics sees the costs of climate change being much lower in poor countries than rich ones – including the costs of lives lost – simply because they are poorer? It now seems certain that poor countries →

will suffer more than developed nations as the world warms through this century. Computer models of climate change's economic damage are often adjusted to treat the developing world more fairly.

Another controversy surrounds the equity between us, living today, and future generations. Conventional economics sees costs and benefits several decades in the future being worth less than costs or benefits in the present, reflecting people's preference for having things now – and reducing costs now – rather than later.

A discount rate of a few percentage points is used to reflect this, so that costs and benefits which will come into play decades in the future are discounted and expressed in net present value terms for today. Some argue that this approach is unfair for future generations and that a zero discount rate should be employed in modelling climate change's economic impacts.

To add to this stew of complexity and argument, models also need to account for a fast-changing world in which populations and economies keep growing, some prices shift as resources such as oil become constrained and many technologies develop, further influencing prices – including the price of low-carbon energy sources.

In 2002, a paper written by DEFRA economists reviewed the studies to date and concluded that £19 per tonne of CO₂ was “a defensible illustrative value” for the SCC in year 2000 prices.

They proposed that this cost should rise by £0.27 a year, reflecting the increasing damage done by each extra tonne of the gas as the atmospheric concentration rose and climate change accelerated. Inflation would be then added on top of that, which meant that by now the SCC would have climbed to more than £25 per tonne.

This particular SCC was derived from one European Commission-funded study rated as best by the DEFRA economists; it used two different computer models. The £19 per tonne figure was, said the civil servants, “some way above the majority of other estimates produced to date.”

They proposed a lower limit of half, £9.50, and an upper limit of double, £38, for use in “sensitivity analysis”; in other words, for testing what the outcome of any policy appraisal would be if the £19 figure was off the mark.

These simplistic high and low limits reflected “the huge uncertainty surrounding this estimate” and the need to take account of “the probability of a so-called climate catastrophe”.

“I don't see how a carbon price used to justify this kind of carbon-intensive project can be part of a credible government policy for cutting UK emissions by 60% by 2050”

Professor Paul Ekins, King's College, London

These so-called integrated assessment models have moved on from simple beginnings more than 15 years ago. The latest and largest of them try to take all of these factors into account. But the small, albeit growing, number of researchers working on them around the world agree there is still a long way to go.

The costs of carbon

One key value that this modelling tries to assess is the social cost of carbon (SCC). This is the damage done by each extra tonne of CO₂ emitted during the century or more that it spends in the atmosphere, brought back to today and expressed in net present value terms.

Another key concept of climate change economics is the marginal abatement cost (MAC), which is the cost of preventing one tonne of CO₂ being emitted to cut emissions by a particular amount compared with the business-as-usual scenario.

This is being assessed by another community of researchers, who look at the shifting prices of curbing carbon through energy efficiency improvements, switching to low-carbon energy sources and conserving forests and wetlands.

Estimates of the SCC and MAC should guide decisions on how, and by how much, to cut rising greenhouse gas emissions. They could be used to set carbon taxes which charge greenhouse gas emitters for the climate change damage they inflict on the whole of society in future.

Economists argue that any rational strategy for tackling climate change should include a global carbon tax, but the political and diplomatic obstacles to this are insurmountable. Hence the need for a ‘shadow price of carbon’ which tries to set out what the correct level for such a tax would be, for use in policy appraisal.

Developed world governments and the UN's Intergovernmental Panel on Climate Change have been paying more and more heed to the climate economists and their integrated assessment models.

The government adopted this figure as, in effect, a shadow price of carbon for use in policy and project appraisal even though some economists claimed it was too high (ENDS Report 349, p 47).

The government commissioned further assessments by leading climate economists, an international seminar was held, computers churned through more model runs, long reports were written – but the central figure of £19 per tonne SCC survived until 2007.

Unfortunately, it was not always heeded. One DEFRA-commissioned review by AEA Technology found “a number of relevant policy appraisals or policy areas across government where the SCC was not used at all, even though the policies involved changes in greenhouse gas emissions”.

And last year, the Sustainable Development Commission slammed Ofgem for using a lower carbon price in cost-benefit analyses (ENDS Report 393, p 14).

Curbing the wriggle room

One problem was that the wide price range, from £9.50 to £38, allowed departments too much ‘wriggle room’.

DEFRA's Chief Economist Richard Price told ENDS: “That undermined its use in decision-making; there was the risk departments could in effect use a figure which suited them.”

It was Sir Nicholas – now Lord – Stern's monumental review of climate change economics that finally saw off the government's old SCC. His report, commissioned by the then Chancellor Gordon Brown and published in 2006, concluded that nations, led by the developed world, should devote significant resources to cutting greenhouse gas emissions now to reduce the high risk of massive climate change damage in the future (ENDS Report 382 pp 34-36).

The Stern review team looked at the work of the computer modellers and used one particular integrated assessment model for guidance. Called PAGE (Policy Analysis of the Greenhouse

Effect) 2002, it was developed by Dr Chris Hope at Cambridge University's Judge Business School. The Stern team used it for several months, carrying out thousands of simulations of how the global climate and economy would change in the coming couple of centuries under a wide range of scenarios and assumptions.

This led them to conclude that emissions should be drastically cut from business-as-usual levels to stabilise greenhouse gas concentrations at a level equivalent to 450-550 parts per million of CO₂. As part of their work with PAGE2002, they came up with two different SCC estimates.

The first, at \$85 per tonne of CO₂ in 2000 prices, was based on the climate change damage which would happen if nothing was done and business as usual continued. The second, at \$30 per tonne, was based on cutting emissions to stabilise concentrations at 550ppm CO₂ equivalent. This estimate of the SCC came out far lower than the business-as-usual-based one because even though a lower tonnage of greenhouse gases was emitted overall, vastly less economic damage was done. The denominator shrank less than the numerator.

It is this second SCC estimate that lies behind the government's new shadow carbon price. If you take the long-term exchange rate between the pound and the dollar, factor in purchasing power parity, then inflation since 2000 and, lastly, add in a further 2% a year to reflect the increasing climate damage as greenhouse gas concentrations rise, then \$30 becomes £26.50 per tonne of CO₂. By 2050 this will have climbed to £60.80 in 2008 prices.

DEFRA claims this new figure, which works out pretty close to what its old SCC would have risen to by now, is a big improvement. It is based on an upper stabilisation limit for greenhouse gases. It also flags up the UK's willingness to pay to tackle climate change, and thereby its willingness to show leadership to other nations in international climate negotiations.

Strange paradox

The plan is to review the shadow price every five years, taking account of the growing understanding of climate change science and economics and the outcome of international negotiations on stabilising greenhouse gases. But the price may well change even before this year is out. The DEFRA economists are about to review the marginal abatement costs (MAC) for reducing emissions worldwide, and will reassess the shadow price in the light of their findings.

MACs matter. In a theoretical, perfect world in which economists knew everything and had to assume nothing, the chosen stabilisation level for greenhouse gases would represent a perfect balance between the costs of reducing emissions from business as usual and the benefits of reduced climate change damage. The MAC and the SCC would be the same figure.

However the shadow price changes, it will be debated for years to come – not just the value itself, but how it should be used in policy-making. This is largely because so much uncertainty and debate is wrapped into the modelling work underpinning it.

For environmental economist Paul Ekins, Professor of Energy and Environment Policy at King's College, London, the fact that it has already been used in a cost-benefit analysis which justified an emissions-escalating policy – Heathrow expansion – calls into question the whole approach.”

“I don't see how a carbon price used to justify this kind of very carbon-intensive project can be part of a credible government policy for reducing UK emissions by 60% by 2050,” he said.

He points to a strange (for the layperson) paradox in estimating an SCC, and from that a shadow price. Some, but not all, computer simulations (and certainly Stern's) indicate that the higher the stabilisation level for greenhouse gases in the atmosphere, the



Using the new shadow price of carbon did not prevent government from backing a massive expansion of Heathrow

higher the SCC. If, in short, you assume humanity is going to do little to reduce emissions, the SCC is large. If carbon prices reflect that, plenty would be done to tackle climate change.

If, however, you assume governments are going to drastically curb emissions, and set a low stabilisation level, the SCC drops. If you then set a low carbon price, you do very little to tackle climate change. It the opposite of a self-fulfilling prophecy.

The government's new shadow price goes roughly down the middle. It is based on a stabilisation level of 550ppm in CO₂ equivalent, regarded by many as dangerously high. Chris Hope, the researcher who developed the PAGE2002 computer model, says his own work suggests a rather lower level would be optimal.

In fact, 550ppm is Stern's recommended upper limit; his review says this would be “a dangerous place to be, with substantial risk of very unpleasant outcomes”. Even so, getting there implies very large cuts in greenhouse gas emissions starting in developed countries now and spreading to the developing world within 20 years.

DEFRA's economists insist this is realistic, given the outcome of the UN Climate Summit in Bali at the close of 2007 (ENDS Report 395, pp 4-5). “It is now a more plausible assumption that nations will act than that they won't,” Richard Price told ENDS.

But is it? Given the continuing uncertainty that the US and major developing countries will commit to reductions, given that fossil fuel use and deforestation keep growing, it could be argued that stabilisation seems likely to occur at a much higher level.

In which case, a much higher SCC and shadow carbon price would be justified. But this situation would also imply that nations were doing little about climate change, and that the UK – responsible for some 2% of global emissions – was taking drastic action to curb them on its own and making little difference in the process. That would be a political impossibility.

So the shadow price of carbon is more of a first stab than a last word. One day it may have the status of the Bank of England's base rate, supremely influential and regularly reset by an uber-expert committee then announced to an eagerly waiting world. But that lies some way in the future. ■

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1. *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, by Richard Price, Simeon Thornton and Stephen Nelson*
2. *How to use the shadow price of carbon in policy appraisal*