Chapter 7

Towards a global deal on climate change

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Greenhouse gas (GHG) emissions represent the biggest market failure the world has ever seen. GHGs cause damage and without specific policies nobody pays for this damage. We all contribute to producing them; and many people around the world are already suffering from the effects of past emissions. Moreover, current emissions have the potential to cause catastrophic damage in the future. Due to the global nature of the link between emissions and damage, we need a global response to this problem. Failure to analyse the problem in terms of the great risks, and the long-term and global co-operation required, will produce (and has produced) approaches to policy that are misleading and dangerous. The arguments for strong and timely action are overwhelming. The costs of inaction, which means continuing with current paths and practices, or 'business as usual' (BAU), should be measured in terms of the possible outcomes and damages compared to a global strategy that sets sensible targets.

The world must create and implement a global deal that is effective, efficient, and equitable.[1] The world must create this deal quickly – indeed, the meeting of the United Nations Framework Convention on Climate Change in Copenhagen in December 2009 should be our deadline. Importantly, this deal must be implemented with real commitment by all countries of the world.

We do not wish to pretend that reaching agreement will be easy; on the contrary, the road to Copenhagen and beyond will be very tough and full of obstacles, principally in the form of resentment, particularly towards rich countries for their historical responsibility for high-carbon growth, and narrow perspectives of self-interest. Central amongst these obstacles will be an argument that a first priority should be to deal with the current economic crisis and that action on climate change can be postponed. Often this argument comes from those who are, in any case, not keen on taking action and who use the economic crisis as an excuse. This argument is erroneous and must be confronted (see Rockström *et al.,* this volume). There is no doubt that the economic crisis is extremely serious, and requires strong, co-ordinated action, both nationally and internationally. The error lies in seeing responses to the economic crisis and to climate change as being in conflict. They are not: the economic crisis becomes an obstacle to urgent action on climate change only if we allow it to do so by failing to put the arguments clearly.

There are two important lessons from the economic crisis that are relevant for action on climate change. First, by ignoring the dangers and delaying action we risk greatly magnifying the ensuing damages. Second, our reaction to the current crisis should not sow the seeds of the next economic bubble, as was the case after the dot-com bubble of the 1990s, when economic policies helped to create the housing bubble of the 2000s, which was a prime cause of the economic crisis of

[1] A more extensive discussion of a global deal is provided in the book *A Blueprint for a Safer Planet* (Stern, 2009)

2008–9. Investments to manage climate change are less costly during a slow-down. Furthermore, the foundations for growth in the next two or three decades (i.e. investments in low-carbon technologies) can be created now.

In order to construct and implement a deal on climate change the peoples of the world and their leaders require a clear understanding; not only of the huge risks we face, and thus why such a deal is necessary, but also of the whole range of technologies and policies that are available to us to make effective action possible. The purpose of this book and this essay is to contribute to this understanding.

The price of failure will be a world that is subject to devastating physical change, mass movement of people, and conflict. The prize of success will be sustainable growth, a significant reduction in world poverty, and a cleaner, safer, quieter, more diverse, and more prosperous future for all.

Risks, targets and costs

Targets

The relation between the stock of GHGs in the atmosphere and the resulting temperature increase is at the heart of any risk analysis. It is the clearest way to begin and anchors most of the discussion. There are many models that estimate these links: running a model many times for different parameter choices yields probability distributions of outcomes – in other words, it allows us to take into account the uncertainties in the link between emissions and temperature changes (see Table 1).

Current concentrations of GHGs are around 430 parts per million (ppm) of carbon dioxide equivalent (CO_2-eq – which aggregates carbon dioxide and other GHGs). We are currently adding about 2.5 ppm CO_2-eq per annum. The rate of emissions growth appears to be accelerating, as a result of continued rapid growth in the developing world. There seems little doubt that, in the absence of any restraining policy, the annual increase in the overall quantity of GHGs will average somewhere above 3 ppm CO_2-eq – potentially 4 ppm CO_2-eq or more – over the next 100 years. That is likely to take us beyond 750 ppm CO_2-eq by the end of this century.

This level of concentration would give us, if we were to stabilize there by 2100, a fifty-fifty chance of a temperature increase above 5 °C. We do not really know what the world would look like with a climate 5 °C warmer than in preindustrial times. The most recent warm period was around three million years ago when the world experienced temperatures 2 °C or 3 °C higher than today (Jansen *et al.,* 2007). Humans have not experienced anything that high (Hansen *et al.,* 2006). During the last *glacial maximum* (around 21 000 years ago) global temperatures were around 4–7 °C cooler than today (Solomon *et al.,* 2007), and ice sheets extended to latitudes

Table 1. *Probabilities of exceeding a temperature increase at equilibrium (%).* (*Source:* based on Stern, 2007, p. 220, using Hadley Centre modelling (Murphy *et al.,* 2004)).

Stabilization level (in ppm CO_2-eq)	2 °C	3 °C	4 °C	5 °C	6 °C	7 °C
450	78	18	3	1	0	0
500	96	44	11	3	1	0
550	99	69	24	7	2	1
600	100	94	58	24	9	4
750	100	99	82	47	22	9

just north of London and just south of New York.[2] As the ice melted and sea levels rose, and taking into account the changed topography, Britain separated from the European continent and there was major re-routing of much of the global river flow. Such magnitudes of temperature change can transform the planet.

The last time the Earth's temperature lay in the region of 5 °C above the preindustrial level was in the Eocene period around 35 – 55 million years ago.[3] Much of the world was covered by swampy forests and there were alligators near the North Pole. The point is not particularly about alligators, it is about the transformation of the world; these kinds of variations would bring very radical changes to where and how different types of species, including humans, could live. Many of the changes would take place over 100 or 200 years rather than thousands or millions of years. At a temperature increase of 5 °C most of the world's ice and snow would disappear, most likely including the Arctic and Antarctic ice sheets and the snows and glaciers of the Himalayas. According to the IPCC Fourth Assessment Report, the former effect would – taking the two ice sheets together – eventually lead to a sea-level rise of over 10 metres, and possibly much higher. The latter effect would thoroughly disrupt the flows of the major rivers from the Himalayas, which serve countries containing around half of the world's population. There would be severe torrents in the rainy season and dry rivers in the dry season. The world would probably lose more than half its species. The intensity of storms, floods and droughts is likely to be much higher than at present.

Whilst we cannot be precise about the magnitude of the effects associated with temperature increases of such size, it does seem reasonable to suppose that they would be, or are at least likely to be, disastrous. They would probably involve very

[2] http://math.ucr.edu/home/baez/temperature
[3] See footnote 2.

large movements of population from regions where human life would become extremely difficult or impossible. History tells us that large movements of population are likely to bring major conflict, and this movement would probably be on a huge scale.

If we fail to act there is a high probability that these devastating impacts and conflicts will become reality. As Table 1 shows, we can cut the probability of temperature change above 5 °C from 50 % to 3 % by stabilizing emissions at 500 ppm CO_2-eq. We cannot be very precise about these probabilities (the ones we have used here, from the Hadley Centre, are probably cautious)[4], however, the point is that the reduction in risk is huge.

By using extremely simple models one can try to quantify the avoided damages although our description of the risks should make it clear that it is very hard to attach convincing figures to the potential losses. Even from a very narrow perspective, world wars seem to involve losses of 15 % or more of GDP and the conflicts we are discussing are likely to be on a greater scale, lasting longer and, of course, affecting much more than GDP. The Stern Review (Stern, 2007), which looks at damages up to the year 2200 and extrapolated thereafter, concluded that such costs can be estimated as being equivalent to a 5 – 20 % loss of global GDP averaged over space, time and possible outcomes. Such models can provide useful insights but we warn strongly against taking them too literally.

Recent developments on the risk and potential damages of climate change

There are a number of factors that climate change scientists and economists have raised recently which point to a worsening of the prospects on climate risk. First, recent data – particularly from developing countries – indicates that emissions are growing more quickly than we thought. For example, a recent study by Max Auffhammer, University of California Berkeley, and Richard Carson, University of California San Diego, indicates that carbon dioxide emissions in China over the period 2004 – 10 will have grown at 11% per annum (Auffhammer and Carson, 2008). BAU assumptions used by the IPCC (Solomon *et al.,* 2007) projected a growth of only 2.5 – 5 % per annum. At this pace, by 2010 China will have increased its carbon emissions from 2000 by around 1.5 – 3 billion metric tons of carbon dioxide. To put it another way, the projected annual increase in China over the next several years alone is greater than the current emissions produced by Germany. If

[4] Work by the Hadley Centre and the IPCC (Murphy *et al.,* 2004 and Wigley and Raper, 2001) suggests that 550 ppm CO_2-eq is associated with a 24 % probability of exceeding 4 °C, a level at which it is projected that significant and irreversible changes would occur. Stabilization below 500 ppm CO_2-eq would be significantly less risky (11% probability of exceeding 4 °C). For details see Stern (2007), p. 220.

indeed emissions are growing more quickly than we thought, then the dangerous concentration levels associated with higher probabilities of disastrous temperature increases will be reached much more quickly.

Second, the key feedbacks of the carbon cycle, such as the reduction in the absorptive capacity of the oceans (and thus the reduced effectiveness of a key carbon sink) and the release of methane from the permafrost have not been taken into consideration in the projected concentration increases quoted here. If these factors are considered it is likely that stabilizing GHG concentrations at stocks associated with lower probabilities of disastrous temperature increases could be even more difficult.

Third, it is increasingly clear that we know little about what would happen to the planet if we were to see very high concentrations of GHGs. However, given the nature of feedback mechanisms scientists agree that the damages associated with very high GHG concentrations could be enormous. Most of the current research on damages makes conservative assumptions about the implications of high levels of concentrations. As the Harvard economist Martin Weitzman, (Weitzman, 2008; Weitzman, 2007a; Weitzman, 2007b), among others, has convincingly shown in his research, considering the risk of very high GHG concentrations escalates the estimations of climate change impact – and its potential cost to the economy.

The balance of the evidence implies that the level of risk suggested by the IPCC Fourth Assessment Report (Solomon *et al.,* 2007) and the Review (Stern, 2007) may be underestimated. Therefore, the opinion expressed by some commentators – that the Stern Review was alarmist – is simply wrong.

Costs of abatement

Up to this point our discussion of targets has focused on those for the stabilization of stocks of GHGs in the atmosphere. We must now ask about the implications for emissions pathways and how much, with good policy, GHG abatement would cost. A broad answer was given in the Stern Review (Stern, 2007) – around 1–2% of world GDP per annum to get below 550 ppm CO_2-eq – but we must look at the argument in a little more detail.

Figure 1 illustrates possible paths for stabilization at 550 ppm CO_2-eq (long-dashed line), 500 ppm CO_2-eq (dotted line), and 450 ppm CO_2-eq (dot-dashed line); the solid line represents BAU. There are many paths for stabilization at a given level – see, for example, Stern Review, Fig. 8.2 (Stern, 2007, p. 226) – but all of them form a similar pattern to those shown (if a path peaks later it must fall faster). And if the carbon cycle weakens, the cuts would have to be larger to achieve stabilization at a given level – see Stern Review Fig. 8.1 (Stern, 2007, p. 222). Broadly speaking, however, a path stabilizing at 550 ppm CO_2-eq or below will have to

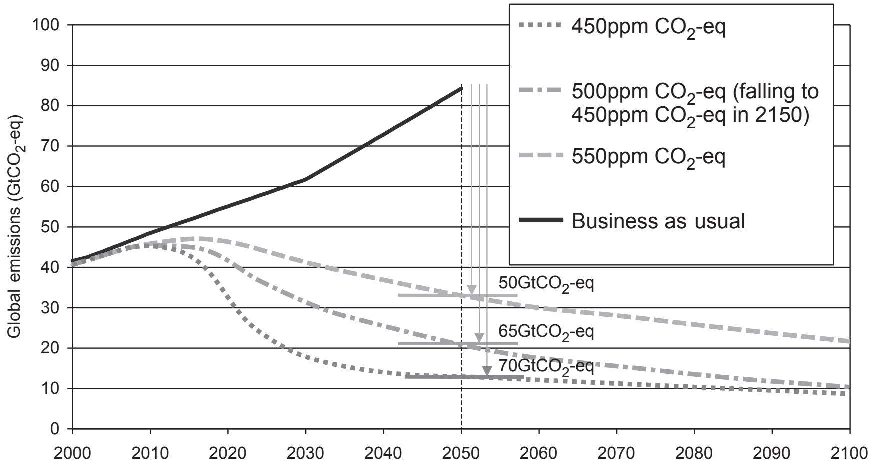

Fig. 1. Business as usual (BAU) and stabilization trajectories for 450–550 ppm CO_2-eq. (*Source:* Stern, 2007, p. 233)

show emissions peaking in the next 20 years. For lower stabilization levels, the peak will have to occur sooner. The magnitudes of the implied emission reductions between 2000 and 2050 are around 30% for 550 ppm CO_2-eq, 50% for 500 ppm CO_2-eq, and 70% for 450 ppm CO_2-eq. Cuts relative to BAU are indicated in the figure. The stabilization pathway includes different options for cutting emissions that would be more or less prominent at different times. In the earlier periods there would be greater scope for energy efficiency and halting deforestation. With technical progress different technologies in the power and transport sector would play an increasingly strong role.

Both the bottom-up and the top-down studies in the Stern Review (Stern, 2007) produced figures in similar ranges – around 1% of world GDP per annum for stabilization below 550 ppm CO_2-eq. We would now argue, given the growing evidence on the magnitude of the risks, that holding concentrations below 500 ppm CO_2-eq and then attempting to reduce from there to below 450 ppm CO_2-eq would be an appropriate target to limit temperature increases to not more than 2 °C which many climate scientists believe is the threshold beyond which serious impacts would occur. The costs involved might be of the order of 1–2% of world GDP per annum.

The calculated order of magnitude may be understood as follows. The reductions required to keep concentrations below 500 ppm CO_2-eq in 2050 may be around 65 gigatonnes CO_2-eq compared to business-as-usual emissions (see Fig. 1). An average cost of USD 30 per tonne would produce an overall cost of around USD 2 trillion. If global GDP doubled by then, to USD 100 trillion, the overall cost would equate to around 2% of global GDP.

As we learn more about new technologies, methods and economic policies these costs may fall sharply and so the above projections may apply only over a few decades. They also ignore the many co-benefits of action, including less pollution, greater energy security, and increased biodiversity. There is, of course, considerable uncertainty over cost estimates. Bad policy or delayed decisions could produce higher figures. Greater technological progress could also result in lower figures. Assumptions about substitutability between different goods and options also matter.

Since the Stern Review (Stern, 2007) was published there have been a number of new studies, both bottom-up and top-down. Significant examples of the former include those from McKinsey (Enkvist *et al.,* 2007) and the IEA (2007), both of which indicated costs for given targets either in the range we suggested in the Stern Review, or somewhat lower. Similar conclusions were drawn in the IPCC Fourth Assessment Report (Metz *et al.,* 2007).

In summary, looking back at the Review, we would suggest that subsequent evidence and analysis have confirmed, or at least indicated, that the range of our cost estimates for stabilization of GHG concentrations may be on the high side. Good policy and timely decision-making are, however, crucial to keeping costs down. Merely adopting a 'wait and see' approach, or a 'climate policy ramp', risks not only excessive and dangerous levels of GHG stocks but also much more costly abatement if, as is likely, we later realize that the response was delayed and inadequate.

A structure for a global deal

The balance of scientific evidence clearly demands that all countries plan credible emissions reduction policies now. If mankind is to avoid substantial damages to future generations, large-scale and urgent international action is required. Market mechanisms should be central in this, with both economic instruments and discretionary policy being used to provide incentives for behavioural change. The UN Conference of the Parties in Copenhagen in late 2009 will be decisive in determining the post-2012 policy frameworks, and designing an effective institutional architecture. It is important that the text of any deal agreed in Copenhagen is guided by clear principles based on rigorous analytic foundations and a common understanding of the key challenges.

The challenges are far-reaching, comprehensive, and global; but they are also manageable. The activities and technologies necessary to eliminate the bulk of the risks associated with climate change are already available, or can be developed through appropriate policies to support innovation. Policies must be designed and applied carefully. Badly implemented policies can create additional market distortions, introduce perverse incentives, and foster protectionism. Care must be taken to ensure that additional policies are not simply layered on top of existing bad policies, such as distortionary energy market subsidies, trade restrictions, or inadequate agricultural policies. Where possible, policies must encourage market-based solutions, minimize transactions costs, and stimulate reform of existing distortion mechanisms. For markets and entrepreneurship to work, the policy framework must be credible, durable, and predictable, while allowing the necessary flexibility.

The following is an attempt to describe the outline of a possible global deal (under six broad headings), based on the preceding analysis and on personal involvement in public discussion over the last two years. This work is described in full in a paper entitled *Key Elements of a Global Deal* (Stern, 2008), which was published in March 2008 at the London School of Economics. The purpose of this paper was to put forward a coherent set of proposals on global policy that satisfy three basic principles:

- Effectiveness – it must lead to cuts in GHG emissions on the scale required to keep the risks from climate change at acceptable levels.
- Efficiency – it must be implemented in the most cost-effective way, with mitigation being undertaken where it is cheapest.
- Equity – it must take account of the fact that it is poor countries that are often hit earliest and hardest, while rich countries have a particular responsibility for past emissions.

Different technologies and different policy instruments can be applied to different sectors and countries. Indeed, the more differentiated the global strategy, the greater the scope for learning, so it is important not to be unduly prescriptive on the details of policy action. However, it is also important that the various initiatives address the overall objective. A global treaty needs to be agreed by 2009 and translated into national policy and action plans by 2012, when the current Kyoto agreement ends.

Emissions targets

Total anthropogenic greenhouse gas emissions in 1990 are estimated to have been 41 gigatonnes compared to approximately 45 gigatonnes in 2005, with significant shifts in the international distribution of these emissions over that period (CAIT, 2008). The scale of the emissions reductions required, and the welcome rapid economic growth in populous parts of the developing world, means it is necessary for developing countries to play an active role if the deep cuts in emissions, suggested at the G8 conference in Heiligendamm, Germany in June 2007 and confirmed at Hokkaido, Japan in June 2008 and L’Aquila, Italy in 2009, are to be implemented (G8, 2007; G8, 2008; G8, 2009). By 2050, eight billion out of a world population of around nine billion will live in what is currently termed the developing world (United Nations Secretariat, 2006). It is not in these countries' national interests to wait and allow developed countries to take the lead. Countries with strong emissions growth such as China and India will need to plan to limit and reduce emissions within the next ten to twenty years. For this they will require global co-operation, and they are unlikely to be able or willing to achieve these ambitious reductions without substantial technological and financial support and opportunities to develop, and ultimately export, low-carbon technologies.

Effective action must produce the following outcomes:

- World targets for global annual emissions of no more than around 30 gigatonnes CO_2-eq by 2030 and around 16 gigatonnes CO_2-eq by 2050 from the present level of 47 gigatonnes CO_2-eq. These reductions are required to have a reasonable chance of containing temperature increases to no more than 2 °C and to limit the grave risks associated with severe climate change.
- Average per-capita global emissions will – as a matter of basic arithmetic – need to be around 2 tonnes CO_2-eq by 2050 (20 gigatonnes divided by 9 billion people).
- The developed world must lead in committing to strong mid- and long-term targets.
- By 2020, developed countries need to demonstrate that they can deliver credible reductions, without threatening growth, and that they can design mechanisms and institutions to transfer funds and technologies to developing countries.
- Subject to the above, a formal declaration is needed stating that developing countries will also be expected to take on binding national targets of their own by 2020, but benefit from one-sided selling of emissions credits in the interim.
- Fast-growing middle-income developing countries will need to take immediate action in order to stabilize and reverse emissions growth, adopting sectoral targets immediately and possibly even national targets before 2020.
- Irrespective of targets, all countries need to commit to developing the institutions, data and monitoring capabilities and policies to avoid high-GHG infrastructural lock-in.

Only sound, measured and co-ordinated policy, and timely international collaboration can deliver strong and clean growth for all at reasonable cost. It is important to weigh up the competitiveness risks and opportunities for firms, countries, and sectors, especially where some countries or sectors apply climate policies earlier and more ambitiously than others do.

There will be losers, and the impacts of transition will need to be managed. However, transition to a GHG-constrained world will create opportunities for companies and sectors that anticipate new markets. Moreover, the evidence to date suggests that few firms are likely to relocate activities to less restrictive jurisdictions. Overstating the problems relative to the opportunities carries the risk of encouraging involved parties to wait for others to act before taking action themselves. By contrast, the expectation of a credible global agreement would heighten the incentives for companies and governments to act quickly and effectively.

The role of developing countries

Emission reductions on the required scale cannot be achieved without contributions from all countries, both rich and poor. Already, developing countries account for about 50 % of energy-related carbon emissions, and their share is expected to rise to 70 % by 2030 in the absence of appropriate policies (IEA, 2006).

The arithmetic of global climate change abatement is such that, under the Kyoto successor treaty, the role of developing countries will have to be scaled up substantially. China, for example, currently emits about 6 tonnes CO_2-eq per person, and India is approaching 2 tonnes CO_2-eq. As a matter of pure arithmetic, climate stabilization will require all countries to reduce and stabilize their emissions at around 2 tonnes CO_2-eq by 2050. This target for per-capita emissions by mid-century is so low that there is little scope for any major group to go significantly above or below it. If one or two large countries were to merely reduce emissions to, say, three or four tonnes per capita, it is unlikely that other major countries or groups of countries would be able to offset this by reducing emissions close to zero; as a result the global target would most likely be missed. Indeed, all emissions trajectories should be designed with the target of two tonnes in mind. This is a pragmatic approach and not a strongly equitable one. It takes little account of the greater per-capita contributions of the developed countries to historical and future GHG emissions.

Achieving growth and fighting poverty are key objectives for all countries, but particularly for the developing countries. The world community must recognize that the poorer countries will see emissions grow for some time. But it is not slower growth that will allow developing countries to achieve this fall in emissions. It will be low-carbon growth using technologies demonstrated and shared by the rich countries augmented by developing countries' own technological advances and drives for energy efficiency.

In principle, the best way of achieving this would be to assign emissions targets to most countries, including major 'emerging emitters' such as Brazil, China, India, and Indonesia. However, it may not be feasible politically for these countries to make firm commitments at Copenhagen in December 2009. Developing countries may not be ready to adopt such targets until there is substantial evidence through actions in the developed countries that:

1. Low-carbon economic growth is possible;
2. Financial flows to countries with cheap opportunities to abate GHGs can be substantial; and
3. Low-carbon technologies will be available and shared, allowing developing countries to innovate, develop, and ultimately export their own low-GHG technologies.

If developed countries meet these conditions, developing countries might be willing to discuss binding caps from 2020. These caps cannot be decided upon now, but would be subject to the experience and performance of all countries over the next decade, and would both differ according to local circumstances and reflect countries' 'common but differentiated responsibilities', including historical contributions to emissions. A global deal could embody the presumption that once countries meet certain baseline criteria – for example in terms of GDP per capita or other metrics of economic development – they would be expected to adopt emission caps.

In any case, developing countries should start planning on this basis now, setting out credible action plans to achieve ambitious stabilization targets in the long term. Development plans have to place climate change – both mitigation and adaptation – at their core. Deforestation, in particular, must be a key element.

International emission trading

Putting a price on greenhouse gas emissions should be a central pillar of mitigation policy (see Edenhofer *et al.* and Mirrlees, this volume). It is crucial in making polluters pay for the damages they cause in order to change behaviour on the massive, widespread, and cross-cutting scale necessary to tackle climate change. If there was a clear price to pay for every tonne of carbon dioxide emitted, then consumers and producers across the economy would think hard about whether there were less carbon-intensive products they could buy, or produce. In order to provide the most effective marginal incentive, the price needs to be credible, long-term, and applied across the whole economy.

International cap-and-trade means, first and foremost, that an upper limit is placed on emissions of GHGs. Imposing a fixed quantity target on the world reduces the risk of dangerous climate change impacts and tipping points. A fixed quantity target is therefore a direct link between the science and the policy instrument, thus ensuring that policy is effective. Trading in turn allows the required reductions in emissions to be achieved as cost-effectively as possible.

Currently there are several regional and national emissions trading schemes in existence. The EU emissions trading scheme (ETS) achieved sales of around

USD 50 billion in 2007 (Phase I and II), while sales under the UNFCCC's clean development mechanism (CDM) were approximately USD 13 billion (up from USD 24 billion for the EU ETS and USD 6 billion for the CDM in 2006). It is a major challenge to link, improve and expand these schemes, designing the right institutional frameworks, laws, accrediting and monitoring systems. But the world possesses the resources and the experience of successful cap-and-trade schemes to do it, and the potential rewards are huge.

The vision of the international emissions trading regime outlined in this essay is of a full cap-and-trade scheme covering all gases, sectors and including more advanced developing countries by 2020. In the transition to this goal, most of the effort (and demand for credits) will come from developed countries, while developing countries will receive finance for low-carbon development through selling credits. Prices high enough to generate a strong response will depend on ambitious and binding national targets. This underpins the 'demand side' and will also ensure strong action domestically. Efficiency requires that the supply side works smoothly and effectively.

Supporting emissions reductions from deforestation

Addressing forestry as part of a global climate change deal – and in particular deforestation and forest degradation in tropical rainforest countries – is essential if overall targets for stabilizing carbon emissions are to be met. A total of 13 million hectares of forests are destroyed every year (FAO, 2005) – an area half the size of the United Kingdom, or one third of the size of Japan. According to the International Panel on Climate Change, 'forestry' currently contributes 17.4 % of global annual GHG emissions, the overwhelming majority of which comes from burning or decomposition of tropical forests. These emissions include around 5.9 gigatonnes of carbon dioxide, approximately equivalent to the total annual carbon dioxide emissions from the USA (Solomon *et al.,* 2007; IEA, 2007).[5]

Forestry measures, in particular to reduce deforestation, have the potential to make a substantial and relatively immediate contribution to a low-cost global mitigation portfolio that combines synergies with adaptation and sustainable development. Standing forests also perform other significant environmental services, such as the regulation of water supplies and the conservation of biodiversity.

There are many causes of tropical deforestation. It will not be possible to reduce emissions effectively unless these drivers are addressed. Poor local communities are often blamed, but more often it is government incentives and the demand for

[5] World Energy Outlook 2007 estimate for US CO_2 emissions in 2005, not including land-use change, is 5.8 Gt CO_2.

internationally traded commodities such as timber, palm oil, and soy that drive deforestation. The issue of biofuels is just one example of a policy, pursued by developed and developing nations alike, that may (indirectly) play a role in incentivizing deforestation by increasing the demand for agricultural commodities and at the same time the profits to be made from converting forests to agricultural use (see Creutzig and Kammen, this volume).

Reducing deforestation will involve reversing this equation to make standing forests worth conserving. Consequently, any financing framework that successfully addresses the mitigation costs of reduced deforestation needs to be on a scale sufficient to cover these opportunity costs, as well as any transaction costs (including administration, implementation, and enforcement) and insurance.

Global estimates for the opportunity costs involved in halving deforestation have ranged from USD 3 billion[6] to USD 33 billion annually (Obersteiner, 2006), with a number of estimates in between. There is likely to be a large amount of deforestation that can be avoided at modest cost although marginal costs may rise substantially with amounts avoided. Much depends on assumptions concerning 'leakage', and leakage in turn depends on the scale and effectiveness of action.[7] Furthermore, the administration costs associated with achieving reduced deforestation through national payment schemes (one of a number of options) have been estimated to range from USD 250 million to USD 1 billion annually by the tenth year of operation (Grieg-Gran, 2006).

Technology

Over the past 100 years, the global economy has developed largely on the back of the increasing application of carbon- and energy-intensive technologies in all major sectors. In recent years this trend has accelerated, driven by (a) surging growth in the developing world (especially China), (b) relatively low energy prices until 2005, and (c) increasing use of coal as the primary energy source for the power sector. The underlying rate of decrease in carbon intensity, defined as tonnes of carbon per GDP, is 1% per annum. Hence, given that the world economy continues to grow by 3–4% per annum, carbon emissions will continue to grow at 2–3% per annum under a business-as-usual scenario.

The challenge of significantly reducing emissions while maintaining economic growth requires a dramatic shift in the technologies that determine the carbon intensity of the economy. A number of studies indicate that the required GHG abatement can be achieved through the deployment of existing and near-commercial

[6] The lowest cost in the Grieg-Gran (2006) range, which does not take into account returns to selective logging before deforestation takes place.
[7] For example, Blaser *et al.* (2007) estimate costs of USD 12.2 billion annually to reduce emissions to zero by 2030.

technologies. New technologies will further lower the costs of transitioning to a low-carbon economy and are thus highly desirable. But in order for existing technologies to be fully diffused and adopted, and for new innovations to occur, three forms of market failure must be overcome. First is the general failure to internalize the costs of GHG emissions. This can be addressed by an appropriately determined carbon price. Second are market failures that have restricted the deployment of many existing energy-efficient technologies despite rising energy prices, and that cannot easily be addressed with a price on carbon. These include principal-agent problems (e.g., property owners not having incentives to deploy energy-saving technologies in commercial buildings), overly high consumer discount rates, lack of information, government energy subsidies that encourage energy consumption, and energy or carbon costs that are low in terms of individual purchase decisions but high in aggregate terms. Third and finally, are market failures specific to the nature of technology itself. These include lock-in of high-carbon technologies due to infrastructure or increasing return effects, risk aversion in the face of technological or carbon price uncertainty, spillovers of investment in research and development that benefit competitors, and learning-curve effects that create high prices for early adopters, thus discouraging demand.

Thus, the key message is that while a clear, appropriately determined and institutionally stable market price for carbon is necessary to stimulate the required technology response, it is not sufficient. An effective, efficient, and equitable policy response in this area must not only motivate market forces, but also overcome market imperfections.

Adaptation

In addition to a fair distribution of the burden of emissions reduction, a further policy response is required to assist those facing the impact of emissions for which they were not responsible. This requires support for adaptation in those countries hardest hit by climate change. The most effective form of adaptation to a changing climate is robust, climate-resilient development. Adaptation assistance needs to be integrated into development spending to deliver development goals in a climate-resilient manner, rather than being earmarked for climate-specific projects.

Just as adaptation planning needs to be integrated into development plans and strategies, so adaptation funding should be integrated into development spending at regional, national and local levels, ideally by delivery through the same multilateral channels, and not by setting up parallel processes. Money should be spent through national development plans, reflecting overall national priorities, with delivery following the principles of the Paris Declaration (OECD, 2005): ownership, alignment, harmonization, managing for results, and mutual accountability.

Allocation of funding between countries will need to reflect a combination of several factors: impacts of climate change, vulnerability to those impacts, capacity for internal investment, and the commitment and ability of local governments to deliver appropriate outcomes.

Money and other assistance will be best used if national governments are responsible for using funds to deliver broad contracts on issues such as poverty, health and climate vulnerability. Delivery of these goals will need to be monitored and evaluated. Based on this evaluation, recipient governments will in turn need to be held accountable by their citizens – who stand to lose most from a changing climate – and by the international community. International financial institutions, including the World Bank and International Monetary Fund, should monitor, report on and, where necessary, facilitate non-financial aid such as access to insurance, technology and information, as well as other market-based facilities.

A blueprint for a safer planet

We have described how we can offer a 'blueprint for a safer planet'. If we follow the route we have tried to chart, or something similar, as we believe we can, we will not only protect the planet for our grandchildren but we will also reduce dramatically the severe threat of global conflict that unmanaged climate change would eventually cause.

It is crystal clear, however, that this is a global challenge and can be confronted effectively only by concerted action across the world. It will require international collaboration on an unprecedented scale; that is the only way it can work. While there are different forms of mutual understandings and institutions that can support such action, a spirit of internationalism, mutual dependence and shared destiny is fundamental. If we cannot create this collaboration we will have failed future generations and ourselves.

The meeting of the United Nations Framework Convention on Climate Change at Copenhagen in December 2009 is the most important international gathering since the Second World War. The world set itself the task, in Bali in December 2007, of reaching an agreement on a successor to the Kyoto Protocol by the end of 2009. If we fail to construct a strong global deal in Copenhagen we risk years of dangerous delay. Delay means higher concentrations and growing emissions; it means that the starting point for both stocks and flows will make the required emission reductions greater and more difficult to achieve; and furthermore, it means that the confidence in future policy of the investors, those who will take the practical measures, will be severely damaged. The emerging carbon markets, crucial to necessary incentives, will be undermined. We cannot postpone the construction, agreement and action on a global deal.

We can and must now handle the short-term economic crisis, foster sound economic growth in the medium term, and protect the planet from devastating climate change in the long term. All three can be done in unison and all three are urgent. To try to set them against each other as a three-horse race is as confused analytically as it is dangerous economically and environmentally. The current economic crisis certainly requires an urgent response, but so does the climate crisis.

We need political leadership that is not only thoughtful and measured but also courageous and inspirational. That leadership must set out the compelling scientific and economic case for strong action. It must show not only the severe risks posed by climate change, but also that if we act sensibly and strongly starting now, we can dramatically reduce those risks at reasonable cost. That leadership must be courageous too in confronting the short-term, narrow and confused interests that will make a lot of noise and argue for postponement of action, or in some cases for little or no action. It is a time for clarity and strength in both vision and action.

Strong action on climate change will not only protect the lives and livelihoods of our children and grandchildren, it will allow them to experience the wonder of the natural environment which we still enjoy. Low-carbon growth will deliver much more than this. It will also create an industrial revolution that will drive growth in the coming decades. But still more important, it will create a world that is much freer from conflict over scarce resources, including water and hydrocarbons; a world that will be more secure in its energy supplies; a world that will be quieter and cleaner; a world with greater biodiversity, less pollution, and more beautiful in the physical and natural environment. It will also be a more co-operative world where we have a much better chance of dealing with the many global problems, above all entrenched poverty, that we face and will face as citizens of one planet.

This is indeed an inspirational story. But it is also a practical story, indeed the only practical story. We have a short window of opportunity to turn it into a reality. Whilst it is time for leadership, we must all contribute to the creation of this reality; from my own world of the university and of policy analysis from those who will invest in the new opportunities, and from those who will change the way they consume. We know what we have to do, and the prize is enormous. The people and politicians of the world, community by community, nation by nation, will now determine whether we can create and sustain the international vision, commitment and collaboration that will allow us to take this special opportunity and to rise to the challenge of a planet in peril.

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