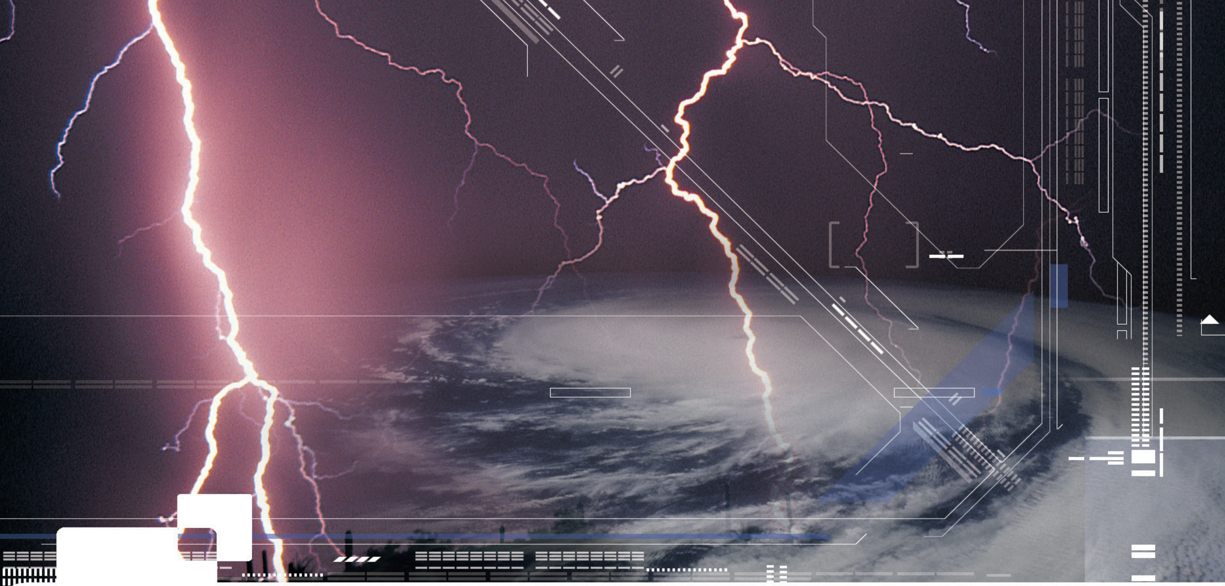


Beyond Copenhagen:

A climate policymaker's handbook

Edited by Juan Delgado and Stephen Gardner

BRUEGEL BOOKS

Beyond Copenhagen:
A climate policymaker's handbook

Edited by Juan Delgado and Stephen Gardner

BRUEGEL BOOKS
Beyond Copenhagen: a climate policymaker's handbook

Edited by Juan Delgado and Stephen Gardner

Cover design: Jean-Yves Verdu
Production: Stephen Gardner
Printed and bound in the United Kingdom

Bruegel
33, rue de la Charité, Box 4
1210 Brussels, Belgium
www.bruegel.org

ISBN: 978-9-078910-15-2

Contents

Foreword

Why do reasonable people disagree when they should agree? Why is it so difficult to reach international agreement on the management of a global public good such as the climate?

Scholars of policy discussions have shown that disagreements often arise from cognitive differences (over a phenomenon's true model), from distributional conflicts, and from time-preference heterogeneity. Global warming ranks high on all three dimensions. This explains the extreme difficulty of the international policy discussion.

Trade provides a useful benchmark for assessment. Trade negotiations look hopelessly intricate to outsiders but are conceptually remarkably simple. To start with, they are underpinned by a well-established theory that makes it plain that trade improves the welfare of participating countries. Second, trade opening is a positive-sum game benefiting all participating countries. There are losers within countries, but most of the time they can be compensated through national rather than international policies. Third, the intertemporal trade-offs involved in trade matters are uncomplicated: within each country, the short-term pain is offset within a few years by permanent gain.

Let us now use the same criteria for assessing the climate agenda. There is no real remaining controversy about the reality of climate change, but the evidence about the impact of climate policies is still marred by significant uncertainty. In particular, no one knows if innovation will in future dramatically reduce the cost of emissions abatement, and this significantly affects the policy trade-offs. Second, emissions control involves significant distributional effects among countries, most notably between 'North' and 'South': some major developing countries argue (rightly) that they have not contributed significantly to greenhouse gas stocks, and they claim (questionably) that they should therefore be exempt from constraints on emissions for an extended period. This complicates agreement a great deal. Third, intertemporal trade-offs are horribly complex as climate change policies essentially consist of trading off our welfare against that of our offspring in five decades or more. Even economists – not to speak of policymakers – are still debating how to weigh future gains against present losses, as illustrated by the controversy over the discount factor used in the Stern Review on the Economics of Climate Change.

Two factors add extra complexity. With the General Agreement on Tariffs and Trade (GATT), the world has been equipped for more than half a century with a set of principles for trade policies and trade negotiations, to which all countries have adhered. In comparison, the Kyoto Protocol was an important first step, but it is an *ad-hoc* agreement whose structure is debatable, not least because it does not impose any obligations on developing countries. Also, climate policies entail huge changes for the economy – they have an impact on competitiveness, affect innovation, modify the growth path and, last but not least, imply major changes in consumption patterns and lifestyles.

All this leads to seeing Copenhagen as a step in what will necessarily be a protracted and imperfect process. It is to be hoped that it will result in a broad agreement and will pave the way for further decisions, but it will certainly not end discussions on controversial matters. And whatever shape the Copenhagen agreement takes, implementation will be crucial. As shown by the Kyoto Protocol, a lack of enforcement mechanisms can seriously jeopardise an agreement.

Against this background, the role of experts and think tanks is to help clarify the issues and put the debate on the right track. This was Bruegel's aim when Juan Delgado organised two workshops under the auspices of the French Presidency of the European Union during the second half of 2008. We have asked some of the participants in the workshops to provide their views on different ingredients for a global climate agreement in order to provide a guide for policymakers. These contributions summarise the authors' extensive research on the topics.

The volume therefore does not aim to give a unified point of view but to explore different ways to approach a global post-2012 climate agreement.

Financial aid from the French *Ministère de l'Ecologie, de l'Energie, du Développement durable et de la Mer* is gratefully acknowledged both for the organisation of the workshop and for the publication of this volume.

Jean Pisani-Ferry, Director of Bruegel

Brussels, September 2009

1

A tourist guide to Copenhagen: open issues for a global climate agreement[1]

Juan Delgado

The Fifteenth Conference of the Parties (COP-15) to the United Nations Framework Convention on Climate Change in Copenhagen in December 2009 is fast approaching. The conference will set the basis for a global climate agreement that will replace the Kyoto Protocol after 2012. But the foundations of such an agreement are still shaky. Pressure on negotiators is high, and there has been some progress. The cost of disagreement would be substantial. The outcome will be crucial for the future of humanity.

The main elements of this putative deal were codified at the end of 2007 in the Bali Action Plan[2], to which all participants in the post-Kyoto talks subscribe: the need for a long-term climate goal, the need to focus on mitigation, but also on adaptation, steps to promote development (such as actions to combat deforestation and build resilience) and encourage technology transfer, providing finance for clean technology and mechanisms for comparing efforts and achievements under a future deal.

The June 2009 discussions in Bonn showed that domestic realities play an important role in determining each country's approach towards climate policies, and that the determination of each nation's contribution to funding of the future global deal is still a major obstacle to the final agreement. Climate is far from being perceived as a global public good.

Kyoto has shown us what works and what does not work but a future agreement has to go beyond Kyoto in two senses. First, it should develop those instruments that have worked under Kyoto. Second, it should incorporate new aspects in order to attract those countries that were absent from Kyoto. This implies that the new agreement will surely be more sophisticated than Kyoto. Targets alone will not be enough, agreements will have to include policy roadmaps. Current technologies will not do the job, new technologies will be needed and innovation policy will play an important role both for mitigation and for adaptation. Finally, a satisfactory agreement should be equitable in terms of funding and burden-sharing in order to attract developing countries, and should be non-distortionary in terms of trade so that it is acceptable to developed economies.

What Kyoto taught us

To a great extent, the experience of the Kyoto Protocol overshadows discussions on the shape of a post-2012 international climate agreement. It is useful therefore to understand the key features of the Kyoto Protocol. Its central provisions are an equity dimension – that the burden of responding to climate change will be shared according to wealth and historic responsibility for global warming – a focus on committing to achieve results rather than on making specified efforts, and an emphasis on mitigation rather than on adaptation. The Kyoto Protocol led to the establishment of market-based approaches to climate change, specifically cap-and-trade systems (and in particular the EU emissions trading scheme (ETS)), and the Clean Development Mechanism (CDM – see the glossary for an explanation of terminology).

Kyoto has focused on targets and not on policies. Under Kyoto, countries have had discretion to choose their climate policies according to their priorities. Kyoto has also been 'fair' in that the emphasis is on industrialised countries to mitigate emissions – in other words, those countries with the greatest capacity to take action, and also those countries that are historically responsible for greenhouse gases (GHG) in the atmosphere. Kyoto also survived a very difficult political process and, though far from perfect, came into force and has stimulated national or regional climate policies.

However, Kyoto has weaknesses. It has not led the world's biggest emitters, China and the United States, to reduce their emissions. In the Chinese case, this is because – like other large emitters Russia and India – China is not subject to an emissions reduction target. The US, meanwhile, did not ratify the Protocol, underlining the lack of any enforcement mechanism for signatories that walk away. Countries may also walk away from the Protocol *ex post* by not meeting their emission reduction targets. Canada, for example, has already announced it will not stick to its Kyoto commitment.

The non-observance or non-ratification of Kyoto by some of the main emitters has been the cause of the existence of carbon leakage, the process by which industries subject to costs related to climate mitigation simply relocate to less-regulated parts of the world. Concern about this was a major reason for US non-ratification of the Protocol, and is one of the main concerns in the current debate about a new climate agreement. Although Kyoto introduced flexibility mechanisms such as the CDM in order to reduce the cost of climate policies, increase efficiency and help developing countries to develop their own climate policies, the effectiveness of such mechanisms has been questionable. Finally, Kyoto contained weak compliance mechanisms and was focused on mitigation and not on adaptation.

The Copenhagen challenge is to create a post-Kyoto agreement that will correct the weaknesses and put in place a scientifically sound, economically rational and politically pragmatic global climate policy architecture (Joseph Aldy and Robert Stavins outline two of the possible architectures in their contribution to this book). Developments in understanding of the global warming problem should help to push this. There is greater concern about climate and environment, among both the general public and the business community, than there was at the time Kyoto was signed. There have also been great strides in reporting on emissions and verification of emissions reporting. Climate science has moved on and the effectiveness of policy instruments has been tested, meaning the post-Kyoto negotiations will be much better informed than the Kyoto negotiations. Whereas Kyoto led to substantial free-riding, the economic incentives for responding to climate change are now stronger and better understood.

Targets, harmonised policies, or both?

Discussions on a post-2012 framework are revisiting questions that arose when Kyoto was negotiated: is it better to adopt a target-led approach, with countries responsible for keeping their emissions below certain caps, or would harmonised policies be more effective? The European Commission has said that emerging economies should commit to reducing the carbon intensity of their development, and should put in place a 'map of policies' that will lead to emissions being up to 30 percent lower than business as usual. Such an approach may make it possible to move away from negotiations focused largely on numbers and towards negotiations including credible policy paths that make those targets implementable and realistic. The commitment to policies rather than targets would make commitments more credible and compliance monitoring more effective.

This issue arose in the Kyoto negotiations, but harmonised policies were resisted by the US in particular as part of a resistance to any approach that might lead to what could be perceived as a United Nations carbon tax. Instead, under Kyoto, industrialised countries were allocated greenhouse gas emission reduction targets relative to historic base years (1990 in most cases).

The post-Kyoto deal does not need to be an either/or choice between targets and a 'map of policies'. It could include both. However, a significant weakness to be addressed is governance. The experience of the EU emissions trading system has shown that strong domestic institutions and implementation are necessary to make such a scheme work. Not every policy is implementable in every country. One size does not fit all countries. The range of available policies should be flexible enough to respond to the institutional features and the economic development of each nation. Other domestic policies that could be codified in an international agreement include energy efficiency policies, and policies to target the most significant sources of emissions. However, resistance to international oversight of domestic policies will have to be addressed.

Beyond the question of targets, there are three central issues that a post-2012 global agreement should tackle:

- Climate and development: the impact of climate policies on growth, and especially on development, is one of the main obstacles to implementation. A fair burden-sharing rule and cost-efficient measures are essential for the acceptability of climate policies.
- The link between climate policies, trade and competitiveness: how climate policies interact with trade policies and how to tackle carbon leakage.
- The role of technology for global warming mitigation and adaptation: technology is essential to meet any emissions target. The shape of innovation policies, their funding and their interaction with other policies will be essential for the effectiveness of emission-abatement policies.

Developing countries: us and them

Climate negotiations show a clear divide between developed and developing countries: us and them. The historical responsibility for the stock of carbon dioxide, the fact that emissions in developing countries are partially caused by products exported to developed economies and the likely impact of climate policies on development are at the centre of the discussion between developed and developing economies.

The largest emerging economies, China and India, both have climate policies, emphasising energy efficiency, reductions in the carbon intensity of development, reforestation, better pollution control, and renewable energy. Both refuse to countenance binding targets on their emissions, as these are seen as caps on development for countries in which the vast majority of people are still extremely poor by the standards of the industrialised world. A 'cap-or-else' approach in negotiations would not succeed in bringing developing countries on board. China and India also both emphasise international cooperation and transfer of funds and technology as crucial to their decision to sign up or not to a post-Kyoto regime.

A common criticism of EU policies is that they are directed to controlling emission flows but not stocks, although stocks have been mostly caused by developed economies. This responsibility for past emissions should in some way be reflected in future policies.

Emissions in developing countries are partially generated by production of products that are exported and consumed in developed countries. Some claim that a fair deal would imply taxing consumption rather than production (see Dieter Helm's contribution to this volume). In the absence of a consumption-based approach to the taxing of carbon, compensation mechanisms might be necessary to make sure that the allocation of the burden between consumers and producers is to some extent 'fair'. It is however also true that taxing the emissions integrated in consumption might not be effective enough in creating incentives for 'dirty' producers to use less carbon-intensive production technologies.

The impact of climate policies on development is also a common fear for developing countries. To make the development path less carbon intensive, it is important that targets and funding are to certain extent decoupled (ie that targets allocated to developing countries do not necessarily have to be funded by developing countries) and that international cooperation is enhanced to facilitate the flow of both funding and new technologies. As highlighted by Axel Michaelowa and other contributors to this volume, it is important both for Europe as well as for developing countries that the project-based market mechanisms established under the Kyoto Protocol – the CDM and the Joint Implementation (JI) projects – still operate. For Europe, this is because these mechanisms could help to curtail emissions at a lower cost, while for developing countries they constitute an important source of finance and technology transfer. However, the conditions under which such projects qualify for awards of carbon credits should be carefully revised in order to make sure they are effective in reducing GHG emissions.

A new global agreement should expand the range of instruments for fighting climate change, including other ways of reducing carbon emissions, such as reforestation. Reforestation projects are a very important tool to reduce emissions in some developing countries (eg Brazil, Indonesia). At the moment, such projects do not qualify for the Kyoto flexible mechanisms though this is likely to change. Expanding the range of available instruments will increase efficiency and reduce costs.

Making development and climate policies compatible is one of the challenges of a new global agreement.

Climate, trade and competitiveness

The absence of climate policies in some countries, or their incompleteness, creates trade distortions between countries. This could be a significant obstacle to a global climate agreement.

Concerns about carbon leakage must be addressed to avoid the negative consequences of offshoring emissions – a potential dislocation of production, with no overall effect on carbon levels. Future policies must be acceptable for continued economic activity while addressing the environmental downsides of production and trade. This implies a coordinated approach internationally, and a move towards similar standards and commitments within international trade rules. However, experience shows that defining these rules is a long and tortuous process.

Trade policy can act as a facilitator of technology transfer, but risks of protectionist backlashes must be minimised. Trade can reduce poverty and mitigate climate change for example through the promotion of clean growth by removal of barriers to trade in renewable energy technologies, clean coal, energy-efficient devices and other areas. A move towards trade liberalisation to build markets in these sectors would be preferable to trade restrictions.

The threat of 'green tariffs' to protect domestic products from competing products coming from countries with less stringent climate policies is a recurring one. The asymmetric implementation of climate policies places firms (especially in carbon-intensive industries such as cement, steel or aluminium) located in countries applying a price to carbon at a competitive disadvantage, and might provide them with incentives to relocate to countries with weaker environmental regulation.

Even if all countries implemented climate policies, competitive trade distortions are likely to remain since it is unlikely that the coverage of such policies will be the same in all countries, given their diverse emission profiles, potential for abatement of emissions, and institutional frameworks. Commitments and policies are likely to differ for each country. A common set of commitments and policy architectures for all developing countries might therefore not be feasible. The asymmetric impact of climate policies will remain. In view of such asymmetries, industries will still be able to use regulation strategically when choosing the location of their production. Cross-country competitive distortions will continue to exist even if a 'satisfactory' agreement is reached. Carbon leakage problems will be solved by the convergence of climate policies and this is a long-term process. Focussing the current discussion on carbon leakage might be an obstacle to the future convergence of climate policies.

The likely outcome of a global agreement will be heterogeneous policies in different countries covering different sectors with different obligations. This could set the basis for the creation of a global carbon market but, given the likely strong asymmetries in national policies, it would be far from being comprehensive, at least in its initial stages. As suggested by Denny Ellerman in his contribution to this volume, a global carbon market will be more likely to emerge from the linking of different national initiatives, rather than from a policy objective from the outset to establish a global carbon market.

Trade instruments could however become powerful enforcement tools. A weakness of the present system is lack of compliance mechanisms. Use of trade instruments within a system of trade agreements and retaliatory measures could offer a way of ensuring compliance with post-2012 climate rules – a means of identifying who is playing the game and who is not, with a formal regime of judgements and sanctions. Should trade instruments be used, there are arguments for and against their unilateral application, as has been suggested in the EU with the idea of border measures for carbon-intensive goods as a way to assuage the competitiveness fears of EU industry subject to participation in emissions trading. On one hand, even if such a border tax was consistent with World Trade Organisation rules, it could lead to retaliatory measures, and thus an undermining of economic efficiency. On the other hand, there is an argument for the EU using the power of its market to require certain standards from importers, as in the case of the REACH chemicals legislation[3]. Standards might be equally effective and politically more acceptable than tariffs.

Trade instruments might be an effective means for tackling non-compliance, but they could also be a source of conflict if used as a tool for correcting the inevitable initial asymmetries derived from the different starting points and economic and institutional characteristics of different countries.

Technology and innovation: a two-way approach

As emphasised by Valentina Bosetti, Carlo Carraro and Massimo Tavoni (see chapter 5), innovation is a vital factor in the climate and energy debate, covering energy efficiency, mitigation (for example carbon sequestration), and energy sources (for example renewables and nuclear). The promotion and circulation of new technologies is therefore an essential ingredient of an effective global agreement. Innovation can create substitutes for resources and help with adaptation to climate change. Sustainable development should encompass innovation. Growth in productivity, and decoupling of growth from capital accumulation and carbon intensity, will be dependent on innovation. Current technologies are not sufficient to do the job. New known and unknown technologies are needed to play an essential and central role in fighting climate change.

Carbon markets and price signals might not be sufficient to correct the CO2 externality since they might not provide sufficient incentives to reach the optimal level of innovation in the long term. Carbon markets might be short-sighted, and they do not cover all sources of carbon emissions. Innovation allows emissions abatement costs to be reduced and also improves measurement tools, allowing more targeted and precise policies. A combination of carbon-pricing policies and innovation policies is necessary to reduce carbon emissions effectively. The EU is following a dual path of a carbon price and innovation support, with the ETS and the strategic energy technologies action plan (SET-Plan)[4], though funding sources for innovation support are not always clearly delineated.

Spillovers from innovation

Spillovers from innovation not only occur within industries, but also between developed and developing countries. Accelerating innovation in developed countries helps to increase the competitiveness of green technologies and facilitates the adoption of such technologies by developing countries, even if developing countries do not have active climate policies in place. Stimulating innovation in developed countries gives developing countries an incentive to adopt the technology and jump forward in terms of their development paths[5]. More work has to be done to assess these factors, with the impact of innovation possibly playing a greater part in post-Stern evaluations of the economic costs of climate change[6]. Assessments of the impact of technology on the damage side needs also be carried out.

Major cuts in GHG emissions must be achieved in emerging economies and poorer countries. It is therefore essential that new climate-friendly technologies reach developing countries. The CDM in its current form, which allows firms to buy carbon credits in developing countries, helps to transfer new technologies from rich countries to developing countries (see Dechezleprêtre *et al*, 2007) but may not be sufficient to make the most of new technologies. Further analysis of instruments to facilitate the transfer of technologies to developing countries should be pursued.

Which technologies?

Carbon markets or taxes are technology-neutral, but other measures to encourage innovation can favour certain technologies, such as feed-in tariffs for renewables in Germany, which are strongly biased toward solar generation. Choices about which technologies to support must be made; choices also have to be made about what support schemes should look like, notwithstanding the risk that governments want to pick 'technological winners' and provide support to certain technologies in order to promote domestic industry using climate policy as an excuse to undertake industrial policy. Policies pursued on this basis could result in inefficient investment and increase the costs of tackling climate change. Support for new technologies should be directed towards the gaps not filled by investments triggered by carbon markets.

What should drive the level of support is not the cost difference compared to conventional technologies, but the magnitude of the externalities associated with each technology. For example, a technology that has high potential to contribute to reducing carbon emissions at a low cost and development of which relies on extensive experimentation and widespread market availability is a good candidate for relatively large support. On the contrary, technologies that reach maturity rapidly and depend mostly on firm-specific research might not be good candidates for extra support. Support beyond the magnitude of the relevant externalities might lead to an inefficient growth path.

Short-term targets might also create the wrong incentives to under-invest in technologies that will have an important role in the longer term. Care should be taken in deciding the targets and their time horizon as well as the link between short- and long-term targets.

Interaction between innovation policy and carbon markets

Reducing greenhouse emissions should be the main focus of climate policies. All climate-policy instruments should be designed to deliver the objective at the minimum cost. In that sense, innovation policy is no more than a complementary policy tool to other instruments to reduce greenhouse gas emissions, such as cap-and-trade schemes or carbon taxes. The interaction between such instruments should be carefully fine-tuned in order to achieve the optimal combination. The cost efficiency of innovation policies should be measured in terms of how much it costs to reduce a ton of carbon through supporting new technologies in comparison with other instruments. This exercise will not be trivial since the impact of innovation policy is not immediate, while investment has to start today.

Conclusions

The objective for international climate negotiators is a scientifically sound, economically rational and politically pragmatic global climate agreement to succeed the Kyoto Protocol. But the tools and the political will are in the hands of national governments. National policy instruments might not be the straightest path towards a global objective, but they are probably the only tools available. A bottom-up approach to climate policies seems most pragmatic and effective, but it needs to be enriched. A Kyoto-type agreement has proved to be too minimalistic for the level of ambition needed in the post-Kyoto period. The new global climate agreement should be more wide-ranging in order to enhance cooperation, guarantee compliance and ensure its effectiveness.

Breaking down the barriers between developing and developed countries requires clarification over funding and acceleration of the transfer of technology. Trade and competitiveness concerns will disappear if climate policies converge. However, convergence should not be imposed from the beginning but should evolve as a consequence of a comprehensive agreement based on a combination of flexible tailor-made instruments and targets.

This volume offers a compendium of independent views on the different ingredients that could go into a global climate deal. Contributors do not aim to provide a single view but a diversity of approaches to a global climate consensus.

Dieter Helm starts by analysing critically EU climate policies, highlighting those elements that could be an obstacle to the integration of EU policies into a global agreement. Denny Ellerman advocates an agreement that would frame the appropriate conditions for local (even partial) carbon markets that may, in the future, set the basis for a global carbon market by linking the different mechanisms in place in different territories. Facilitating the acceptance of a global agreement by developing countries is essential to making the agreement effective in terms of mitigating global warming. Axel Michaelowa analyses how flexible mechanisms should be reformed in order for them to be an effective instrument for the development of climate policies in developing countries, for the transfer of technology from developed to developing countries, and for the abatement of emissions at the lowest cost. Valentina Bosetti, Carlo Carraro and Massimo Tavoni analyse the role that technology and innovation could play in reducing global emissions. They put forward a dual approach where both price and quantity policy instruments and technology policy have a role in a future global agreement. Finally, Joseph Aldy and Robert Stavins suggest two possible policy architectures that, in combination with other policy instruments, could be the basis for the implementation of a scientifically sound, economically rational, and politically pragmatic post-2012 agreement for addressing climate change.

Innovation, technology transfer, flexible mechanisms, effective policies and targets, financial cooperation, free trade and carbon markets: the ingredients are on the table. It is now up to policymakers to agree the right blend and the most appropriate recipe.

2

EU climate policy and Copenhagen: does it make much difference?

Dieter Helm

The European Union's climate package was signed off by the Council of Ministers in December 2008 (European Parliament, 2008). It is very ambitious, and it is firmly set within the context of the process of agreeing an international climate deal at the Copenhagen Summit in December 2009, as a follow-on from the first Kyoto period.

The package is full of detail, but its overall architecture is remarkably simple. The EU commits to reducing emissions by 20 percent from the 1990 level by 2020, and 30 percent if the United States and others take similar measures[7]. This will be achieved through three main policy instruments: the EU emissions trading system (ETS), a 20 percent target for renewables as a proportion of total energy by 2020, and a 20 percent target for energy efficiency.

These ambitions are underpinned by a series of bold claims about the (low) costs, the contribution to jobs and growth, and the building of new infant industries, which will give Europe a comparative advantage in world markets.

The neat packaging of all these components around the number '20' is political, not economic, and it is extremely unlikely that all these dimensions of climate change policy will happen to coincide with 2020, or 20 percent for the targets. This short paper explains why the EU package is not quite what it seems, starting with the overarching 20 percent target (section 2), before turning to the roles of two of the main instruments: the EU ETS and the renewables target (sections 3 and 4 respectively). The package is notable not just for the chosen instruments, but also for what is left out (section 5). The missing parts turn out to be at least as important as the parts included, and these form the basis for considering what Europe could positively do at Copenhagen to make a significant difference to climate change, which the existing package will not (section 6).

2. The 20 percent target: production, not consumption

The 20 percent target sounds like a big number, especially when set aside the US's modest legislative plans, which if implemented would reduce emissions by 2020 to a level around four percent below that of 1990. A 30 percent target sounds even bigger. But before any conclusions are drawn, it is important to look at the basis for the number. The 20 percent refers to production, not consumption of carbon, and it is not confined to the EU only, but includes emission reductions in third countries through Clean Development Mechanism (CDM) credits[8].

Production of carbon within the EU depends upon the industrial mix. The production measure has not so far included shipping and aviation – and going forward will only imperfectly include them – and it also excludes imports of carbon-intensive goods. Thus it is possible that, within the EU, production may be low-carbon, with high-carbon production located overseas, and the carbon-intensive goods then imported into the EU. For example, large-scale energy-intensive industries such as steel and shipbuilding may migrate to China, China may use coal-generated electricity in manufacturing (with lower efficiencies and pollution controls than in Europe) and then export the finished product (by ship) to Europe.

It is even possible that carbon production might fall steeply inside Europe while at the same time carbon consumption rises sharply. That is precisely what has been happening in one of the countries that claims to be meeting its Kyoto target – the

United Kingdom. Between 1990 and 2005, the UK's carbon production fell by more than 15 percent, while carbon consumption rose by more than 19 percent over the same period (Helm, Smale and Phillips, 2007). This inversion will vary between European countries, but the trend towards outsourcing carbon-intensive industries to countries such as China and India is a general one.

It is carbon consumption that matters in calculating contributions to atmospheric concentrations. What the Kyoto Protocol does is to set the targets in a way that suits the Europeans (and the US too), and it is therefore not surprising that Europe signed up to Kyoto so readily, further encouraged by the collapse of the eastern European economies and Russia after 1989. That the Copenhagen position has been defined in these production terms is therefore politically unsurprising. However, it remains sadly true that Kyoto has probably achieved very little so far, and that when account is taken of carbon outsourcing, the achievement of the 20 percent production target will have, at best, modest effects on the carbon concentrations in the atmosphere.

But it is worse: the production-based approach couches China as the villain in the Copenhagen negotiations. The Europeans' position is that since the EU is taking on the 20 percent production target, China should take on a production target too[9]. From China's perspective, the reply can be that it is in part emitting carbon on behalf of the EU and the US. It remains the case that China is also producing carbon from manufacturing for its own internal consumption, but it is the export side of the economy which has been growing fast.

3. The EU emissions trading system

Central to the efficient achievement of any carbon target – whether production or consumption – is a long-term carbon price. This internalises the externality, without requiring a prior view to be taken about the relative merits of demand versus supply-side responses, or of the technologies. The price also allows the market to adjust the time profile of carbon reductions.

At first glance, the EU ETS provides an attractive market-based instrument. It is arguably inferior to a carbon tax[10], though in practice the differences are ones of degree rather than kind, once the quantities within the EU ETS are adjusted over time. In practice, however, the EU ETS departs considerably from an efficient design. The main faults are: it is short-, not long-term; the quantities are open to manipulation; and the price that results is likely to be (well) below either the social marginal cost or the marginal cost of meeting the target (where the target is non-optimal).

The time dimension matters greatly. The EU ETS is currently in phase 2 through to 2012, and the framework for 2012-20 is far from concrete. Although the caps are set out to 2020, there is considerable scope built in for *ex-post* adjustment, especially if the EU ETS is to be broadened over the period to bring in others, notably the US. Unsurprisingly then, the price revealed is very short-term. Yet the capital stock is largely given for this short term – indeed, through to 2020. What matters is how that capital stock is replaced, particularly in the energy sectors. Investment appraisals need to take account of the expected post-2020 price.

It is argued that the EU ETS is designed to endure and it is reasonable to expect that the price of permits will follow a long-term upward slope. But why? It is possible that other countries do not join in a new carbon framework; that other instruments, such as renewables quotas, will drive low-carbon technologies through regulation or a carbon tax; or even that the whole framework is re-cast in consumption terms as recommended above. And it is possible that decarbonisation might actually happen, in which case the expected carbon price after 2020 might be much lower. Given the low estimates of the total costs of decarbonisation provided by the Stern Review[11] and others, that is indeed what might be expected.

The price in early 2009 is an example of a rapid reversal of expectations: in December 2009, the Commission was confident that the price would be much higher for all the 2008-12 period. Just a few months later it fell sharply, and now there is considerable confidence that it will remain low. This *ex-ante* price confidence reflects a similar pattern in oil and commodity markets. Repeatedly the error that has been made is to assume that oil prices are on an ever-upward path – but, as witnessed after the peaks of 1979 and 2008, the opposite can happen.

Fortunately this problem can be solved without junking the EU ETS. In order to create a long-term price of carbon, a floor price needs to be set, coupled with an agreement never to lower it. Although, in theory, this could be a floor price within the EU ETS[12], the political economy militates against this, for it would require governments to buy up permits at the floor price, and government budgets are unlikely to permit this. The alternative is to have a floor price outside the EU ETS – in effect, a floor carbon tax. This could be set at a low level initially, rising over time. Two variants are possible: the price of carbon is the sum of the floor price plus the EU ETS price; or the floor price is net of the EU ETS, and applies only when the price of EU ETS permits falls to the floor[13].

4. The renewables target

In principle, a carbon price could achieve all the targets. However, the EU climate change package goes in for some over-determination by also fixing a renewables target of 20 percent of total energy by 2020 to be supplied from renewable sources. The explanation for this target is largely political and is tied up with the evolution of green (and anti-nuclear) politics in the EU.

It is not obvious that this is an efficient way of tackling global climate change because, given that it is a short-term target (to 2020), it concentrates investment on those technologies that are quickly deployable. Of these, wind plays a core part, and for some countries like the UK, it commits to a very rapid expansion – in the UK, from around five percent to perhaps 35 percent of electricity generation by 2020.

The consequences are ill thought-out. Wind is intermittent and requires predominantly fossil-fuel back-up. This means gas, unless the security-of-supply consequences of a major EU-wide dash-for-gas are so great that more coal capacity is built[14]. This coal may be 'carbon capture-ready', but most of the carbon will not be captured for a decade. A dash-for-wind could therefore increase the coal burn. Even where gas is the back-up, the possibility that Russia may not have invested enough to honour its European contracts and meet its own demand means that it may itself increase its coal burn to free up gas for Europe. So, once the carbon consequences have been fully taken into account, the net effect on emissions of the dash-for-wind may be (very) small.

Renewables are also expensive relative to alternative ways of reducing carbon emissions – indeed, this is why they are not left to the market in the context of a carbon price as other technologies (such as nuclear) are. These costs could have been directed elsewhere, to other measures which are left out of the climate change package.

5. What is left out: R&D, CCS, nuclear and the post-2020 framework

If the problem is global climate change, an important starting point in designing climate change policy is to identify which emission sources are likely to dominate in the coming period. Even a cursory inspection of the evidence suggests that the expanding share of coal in world energy supply is the main concern, and that this increasing coal burn is located largely in China and India[15].

The question then to ask is: how do the EU climate package measures address coal and China? It is hard to argue that expensive wind farms in the North Sea make much difference. To put it another way, there are numerous other ways of spending these large sums which make a much greater contribution to reducing emissions. First and foremost is carbon capture and storage (CCS): if carbon cannot be captured and stored and if the coal-burn continues to rise, all other measures will be rendered largely redundant in the attempt to limit global warming. Europe fortunately has a large number of depleted gas fields – notably in the shallow North Sea, and often with pipes connected to them. A major EU CCS initiative on an urgent timescale would be one of the key contributions Europe could make to the global efforts. To its credit, the EU is now supporting a number of demonstration plants[16], but the the total national and European support for wind is on an altogether bigger scale.

A second option is nuclear. It can be deployed on a large scale over a reasonable time period. Until very recently, however, many environmentalists believed nuclear power to be anathema. Given the pivotal role that green votes have played in determining coalitions across Europe, this anti-nuclear position has had a major policy impact. It is now dawning on many environmentalists that, without nuclear, climate change probably cannot be halted. Yet the EU climate package is almost silent on this contribution.

CCS and nuclear are themselves unlikely to be enough. New technologies will be needed and there is very considerable research and development under way. In the EU package, this has a marginal role.

6. A better way forward

In the run-up to Copenhagen, and given the political capital invested in the EU climate package, the EU is likely to stick to the package and continue to use it as its baseline for negotiations. No doubt some sort of agreement will materialise, but it is unlikely to do much about climate change. Indeed, the less effective the outcome, the easier it will be to agree. In terms of impact, this is likely to be small, in the face of an emissions trend that is not only upwards, but accelerating.

The outcome is unlikely to make much difference because of the way it is couched and the high costs associated with the current policy instruments. A global agreement requires the full participation of China and India – already one-third of the world's population and by 2050 probably over 40 percent. This requires a sharing of responsibility for consumption, not production. Europe must pay for the carbon in its imports and for its share of shipping and aviation. But that requires EU politicians to explain to their electorates that the costs of mitigating global climate change are going to be much higher than they have so far indicated. Recent evidence suggests that boosting short-term consumption is a much higher priority.

The next step is to encourage a global long-term price of carbon. In principle, this could be achieved by marrying up various cap-and-trade schemes, including the EU ETS. But this will take (much) time, and little is likely to be practically achieved for a decade. The pace of emissions growth dictates a faster time, and therefore the introduction of floor carbon taxes is a matter of urgency – starting with the EU. Relying on the EU ETS as the principal mechanism to establish a carbon price will inevitably result in lower prices than necessary, and the emergence of an international ETS price will take longer than the problem demands.

In terms of direct technology support, it is not at all clear that this should go so predominantly to wind. It would be better to concentrate on the core problem of the next two decades – coal and therefore CCS. But whilst these are short- to medium-term issues, the overwhelming challenge is to develop new technologies. An international collaboration on R&D would probably make more difference than all the other policies added together.

It is late in the day for the EU to change tack, and probably too late for Copenhagen. But Copenhagen is just one conference in what will be a long series of repeated negotiations. It would be better to go back to the drawing board than to push for an agreement without a solution at Copenhagen. Locking in a production approach, the EU ETS and wind technology may even do more harm than good.

3

A global carbon market: from Kyoto to Copenhagen via the EU ETS

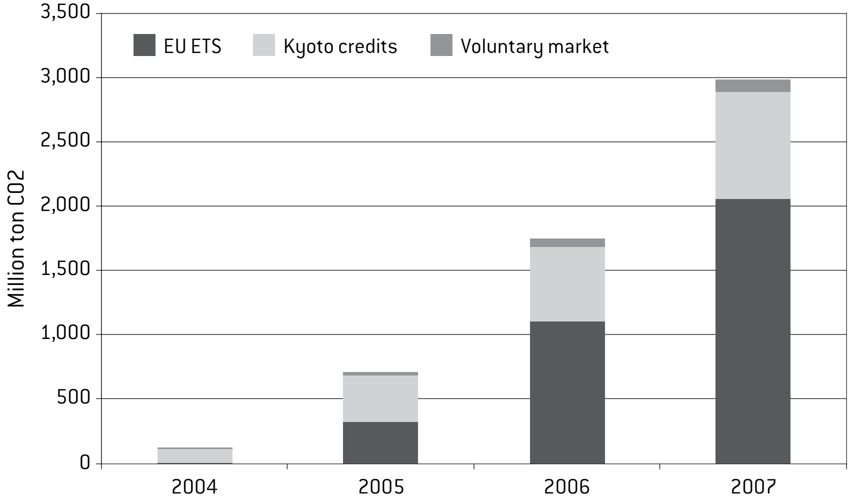
Denny Ellerman

The Kyoto Protocol created the prospect of a global carbon market to facilitate an efficient policy response to concerns about climate change, but the road from Kyoto has taken many unexpected turns. At the same time, the European Union's emissions trading scheme (ETS) – a system inspired by the Kyoto Protocol but also independent of it[17] – has shown the way to a global carbon market. If the road from Copenhagen is to avoid the detours and dead-ends of the Kyoto Protocol, the path blazed by the EU ETS will need to be followed.

The world carbon market has grown exponentially in the last few years, from a little over 100 million tons in 2004 to three billion tons in 2007 (Figure 3.1). This market consists of three distinct sub-markets – a voluntary one, the Kyoto market (trading in credits from CDM and JI projects), and the EU ETS – but there should be little doubt that the spectacular growth of the global carbon market is due to the EU ETS, especially when its influence on the Kyoto credit market is taken into account.

The distinguishing feature of these three sub-markets is the source of demand and the motivation for that demand. Private entities are the source of demand in the voluntary market, very much as is the case in more familiar markets. It is appealing to imagine that this market will grow as increasing numbers of people become convinced of the need to reduce their carbon footprint, just as they might become convinced of the benefits of buying an iPod. Unfortunately, the benefits from purchasing a verified emissions reduction (VER) credit, the currency in this sub-market, are not evident beyond whatever personal satisfaction the purchaser can muster for doing the right thing. The quality of VERs has also been uneven, but the fundamental problem inhibiting growth in this sub-market is the insubstantiality of the benefits and the evident free-rider problem. This characteristic makes the demand for VERs especially fickle and the prospects for growth particularly dubious.

Figure 3.1: Global carbon market, annual trading volume, 2004-2007



Source: World Bank, *State and Trends of the Carbon Market*, 2008 and preceding editions.

The principal buyers in the Kyoto market are the governments that have fallen short of the emission targets agreed to in the Kyoto Protocol and who take those commitments seriously. Three fully substitutable products are traded on this market:

AAUs: The tradable Assigned Amount Units that each Annex I government signatory (generally industrialised economies) to the Kyoto Protocol received as an allowance target for its emissions over the 2008-12 period;

CERs: The Certified Emission Reduction credits for project-based emission reductions achieved in non-Annex I countries (generally developing economies); and

ERUs: The Emission Reduction Unit credits for project-based emission reductions achieved in Annex I countries (which also involve a transfer of AAUs).

The Kyoto market can also be characterised as voluntary, although the buyers are different from those in the true voluntary market and, it is to be hoped, not so fickle. Still, purchases depend on the willingness of the governments of sovereign nations to honour their Kyoto Protocal commitments, and perhaps additional commitments to be made in subsequent international agreements. The prospects for continuing commitments appear good for European governments, but the same cannot be said for several other signatories of the Kyoto Protocol. Japan is an important participant in the current market, but it is also the unhappiest camper in Camp Kyoto. Canada has officially stated that it will not meet its commitments under the Kyoto Protocol and how the prospective non-compliance of this usually exemplary world-citizen nation will be handled is a subject that few wish to discuss openly. Russia's ratification (in exchange for EU support of Russia's World Trade Organisation membership) allowed the Kyoto Protocol finally to enter into force, but Russia's commitment under the Kyoto Protocol did not require it to do anything and no one expects much from Russia in future climate negotiations. The United States and Australia appear to be willing to make commitments as the result of elections, but these changes only emphasise the problems with the Kyoto (or any alternative government-based) market.

A hybrid market

The EU ETS is a hybrid: the sources of demand are private but participation is not voluntary. It is forced on private agents by a government requirement to surrender European Union Allowances (EUAs), the currency of this market, equal to emissions. Some target allocation of EUAs has been issued to installations subject to the surrender requirement – all large stationary sources in the EU – and the buyers are those with emissions greater than their allocations, replicating on a smaller scale the buyers in the Kyoto market.

This market is also linked to the Kyoto market in two ways. Since all but two of the member states of the EU have emission limitation requirements[18] under the Kyoto Protocol, each EUA is linked to an AAU. In tying AAUs to EUAs, EU member states have effectively passed about 40 percent of their Kyoto obligation onto private entities and let them work out how best to make the required emission reductions. In addition, the private entities subject to the EU ETS requirements can purchase CERs or ERUs (but not AAUs) and submit them for a portion of their surrender requirement. Thus, the Kyoto and EU ETS sub-markets of the present global carbon market are linked. The fewer the EUAs (and associated AAUs) issued to the private entities in the EU ETS, the more AAUs remain with the issuing governments to cover non-ETS emissions and the less the demand by those governments in the Kyoto market. And, of course, the fewer the number of EUAs issued, the more the private entities subject to the EU ETS must abate or purchase more CERs and ERUs to cover emissions.

This link between the EU ETS and the Kyoto market explains how the EU ETS became the driving force in the global carbon market. Since the EUA price has been higher than expected prices in the Kyoto market, a worldwide impetus has been given to project developments that create CERs and ERUs that can be sold into the EU ETS market. Although an undetermined share of the CERs and ERUs created to date will be bought by governments, most of the nearly one billion tonne growth in this market has been motivated by EU ETS buyers.

This combination of government fiat and private actors is the secret to the success of the EU ETS in creating a global carbon market. While governments can be fickle as regards international agreements, policies implemented domestically tend to stick. Thus, the future prospects for the continuation of this market are far brighter than for the other two sub-sectors of the global carbon market. As evidence, one needs only to recall the amendments to the ETS Directive finalised in December 2008

(Official Journal, 2009), which guarantee this market well into the 2020s and beyond, independently of what happens at Copenhagen or subsequent international gatherings.

The EU ETS is important not just in accounting for the virtual entirety of the growth in the global carbon market to date, but also and more importantly for demonstrating the feasibility of a multinational system and for reminding all players of how real demand is created, and thereby real markets. The creation of this multinational system involving private agents from 27 sovereign nations is little short of astonishing. Although all the participating nations belong to the EU, the latter is capable of effective action only when there is consensus between the members. All member states participate in the EU ETS despite large differences in *per capita* income among member states (a factor of five) and very different historical circumstances and experience with markets. Finally, in the recent amendments to the ETS Directive, these nations agreed again, unanimously, to continue the programme, to tighten the EU-wide cap significantly, and to differentiate the burden placed on different member states appropriately. This is what a global climate regime will need to do, but it all starts with creating real demand at home.

Patience required

The EU ETS has demonstrated that an enduring global carbon market will not be created by over-arching international agreement, but by the actions of individual nations, perhaps acting together as in the EU, to create real demand through the adoption of compatible cap-and-trade programmes. This reality counsels patience as other nations, such as the US, work through the domestic problems inevitably involved in creating such programmes. International agreements may facilitate domestic actions, much as the Kyoto Protocol inspired the creation of the EU ETS, but creating real demand depends on country-specific trade-offs and decisions that are fundamentally internal and political.

While patience with this bottom-up process will be required, this counsel need not be a source of despair. Vision, perseverance, and a readiness to turn accident to advantage explain a lot of history. In fact, the creation of the EU ETS is surprising given the opposition of most European nations to emissions trading in the negotiation of the Kyoto Protocol. The U-turn has been due in part to the vision and perseverance of key actors, but historical accident also played a strong role. A budding sense of European identity, an increasing desire to stand out globally and to lead in some manner (preferably employing 'soft power') and the unexpected US non-ratification of the Kyoto Protocol provided the basis for the political consensus that allowed all the member states to create the real demand that would make the whole thing work. Finally, given the commitments in the Kyoto Protocol and the seriousness with which they came to be viewed, passing on (or, some might say, off-loading) those commitments onto the private sector provided compensating advantages that made this course of action relatively painless for governments.

A facilitating framework

What then remains for Copenhagen if the key decisions in the creation of a global carbon market are not taken there? The two most important results can be summarised as a facilitating framework and Clean Development Mechanism (CDM) reform. A facilitating framework should aim at making it easier for nations to take the measures required to create real demand and thereby to expand the global carbon market. CDM reform is needed to establish indirect linkage between the existing global carbon market and newly emerging but separate markets that will arise from the inevitably bottom-up process of creating real demand.

The spirit of the facilitating framework should be educational. Aspirational targets and timetables may be inevitable but, if so, they cannot be so demanding as to invite open rejection, silent disregard, or never-again compliance as has been the case with the Kyoto Protocol for the US, Canada and Japan, respectively. The compliance of a number of western European nations either individually or through the European burden-sharing agreement is laudable, but it must also be recognised that the targets for the EU15 are in general much less demanding than those for the US, Canada, and Japan. And, of course, the non-binding targets of other Kyoto signatories, such as Russia, eastern European nations, and even some EU15 nations, provide no real test at all.

A more supportive framework would be one that recognises that cap-and-trade is not an obvious approach to environmental regulation and that constructing a market where none has existed is not a usual government activity. These are not natural markets that have developed through ageless custom and for which government need only provide useful policing and enforcement of contract and property rights. Not only must difficult decisions be made concerning the appropriate amount of scarcity and the distribution of the new property rights, but a significant infrastructure for monitoring, reporting, verification, and allowance-tracking must be created from scratch. What can be broadly characterised as education can go a long way towards making the inevitably internal decisions easier through exchanges of information and of experience in addressing these issues. Such activity was one of the most important activities of the European Commission in facilitating the adoption of the EU ETS. Something similar will be needed on the global stage.

Improve the CDM

CDM reform involves not only the obvious correction of problems revealed in the first years of operation, but also, and more importantly, completing its transformation into an entity that certifies the integrity of project-based emission reductions in countries and sectors that have not yet established cap-and-trade systems. Like the EU ETS, it should be inspired by, but independent of, time-limited international treaties.

The benefits of a viable, independent, and long-lasting CDM are three-fold. First, to the extent that cheaper emission reductions are provided, the cost to nations imposing limits on their own greenhouse gas emissions is reduced. The global nature of the problem justifies such offsets, and nations adopting limits will naturally seek to limit costs by allowing their use. The existence of a credible source of offsets of the requisite integrity will spare each nation adopting a cap-and-trade programme the necessity of setting up their own certification procedures.

Second, in a bottom-up world in which nations act independently, common offsets provide an indirect means of linking otherwise separate systems and facilitating mutual recognition. Credits generated by these projects will naturally flow to the market with the highest price and thereby will tend to align prices in otherwise separate markets. Negotiation will be required to achieve the full mutual recognition that would characterise a fully integrated global carbon market, but those discussions will be much easier the more aligned the prices in the two systems are. Similar prices will make both the practical consequences of mutual recognition and nettlesome conceptual issues like 'equivalent stringency' fade away into insignificance.

The third and final benefit of a more permanent CDM is that it will make it easier for developing countries to ‘graduate’ into the ranks of those nations and sectors adopting limits on greenhouse gas emissions. This too is an educational mission, with projects providing the experience with emissions trading and its non-negligible requirements that will prepare the way for the adoption of sector or country limits at some future time.

In all of these functions, the CDM’s role is transitional since there will be no need for it when all nations, or all significant ones, have adopted limits. This, however, is a long way off and in the meantime there is a pressing need for certifiable credits, indirect linking and learning by experience.

These goals for Copenhagen may be viewed as uninspiring and pedestrian, but climate change policy is a field all too often characterised by soaring but failed ambition, and one sorely in need of modest but real accomplishments, such as the EU ETS. The EU's cap-and-trade programme has kept the hope created by Kyoto alive and shown that an enduring carbon market with global reach can be created. While the EU ETS has blazed the way to a global carbon market, it remains a path and not yet a highway. Persevering along it and getting others to follow will take patience and fortitude. While this may be frustrating, it is the reality of the present and likely future global governance structure, and demonstrates the difficulty for even well-organised societies to solve problems of collective action.

4

Will the CDM become a victim of its own success? Reform options for Copenhagen

Axel Michaelowa

Often, putting in place a new policy instrument requires a lot of persuasion. Once policymakers have understood the concept behind the instrument, it can seem very attractive as long as it has not been applied in practice. But when the first real-life implementation challenges have to be faced, politicians lose interest and switch their attention to new, as yet uncompromised, instruments. Once this instrument has lost its lustre as well, sometimes they then ruefully turn back to the first instrument and try to make the best of it.

In international climate policy the Clean Development Mechanism (CDM) has completed the first part of this cycle. It took about a decade from 1991 to convince policymakers that the concept of project-based offsets was not some lunatic idea but a sensible incentive that could mobilise low-cost emission reductions. After 2000, several years were spent setting up the rules to prevent 'paper credits', ie credits not covered by real emissions reductions, with a small group of overworked UN officials performing near miracles.

With these rules in place and the European Union's emissions trading scheme providing a powerful monetary incentive, the CDM took off in 2005 in a way that had not previously been imagined. By early 2009, almost 5,000 projects were working their way through the system and the creation of close to three billion CDM credits

(Certified Emissions Reductions or CERs) was forecast by the end of 2012.

The key challenges to the CDM

While the success of the CDM has spawned an industry of project developers and consultants, since mid-2007 the mass media have started to draw attention to the scheme's shortcomings. US newspapers in particular have stridently criticised the mechanism as a failure. The increasing media attention has led to a reaction on the part of CDM regulators, as well as to a negative attitude on the part of US policymakers. The latter is surprising because the US had been the country pushing most strongly for the inclusion of the CDM in the Kyoto Protocol. What challenges does the current CDM face?

The CDM gold rush and additionality

Obviously, a gold rush like the one experienced by the CDM will expose any weaknesses of the instrument. The CDM's key weakness was the challenge in defining the concept of 'additionality'. A CDM project should only be awarded emission credits if the project would not have taken place without the incentive provided by the CERs, making the credits 'additional' to business as usual. Of course it is not easy to judge entrepreneurs' minds or to assess their project investment decisions. It is no surprise that business lobbies wanted to get CERs for any project where emissions were below a predetermined baseline, whereas environmental NGOs wanted to reject any profitable project. But the CDM regulators worked out a sensible compromise. The entrepreneur defines the most profitable realistic alternative to the CDM project and as long as the CDM project is less profitable, it is additional. Optionally, the project developer can also show that his project faced prohibitive barriers that were only removed by access to CDM credits. But the problems started when this apparently sensible rule had to be applied in practice.

In the CDM system, independent auditors play a crucial role. They check ('validate') the project documentation provided by the entrepreneur, making sure it is in conformity with the rules. If they had done their job properly, the additionality crisis would probably never have erupted. But from the outset, the validators became servants of the project developers and wilfully repeated their sometimes extremely flimsy arguments. At that stage, the regulators did not have enough manpower to check the project documentation, and therefore a non-negligible share of projects without demonstrable additionality was registered.

The regulators did however notice that problems were building up, and so introduced a second layer of checks through CDM experts, the so-called Registration and Issuance Team. These checks immediately led to the review and rejection of some projects, but it was not until the UNFCCC Secretariat had hired more staff that another layer of checks was introduced. Moreover, the additionality test was specified much more clearly. Currently, about 10 percent of projects are rejected because they are not additional. However, most of these projects are relatively small and other projects based on the same flawed argumentation continue to pass. A reason for this inconsistent treatment by the regulators might be their lack of immunity against legal cases brought by large companies whose projects have been rejected.

Project developers have therefore become increasingly bold. They submit projects that started long ago. More and more large renewable energy projects with doubtful additionality are entering the pipeline. Chinese hydropower plants that report an unrealistically low plant load factor and therefore manage to show low profitability are particularly notorious. However, since late 2008, validators have become much more careful after market leader Det Norske Veritas was suspended for non-compliance with the rules for auditors (Det Norske Veritas was suspended in late 2008, and reinstated in February 2009).

Baseline methodology challenges

To calculate the number of CERs generated by a CDM project, a reference emissions level or 'baseline' has to be defined. According to the CDM rules, this has to be done using a methodology specific to each emissions mitigation technology. Methodologies – which also apply to the monitoring of emission reductions – are proposed by the project developers and checked by an expert panel, prior to the regulators finalising their decision on a proposal. While such a bottom-up procedure makes sense insofar as scarce regulatory capacity does not have to be spread too thinly, the stubbornly high rejection rate of submitted methodologies is a cause for concern. Over half of the proposals have been rejected and the success rate has not improved over time. This is a consequence of parallel learning by the project developers and regulators. A methodology approved in 2005 would no longer stand a chance of passing today. Therefore, methodology development has become an art exercised by highly skilled and paid consultants.

Several strategies have been developed to get methodologies approved. The easiest one is an extremely narrow definition of applicability criteria. This allows the formulae to be kept very specific, and the number of baseline scenario alternatives to be limited. Somewhat more complex is the submission of a simple methodology first that is approved relatively easily, and is then revised successively to fit to the project. For some time, it was also possible to submit a proposal for a small-scale methodology, which was almost sure to be passed. But after this route had been used excessively, it was aligned with the standard procedure.

But even once a developer has got a methodology approved, he cannot rest on his laurels. This is due to the fact that the regulators can see the flaws of the methodology once its application has started. The regulators then revise it, frequently requiring more complex equipment or reducing the CER volume that can be generated by a project. Some methodologies have been revised every three months, and almost none have been retained in their original versions. A particularly challenging activity is the 'consolidation' of methodologies, meaning that similar methodologies are thrown together and afterwards lose their validity.

Data used for baseline methodology development have also become a headache. To facilitate project development, some countries have published emission factors for their electricity grids. This has made life easier for the project developers. However, once the methodology changes, the data are no longer consistent with it. In early 2009, a number of renewable energy and energy-efficiency projects in India were stalled because the regulators required validation of the officially published grid electricity baseline data. As this validation is difficult and requires in-depth understanding of the Indian power sector, no private project developer was willing to bear the cost of this exercise, which could easily reach €100,000.

Monitoring and issuance challenges

Once a CDM project has been registered and starts operation, it has to monitor the emission reductions it achieves. This monitoring must be done according to the monitoring plan described in the project documentation. Many projects now face the challenge that their design changes between the point at which documentation is submitted for registration and actual implementation. For example, a hydropower plant might use a generator from a different supplier than originally envisaged, with a different capacity. Or an energy-efficiency improvement project might use newly introduced technology that did not exist when the documentation was written. For any design change, the CDM rules require a revision of the monitoring plan. Due to the regulatory overload, such revisions can easily take half a year.

Another challenge, especially for projects that started in the early phase of the CDM, is that local staff do not understand the importance of monitoring and there are periods where the monitoring equipment does not work. For example, in a large gas-flaring reduction project in South East Asia, data was not collected properly for a period of several months. The project developer asked for a (one-time) deviation from the monitoring plan. It took more than a year before a regulatory decision was made to accept this deviation. Currently, there is an intense discussion about the interpretation of the principle of achieving a 95 percent confidence interval in monitoring if there are only a limited number of data points during a certain period.

A major problem is that, initially, technology-specific expertise was scarce at the

UNFCCC Secretariat. Therefore, in order to be conservative, very strict requirements for monitoring equipment were set. For example, quarterly monitoring of the methane content of the exhaust gas from flares burning landfill gas was required. The necessary equipment is very expensive and not available in many CDM host countries. It took more than a year before the regulators allowed use of a default factor for flare efficiency, which then led to an upswing of landfill gas project submissions.

Where technologies become more complex, monitoring standards from industrialised countries have frequently been prescribed. However, the regulators decided in a landmark ruling that no standard should be prescribed. How this rule is going to be implemented remains to be seen.

Notwithstanding all these challenges, until early 2009, issuance of CERs was rarely rejected. However, the share of reviews is creeping upwards. It is also a sign of relevant problems that CERs have so far been issued for only a third of registered projects.

Reform proposals on the table

As the negotiations of the post-2012 climate policy regime are currently in full swing, there are several fora for discussing CDM reform. One centres on short-term reform, the other discusses sweeping reforms for the time after 2012.

Short-term reform

Additionality testing can be substantially improved. Investment analysis should become mandatory and should be made subject to checs by a local expert. Incentives for the validators should be improved by hiring them through the UNFCCC Secretariat. Parameters used in the investment test should be checked by a local expert hired by the Executive Board (EB) of the CDM. Benchmarks used to determine the attractiveness of an investment should be based on objective criteria supported by published data. Definition of the prohibitive character of barriers can be further clarified.

The current institutional structure of the CDM is seen by some observers as being incapable of effective administration of the CDM. The EB has reacted to criticism regarding the performance of validators by drafting a Validation and Verification Manual, which became mandatory in late 2008. Moreover, the huge increase in support staff allows the EB to delegate tasks and improve the consistency of its decision-making. However, the introduction of an appeals mechanism for project developers as well as a clear hierarchy for decisions has been proposed, and was endorsed by the Conference of Parties at Poznan in 2008[19].

In mid-2007, the CDM regulators introduced a new 'programmatic' CDM approach. This allows the bundling of many small projects over a period of 28 years, even if the exact timing and number of projects are not known at the time the programme starts. Unfortunately, the detailed rules for registration of a programme contain several prohibitive elements so that, to date, not a single programme has been registered. The Poznan conference asked the CDM regulators to remove these obstacles as quickly as possible but they have not yet been able to do so.

Post-2012 reform

The main reform options under discussion represent an attempt to improve the environmental integrity of the CDM. They can be differentiated into three main strands:

- Replacing project-based additionality testing by benchmarking;
- Going beyond 1:1 offsetting as a means of generating a contribution of the CDM to global emissions reductions;
- Introducing a sectoral crediting mechanism.

Benchmarking, ie deriving the baseline from the performance of a certain percentile of similar projects, has had a chequered history. In general, the sectors that can most easily be benchmarked produce goods or services identical in their nature and in their production processes, are highly concentrated, have no geographical factors distorting the level of performance, and already have a large amount of available data. Benchmarking was already under discussion in the late 1990s and retained a small foothold through a rule that allowed the baseline to be set at the level of the 20 percent best comparable installations. However, this option featured only in a small number of approved baseline methodologies. Nevertheless, many observers have proposed using benchmarks for determining additionality.

Using the same benchmark for the demonstration of additionality and the level of the baseline does not, however, seem to be an appropriate way of guaranteeing the additionality of CDM projects. Thus a double benchmark concept has been proposed by some. This sets separate benchmarks for additionality and the baseline, with the additionality benchmark more stringent than the emissions benchmark. However, the setting of the additionality benchmark level is challenging. If it is set too stringently, no CDM projects will be implemented, while a loose benchmark will allow too many projects to generate CERs, which would have happened anyway. Contrary to the current situation of bottom-up methodology development by single project developers, a higher-level institution, for example an industry association, would develop benchmarks under the CDM. The institutions developing the benchmark have to incur significant costs for benchmark development, while the individual project developers would benefit due to reduced transaction costs. If data or benchmarks collected and developed by industry initiatives are used under the CDM, rules and monitoring, reporting, and verification procedures will have to be established at international level. At the same time, solutions will have to be found for dealing with confidentiality of data. Benchmarking might be as prone to gaming as project-based baseline setting.

A top-down approach to protecting the additionality of the CDM and even to generating net global emission reductions has recently been proposed. Emissions reductions achieved by CDM projects would no longer be converted 1:1 into CERs, but there would be a discount factor. For example one tonne of CO2 reduction would only generate 0.5 CERs. Discounting could be differentiated according to countries or project types. In the former case, more advanced countries would face a higher discount factor than less advanced ones. This would encourage the advanced countries to take up emission reduction commitments. Differentiation according to project type could take into account the probability that projects of a certain type are additional, or the contribution of a project type to sustainable development. Discounting has been boosted by the draft American Clean Energy and Security Act, which was passed by the US House of Representatives in June 2009. This bill initially proposed a 20 percent discount for CERs to apply from 2012. In a later version, this was modified so that the discount would kick in only after a certain grace period.

The EU has proposed a sectoral crediting mechanism. A host country would propose coverage of a sector and the target level, allaying fears of being bullied into the sectoral crediting mechanism. A new UNFCCC body or the current CDM regulators would evaluate the proposed target and the target level would have to be confirmed by the Conference of the Parties. The EU wants the no-lose target to be stricter than business as usual. There is consensus that registered CDM projects in a sector covered by the new crediting mechanism can continue to generate CERs until the end of their current crediting period, even if this goes beyond 2012. This amount of CERs would have to be deducted from the sectoral credits generated through the sectoral mechanism. Given the key role of the host-country government in this sector-wide approach, the question looms large of incentives for the individual entities actually reducing emissions as well as the treatment of 'free riders' increasing their emissions. Beyond a sectoral crediting mechanism, sectoral emissions trading on the basis of a mandatory target would be possible if the target is below business as usual.

Summary

Despite implementation problems, the CDM has been a success. It is the only bridge between industrialised and developing countries when it comes to concrete emissions-mitigation action. The success of the CDM has however also shown starkly several shortcomings that need to be remedied to ensure that the mechanism does not lose its near universal acceptance among policymakers. The key challenge is the lack of additionality of a sizeable share of CDM projects. Each non-additional project increases global emissions. Thus the international climate negotiations are discussing reforms. Short-term reforms would improve governance and make regulatory decisions more consistent. Long-term reforms could lead to a shift from the current 1:1 offsetting system to a system that only credits part of the reductions. This would improve additionality on the aggregate level and provide an incentive for advanced developing countries to accept their own emission reduction commitments.

5

Innovation and climate mitigation: a policy appraisal

Valentina Bosetti, Carlo Carraro and Massimo Tavoni

It is now widely accepted that global warming mitigation requires immediate action in all or almost all countries if greenhouse gas (GHG) emissions are to be effectively controlled. There is growing hope that the stalling of international negotiations might end this year in Copenhagen, or in the very near future, thus creating the conditions for a global effort to mitigate climate change. Low-hanging fruit and no-regret options in emissions mitigation may be enough to provide an initial common foundation for action. Nonetheless, a short-term forward-looking policy should also focus on climate-friendly innovation as an indispensable tool for efficiently achieving climate stabilisation.

This chapter[20] analyses the role of technological innovation in the context of climate policies aimed at long-term climate stabilisation. We argue that innovation is key to keeping the potentially escalating costs of emissions abatement under control, and that energy-saving and carbon-saving research and development programmes represent a hedging strategy that should be pursued immediately. If endorsed as stand-alone policy, climate innovation will not be enough to effectively stabilise GHG concentrations at safe levels.

However, if coupled with market-based climate policies, such as cap-and-trade systems or carbon taxes, innovation can deliver substantial emission reductions at lower costs. If it is additional to carbon pricing, innovation can indeed be shown to improve the economic efficiency of climate policy by roughly 10-15 percent.

Introduction

The policy debate on the role and potential effectiveness of technological change for reducing GHG emissions is topical. Not only has the literature on the subject been re-energised in the last decade, but whether or not technology policy should lie at the core of the climate change challenge is also hotly debated at the political level.

Despite the many uncertainties about the magnitude of the impact of technological change on mitigation costs, there is broad agreement that technological innovation is an important condition to foster the necessary de-carbonisation of the world's economies. From the discussion on innovation and environmental externalities affecting energy-related and carbon-saving R&D, one can conclude that the optimal mix of climate policies should also include instruments explicitly designed to foster innovation, and possibly diffusion of technology, in addition to carbon-pricing policies, either cap-and-trade or taxes, that stimulate new technology as a side effect of internalising the environmental externality. Likewise, long-term carbon saving R&D alone might not be sufficient from an environmental perspective, because it provides no direct incentive to control emissions, and because it focuses on the longer term, missing near-term opportunities for cost-effective emissions reductions (Philibert, 2003; Sandén and Azar, 2005; Fisher and Newell, 2004).

Innovation and technology policies have received considerable interest from policymakers in the past few years. Proposals for international technology innovation strategies have been put forward (Newell, 2008), encompassing both domestic and international policies to foster R&D and the sharing of knowledge thus generated. Some climate-related scientific and technology agreements have also emerged in the past few years, including the Carbon Sequestration Leadership Forum, the Asia Pacific Partnership on Clean Development and Climate, and the International Partnership for a Hydrogen Economy.

Innovation strategies have also been analysed in the context of climate coalition formation, suggesting that they are indispensable for improving the robustness of international agreements to control climate change (Carraro and Siniscalco, 1998; Barrett, 2003).

The interplay between innovation and climate policy is thus clearly relevant. A natural question is then how to induce the technological change that will enhance emission reductions, and to what degree policy should focus on stimulating carbon-saving technological innovation.

Unfortunately, energy-economy-climate models that are normally applied to evaluate climate change mitigation policies seldom incorporate innovation mechanisms such as R&D investments or diffusion of technology. Only a few limited analyses are available of the R&D investment needs required to comply with climate-stabilisation objectives (see, for example, Shock *et al*, 1999; Davis and Owens, 2003; Nemet and Kammen, 2007; Bosetti *et al*, 2009a). Most of these are outside the realm of general equilibrium models. For this reason, the interplay between innovation and climate policy on both economic and environmental grounds has seldom been assessed in a satisfactory manner.

This chapter summarises the authors' recent work in the area of climate change mitigation and technological change, as described in Bosetti *et al* (2008), Bosetti *et al* (2009a), Bosetti *et al* (2009b) and OECD (2008). Most of the analysis presented here has been performed with the energy-economy-climate model WITCH (www.feem-web.it/witch), a tool developed within the Sustainable Development programme at the Fondazione Eni Enrico Mattei (FEEM).

Technological innovation and R&D strategies for climate stabilisation

To be environmentally effective, a post-2012 climate policy will need to be consistent with the long-term objective of stabilising carbon dioxide concentrations at a level considered safe, eg 400-450 parts per million (ppm) or below. This task is likely to be difficult and costly, given the current CO2 concentration (about 380ppm, rising at 2-3 ppm per year), the persistence of CO2 in the atmosphere, and the projected energy consumption and related emission trends. Emissions should be curbed promptly and by a significant amount. For example, a scenario compatible with the stabilisation of CO2 concentrations at 450ppm would require mitigating world energy-related emissions by almost 40 percent before 2030, 70 percent before 2050, and 85 percent before 2100.

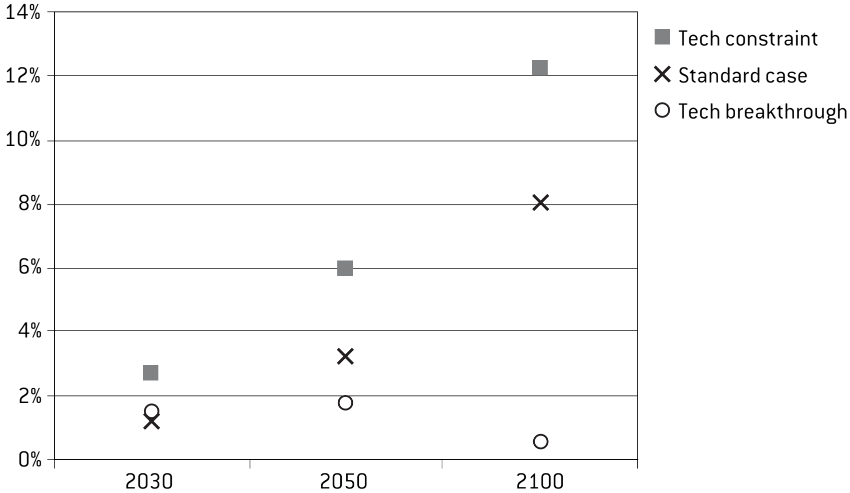
Emission reductions of this sort are challenging, given the expected growth rates of world population and GDP, and the improvement in lifestyles that will, it is to be hoped, take place in the many parts of the world where *per-capita* energy consumption is currently low. The cumulative emission abatement needed from today until 2100 to achieve the 450 ppm CO2 stabilisation target might exceed the total amount of GHGs emitted into the atmosphere since the pre-industrial revolution by almost three times. In *per-capita* terms, average world emissions in the second part of this century would have to decline from about two to 0.3 tonnes of carbon dioxide *per capita* per year (which is today's average in India).

Such a change will require a significant carbon price signal to decrease energy consumption and increase the relative competitiveness of carbon-saving and carbon-free technologies. Major investments in the energy sector would be needed to make this happen. Currently known technologies can significantly contribute to the mitigation challenge, mainly through renewables, carbon capture and storage (CCS), nuclear and biomass, as well as improvements in energy efficiency and demand-side management.

Nonetheless, the development of innovative technologies may prove to be indispensable if we are to meet the increasingly stringent targets outlined above. Yet, the competitiveness of technology is difficult to predict. In the case of energy technologies like CCS or nuclear-power generation, additional factors such as public acceptance, reliability and international security might put at risk their competitive deployment. Furthermore, innovation is inherently uncertain, as shown by the fragmented outcomes of public energy R&D programmes carried out in the 1980s.

Figure 5.1 shows the impact of technology availability on the economic cost of a climate stabilisation scenario. In addition to the standard case, we evaluate the implications of a scenario of limited technology development for power sector technologies such as CCS, nuclear and renewables (Tech Constrained), as well as one in which carbon-free innovative technologies become available within a few decades, pending sufficient R&D investments (Tech Breakthrough)[21].

Figure 5.1: Global GDP losses resulting from a 450ppm CO2-only climate policy under different technology scenarios, in 2030, 2050 and 2100



Source: Estimates from the energy-economy-climate model WITCH (www.feem-web.it/witch).

The results show that very significant reductions in the costs of meeting the mitigation target could be achieved if intensified R&D policies resulted in the development and deployment of new carbon-free technologies, especially in the transport sector. Stabilisation costs in the standard scenario without constraints on technological availability, but also without new carbon-free technologies, are about three percent of global GDP in 2050, and eight percent in 2100. Figure 5.1 emphasises that, provided emission-pricing creates incentives to deploy them, the availability of new carbon-free technologies could reduce to a great extent the overall global costs of meeting the mitigation objectives, ie costs could be 1.8 percent of global GDP in 2050, and about one percent in 2100.

Initially, new carbon-free technologies would likely be economically uncompetitive. However, R&D investments and learning-by-doing processes might bring their costs down to economically relevant levels over time, in the face of the steeply rising costs of emitting GHGs. The relatively greater urgency for technological breakthrough in the transport sector reflects the fact that renewables, nuclear power and CCS provide substantial capacity for reducing GHG emissions from electricity generation even if no breakthrough technology emerges in that sector in the next few decades. If social or other concerns were to inhibit the full deployment of nuclear and CCS options, a new solution for the power sector would become equally urgent.

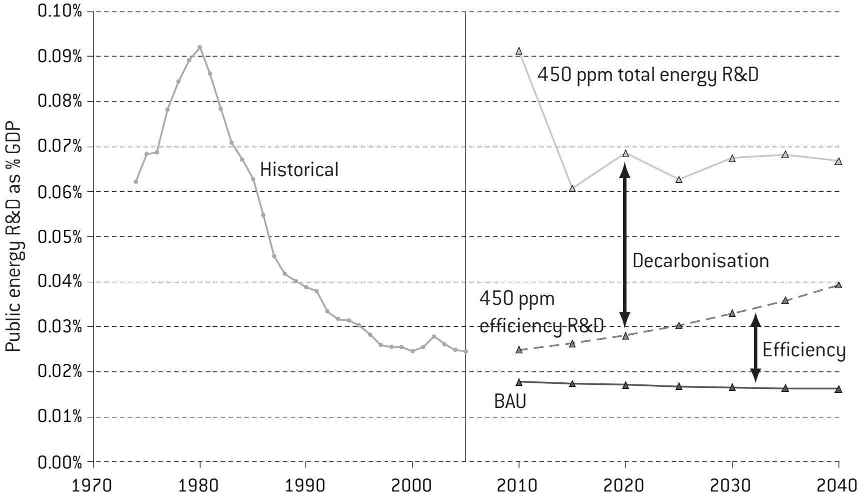
As also shown by Figure 5.1, constraints on the deployment of renewables, nuclear power generation and CCS would raise the cost of achieving the mitigation objectives substantially. Costs would be twice the level of the standard case, ie about six percent of global GDP in 2050, and about 12 percent in 2100.

It should nevertheless be noted that benefits from climate mitigation would materialise only in the long run, whereas the necessary R&D effort would actually raise the medium-term costs. For instance, in 2030, in the technology-optimistic scenario, climate policy costs would be 24 percent higher than in the standard-technology scenario (from 1.3 percent to 1.6 percent), but this extra effort would be more than offset by the benefits of the availability of an affordable and widely deployable mitigation option in the second half of the century.

Developing new technologies will require a massive up-front public R&D effort in the years to come, boosting carbon-saving R&D several fold. For example, public R&D expenditures in the energy sector would need to increase considerably in response to climate policy, as shown in Figure 5.2. This shows that sizeable public energy

R&D investments, in the order of US$40 billion per year and more, should accompany a stringent cap-and-trade system. Note that a US$40 billion R&D investment is one to two orders of magnitude smaller than the physical investments that are needed to decarbonise the economy, eg in technologies such as renewables, nuclear power generation and CCS. Thus, R&D stands out as a relatively cheap hedging investment.

Figure 5.2: Optimal energy R&D investments in the 450 ppm CO2 (550 ppm CO2e) climate policy scenario and in the baseline scenario, compared to historical figures



Source: Estimates from the energy-economy-climate model WITCH (www.feem-web.it/witch).
BAU = business as usual.

Furthermore, the optimum R&D investments would be comparable to those carried out by the public sector alone in the 1980s, and might be well considered as a minimum investment level if the world is actually committed to the unprecedented international effort required by a climate-stabilisation policy. Something is already moving in the policy arena, as proposals to raise considerably the energy R&D budgets have appeared already, even ahead of commitments to a cap-and-trade system[22].

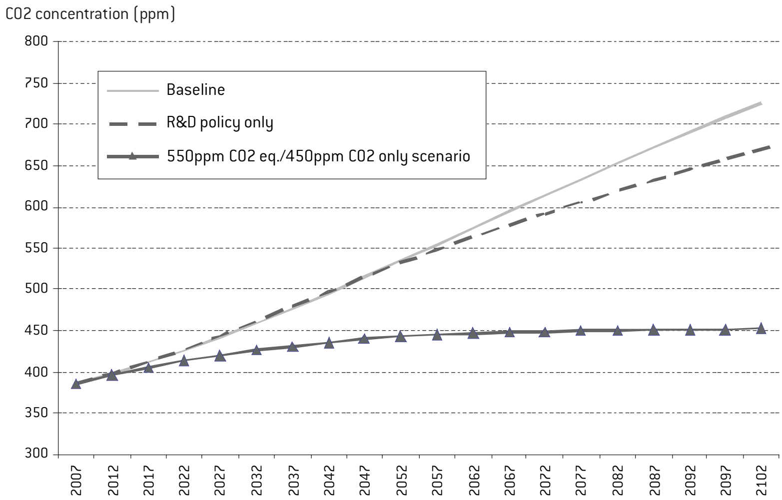
A key policy question is to where such public R&D investments should be directed. The figures indicate that R&D should be aimed at both energy decarbonisation and energy conservation, but that in particular the former should be pursued. Most innovation funding initially should be directed at emission sources other than power generation. Particular attention should be paid to substituting the transport-led oil demand. However, energy-efficiency innovation expenditure becomes more relevant over time and eventually takes the lead.

Can innovation be a stand-alone strategy or do we also need a carbon price?

In the previous section, the relevance of technological innovation for meeting climate-stabilisation objectives was emphasised. The previous section also suggested that technological innovation may not suffice to achieve the 450 ppm CO2-stabilisation target if it is not coupled with a carbon-pricing policy. Indeed, the R&D investments and related effects previously analysed were crucially linked to the implementation of a cap-and-trade scheme. Nonetheless, technological innovation and the deployment of carbon-free technologies have been shown to have a major impact on the cost of climate policy. Therefore, one may wonder whether a stand-alone innovation policy can achieve sufficient emission reductions to stabilise GHG concentrations at about 450 ppm. The question addressed in this section can be phrased as follows. Should climate policy focus only on *either* innovation *or* emission policy (tax or cap-and-trade), or is it worth pursuing a portfolio of different policies?

Let us consider first the environmental effectiveness of stand-alone innovation policies. Our analysis indicates that innovation policies fall short of generating the mitigation needed to stabilise carbon concentrations (see Figure 5.3 and OECD, 2008). At best, emissions (not concentrations) would be stabilised in the second half of the century. In all cases, the atmospheric stock of CO2 would keep increasing and so would global temperature, which remains rather close to the baseline case, even for very high public R&D spending on low-carbon technologies.

Figure 5.3: Optimal CO2 concentration paths in the BAU scenario, in the case of a stand-alone R&D policy, and in the case of a cap-and-trade stabilisation policy

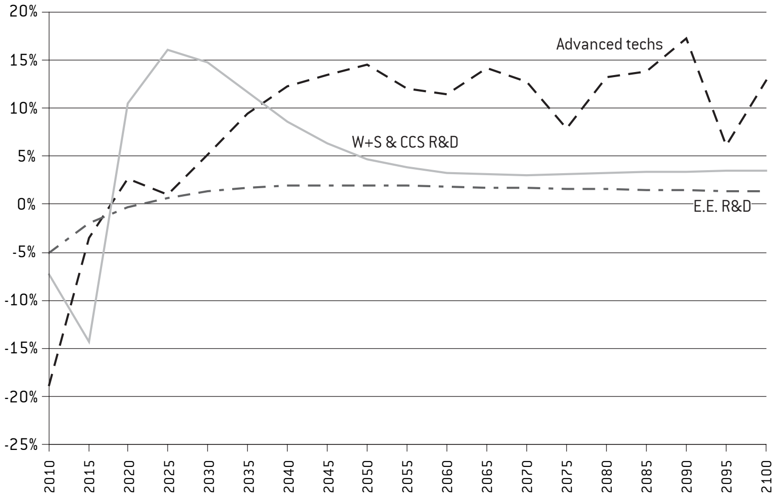


Source: Estimates from the energy-economy-climate model WITCH (www.feem-web.it/witch).
BAU = business as usual.

The essential problem is that, even if innovative and effective technologies emerge, they will not be intensively used until their costs come down close to those of existing competing technologies (unless the new technologies are heavily subsidised or the existing technologies heavily penalised). Carbon capture and storage (CCS) technology provides an example of this challenge. This technology is still new and costly. Intensive R&D efforts might well bring costs down steadily. But this technology would not be widely used in power generation unless there were significant incentives to cut carbon emissions, since otherwise it would reduce generating efficiency and hence would raise costs without providing sufficient returns. This shows that R&D efforts, however intensive, cannot by themselves stabilise CO2 concentrations if incentives to deploy new technologies are weak.

Since stand-alone innovation policies seem unable to achieve sufficient climate mitigation, we must ask to what extent these policies, when combined with carbon pricing, can alleviate its cost. Figure 5.4 reports the efficiency gains of three different policy mixes over the whole century. In all three scenarios, a cap-and-trade scheme aimed at stabilising CO2 concentrations at 450 ppm is coupled with a dedicated R&D programme. In the first scenario, resources are devoted to enhancing energy efficiency. In the second scenario, resources are used to foster the productivity of renewables and CCS. In the third scenario, the objective is to accelerate the penetration of two new carbon-free technologies, one in the energy sector and one in the transport sector.

Figure 5.4: Efficiency gains of hybrid policies over a climate-stabilisation policy (percentage difference in gross world product losses to BAU)



Source: Estimates from the energy-economy-climate model WITCH (www.feem-web.it/witch).
BAU = business as usual.

In all three scenarios, initial efficiency losses are turned into benefits within one to two decades. Substantial differences across the various innovation programmes are nonetheless detectable. A programme dedicated to energy efficiency (E.E. R&D) is the least effective, entailing initial losses below five percent and eventual stable efficiency gains around two percent.

A policy aimed at fostering the productivity of renewables and CCS (wind+solar and

CCS R&D) increases the policy cost by up to 15 percent initially, but this loss is compensated for soon after 2020 by gains of the same order of magnitude. Over time, however, the efficiency gains decline to only a few percentage points after mid century, by which time the technologies are mature, ie their marginal costs are dictated by deployment constraints such as site availability, and the relevance of mitigation efforts in sectors other than power generation is more predominant.

By contrast, a policy focused on breakthrough innovation (Advanced Techs) allows for continued efficiency gains for the entire century (again in the range of 10 to 15 percent), given that it is targeted at expanding the technology portfolio, in both the power and transport sectors. However, the same policy requires a higher initial incremental effort, whereas the benefits accrue more slowly over time, given that the new advanced carbon-free technologies are initially very uncompetitive.

Figure 5.4 suggests a trade-off between timing and effectiveness of innovation policies. Policies aimed at breakthrough innovation deliver the higher efficiency gains because they reduce policy costs when they are higher, namely after 2030, when the mitigation target becomes very stringent. Policies supporting existing technologies such as wind or solar power and CCS provide earlier gains, but those benefits cannot be sustained in the long run. In both cases, some losses are involved in the initial periods. This lowers net-present-value gains, since losses occur when they are weighted more. As a result, the net benefits of coupling carbon pricing and innovation policies are bounded at roughly 10 percent.

Concluding remarks

In this chapter, we have argued that technological innovation and climate stabilisation are closely intertwined. Innovation is a necessary but by far not the only condition for achieving climate stabilisation at moderate economic cost. A steadily rising, global and long-term carbon-price signal is the foremost tool needed to tackle climate change. It is also likely to generate a sizeable increase in energy R&D investment. Nonetheless, having complementary climate and innovation policies might result in some efficiency gains, though they will probably not exceed 10-15 percent[23].

The real issue is indeed the deployment of carbon-cutting technologies. Substitution effects seem to be more important than innovation effects, ie technological innovation should be coupled with incentives to replace existing fossil fuel-based and energy-intensive technologies with energy-efficient and carbon-free ones. As shown, a limited deployment of currently known carbon-free technologies would raise the cost of climate mitigation significantly. Costs would be even higher if new carbon-saving technologies are not developed and deployed. Whereas development crucially depends upon R&D investment, the size and timing of deployment crucially depend upon the size and timing of the carbon-price signal.

6

Towards a post-Kyoto international climate-policy regime

Joseph E Aldy and Robert N Stavins

Global climate change is the ultimate global-commons problem: because greenhouse gases (GHGs) mix uniformly in the upper atmosphere, damage is completely independent of the location of emissions sources. Thus, a multi-national response is required. The greatest challenge lies in designing an international policy architecture that can guide such efforts.

The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) marked the first meaningful attempt by the community of nations to curb GHG emissions. This agreement, though a significant first step, is not sufficient for the longer-term task ahead. Some observers support the policy approach embodied in Kyoto and would like to see it extended – perhaps with modifications – beyond the first commitment period, which ends in 2012. Others maintain that a fundamentally new approach is required.

Whether one thinks the Kyoto Protocol was a good first step or a bad first step, everyone agrees that a second step is required for the post-2012 period. The Harvard Project on International Climate Agreements was launched with this imperative in mind[24]. The project is a global, multi-year, multi-disciplinary effort intended to help identify the key design elements of a scientifically sound, economically rational and politically pragmatic post-2012 international policy architecture for addressing the threat of climate change.

Principles for an international agreement

A set of core principles emerges from the diverse strands of research of the Harvard Project. These principles constitute the fundamental premises that underlie various proposed policy architectures and design elements; as such they can provide a reasonable point of departure for ongoing international negotiations.

First, because climate change is a global-commons problem, cooperation among countries is essential, whether through the UNFCCC; smaller, key coalitions such as the Group of 20 nations (G20); or bilateral negotiations. Furthermore, since sovereign nations cannot be compelled to act, treaties must create incentives both for participation and compliance.

Second, a credible climate change agreement must be equitable. Industrialised nations should accept responsibility for historic emissions, while emerging economies need to take on increasingly meaningful roles over time. In both cases, the scope of attention and action should include all GHGs, not only fossil carbon dioxide (CO2).

Third, a credible agreement must be cost-effective, and therefore needs to bring about technological change and transfer. In addition, it must be consistent with the international trade regime. Fourth and finally, a credible agreement must be practical and realistic. It should build on existing institutions and practices, where possible, and negotiations should attend both to short-term achievements and long-term goals. Finally, since no single approach guarantees a sure path to ultimate success, it is best to pursue multiple approaches simultaneously.

Promising international climate-policy architectures

The decision to adopt a particular architecture is ultimately a political one, which must be reached by the nations of the world, taking into account a complex array of factors. In this chapter, we highlight just two potential architectures, each with advantages as well as disadvantages. Each is promising in some regards, and also raises key issues for consideration.

Formulas for evolving emission targets for all countries

This first option offers a centralised framework of formulas that yield numerical emissions targets for all countries up to the end of this century (Frankel 2008). National and regional cap-and-trade systems for greenhouse gases would be linked in a way that would allow trading across firms and sources (Jaffe and Stavins 2008). Such a global trading system would be roughly analogous to the system already established in the European Union, where sources rather than nations engage in trading (Ellerman 2008).

The formulas are based on what is possible politically, given that many of the usual science- and economics-based proposals for future emission paths are not dynamically consistent – that is, future governments will not necessarily abide by commitments made by today's leaders. Several researchers have observed that when participants in the policy process discuss climate targets, they typically pay little attention to the difficulty of finding mutually acceptable ways to share the economic burden of emission reductions (Bosetti *et al*, 2008, Jacoby *et al*, 2008).

This formula-based architecture is premised on four important political realities. First, the US may not commit to quantitative emission targets if China and other major developing countries do not commit to quantitative targets at the same time. Second, China and other developing countries are unlikely to make sacrifices different in character from those made by richer countries that have gone before them. Third, in the long run, no country can be rewarded for having 'ramped up' its emissions well above 1990 levels. Fourth, no country will agree to bear excessive cost. Harstad (2008) adds that use of formulas can render negotiations more effective.

Through negotiation, an international agreement would establish a formula which assigns quantitative emissions limits to countries in every year up to 2100. The formula incorporates three elements: a progressivity factor, a latecomer catch-up factor, and a gradual equalisation factor. The progressivity factor requires richer countries to make more severe cuts relative to their business as usual emissions. The latecomer catch-up factor requires nations that did not agree to binding targets under the Kyoto Protocol, or that did not comply with their Kyoto targets, to make gradual reductions to account for their additional emissions since 1990. This will prevent latecomers from being rewarded with more generous targets, and will avoid incentives for countries to ramp up their emissions before signing the agreement. Finally, the gradual equalisation factor moves national *per-capita* emissions in the direction of the global average of *per-capita* emissions in the second half of the century[25].

The caps set for rich nations would require them to undertake immediate abatement measures. Developing countries would not bear any cost in the early years, nor would they be expected to make any sacrifice that is different from the sacrifices made by industrialised countries, accounting for differences in income. Developing countries would be subject to binding emission targets that would follow their business as usual (BAU) emissions in the next several decades[26]. National emission targets for developed and developing countries alike would not cost more than one percent of GDP in present-value terms, nor more than five percent of GDP in any single year.

Every country under this proposal is given reason to feel that it is only doing its fair share. The basic architecture of this proposal – a decade-by-decade sequence of emission targets determined by a few principles and formulas – is flexible enough that it can accommodate major changes in circumstances during the course of the century.

Linkage of national and regional tradable permit systems

A new international policy architecture may be evolving on its own, based on the reality that tradable permit systems, such as cap-and-trade systems, are emerging worldwide as the favoured national and regional approach (Jaffe and Stavins 2008). Prominent examples include the EU's emissions trading system (EU ETS); the Regional Greenhouse Gas Initiative in the northeastern US; and systems in Norway, Switzerland and others; plus the existing global emission-reduction-credit system, the Clean Development Mechanism (CDM). Moreover, cap-and-trade systems are emerging in Australia, Canada, Japan, New Zealand, and the US.

The proliferation of cap-and-trade systems and emission-reduction-credit systems around the world has generated increased attention and increased pressure – both from governments and from the business community – to link these systems. By linkage, we refer to direct or indirect connections between and among tradable permit systems through the unilateral or bilateral recognition of allowances or permits.

Linkage produces cost savings in the same way that a cap-and-trade system reduces costs compared to a system that separately regulates individual emission sources – that is, it substantially broadens the pool of lower-cost compliance options available to regulated entities. In addition, linking tradable permit systems at the country level reduces overall transaction costs, reduces market power, and reduces overall price volatility.

There are also some legitimate concerns about linkage. Most important is the automatic propagation of programme elements that are designed to contain costs, such as banking, borrowing, and safety-valve mechanisms. If a cap-and-trade system with a safety valve is directly linked to another system that does not have a safety valve, the result will be that both systems now share the safety valve. Given that the EU has opposed a safety valve in its emissions trading scheme, while it appears possible that such a mechanism may be included in a future US emissions trading system, concern about the automatic propagation of cost-containment design elements is important.

However, there are ways to gain the benefits of linkage without the downside of having to harmonise systems in advance. If two cap-and-trade systems both link with the same emission-reduction-credit system, such as the CDM, then the two cap-and-trade systems are indirectly linked with one another. All of the benefits of linkage occur: the cost-effectiveness of both cap-and-trade systems is improved and both gain from more liquid markets that reduce transaction costs, market power, and price volatility. At the same time, the automatic propagation of key design elements from one cap-and-trade system to another is much weaker when the systems are only indirectly linked through an emission-reduction-credit system.

Such indirect linkage through the CDM is already occurring, because virtually all cap-and-trade systems that are in place, as well those contemplated, allow for CDM offsets to be used (at least to some degree) to meet domestic obligations. Thus, indirectly linked, country- or region-based cap-and-trade systems may already be evolving into the *de-facto*, if not the *de-jure*, post-Kyoto international climate-policy architecture.

A post-2012 international climate agreement could include several elements that would facilitate future linkages among cap-and-trade and emission-reduction-credit systems (Jaffe and Stavins 2008). For example, it could establish an agreed trajectory of emissions caps (Frankel 2008) or allowance prices, specify harmonised cost-containment measures, and establish a process for making future adjustments to key design elements. It could also create an international clearing house for transaction records and allowance auctions, provide for the ongoing operation of the CDM, and build capacity in developing countries. If the aim is to facilitate linkage, a future agreement should also avoid imposing 'supplementarity' restrictions that require countries to achieve some specified percentage of emission reductions domestically.

Conclusion

Great challenges confront the community of nations seeking to establish an effective and meaningful international climate regime for the post-2012 period. But some key principles and promising policy architectures have begun to emerge.

Climate change is a global-commons problem, and therefore a cooperative approach involving many nations will be necessary to address it successfully. Since sovereign nations cannot be compelled to act against their wishes, successful treaties must create adequate internal incentives for compliance, along with external incentives for participation. A credible global climate change agreement must be: equitable; cost-effective; able to facilitate significant technological change and technology transfer; consistent with the international trade regime; practical, in the sense that it builds – where possible – on existing institutions and practices; attentive to short-term achievements, as well as medium-term consequences and long-term goals; and realistic. Because no single approach guarantees a sure path to ultimate success, the best strategy may be to pursue a variety of approaches simultaneously.

The Harvard Project on International Climate Agreements does not endorse a single international climate-policy architecture. In this chapter, we have highlighted two potential frameworks among many for a post-Kyoto agreement. Each is promising in some regards and raises important issues for consideration. One calls for emissions caps established using a set of formulas that assign quantitative emissions limits to countries up to 2100. These caps would be implemented through a global system of linked national and regional cap-and-trade programmes that would allow for trading among firms and sources. Second, we discussed an architecture that – at least in the short term – links national and regional tradable-permit systems only indirectly, through the global CDM. We highlight this option less as a recommendation and more by way of recognising the structure that may already be evolving as part of the *de-facto* post-Kyoto international climate policy architecture.

Notes

1 This chapter discusses some of the issues raised at several events held at Bruegel during 2008 and 2009 on the shaping of a global climate agreement. The note does not however represent the views of participants. Special thanks to Stephen Gardner for fruitful discussion and help in preparing this chapter.

2 Put in place after the United Nations COP13 meeting in Bali, Indonesia, December 2007. See: http://unfccc.int/files/meetings/cop_13/application/pdf/cp_bali_act_p.pdf

3 REACH (registration, evaluation and authorisation of chemicals) requires all chemicals manufactured in or imported into the EU to be screened for impacts on health and the environment. REACH is administed by the European Chemicals Agency. See: http://echa.europa.eu/

4 The EU strategic energy technologies action plan (SET-Plan) is a strategic initiative designed to accelerate the development and deployment of cost-effective low carbon technologies. The plan includes measures relating to planning, implementation, resources and international cooperation in the field of energy technology. It was published in 2007 ('A European strategic energy technology plan (SET Plan) – towards a low carbon future', COM (2007) 723).

5 Acemoglu *et al* (2009) show how endogenous innovation and directed technical change can make compatible sustained growth and the need to avoid climate change. Acemoglu *et al* (2008) argue that by taxing 'dirty' technologies, one directs innovation investment towards clean technologies, with no necessary effect on the overall rate of innovation. In the long-run, such tax might raise growth since it would eliminate the negative impact on growth of catastrophic events associated to the dirty technology. The tax would obviously not be costless and would reduce current output. The tax does not need to be permanent: temporary taxation could be sufficient to induce the use of green technologies, changing the growth path but not affecting the growth rate.

6 The Stern Review on the Economics of Climate Change (Stern, 2007) was published in October 2006 by the British government.

7 '...rising to 30 percent if there is an international agreement committing other developed countries to comparable emission reductions and economically more advanced developing countries to contributing adequately according to their responsibilities and respective capabilities' (European Commission, 2008).

8 'Member States would also have access to CDM credits covering almost one third of their reduction effort' (ibid).

9 The EU has called for China and other emerging economies to reduce emissions by up to 30 percent compared to business as usual. See European Commission (2009).

10 On the choice of instruments, see Hepburn, in Helm and Hepburn (2009).

11 Stern (2007), but see also Helm (2008a).

12 In technical terms, this is a partial Roberts and Spence hybrid scheme (Roberts and Spence, 1976).

13 For a proposed way forward, see Helm (2008b).

14 It is already apparent that there are considerable political pressures to weaken the EU Large Combustion Plant Directive (2001/80/EC) so that the life of existing coal power stations can be extended. The UK has now announced a significant expansion of coal, most of which will be unabated for a decade. See Miliband (2009).

15 China and India have populations of around 1.3 billion and 1.15 billion people respectively, and these populations are expected to grow significantly by 2050. Adding in a further billion for Africa gives more extra people by 2050 than the entire world population in 1950. See IEA, 2008, table 5.1, p. 125.

16 The European Commission published on 19 May 2009 a call for proposals for CCS and offshore wind projects, to be financed from an EU economic stimulus budget, see http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2009:114:0010:0010:EN:PDF

17 The EU ETS was established as the main mechanism to ensure that the EU as a whole keeps to its Kyoto Protocol commitments.

18 Neither Cyprus nor Malta are Annex I signatories of the Kyoto Protocol.

19 The Fourteenth Conference of the Parties (COP14) to the United Nations Framework Convention on Climate Change (UNFCCC), December 2008.

20 This chapter is part of the research work being carried out by the Sustainable Development Programme of the Fondazione Eni Enrico Mattei. The authors are grateful to the OECD for financial support.

21 The two scenarios are detailed in OECD (2008). In the first, the deployment of CCS and

nuclear energy is limited by political considerations, availability of sites, and environmental concerns. In the second, costly R&D investments and learning-by-doing reduce the cost of new carbon-free technologies, which therefore penetrate the market by mid-century.

22 US President Obama recently committed to R&D tax exemptions and an additional investment of US$ 1.2 billion in basic energy-related research, see http://news.cnet.com/8301-11128_3-10202041-54.html.

23 Given the high stakes at play, such benefits might still be significant, and exceed US$ 1 trillion.

24 This chapter draws upon the Interim Report of the Harvard Project on International Climate Agreements (Aldy and Stavins, 2008), and as such we are indebted to the project's 26 research teams, whose work is documented in our book (Aldy and Stavins, 2009). The project grew from our earlier book, Architectures for Agreement: Addressing Global Climate Change in the Post-Kyoto World (Aldy and Stavins, 2007).The Doris Duke Charitable Foundation has provided major funding for the project, with additional support from Christopher Kaneb, the James and Cathleen Stone Foundation, Paul Josefowitz and Nicholas Josefowitz, the Enel Endowment for Environmental Economics at Harvard University, the Belfer Center for Science and International Affairs at the Harvard Kennedy School, and the Mossavar-Rahmani Center for Business and Government at the Harvard Kennedy School.

25 This is similar to Cao's (2008) 'global development rights' (GDR) burden-sharing formula and is consistent with calls for movement toward *per capita* responsibility by Agarwala (2008). On the other hand, it contrasts with the analyses of Jacoby *et al* (2008) and Posner and Sunstein (2008).

26 Somanathan (2008) argues against including developing countries in the short term, even with targets equivalent to business as usual.

Glossary

The following definitions are mostly derived from the United Nations Framework Convention on Climate Change website's glossary of climate change acronyms (available at http://unfccc.int/essential_background/glossary/items/3666.php).

Annex I Parties: Industrialised countries listed in Annex I to the UNFCCC committed to return their greenhouse-gas emissions to 1990 levels by the year 2000. They have also accepted emissions targets for the period 2008-12 as per the Kyoto Protocol. They include the 24 original OECD members, the European Union, and 14 countries with economies in transition. In addition, Croatia, Liechtenstein, Monaco, and Slovenia later joined Annex I, and the Czech Republic and Slovakia replaced Czechoslovakia.

Assigned amount unit (AAU): A Kyoto Protocol unit equal to one metric tonne of CO2 equivalent. Each Annex I Party issues AAUs up to the level of its assigned amount, established pursuant to the Kyoto Protocol. Assigned amount units may be exchanged through emissions trading.

Certified emission reduction (CER): A Kyoto Protocol unit equal to one metric tonne of CO2 equivalent. CERs are issued for emission reductions from CDM project activities. Two special types of CERs called temporary certified emission reduction (tCERs) and long-term certified emission reductions (lCERs) are issued for emission removals from afforestation and reforestation CDM projects.

Carbon capture and storage (CCS): Alternatively, carbon sequestration – the process of removing carbon dioxide from the atmosphere and depositing it in a reservoir.

Clean Development Mechanism (CDM): A mechanism under the Kyoto Protocol through which developed countries may finance greenhouse-gas emission reduction or removal projects in developing countries, and receive credits for doing so, which they may apply towards meeting mandatory limits on their own emissions.

Conference of the Parties (COP): The supreme body of the UNFCCC. It currently meets once a year to review the Convention's progress. The word 'conference' is not used here in the sense of 'meeting' but rather of 'association'. The Fifteenth COP will take place in Copenhagen, Denmark, on 7-18 December, 2009.

Emission reduction unit (ERU): A Kyoto Protocol unit equal to one metric tonne of CO2 equivalent. ERUs are generated for emission reductions or emission removals from joint implementation project.

Emissions trading: One of the three Kyoto mechanisms, by which an Annex I party may transfer Kyoto Protocol units to or acquire units from another Annex I party. An Annex I party must meet specific eligibility requirements to participate in emissions trading.

European Union allowance (EUA): The traded unit in the EU ETS.

European Union emissions trading scheme (ETS): An emissions trading, or cap-and-trade, scheme launched in the EU in 2005, to help the EU meet its Kyoto Protocol commitments.

Greenhouse gases (GHGs): The atmospheric gases responsible for causing global warming and climate change. The major GHGs are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Less prevalent – but very powerful – greenhouse gases are hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6).

Joint implementation (JI): A mechanism under the Kyoto Protocol through which a developed country can receive ERUs when it helps to finance projects that reduce net greenhouse-gas emissions in another developed country (in practice, the recipient state is likely to be a country with an economy in transition). An Annex I Party must meet specific eligibility requirements to participate in joint implementation.

Kyoto Protocol: An international agreement linked to the UNFCCC; it sets binding targets for 37 industrialised countries and the European Community for reducing greenhouse gas emissions.

United Nations Framework Convention on Climate Change (UNFCCC): The overall framework for intergovernmental efforts to tackle the challenge posed by climate change. It recognises that the climate system is a shared resource whose stability can be affected by industrial and other emissions of carbon dioxide and other greenhouse gases. The Convention enjoys near universal membership, having been ratified by 192 countries. The Convention entered into force on 21 March 1994.

Verified emissions reduction (VER): The traded unit in voluntary carbon markets. See chapter 3 of this volume.

References

Acemoglu, Daron , Philippe Aghion, Leonardo Bursztyn, and David Hemous (2009) 'The Environment and Directed Technical Change', mimeo.

Agarwala, Ramgopal (2008) 'Towards a Global Compact for Managing Climate Change', *Discussion Paper 08-22*, Harvard Project on International Climate Agreements, Belfer Center for Science and International Affairs, Harvard Kennedy School, December.

Aldy, Joseph E and Robert N Stavins (2008) 'Designing the Post-Kyoto Climate Regime: Lessons from the Harvard Project on International Climate Agreements', Cambridge, Mass.: Report for Harvard Project on International Climate Agreements, Belfer Center for Science and International Affairs, Harvard Kennedy School, November 24.

Aldy, Joseph E and Robert N Stavins, eds (2007) *Architectures for Agreement: Addressing Global Climate Change in the Post-Kyoto World*, New York: Cambridge University Press.

Aldy, Joseph E and Robert N Stavins, eds (2009) *Post-Kyoto International Climate Policy: Implementing Architectures for Agreement*, New York: Cambridge University Press.

Azar, Christian and Bjorn Sandén (2005) 'Near-Term Technology Policies for Long-

Term Climate Targets – Economy-Wide versus Technology Specific Approaches', *Energy Policy* 33: 1557-1576.

Barrett, Scott (2003) *Environment and Statecraft*, Oxford University Press, Oxford.

Bosetti, Valentina, Carlo Carraro, Emanuele Massetti, Massimo Tavoni (2008), 'International energy R&D spillovers and the economics of greenhouse gas atmospheric stabilization', *Energy Economics* 30(6), 2912–2929.

Bosetti, Valentina, Carlo Carraro, Emanuele Massetti, Alessandra Sgobbi and Massimo Tavoni (2009a) 'Optimal Energy Investment and R&D Strategies to Stabilise Greenhouse Gas Atmospheric Concentrations', *Resource and Energy Economics* 31-2, 123-137.

Bosetti, Valentina, Carlo Carraro, Romain Duval, Alessandra Sgobbi and Massimo Tavoni (2009b) 'The Role of R&D and Technology Diffusion in Climate Change Mitigation: New Perspectives using the WITCH Model', *OECD Working Paper* No. 664. OECD Publishing.

Bosetti, Valentina, Carlo Carraro, Alessandra Sgobbi, and Massimo Tavoni (2008) 'Modeling Economic Impacts of Alternative International Climate Policy Architectures: A Quantitative and Comparative Assessment of Architectures for Agreement', *Discussion Paper* 08-20, Harvard Project on International Climate Agreements, Belfer Center for Science and International Affairs, Harvard Kennedy School, December.

Cao, Jing (2008) 'Reconciling Human Development and Climate Protection: Perspectives from Developing Countries on Post-2012 International Climate Change Policy', *Discussion Paper* 08-25, Harvard Project on International Climate Agreements, Belfer Center for Science and International Affairs, Harvard Kennedy School, December.

Carraro Carlo, and Domenico Siniscalco (1998) 'International Environmental Agreements: Incentives and Political Economy', *European Economic Review* 42(3-5), 561-572.

Davis, Graham and Brandon Owens (2003) 'Optimizing the Level of Renewable

Electric R&D Expenditures Using Real Options Analysis', *Energy Policy* Vol. 31, No. 15, pp. 1589-1608.

DECC (2009) 'Building a low carbon economy: a framework for the development of clean coal', April 23, Department of Energy and Climate Change, UK.

Dechezleprêtre, Antoine, Matthieu Glachant and Yann Ménière (2008) 'The Clean Development Mechanism and the international diffusion of technologies: An empirical study', *Energy Policy* 36(4), 1273-1283.

Ellerman, A Denny (2008) 'The EU Emission Trading Scheme: A Prototype Global System?' *Discussion Paper* 08-02, Harvard Project on International Climate Agreements, Belfer Center for Science and International Affairs, Harvard Kennedy School, August.

European Commission (2008) '20 20 by 2020: Europe's climate change opportunity', COM(2008) 30 final.

European Commission (2009) 'Towards a comprehensive climate change agreement in Copenhagen', COM(2009) 39 final.

European Parliament (2008) 'European Parliament seals climate change package', press release, December 17.

Fisher, Carolyn and Richard G Newell (2004) 'Environmental and technology policies for climate change and renewable energy', *RFF Discussion paper* 04-05, Resources for the Future, Washington DC.

Frankel, Jeffrey (2008) 'An Elaborated Proposal for Global Climate Policy Architecture: Specific Formulas and Emission Targets for All Countries in All Decades', *Discussion Paper* 08-08, Harvard Project on International Climate Agreements, Belfer Center for Science and International Affairs, Harvard Kennedy School, October.

Harstad, Bard (2008) 'How to Negotiate and Update Climate Agreements', *Discussion Paper* 08-19, Harvard Project on International Climate Agreements, Belfer Center for Science and International Affairs, Harvard Kennedy School, November.

Helm, Dieter (2008a) 'Climate-change policy: why has so little been achieved?', *Oxford Review of Economic Policy* 24:2, 211–38.

Helm, Dieter (2008b) 'Caps and Floors for the EU ETS: a practical carbon price', http://www.dieterhelm.co.uk/publications/Caps_Floors_Oct_2008.pdf, accessed 31 August 2009.

Helm, Dieter, Jonathan Phillips and Robin Smale (2007) 'Too Good to be True? The UK's Climate Change Record', http://www.dieterhelm.co.uk/publications/Carbon_record_2007.pdf, accessed 31 August 2009.

Hepburn, Cameron, in Dieter Helm and Cameron Hepburn, eds (2009) *The Economics and Politics of Climate Change*, Oxford: Oxford University Press, forthcoming.

IEA (2008) *World Energy Outlook 2008*, International Energy Agency.

Jacoby, Henry D, Mustafa H Babiker, Sergey Paltsev and John M Reilly (2008) 'Sharing the Burden of GHG Reductions', *Discussion Paper* 08-09, Harvard Project on International Climate Agreements, Belfer Center for Science and International Affairs, Harvard Kennedy School, October.

Jaffe, Judson and Robert N Stavins (2008) 'Linkage of Tradable Permit Systems in International Climate Policy Architecture', *Discussion Paper* 08-07, Harvard Project on International Climate Agreements, Belfer Center for Science and International Affairs, Harvard Kennedy School, September.

Miliband, Ed (2009) 'No new coal without CCS', DECC press statement, April 23.

Nemet, Gregory and Daniel Kammen (2007), 'US Energy Research and Development: Declining Investment, Increasing Need, and the Feasibility of Expansion', *Energy Policy* 35, No.1, 746-755.

Newell, Richard G, (2008) 'International Climate Technology Strategies', *Discussion Paper* 08-12, Harvard Project on International Climate Agreements, Belfer Center for Science and International Affairs, Harvard Kennedy School, October.

OECD (2008), *Climate change mitigation: what do we do ?*, OECD Publishing.

Official Journal of the European Union (2009) 'Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community', OJ L 140, 6 June 2009, p63.

Philibert, Cédric (2003) 'Technology Innovation, Development and Diffusion', *OECD and IEA Information Paper* COM/ENV/EPOC/IEA/SLT(2003)4, International Energy Agency, Paris.

Posner, Eric A and Cass R Sunstein (2008) 'Justice and Climate Change', *Discussion Paper* 08-04, Harvard Project on International Climate Agreements, Belfer Center for Science and International Affairs, Harvard Kennedy School, September.

Roberts, Marc J and Michael Spence (1976) 'Effluent Charges and Licences Under Uncertainty', *Journal of Public Economics* 5(3–4), 193–208.

Schock, Robert, Merwin L Brown, Jae Edmonds, William Fulkerson, David L Greene and Robert L San Martin (1999) 'How Much is Energy Research & Development Worth as Insurance?', *Annual Review of Energy and Environment* 24, 487-512.

Somanathan, E. (2008) 'What Do We Expect from an International Climate Agreement? A Perspective from a Low-income Country', *Discussion Paper* 08-27, Harvard Project on International Climate Agreements, Belfer Center for Science and International Affairs, Harvard Kennedy School, December.

Stern, Nicholas (2007) 'The Economics of Climate Change: The Stern Review', Cabinet Office, HM Treasury.

Contributors

Joseph E Aldy is a Fellow at Washington DC think tank Resources for the Future. He served on the staff of the US President's Council of Economic Advisers from 1997 to 2000, where he was responsible for climate change policy. Dr. Aldy holds a PhD in economics from Harvard University. His research is on international climate change policy architectures, emissions trading programmes and other mitigation policies, and the relationship between economic development and greenhouse gas emissions.

Valentina Bosetti holds a PhD in Computational Mathematics and Operation Research from the Università Statale of Milan and a Master Degree in Environmental and Resources Economics from University College London. At the *Fondazione Eni Enrico Mattei* (FEEM) since 2003, she works as a modeller for the Sustainable Development Programme, leading the cimate change topic and coordinating a research group on numerical analysis of carbon mitigation options and policies. In 2009 she was assigned one of the prestigious 2009 European Research Council Starting Grants.

Carlo Carraro is professor of Environmental Economics at the University of Venice. He holds a PhD in Economics from Princeton University. He is member of the Intergovernmental Panel on Climate Change Bureau and vice-chair of Working Group III. He is also director of the FEEM Sustainable Development Programme and of the CMCC (*Centro Euro-Mediterraneo per i Cambiamenti Climatici*) Climate Impacts and Policy Division. His research focuses on the design of international environmental agreements, on the development of integrated assessment models and on the analysis of climate policy.

Juan Delgado is the Spanish Competition Authority's Chief Economist. He was formerly Research Fellow at Bruegel dealing with regulation, energy and climate. During 2008 he coordinated the seminar series 'Energy and Climate Exchange' and two conferences on climate policies for the French Presidency of the EU that were the basis of this volume. Before then, he was Repsol YPF Fellow at the John F. Kennedy School of Government at Harvard University. He also worked as an economist at the European Commission's Directorate-General for Competition (2001-2004) and with the Spanish telecommunications regulator (1999-2001). Juan holds a PhD in Economics from the Universidad Carlos III in Madrid and a Master in Economics from the University of Warwick.

Dr A Denny Ellerman is a Senior Lecturer at the Sloan School of Management at the Massachusetts Institute of Technology. He is an expert on energy and environmental economics with a particular focus on emissions trading. He is the author of numerous publications on emissions trading, including being co-author of the forthcoming *Pricing Carbon: The European Emissions Trading Scheme*.

Dieter Helm is Professor of Energy Policy at the University of Oxford. He is also Chairman of the Academic Panel, UK Department of Environment, Food and Rural Affairs, and member of the Advisory Panel on Energy and Climate Security, UK Department for Energy and Climate Change. He has previously been an advisor to the British government on a range of transport, energy and technology issues. He is an Associate of the Smith School of Enterprise and the Environment, and associate editor of the Oxford Review of Economic Policy.

Axel Michaelowa is senior founding partner of the consultancy Perspectives and a researcher on international climate policy at the University of Zurich. He is a member of the Clean Development Mechanism Executive Board's Registration and Issuance Team, and has contributed to the development of five approved CDM baseline methodologies. He was a lead author in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change and is member of the board of the Swiss Climate Cent Foundation. He has published extensively on the Kyoto mechanisms and his latest book, *Corporate Strategies and the Clean Development Mechanism* addresses the challenges of unilateral financing of CDM projects.

Robert N Stavins is Albert Pratt Professor of Business and Government, Harvard Kennedy School; Director, Harvard Environmental Economics Programme; Director, Harvard Project on International Climate Agreements; University Fellow, Resources for the Future; Research Associate, National Bureau of Economic Research; and Editor, Review of Environmental Economics and Policy. He was Chairman, US EPA Environmental Economics Advisory Committee, and Lead Author, Intergovernmental Panel on Climate Change. His holds a PhD in economics from Harvard.

Massimo Tavoni has been at FEEM since 2004 as a senior researcher, and is now a research associate at the Princeton Environmental Institute, Princeton University. His research is about energy and climate change economics. He focuses on the evaluation of international climate mitigation policies, with a focus on technological evolution and uncertainty, and the role of tropical deforestation. He holds a *Laurea cum Laude* in Engineering from the University of Bologna, an MSc in Mathematical Economics from the London School of Economics, and a PhD in Political Economics from the Catholic University of Milan.

About Bruegel

Bruegel is a European think tank devoted to international economics. It started operations in Brussels in 2005 as a Belgian non-profit international organisation supported by European governments and leading corporations. Bruegel seeks to contribute to the quality of economic policymaking in Europe through open, facts-based and policy-relevant research, analysis and discussion.

Bruegel issues a range of publications. The Bruegel Blueprint Series provides comprehensive analysis and policy recommendations on central questions of the moment. Bruegel Policy Briefs provide concise, topical analysis targeted at an audience of executives and policy decision-makers, with an emphasis on concrete policy orientation. Bruegel Policy Contributions are responses to requests by policymakers or public bodies, including testimonies at hearings or responses to public consultation. Bruegel and its researchers also publish working papers, op-eds, collaborative papers with other organisations, and essays.

Bruegel's research is independent and does not represent the views of its board or members. For a full picture of Bruegel activities and publications, visit the website at www.bruegel.org.

Beyond Copenhagen:

A climate policymaker's handbook

Edited by Juan Delgado and Stephen Gardner

It is still unclear what a post-Kyoto international regime to tackle climate change will look like. Negotiations on a post-2012 framework are revisiting questions that arose when the Kyoto Protocol was put in place – such as how targets can best be shared out, and how the different interests of rich and poor countries can be addressed – but policymakers must also face new realities. Scientific evidence shows that the climate policies formulated so far are unfit to deal with the magnitude of the challenge.

This book looks realistically at the options for a deal to succeed the Kyoto Protocol. It sets out some of the main ingredients that will have to be included for finalisation of an economically rational agreement that stands a real chance of addressing the threat to the climate system. It critically analyses the European Union's climate policies before reviewing the key elements of such an agreement: carbon markets, flexible mechanisms for transferring money and technology to developing countries, innovation, and the effective enforcement of a global climate deal.

The contributors to the volume are Joseph E Aldy, Valentina Bosetti, Carlo Carraro, Juan Delgado, Denny Ellerman, Dieter Helm, Axel Michaelowa, Robert N Stavins and Massimo Tavoni. The French *Ministère de l'Ecologie, de l'Energie, du Développement durable et de la Mer*, under the auspices of the 2008 French Presidency of the Council of the European Union, contributed financial support to the production of this volume.

bruegel
33, rue de la Charité, Box 4, 1210 Brussels, Belgium
Switchboard: +32 (0)2 227 42 10
Fax: +32 (0)2 227 42 19
www.bruegel.org

ISBN 978-90-78910-15-2 €15
9 789078 910152