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# Post-Kyoto climate policy targets: costs and competitiveness implications

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## Abstract

This article starts with a review of climate policy targets (temperature, concentrations and emissions for individual regions as well as the world as a whole). A 20–40% reduction target for the EU is proposed for the period 2000–2020. It then looks at costs to meet such targets, and concludes that there is widespread agreement amongst macro-economic studies that stringent carbon controls are compatible with a significant increase in global and regional economic welfare. The difference in growth rates is found to be less than 0.05% per year. Nevertheless, concern still remains about the distribution of costs. If abatement policies are introduced in one or a few regions without similar climate policies being introduced in the rest of the world, some energy-intensive industries may lose competitiveness, and production may be relocated to other countries. Policies to protect these industries have for that reason been proposed (in order to protect jobs, to avoid strong actors lobbying against the climate policies, and to avoid carbon leakage). The article offers an overview of the advantages and drawbacks of such protective policies.

*Keywords*: Atmospheric stabilization; $CO_2$; Costs; Post-Kyoto targets; Competitiveness

## 1. Introduction

The United Nations Framework Convention on Climate Change (UN, 1992) calls for a 'stabilization of greenhouse gas (GHG) concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system'. This ultimate objective of the climate convention forms the backbone of international climate politics. It calls upon us to act so as to make sure we do not cause unacceptable damage to humans, human societies, and ecosystems. Several key questions emerge:

- What level of climate change is dangerous? How does that translate into a concentration target for atmospheric greenhouse gases, and ultimately emission targets in the near, medium and long term?

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- What are the costs of meeting those targets?
- How is the competitiveness of one region affected by policies that would deliver such emission reductions, if other regions do not adopt similar climate policies? What policy measures are available to address these concerns, and how do they work?

This article was initially prepared for a EFIEA workshop on EU strategies on post-2012 climate change policies with EU climate negotiators in Scheveningen, Holland on 30–31August 2004, where I was asked to address these questions. Clearly, a detailed review of the literature on these broad and admittedly varying topics cannot possibly be offered within the space of a single article. Therefore I have attempted to offer a review of key points that have emerged in the literature, interspersed with some personal viewpoints.

The article starts off with a discussion of dangerous anthropogenic interference with the climate system, and moves on to review and propose emission reduction targets required to meet a 2°C target (see Section 2). The costs to meet these targets are assessed in Section 3 and it is concluded that the burden sharing of the costs, rather than the total cost as such, is likely to be the most important obstacle to more ambitious climate policies. For that reason, Section 4 addresses the concerns about loss of competitiveness and possible ways to deal with it. Some conclusions are offered in a final section.

## 2. Climate policy targets

A precise statement of what constitutes ‘dangerous anthropogenic interference’ is not possible, since (a) the degree of harm from any level of climate change is subject to a variety of uncertainties and (b) the extent to which any level of risk is ‘acceptable’ or ‘dangerous’ is a value judgment (Azar and Rodhe, 1997; Schneider et al., 2000). Science can provide estimates about expected climatic changes and associated ecological and societal impacts, but ultimately the question of what constitutes dangerous has to be settled in the political arena – given, of course, the best scientific assessments available about the likelihood of various potential outcomes.

Several authors have focused on thresholds in the climate system, beyond which large-scale, often irreversible, changes take place (see Rial et al., 2004, for an overview of non-linearities, feedbacks and critical thresholds in the climate system, and Hulme, 2003, for a discussion about how human societies may cope with such changes). Examples of such thresholds include a shut-down of the thermohaline circulation, disintegration of the West Antarctic ice sheet, disintegration of the Greenland ice sheet, widespread bleaching of coral reefs, and disruption of other ecosystems (see Schneider and Lane, 2005, for a summary of temperature thresholds for each of these impacts).

The European Union (EU, 2005) as well as several scientists and research groups (e.g. Rijsberman and Swart, 1990; the Scientific Advisory Council on Global Change to the Federal Government of Germany (WBGU), 1995; Alcamo and Kreileman, 1996; Azar and Rodhe, 1997; Grassl et al., 2003; the International Climate Change Taskforce (ICCT), 2005) have argued in favour of an upper limit on the increase in the global annual average surface temperature set at or around 2°C above pre-industrial temperature levels.

Other researchers have analysed the data and proposed similar targets. O’Neill and Oppenheimer (2002) conclude that a 1°C target (above 1990 levels) may be required in order to prevent severe damage to coral reefs, a 2–3°C target to protect the West Antarctic ice sheet and a 3°C target to protect the thermohaline circulation. Arnell et al. (2002) find that stabilization at 550 ppm $CO_2$

'appears to be necessary to avoid or significantly reduce most of the projected impacts in the unmitigated case' (in their 550 ppm $CO_2$ run, the global mean temperature more-or-less stabilizes at about 2°C above 1990 levels by the year 2200).

Hare (2003) points out that certain ecosystems (in the arctics or in alpine environments, and coral reefs) may also be severely damaged at global temperature increases below 2°C. Hansen (2005) argues in favour of a temperature increase at a maximum of 1°C above current temperatures, based largely on concerns about the risk for rapid disintegration of the Greenland and West Antarctic ice sheets. Oppenheimer and Alley (2004, 2005) offer an insightful assessment of the role of the possible melting of ice sheets in determining dangerous anthropogenic interference.

Mastrandrea and Schneider (2004) and Wigley (2004) have developed subjective probability density functions for the temperature level at which dangerous anthropogenic interference takes place, based on the so-called 'burning embers' diagram of the IPCC (2001b, see ch. 19). Their median estimates lie at 2.8°C and 3°C, respectively.

Clearly, one should be careful to interpret thresholds as very sharp tipping points beyond which damages suddenly become dangerous or unacceptable for humanity as a whole. Carlo Jaeger (cited at http://www.realclimate.org/index.php?p=115) has argued that setting such a limit is nevertheless sensible, since it is a way to collectively deal with risks. He has made the analogy with setting speed limits: When we set a speed limit at 90 km/h, there is no 'critical threshold' there – nothing terrible happens if you go to 95 or 100 km/h. But, at some speed, risks (the number of accidents and the impacts) would exceed acceptable levels.

Finally, this discussion should not be understood as a call for governments to initiate formal negotiations on long-term temperature targets that should be adhered to over the next hundred years. Such negotiations are likely to end up in a nightmare of complexities and problems. Perhaps even more importantly, uncertainty about the climate system, impacts, costs, baseline emissions, and so on, suggest that adhering to one target over such a long time period would not be very wise. Rather, the purpose of endorsing a target, or merely thinking about a target, is that it gives guidance as to what may be required during the next couple of decades in order to make sure that we do not act now so that we get locked into a future with unacceptable climate damages.

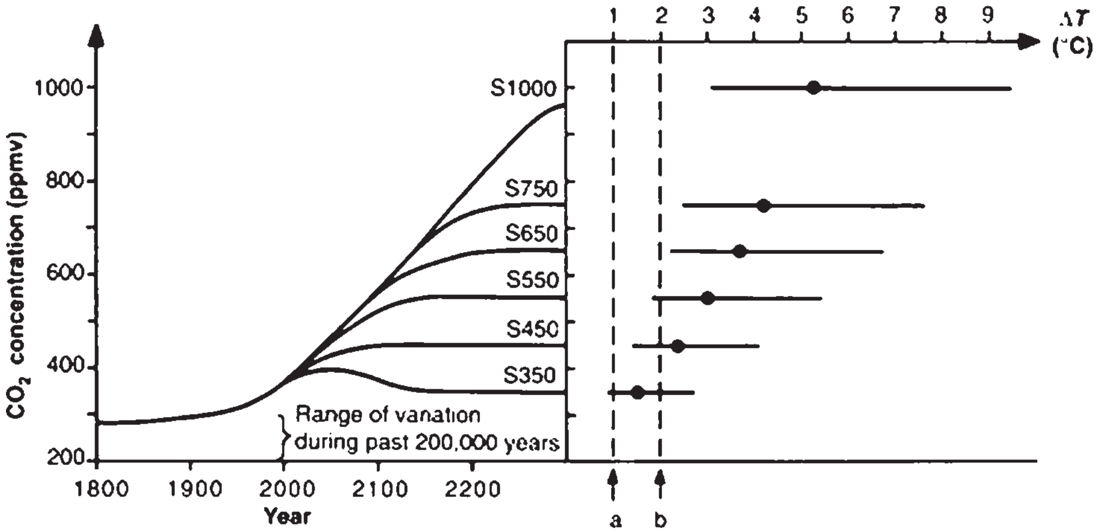
### *2.1. Temperature and concentration*

Here, I pursue the view that a global annual average surface temperature increase of more than 2°C above pre-industrial levels should be avoided (in line with ambitions expressed by the European Union) and estimate the required concentration and emission targets.

In Figure 1, the relation between atmospheric concentrations and the global *equilibrium* average annual surface temperature change is shown (see Azar and Rodhe, 1997). In the graph, the climate sensitivity (the equilibrium temperature change for a doubling of pre-industrial $CO_2$ concentrations) is assumed to be 1.5–4.5°C/$CO_2$-equivalent doubling (IPCC, 2001a; Kerr, 2004). Further, a net contribution to the radiative forcing from other greenhouse gases and aerosols of 1 W/m$^2$ is assumed.[1]

It can be seen from Figure 1 that a $CO_2$ concentration of 550 ppm is expected to lead to a temperature increase in the range 1.9–5.5°C. For 350 and 450 ppm $CO_2$, the expected equilibrium temperatures are 0.9–2.6°C and 1.4–4.5°C, respectively. Thus, in order to be relatively certain that a 2°C target is actually met, $CO_2$ concentrations would have to remain below 400 ppm.

There is a growing literature aiming at developing probability density functions for climate sensitivity (e.g. Andronova and Schlesinger, 2001; Forest et al., 2001; Wigley and Raper, 2001;




*Source*: Azar and Rodhe (1997), reprinted with permission from *Science*.

Figure 1. Global average surface equilibrium temperature change for various stabilization targets. Dashed line (a) refers to an estimate of the maximum natural variability of the global annual average surface temperature over the past millennium, and dashed line (b) shows the 2°C temperature target.

Gregory et al., 2002; Stainforth et al., 2005). These studies support the IPCC range in general, but have tails below 1.5°C and higher than 4.5°C; in some cases much higher.[2]

Taking these distributions into account would make it possible to estimate probabilities for the level below which the concentration of $CO_2$ has to stay in order to avoid any given temperature increase. Such studies have been performed by Baer (2004) and Meinshausen (2005), who both conclude that 400 ppm $CO_2$-equivalent (corresponding approximately to 360 ppm $CO_2$ only) is probably required if we are to be relatively certain to avoid a temperature increase of 2°C.

### *2.2. Global emission trajectories towards 2°C target*

In Figure 2, emission trajectories towards 350, 450 and 550 ppm are shown. All these concentration targets are potentially compatible with a 2°C temperature target but with very low probabilities for the 550 ppm case (as illustrated in Figure 1). It can be seen that the implications for the global energy system over the next 50 years differ radically depending on the climate sensitivity. If the climate sensitivity is so low that the 550 ppm $CO_2$ case is compatible with the 2°C target, then global carbon emissions may increase by 20% until the year 2050. On the other hand, if the climate sensitivity is so high that the 350 ppm concentration target is required, then emissions need to be reduced by 75% over the next 50 years. The importance of the climate sensitivity for the required emission trajectory towards a 2°C target has also been highlighted by Caldeira et al. (2003).

A key question is what this uncertainty about the climate sensitivity and the ultimate temperature target implies for the near-term emission reduction requirements. This question received widespread attention with the publication by Wigley et al. (1996), who argued that delaying emission reductions compared to the IPCC stabilization scenarios (IPCC, 1994), would not only be possible but also more cost-efficient.

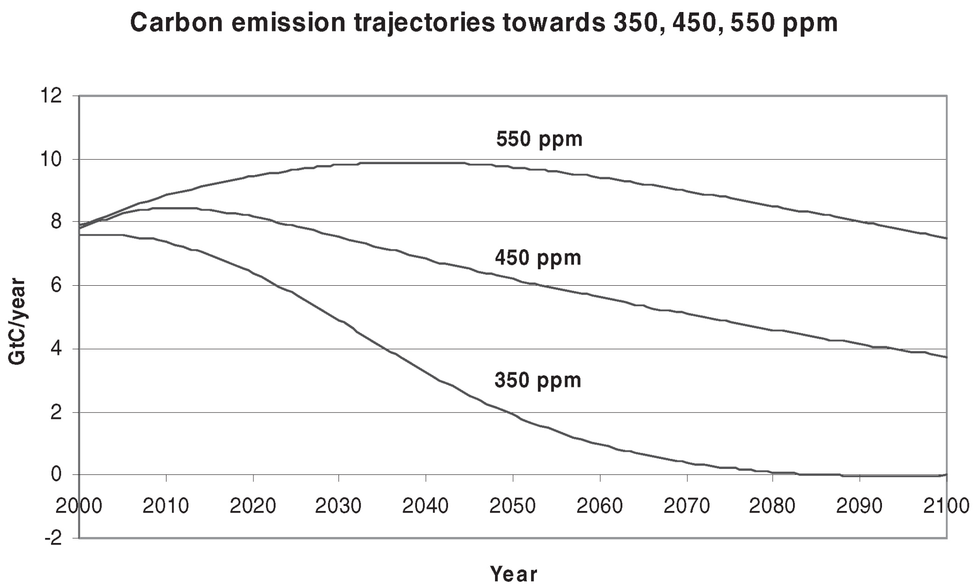



Figure 2. Emission pathways towards 350, 450 and 550 ppm developed as the average of IPCC S350–S550 scenarios (IPCC, 1994; Wigley et al., 1996). Each pathway may be compatible with a 2°C temperature target, but this would require a climate sensitivity of around 1.5°C/$CO_2$-equivalent doubling for the 550 ppm $CO_2$ target.

But the challenge now, as IPCC (1996) states, 'is not to find the best policy today for the next hundred years, but to select a prudent strategy and to adjust it over time in the light of new information'. If we follow an emission trajectory towards say 550 ppm, and later on find out that a 400 ppm target is required, the long-life time of carbon in the atmosphere and the inertia of energy capital as well as the political system, may make it impossible to meet this lower target (see, e.g., Ha-Duong et al., 1997; Schneider and Azar, 2001).

Azar and Rodhe (1997) concluded that 'until it has been proven that a temperature increase above 2°C is safe or that the climate sensitivity is lower than the central estimate, the projections shown … suggest that the global community should initiate policies that make stabilization in the range 350 to 400 ppmv possible'.

It is in this context interesting to reflect on the policy implications of a recent publication by Wigley (2004). He assumes a probability density function for the temperature target, with a mean at 3°C, and combines that with a probability density function for the climate sensitivity (Wigley and Raper, 2001). Given his mean target of 3°C, he finds that there is a 50% probability that the concentration of $CO_2$ needs to be stabilized below 536 ppm. However, he also finds that there is a 23% probability that the concentration of $CO_2$ needs to be stabilized below 400 ppm $CO_2$. Thus analyses with medium targets of 3°C and 536 ppm $CO_2$ could also well justify decisions to act now so as to keep 400 ppm $CO_2$ within reach.

The exact reduction target in the near term that these considerations imply depends on whether one allows for a temporary overshoot of the concentration or the temperature target. For instance, if negative carbon emissions can be obtained (through the use of air capture or biomass with carbon capture and storage; see Lackner, 2003; Obersteiner et al., 2001), then a 350 ppm concentration target by the year 2100 could be met even if atmospheric concentrations exceed

400 ppm by the middle of the century (see, e.g., Azar et al., 2005). An overshoot of the temperature target might lead to irreversible changes in the climate system or in ecosystems, which means that the pathway to the target is of importance. Allowing for such temporary overshoots might, thus, come into conflict with the recognition in the UNFCCC that it is not only the absolute level of climatic change, but also the rates of change, that matter. Another factor determining how much needs to be done in the near term is the inertia in the energy system and the political system. If the maximum rate with which emissions may be reduced is assessed to be low, then relatively more ambitious policies need to be introduced in the near term (see Meinshausen, 2005, for illustrations of what delayed abatement implies for subsequent required rates of change).

### *2.3. Regional emission targets*

Breaking down global emission pathways into reduction targets for individual countries or regions is probably one of the more contentious challenges for climate negotiators. It should be clear that there is no single correct answer to the question of how much the EU needs to reduce the emissions in order to meet a, say, 450 ppm concentration target. The reason for that is not only that there is some degree of freedom as to when the reductions should take place, as discussed above, but also – and perhaps more importantly – that there are several different methods that can be used to share the burden of emission reductions between countries and regions; e.g. equal per capita, contraction and convergence (Meyer, 2000), multistage, intensity targets, global triptych and multi-sector convergence (see, e.g., den Elzen, 2002; Grassl et al., 2003; Höhne, 2005).

Due to space limitations, it is not possible to review these results in detail. Instead, I will offer an illustration of the implications of one approach – contraction and convergence by the year 2050 with a focus on $CO_2$ for three different concentration targets (350, 450 and 550 ppm). Results where other approaches are taken and when all the Kyoto gases are considered are discussed later.

In Figure 3, per-capita emissions in the European Union and China over the next 50 years that would be compatible with a global effort to meet these three targets are shown. The emission pathways are developed in the following way. It is assumed that all countries receive emissions allowances for the year 2000 that represent their current emissions. For the year 2050, allowances are allocated on a per-capita basis globally. For the years in between, a linear weighting scheme is assumed.[3] In addition, I have assumed that the contributions from deforestation and land-use changes drop linearly from 1.5 GtC/year at present to zero by the year 2050. The global population reaches 9.1 billion by the year 2050 (UN, 2004).

For the year 2050, the required reduction in EU lies in the range 50% (for a 550 ppm target) to 90% (350 ppm). It is worthwhile to note that there is such a sharp reduction requirement for the 550 ppm target despite the fact that the global carbon emission trajectory leading to 550 ppm actually increases by 20% (see Figure 2). The reason for this is that the contraction and convergence approach requires that emission allowances should be allocated on a per-capita basis.

For the year 2020, the per-capita reduction targets for the EU, should be in the range minus 20–40% compared to the year 2000 for the 350 and 450 ppm targets, respectively. I am deliberately rounding numbers in order to avoid creating the impression that one can be very precise in establishing what needs to be done in one region in the near term in order to meet a global long-run target. It is interesting to compare these targets with those proposed by the Council of the European Union (on 10 March 2005). The EU proposed that the developed countries adopt reduction targets (for all Kyoto greenhouse gases) in the order of 15–30% below 1990 by the year 2020 (see EU, 2005).

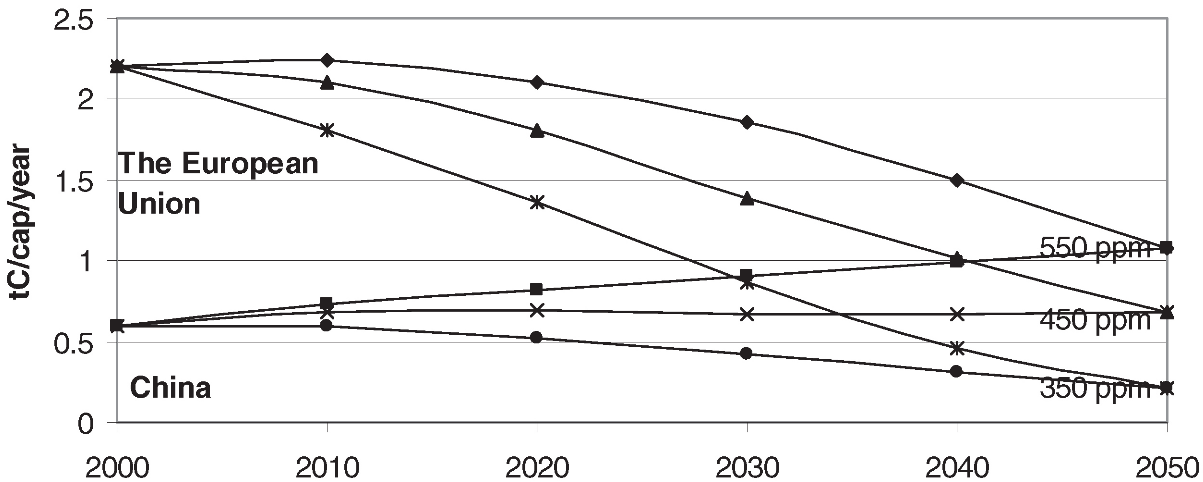



Figure 3. Per-capita emission trajectories for China and the EU towards 350, 450 and 550 ppm, under contraction and convergence by 2050. Population scenarios are taken from UN (2004) and per-capita emissions for the year 2000 from Marland et al. (2003).

Other, more detailed assessments of the reduction requirements generally fall in this range, not only for the contraction and convergence but also for other allocation methods; e.g. the Triptych regime and various forms of multistage models (see den Elzen, 2002; Nakicenovic and Riahi, 2003; den Elzen et al., 2005; Höhne, 2005; Persson et al., 2005).

den Elzen and Berk (2004), for instance, find that a reduction of all Kyoto greenhouse gases by approximately 30% is required over the years 1990–2025 in an 'enlarged EU' in order to meet a 550 ppm $CO_2$ equivalent target for not only contraction and convergence by 2050 but also for Triptych and for a multistage approach. The reason why their number is lower than the upper range in our estimate is that our higher value reflects a more ambitious reduction target (compatible with 350 ppm $CO_2$).

Cases where the allocation approach does have a significant impact on the near-term reduction requirements include (rather obviously) equal per-capita now, contraction and convergence by the year 2100, which gives less stringent reductions in the North (and correspondingly more stringent targets in the South), and the Brazilian proposal, which requires somewhat steeper reductions in the Annex-1 countries because of its focus on historical responsibility.

For China the large difference in the 350 and 550 ppm global emission trajectory (Figure 3) translates into either a possibility to increase its per-capita emissions by 80% (in the 550 ppm case) or decrease them by 70% in the 350 ppm case.

I chose to include only the EU and China in the graph in order not to complicate the picture with too many regions, but it is worthwhile to note that the results for the EU also hold (in broad terms) for Japan, the Former Soviet Union FSU) and South Africa. The USA, Canada, Saudi Arabia and Australia have substantially higher per-capita emissions, so the reduction requirements are sharper. The results for China hold roughly also for fossil-fuel-related emissions from Latin America. India, Africa and Indonesia emit roughly half as much per capita as China and Latin America and may thus be allowed to increase their emissions of $CO_2$. On the other hand, methane and $N_2O$ emissions in India, Indonesia and southern Africa are larger than the emissions of fossil carbon, so taking these gases into account implies more stringent emission targets for these countries.[4]

It may also be noted that there are many countries that traditionally refer to themselves as belonging to the South, that emit more or much more than 1 tC/cap/year (e.g. Malaysia, Iran, South Korea, Mexico, Argentina and, as already mentioned, Saudi Arabia and South Africa).

Different allocation methods yield more variable results for developing countries than for developed countries, in particular for countries with very low emissions at present. For India and sub-Saharan Africa the choice of methods may imply differences in emission profiles (or allocated allowances) that amount to several hundred percent of their current per-capita emissions (see, e.g., Höhne, 2005, ch. 6, figs 4 & 6).

Finally, the actual emissions under a contraction and convergence approach, or any other allocation approach, will depend on whether trade in allowances is allowed or not. Analyses of such trade in allowances are uncertain, since they depend on assumptions about baseline economic development, options to reduce emissions in different regions, political pressure to carry out most of the reductions domestically, etc. For examples of such studies, see Nakicenovic and Riahi (2003), den Elzen et al. (2005) and Persson et al. (2005). Most studies conclude that rich countries generally end up being buyers of permits under a contraction and convergence approach by the year 2050 scheme aiming at 450 ppm, but that China also rather soon ends up being a net buyer (because of its high growth rate and large coal resources).

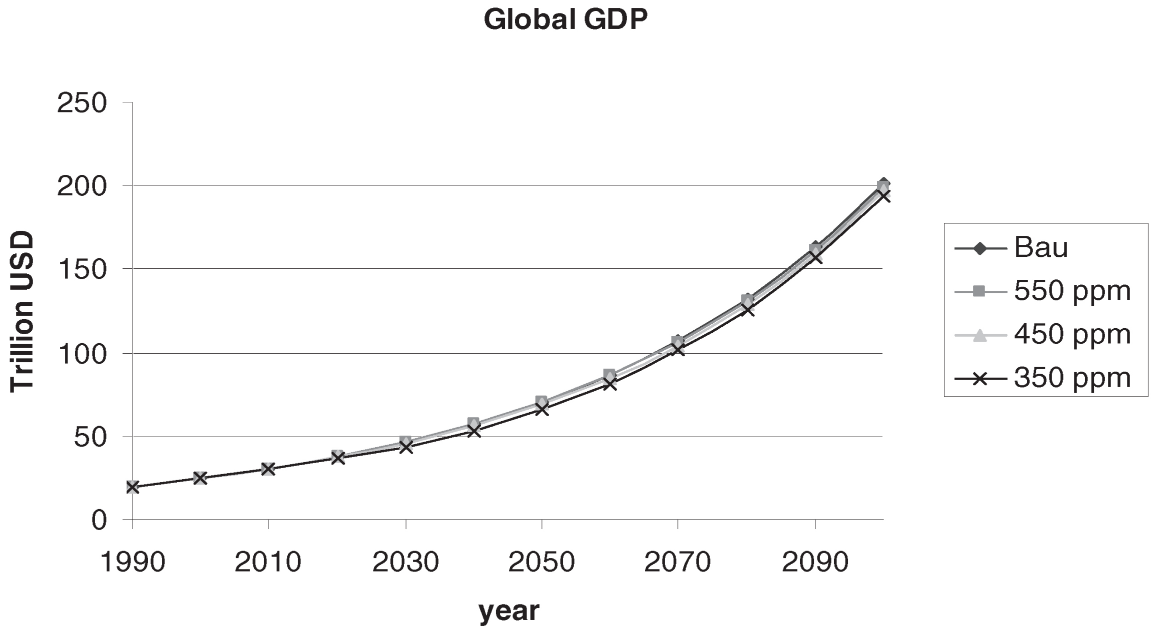
## 3. Overall cost of mitigation

There is much concern about the cost of meeting stringent climate targets. In the public debate, claims are even made that climate policies will threaten our current standard of living. But what does the economics literature tell us? In the latest IPCC assessment, the cost of stabilizing the atmospheric concentration of $CO_2$ at 450, 550 and 650 ppm is estimated to lie in the range US$2.5–18 trillion, US$1–8 trillion and roughly US$0.5–2 trillion, respectively (IPCC, 2001a, ch. 8).

In order to better understand what these numbers mean, it may be useful to view them in light of the expected overall global economic development. This is done in Figure 4 (see Azar and Schneider, 2002). The difference between global income under a 350 ppm scenario and the business-as-usual income (a growth rate of 2.1% per year) represents a net present value cost of US$18 trillion. Thus, although trillion-dollar costs are large in absolute terms, they are minor compared with the perhaps ten-fold increase in global income expected over the next hundred years. Similar observations can be made for the cost of meeting near- and mid-term climate targets.

Figure 4 should not be interpreted as if we were trying to argue that it is inexpensive to meet low stabilization targets. The point is to reject the rather widespread misperception that climate policies are not compatible with continued economic development. If policymakers and the general public would understand that the cost amounts to a few years' delay in becoming ten times richer by the year 2100 or as a difference in growth rate of on average less than 0.05% per year – hardly noticeable even in retrospective! – the willingness to accept climate policies would probably be higher.

It would also be wrong to conclude that the minor difference in growth rates between a stringent climate policy and business-as-usual implies that the low carbon future will materialize by itself. On the contrary, major efforts are required to achieve the almost complete transformation of the energy system that is required (see IPCC, 1996b, ch.11, or Azar et al., 2003, for examples of energy scenarios meeting stringent climate targets). There is in particular a need for (i) introducing and continually increasing the cost of emitting $CO_2$ (through the use of a tax, or a cap-and-trade system), (ii) for standards for energy efficiency improvements, and (iii) for a concerted effort to




*Source*: Azar and Schneider (2002), reprinted with permission from Elsevier.

Figure 4. The development of global income, with and without climate policies. Climate damages are not quantified and thus not included in the graph.

enhance technology development not only through more R&D spending but also through the creation of niche markets for the emerging more-advanced carbon-free energy technologies (see Sandén and Azar, 2005).

## 4. Some perspectives on climate policy and the implications on competitiveness

The difficulties in achieving agreements on climate policies stem from many factors: for instance the fact that costs of climate change and of emissions abatement will not be shared equally across countries, there is not enough public awareness and support from climate policies, there is a widespread misperception that the costs of dealing with climate change will threaten overall economic welfare levels, and the cost of the policies will fall on people living now, whereas benefits will accrue to future generations.

An additional key obstacle is opposition from sectors or industries which would be heavily affected by climate policies. This aspect becomes particularly relevant if the policy ambitions differ across countries.[5] Climate policies would then, it is often argued, lead to relocation of production, which could be costly in terms of premature closure of industrial facilities and losses of jobs, and lead to increases in carbon emissions in other countries (sometimes referred to as ‘carbon leakage’).

The mere expectation that such competitiveness losses may occur is sufficient to set strong interest groups in motion against climate policies. The most well-known example is probably the Byrd–Hagel resolution in the US Senate in 1997, which explicitly stated that the USA should not accept any outcome in Kyoto unless it mandated ‘specific scheduled commitments to limit or reduce greenhouse gas emissions for Developing Country Parties within the same compliance period’. Competitiveness concerns also partially explain why the EU chose to grandfather permits and why countries have been very generous when it comes to the total amount of allowances allocated in the EU Emissions Trading Directive (Grubb et al., 2005).

Thus, it is worthwhile to better understand the concerns about competitiveness and what governments may possibly do about it. Whether they should introduce protective policies is a political question that will not be addressed here. Rather, I will review insights from the literature and offer perspectives on questions such as 'What are the consequences of protecting, or not protecting, sensitive industries?' and 'What are the pros and cons of different protective policies?'.

*Loss of nationwide competitiveness – or?*

It is misleading to speak of losses of competitiveness at the country level as a result of climate policies. In fact, nationwide competitiveness is not even a well-defined concept in economics (see Krugman, 1994; Babiker et al., 2003). Households and transportation do not 'compete' with their likes in other countries. Further, according to the theory on international trade, an economy should specialize more in producing the goods it is comparatively better at, regardless of whether it has an absolute advantage over its trading partners. Implementing a uniform carbon price will shift advantage from carbon-intensive industries toward less carbon-intensive industries (compared with trading partners that do not implement such policies).

At the micro level, however, competitiveness is a useful concept. A company could be said to be competitive if it can produce goods at or below the prevailing market price. Energy- and carbon-intensive industries that face competition from regions without climate policies may lose competitiveness if the cost of energy and carbon increases.

But it should also be recognized that most industries have low energy costs compared to their turn-over, and these may even gain competitiveness and increase output (this is a common result in computable general equilibrium models, which even suggest that output in manufacturing industries may increase; see, e.g., Bergman, 1996). The way this could operate at the international market is as follows: a drop in the exports (or an increased import) of energy and carbon-intensive goods would eventually lead to a slight depreciation of the exchange rate (*ceteris paribus*). This depreciation would improve the competitiveness of manufacturing industries whose lower production costs (in international currency) would outweigh the impact of higher energy prices.[6] Thus, although it is not correct to talk about nationwide losses of competitiveness, a slight depreciation of the currency nevertheless implies higher import prices; i.e. a slight loss in real income.

*Competitiveness of energy-intensive industries*

Energy- and carbon-intensive industries include steel, aluminium, chemicals (e.g. fertilizers), cement and refineries.[7] Producers of these products have limited opportunities to pass on increases in production costs to consumers since the price is often set by international markets (where producers do not face the same carbon price). Electricity generation from fossil fuels is clearly also energy- and carbon-intensive, but if there is no trade in electricity with non-abating regions, then electric utilities can obviously not lose competitiveness to producers in these regions.[8]

For many of these energy-intensive companies, competitiveness, measured as their production costs compared with those of competitors outside the climate abating regions, is at stake. Table 1 shows estimated increases in production costs for a US\$10/t$CO_2$ tax on various energy-intensive industries (assuming constant production technology). The cost increase includes the tax on on-site emissions and the higher electricity prices that result from the carbon tax.

Table 1. The impact of a US$10/t$CO_2$ carbon tax on the production cost of energy-intensive products (Reinaud, 2004)*

| Impact of a US$10/t$CO_2$ tax | Steel basic oxygen furnace | Steel (electric arc furnace) | Cement | Newsprint | Aluminium |
|---|---|---|---|---|---|
| Cost increase (%) | 7.7% | 1.5% | 18.6% | 3.9% | 2.4% |
| Total cost increase (US$/t) | 20.6 | 3.4 | 8.7 | 4.5 | 28.6 |

* Reinaud writes that these numbers are rough estimates of the *upper* boundary of the costs since they do not include options to lower carbon emissions or electricity use in these industries. In addition, the cost number refers to the average plant. Further, the author has chosen to use the *average* carbon emission factor (gC/kWh) for electricity generation in Europe when estimating the impact on the electricity price. But, if the emission factor of the *marginal* electricity source were to determine the impact on the electricity price, the cost increase for aluminium could be more than twice as high, since it is the change in electricity price that is the most crucial parameter for aluminium.

In the EU Emissions Trading Scheme (EU ETS) the increase in average production cost is much smaller because of the grandfathering of emission permits. Energy-intensive companies are basically given as many permits as they need for this first phase, 2005–2007, and may chose to 'consume' these permits in order to keep the price impact down. For that reason, Carbon Trust (2004) concludes that the EU ETS is not likely to pose any significant threat to energy-intensive industries in Europe, except possibly for aluminium industries, which will face a higher electricity price but will not receive any grandfathered permits. The impact on the aluminium sector thus depends on the extent to which the electric utilities are successful in passing on the opportunity costs of the permits to consumers.

This observation is similar to the conclusions drawn from studies about the relocation of industries facing unilateral regulations of other environmental problems, e.g. sulphur, emissions of metals etc. The general result from the literature on this issue is that it has proven difficult to demonstrate a strong case for such relocation (Jaffe et al., 1995; Persson, 2003; Cole, 2004). It would be premature, however, to conclude that this would be the case for stringent climate policies, since the costs of dealing with the $CO_2$ problem per unit of output in energy-intensive industries is significantly higher than the cost of dealing with many other environmental problems.

In the longer term, e.g. if the EU aims at reducing emissions by 20–40% by the year 2020, carbon prices might be several times higher than US$10/t$CO_2$. Bollen et al. (2004), for instance, estimate that a permit price of €58/t$CO_2$ by the year 2020 would reduce emissions in EU-25 by 31% compared with 1990. Although the authors also emphasize that there is a great deal of uncertainty about the exact value of the permit price, it is nevertheless likely that the required permit price will be in the tens of euros per tonne of $CO_2$ and such high permit prices would be likely to lead to severe competitiveness problems for energy-intensive industries from companies that do not face similar carbon penalties.

### *Higher cost of climate policies if industries are protected – or?*

Economic assessments generally find that the cost of meeting a *domestic* carbon target typically increases if protection of sensitive industries takes place (see, e.g., Böhringer and Rutherford, 1997; Babiker et al., 2000, 2003; Bye and Nyborg, 2003).[9] For instance, Böhringer and Rutherford (1997) found that the cost of meeting a 30% reduction target for Germany would increase from 0.6% of its GDP to 0.8% of GDP if energy-intensive industries are protected. The fundamental reason for the expected increase in cost is that lowering the tax, or in general the effort to reduce the emissions, in one sector, means that more costly options have to be employed in other sectors. However, let us assume that the aim of the unilateral climate policy is to meet a global emission target (defined as the sum of the domestic emissions plus the impact on the emissions in the rest of the world). Then the cost is typically lowered if some form of protection of heavy industries takes place (see, e.g., Bergman, 1996; Hoel, 1996; Böhringer and Rutherford, 1997).

These results are all obtained with the use of general equilibrium models, which typically are poor at capturing non-equilibrium effects, such as unemployment.[10] For that reason they may underestimate the social costs associated with rapid closures of large industries.[11] In addition, these models are rarely, if ever, run under the assumption that other countries will eventually also initiate carbon abatement policies. If they do, it could be argued that it would be economically inefficient to pursue a policy that leads to relocation of industries away from Europe if it is believed that these industries would be competitive in a near future with similar carbon constraints in the rest of the world. Such considerations could offer an argument in favour of temporary protection, but they also imply that the risk for relocation of industries is lower than what one may conclude from static analysis. Companies are, of course, aware of the fact that other countries may also introduce climate policies.

*Losing or gaining markets?*

Even if there is some risk that energy-intensive industries may relocate to other regions if Europe unilaterally pursues more ambitious climate policies, it should also be kept in mind that such policies would probably enhance the development of carbon-efficient technologies in Europe. This may be economically positive for Europe in the longer term, since it is most likely that other countries will eventually start to abate carbon. European industries may at that time gain a competitive advantage on these new markets. The Danish export of wind power is an example worth noting. This perspective is sometimes referred to as the Porter hypothesis (Porter and van der Linde, 1995).

Furthermore, technology development that leads to more efficient technologies in Europe (say in the automotive industry, in electric appliances etc.) may set the standard also in other countries regardless of their climate ambitions. This would, in turn, lead to reductions in carbon emissions in their countries, i.e. a reversed form of carbon leakage (see, e.g., Grubb et al., 2002).

*Options for protection*

There are several different policy options that may be employed to protect the energy intensive industries from climate policies, e.g.,

- Allocate carbon emission allowances freely on the basis of past emissions (grandfathering).
- Introduce so-called border tax adjustments (BTA), i.e. import taxes and export subsidies, that level the playing field with countries outside the carbon-abating region.
- Differentiate mitigation efforts between sectors (different carbon tax levels, full tax exemptions, trading schemes that only cover certain sectors, as is the case with EU ETS, etc.).
- Direct subsidies to compensate industries that lose competitiveness.

In common for all these options is the fact that there will be methodological problems in the implementation phase and that protective policies may come into conflict with basic ambitions of achieving free trade and non-distorted markets. There have already been complaints about unfair allocations to companies in different countries in the case of the EU ETS. Another problem is that there would be a risk that these protective policies would be self-reinforcing in the sense that industries, once protected, will continue to claim the right to protection even when the carbon-abating efforts of other countries increase. The coal subsidies in Germany are a case in point, where subsidies amount to €82,000 per job in 2001 (see press release from the Federal Environmental Agency in Germany; FEA, 2003). Yet another problem is that there is a risk that one introduces policies to protect industries which really do not need protection. This would be the case for energy-intensive industries which plan to remain in the country but manage to get subsidies by threatening that they would relocate unless some form of compensation is given. Another example could be firms that would move abroad regardless of the climate policy, but stay only to get subsidies (e.g. aluminium industries in search of low cost electricity options – which may be found in regions with large hydro resources compared to the electricity consumption).

A difference between these policies is that some lead to the protection of the continued operation (e.g. direct subsidies that match the extra cost faced by the industries), whereas others aim at protecting the interests of the capital owners (e.g. grandfathered permits that could be sold and generate revenues to the capital owners even if the plant were to be taken out of operation).

Below, we will discuss some of these protective policies in more detail.

*Cap and trade with grandfathering of emissions allowances*

Grandfathering permits, i.e. the free allocation of permits based on historical emissions, rather than auctioning (or the use of taxes), has several drawbacks or features worth paying attention to. First, grandfathering is expected to increase the cost of meeting any given target substantially (see IPCC, 2001a). The reason for that is that the loss of government revenues that a tax or auctioned permits would have generated could have been used to offset distortive taxes.

A second important feature is that grandfathering based on historic emissions fails to offer protection to *electricity*-intensive industries (e.g. aluminium smelting; see, e.g., Reinaud, 2004; Carbon Trust, 2004). This has already caused concern amongst electricity-intensive industries in Europe.[12] For that reason, complementary measures may nevertheless be needed, for instance direct subsidies to electricity-intensive industries that cannot pass on increases in production costs to consumers. Spain and Ireland have introduced legislation that prevents electric utilities from raising the price of electricity (Reinaud, 2004).

A third potential problem is that if grandfathering of emission permits becomes the norm in environmental policy, the incentive to be proactive and reduce emissions in advance of environmental policy breaks down.

Fourth, energy-intensive industries often argue in favour of grandfathering so as to ensure continued operation in the face of ‘unfair’ competition from regions without (similar) climate policies. However, whether grandfathering offers such protection or not depends on how allocation decisions are made in subsequent commitment periods, and whether firms are behaving as profit maximizers or not. Permits allocated based on past emissions can be seen as a one-time donation to the capital owners. Whether the firm would continue to operate or not would then depend on the relation between the expected profits from selling the permits and the expected profits of continued operations. The time span over which the permits are allocated are here an important factor that determines the relative profitability of closing versus continued operation. Regardless of whether the plant closes down or not, such a policy would offer effective incentives to reduce the emissions, at least as long as the updating of the allowances for subsequent periods does not depend on the emissions in the preceding period.

If emission allowances are continually updated based on the emissions in the preceding period, then there would be incentives to increase emissions so as to get more permits. If the commitment periods are short, it is rather unlikely that it would be profitable to close down the firm, and under these conditions the policy would look more like a subsidy. This would protect the firm from closing down but in its extreme version would imply that there would be no climate policy at all. It may be noted that the decision on how to update allowances for the next period in the EU ETS is yet to be taken, so this is not simply an academic observation.

Finally, grandfathering to industries that may pass on most of the opportunity cost of the permits to consumers may see their profits increase as a result of climate policies. The value of the permits allocated to coal-fired power plants may actually be of the same order of magnitude as the value of the entire plant.[13] The fact that a carbon policy might lead to increased profits for a carbon-intensive industry might be difficult to digest, at least in the perspective of the 'polluter pays' principle.

One possible compromise would be to employ selective and partial grandfathering: selective in the sense that auctioning would be the norm but with grandfathering for the energy-intensive sectors, and partial in the sense that the companies would at most be grandfathered to the extent that profit levels do not increase (see Kågeson, 2000). Goulder (2005) reports that only a small share of the allowances need to be grandfathered in order to maintain profit levels in the US economy; the exact level depends on how much of the price increase may be passed on to the consumers. He concludes that 'major stakeholders can be compensated without significantly increasing the overall policy costs'.

*Border tax adjustments*

An interesting, but also complicated and for some contentious, approach might be to introduce import taxes (and possibly export subsidies) on carbon-intensive products, to (and from) countries in which there is no carbon abatement policy. The import tax would have the benefit that it would be close to equivalent (for European consumers) to a tax on production in other countries intended for European markets, and the export subsidy should be set so as to level the playing field in regions outside Europe (and all the other regions that have taken on climate policies).

The introduction of such border tax adjustment would almost certainly lead to problems with WTO rules (National Board of Trade, 2004), but pursuing this approach would, in addition to its immediate climate benefits, have the benefit of sending a message to other countries, as well as people not directly involved, interested or engaged in climate affairs, that the EU takes the threat of climate change seriously. Clearly, any country that would take on commitments with similar carbon prices as those that prevail in the EU would automatically be exempted from border tax adjustments, and the EU may argue that any country that has a problem with these tariffs can simply join the climate treaty (see also Hoel, 1996).

One problem with this approach is that it is very difficult, if not impossible, to calculate the correct level of the tariff on all products – just imagine keeping track of the embodied carbon emissions in each product entering the EU. For that reason, the only reasonable approach would be to include only a few products, e.g. steel, aluminium, some other metals, and fertilizers etc. The tax could be set based on some form of benchmarking, for example the best available technology, so as to make sure not to discriminate against any foreign producer who is very efficient. But even this approach would not be free from problems. In the case of aluminium, the emissions associated with its production would depend very much on whether coal or hydro is the marginal electricity source, and that choice (or property of the electricity system) has nothing to do with the best available technology to produce aluminium. Thus, it will not be possible to completely avoid the problem of site-specific emission factors. There is also a borderline problem: if energy-intensive materials (e.g. steel) are faced with an import tax, then what about manufactured goods (e.g. car bodies, cars etc.).

*Differentiated efforts – including the European transport sector in the EU ETS*

The EU ETS scheme only includes emissions from large point sources. Calls have been made to include also other sectors, e.g. the transportation sector and residential sectors. This could be done by requiring that importers and refineries need to hold permits for emissions that will be generated by users of gasoline and fuel oil. But such a decision would have implications, as we will see, for the competitiveness of energy-intensive industries.

There are basically two arguments in favour of inclusion. First, it would improve cost-efficiency of European climate policies (equalize carbon prices across a wider range of emission sources). Secondly, since the current EU ETS only covers some 40% of the overall $CO_2$ emissions in the EU, it has proven difficult to relate the target for the trading sector to the overall Kyoto target for the EU. By claiming that emissions will be reduced substantially in the non-trading sectors, it has been possible for several countries to allow for generous, perhaps too generous, allocations in the trading sectors.

The key argument against including other sectors is that a sufficiently strong target to comply with the Kyoto targets would imply that one of these sectors, the transportation sector, which probably has the largest willingness and capacity to pay for permits, would drive the price of the allowances to levels that would be difficult to deal with for the energy-intensive industries. It is in this context worth observing that the Swedish carbon tax on households and transportation is currently around US\$100/t$CO_2$, whereas the permit price in the EU ETS is, in February 2005, around €10/t$CO_2$. ('The transportation sector would buy all the permits', exclaimed a frustrated representative for an energy-intensive industry to me recently) Such prospects could make it politically very difficult to introduce a sufficiently stringent cap in the trading sector because of lobbying from energy-intensive industries. In addition, including the transportation sector under the cap means that other measures to reduce the emissions in this sector will not lead to lower emissions, because the overall cap is already set.[14] Thus, there is a risk that the overall abatement will become less stringent if these sectors are also covered in the EU ETS.

## 5. Summary and conclusions

In this article, targets for the global average annual surface temperature, atmospheric concentration of $CO_2$ and emission of $CO_2$ have been reviewed and proposed. It is concluded that the EU needs to reduce emissions by 20–40% by the year 2020 compared with the year 2000 if we want to stabilize atmospheric concentration of $CO_2$ in the range 350–450 ppm $CO_2$ and pursue an approach based on contraction and convergence by the year 2050. For many developing countries, per-capita emissions are already above the per-capita targets by the year 2050, in particular for targets lower than 450 ppm. For developing countries with low emissions per capita, there is still room for substantial increases in emissions.

The article then assessed the cost of stabilizing the atmosphere at these levels. It is found that models that are generally perceived as being pessimistic find that the costs are compatible with continued impressive growth in global GDP. The reduction in growth rates, averaged over the entire century, is less than 0.05% per year. A key conclusion is that overall costs to meet stringent climate targets do not seem to be large enough to explain the strong resistance to the introduction of climate policies. Instead, it is the fact that the reductions will create winners and losers that probably causes the most severe opposition. This problem is aggravated by the fact that all countries of the world do not move ahead with climate policies at the same speed, and they are not likely to do so in the near future either.

It is concluded, however, that energy-intensive industries are not likely to lose competitiveness to any large extent under the current first phase of the EU ETS. For stricter emission reduction targets, such as those envisaged above, many energy-intensive companies would most probably lose competitiveness under the assumption that there would be no climate policies in major producer countries. If the rest of the world follows the EU in its climate ambitions, which of course is necessary for the EU climate policies to be meaningful, there would not be any need to introduce protective policies. Under such conditions would it be economically more efficient if the full cost of carbon were to be reflected also in the price of energy-intensive goods, since that would lead to substitution away from these materials.[15]

But as long as there are large differences in the climate ambitions across countries, there will be discussions about unfair competition and carbon leakage. Two contrasting positions may be taken regarding the question of whether protective policies are attractive or not. One view would be to suggest that the EU moves ahead with uniform carbon prices in all sectors of the region of concern, aiming primarily at meeting the domestic carbon target at the lowest possible cost, and hoping that such leadership inspires followers in the rest of the world and creates incentives for the development of more advanced technologies that can be exported.

The second view would be to argue in favour of the introduction of some form of protective policy so as to protect jobs or capital owners, or both. This article has reviewed some policies that aim at achieving these goals. Buying acceptance for climate policies might be important and necessary, but the policies used to protect the industries may be costly and they may also be difficult to get rid of (just witness the history of the common agricultural policy, introduced after World War II to ensure food production in Europe, but still in place). It is beyond the scope of this article to propose any solution to this trade-off, but it seems clear that more research is needed to develop policies that combine the conflicting objectives of being cost-efficient and politically feasible.

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## Notes

1 Clearly, there is uncertainty about the long-run contribution from these gases but our assumption can be compared to the median value for the total value of the contribution from all non-$CO_2$ gases (including aerosols) in the SRES scenarios, which as estimated by Wigley (2004) is 1.5 W/m$^2$ (the 90% confidence interval is ±1 W/m$^2$). The SRES scenarios are base-case scenarios without any policy-driven reductions in the emissions of greenhouse gases (in order to mitigate climate change). With mitigation it is reasonable to assume that it is possible to get down to 1 W/m$^2$.

2 The study by Stainforth et al. (2005) reports a range of 2–11°C per $CO_2$-equivalent doubling, but there are rather compelling reasons to be cautious when interpreting the higher range. For instance, evidence related to changes in greenhouse gases during the last glacial era and the estimated temperature change suggests that it is unlikely that the climate sensitivity can be so high.

3 A region's share, $x_i(t)$, of the allowable global emissions is given by $x_i(t) = (1–t/50) \cdot E_i(2000)/E_{tot}(2000)+t/50 \cdot P_i(2050)/P_{tot}(2050)$, where $t$ is years after the year 2000, $E$ and $P$ are emissions and population in region $i$ or in total.

4 Emissions of fossil carbon per capita in India, Indonesia and sub-Saharan Africa are 0.3, 0.3 and 0.1 tC/cap/year, respectively. Emissions of greenhouse gases including fossil carbon, methane and nitrous oxide calculated using 100 GWPs, are estimated at 0.5, 0.7 and 0.5 tC/cap/year, respectively; see Höhne (2005) based on UNFCCC.

5 Such differences are built into the Kyoto framework – the rich countries will have to take the lead – but similar problems can be expected for decades ahead since different countries view climate change differently and the alternative – to wait until everybody agrees that something should be done – would probably imply a rather long period of waiting. One approach could be to include all countries in a cap-and-trade system and distribute permits generously to those who resist so that they may end up being winners of the climate policy. This is roughly what happened with Russia in the Kyoto negotiations but it has so far – for both good and bad reasons – not received sufficient support to bring other countries on board in this manner.

6 The mirror image of this argument goes under the name the 'Dutch disease'; i.e. the fact that countries which experience an export boom in one sector (e.g. as a result of a discovery of petroleum) will see more resources drawn to that sector. The increase in export leads to an upward pressure on the exchange rate and to higher salaries in this sector, which leads to loss of competitiveness in other sectors.

7 Most of the carbon in the crude oil remains in the product, but there are some emissions in the refineries that, if taxed, would increase production costs and might lead to relocation of the refinery. It is in this context also worth observing a related problem: if ethanol, methanol, DME or FT diesel from biomass were to become competitive in Europe because of its carbon policies or the biofuels directive, it would be important to make sure that other regions did not produce the same fuels from fossil fuels (since that would be considerably cheaper, in particular for methanol and DME) and sell it as if it were fossil-carbon-free. Although the chemical composition of the fuels is the same regardless of the energy source, the isotopic content is different.

8 This is the case for large markets or islands (e.g. Australia, the EU, North America, and Iceland). But competition could also occur if, say, Turkey and Ukraine were to start selling large amounts of electricity to the EU as a result of climate policies in the EU, then countervailing measures would also have to be considered.

9 Bergman (1996) is an exception who finds that differentiated taxes will lead to lower costs to meet a domestic carbon target. He even concludes that 'differentiated taxes seem to be an almost perfect substitute to internationally coordinated taxes'.

10 They are also incapable of capturing non-equilibrium effects on energy markets, e.g. opportunities to increase energy efficiency and thus reduce carbon emissions at no costs (see, e.g., Ayres, 1994).

11 Furthermore, costs are almost exclusively measured in monetary terms, but the social costs of high unemployment rates in certain regions may also need specific attention.

12 Recently, they urged EU governments to block windfall profits from the EU Emissions Trading Scheme (see http://www.pointcarbon.com/article.php?articleID=4212&categoryID=279, Aug 8, 2004).

13 A coal-fired power plant is estimated to emit 225 gC/kWh (40% efficiency). At US$100/t$CO_2$, this amounts to 0.8 cents/kWh. At a capacity factor of 75% the power plant would produce 6,570 kWh/year per installed kW. Thus, if the price increase can be passed on to consumers and the plant owner gets permits that correspond to its emissions, then the additional revenue is US$53/kW of capacity/year. Assuming that the permit price increases with the discount rate, then 25 years of permits would be equal to US$1,330/kW of installed capacity; more than the cost of building a coal-fired power plant!

14 This view is only partly valid. Policies to improve energy efficiency in cars or buildings, for instance, would not lead to lower emissions in a trading scheme in the current phase – that is certainly true – but it would lower the permit price, which in turn would make it possible for policy makers to adopt more stringent targets in subsequent periods.

15 This would not only lower the cost of meeting the climate target, but also bring about other environmental benefits associated with the reduction of mining and metals refining (see, e.g., Kåberger et al., 1994).

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