

## Breaking the Climate Deadlock

## A Global Deal for Our Low-Carbon Future

**Tony Blair**



THE °CLIMATE GROUP



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# Foreword

## by Tony Blair

There has been an enormous shift in opinion on climate change in recent years in favour of radical action. There is a coincidence between concern over the climate and anxiety over oil prices. Both point to a reduction in carbon dependence. Energy security has likewise leapt up the agenda.

For many reasons, now is the time to act. The challenge is to set a framework that allows change to happen at a pace that is (a) sufficient and (b) sensible. The good news is that there is a large degree of consensus as to the nature of the challenge and the need to deal with it.

Most people no longer need persuading that the changing climate poses a serious risk to humankind. Everyone, with oil at over \$100 a barrel and with resources scarce, agrees that energy security is a crucial issue. There is now agreement that we should shift our economies away from carbon dependence. Again, most people agree that a framework for national and international action is needed to incentivise, encourage and oblige such a radical shift.

The question is: how? What is the framework that is sufficiently radical about where we have to go; and sufficiently realistic about where we are and the speed of travel? If we are not radical enough in altering the nature of our economic growth, we will not avoid potential catastrophe to the climate. If we are not realistic enough in setting a framework to get there, we will fail to achieve agreement.

Our citizens are alarmed at growing damage to the climate. Our citizens can also be alarmed at the radical scale of action necessary to prevent it. The task of political leadership is therefore to achieve the right national and international action that puts the global economy on a path to low-carbon growth, but does so in a way that does not hinder the completely legitimate aspirations of people – especially those in the poorer parts of the world – to enjoy the material and social benefits of growth and consumption. Given the complexity of the issues involved, the imprecision of much of the data, and the extraordinarily tricky interplay between the political, the technical and the organisational, answering the question of “how?” is as difficult as any the international community has grappled with since the design of the post-war Bretton Woods economic institutions.

The UNFCCC is charged with making the global deal and there is no route to such a global deal except under its authority. The purpose of this report is to lay out the issues, bring together the information currently available, and suggest a process for resolution. This is meant as an aid to the proper, formal UN process.

But we should be open about the substantial present political risk.

There is a danger of a yawning chasm between, on the one side, those in the scientific, NGO, and expert community who want very radical action immediately to cut greenhouse gas emissions; and on the other side, those in positions of political leadership who fear they are being asked for something beyond their power to deliver without damage to economic growth.

Just test it in this way. The core demand many make is for a 2020 interim target to be agreed in the UN negotiating process at Copenhagen at the end of 2009. The target demanded for developed countries is of the order of a 25-40 percent cut in emissions. It is a very bold commitment indeed. But, on closer analysis, it is even bolder than it appears. The target is set on a 1990 baseline – i.e., our progress in the next 11 years is to be measured against what happened almost 20 years ago. But many developed nations have seen emissions rise since 1990, not fall. In the US they have risen by over 16 percent; in Japan by over 7 percent. Some European countries – notably Germany and the UK – have seen falls. But just in the last 3 years, in Europe as a whole they have been roughly static. So a baseline of 1990 makes the target even tougher than it sounds.

Essentially, we are asking North America, Europe and Japan to move from a situation of rising or static emissions in the last 12 years, to a significant, unprecedented cut in the next 12 to allow global emissions to peak by 2020.

Scientists will say: it is essential.

Political leaders will ask: is it possible?

We are not assisted by the fact that many of the figures used are open to intense debate as our knowledge increases. For example, we talk of a 25-40 percent cut by 2020. But, to state the obvious, 25 is a lot different from 40 percent. Some will say that to have a reasonable chance of constraining warming to approximately 2°C, we need greenhouse gas concentration to peak at 500 parts per million by volume (ppmv); some 450 ppmv; some even less. Some insist that 2020 is the latest peaking moment we can permit, beyond which damage to the climate will become irreversible; some, though generally not in the scientific community, say 2025 or even 2030 may be permissible.

Then there are important facts and deep political realities that we can easily miss.

- Energy efficiency would provide around one quarter of the gains necessary and, incidentally, save money, but its significance is often ignored.
- The vast majority of new power stations in China and India will be coal-fired; not “may be coal-fired”; will be. So developing carbon capture and storage technology is not optional, it is literally of the essence.
- Without at least some countries engaging in a substantial renaissance of nuclear power, it is hard to see how any global deal could work.
- Around 70-80 percent of the current stock of CO<sub>2</sub> emissions in the atmosphere was created by the developed world.
- But if the US meets the boldest targets for reductions while China continues on its present path, and India follows, the climate will still suffer irreversible damage.
- For developing countries to grow sustainably they will need funds and technology, otherwise they will not be able to peak and then reduce emissions within the necessary timescale.
- Deforestation amounts to around 15-20 percent of the entire emissions problem.
- Certain key sectors like cement, steel and of course power most of all, account for a huge percentage – almost half of all emissions.
- Airline and shipping emissions, though only 5 percent today, are a fast growing part of the problem.
- Done right, the costs of abatement will be manageable and probably less than predicted; and there are potentially real opportunities for the new low-carbon economy that will develop.

There is another crucial political reality. The science is developing all the time. The one certain thing is that what is said today, in 2008, will not be quite the same as what is said by the time of Copenhagen, let alone in 2012 or 2015. Our knowledge is growing the whole time. Another pretty safe prediction: technology will develop in ways we cannot predict. But, for sure, if a clear set of incentives are given, the market will respond, human creativity and ingenuity will get to work, answers will be given tomorrow that cannot be contemplated today.

There is also an immense political danger which anyone who has participated in intricate and politically sensitive multilateral negotiations understands. If the Copenhagen meeting happens without a clear political direction already having been given, then it will be a negotiator’s nightmare. What is more, the danger is that countries then approach Copenhagen with minimalist positions, knowing concessions will be dragged out of them; rather than setting out genuinely the maximum that they think they can realistically achieve. The consequence will be an agreement of lowest common denominator, with a hotchpotch of complicated mechanisms that leaves the world little further forward and public opinion disillusioned and dissatisfied.

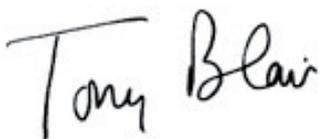
There is a different and better way of approaching a global deal. What is essential is that the world, especially the world of business, gets from Copenhagen a clear, unequivocal, radical direction. The exact speed of travel may vary and will be adjusted in time. But everyone needs to know that the direction is plain and unambiguous. Such a deal can be based around the following points:

- A The trend of opinion – scientific and political – is clear, for reasons of energy security as well as climate change: we have to change the way we grow, to reduce radically our dependence on carbon. That is why a 2050 global target of at least a 50 percent reduction in emissions should now be able to be agreed.
- B The crucial thing at Copenhagen is to set a clear direction in order to achieve such a reduction, both for the developed and developing world. We must get the process of change under way; establish the pathway with interim targets for developed countries; but realise that between now and 2050 a lot will change about what we do and what we know.
- C The Hokkaido Toyako G8+5 and the Major Economies Meeting (MEM) should set out the agreement to the critical 2050 target and identify the core elements that go into the global deal.
- D There should then be a requisitioning of the necessary research and analysis so that the core elements have a real and substantial factual underpinning to support agreement on them.
- E The G8+5 and other major economies (for example, as with the MEM) in Italy in 2009 should then get agreement on the core elements and how they fit together, and this should feed in to the Copenhagen process of the UN, which then can make the global deal.
- F The Copenhagen agreement should be the maximum that is politically realistic and achievable at this time, i.e., 2009.
- G A process should then be agreed to provide for periodic reviews of what has been done and what is necessary to do, so that the agreement can be adjusted. This should happen in a smaller forum of the key economies and feed into the UN process. So the idea would be for a rolling treaty, not a one-off resolution of an issue that cannot be concluded in 2009, or even shortly after.
- H Copenhagen can then do its work, knowing there is a political direction from the countries that account for 75 percent of emissions; knowing that it is not expected to solve, once and for all, all issues; knowing that there will be then a continuing political process that will allow for further radical steps as our actions and our knowledge become clearer.

Such a way of doing things rests on one fundamental assumption: that the problem today is not one of political will; that the political dilemma is not “whether” but “how”. There are good grounds for making this assumption. The attitude of countries like China and India is no longer: you, the wealthy created this challenge; you can solve it. They know climate change is “our” problem not “yours”. How we address it is a matter of equity. But the change in climate is the same whether the emissions originate in New York or Shanghai. And of course, the most vulnerable to the impact of climate change live in the poorest areas of the world.

Likewise, in the US today, there is a broad swathe of consensus that the primary responsibility for making near-term reductions in emissions rests with the developed world. Opinion in Japan, under PM Fukuda’s leadership, has shifted. In Europe, there is a genuine and deep consensus about the need to act.

The challenge is not one of will. It is how to get a deal that sets us clearly on a path to a low carbon future; that is fair; and that is do-able. That is radical and realistic. In this report, we describe the elements that could go into such a deal and the thinking behind them.



**Tony Blair**



# Executive Summary

## A The challenge is immense

There is now virtually overwhelming evidence about climate change and its consequences; there remain uncertainties, but the risks of negative and irreversible consequences are clearly high.

- Over 2,500 scientists from over 100 nations participating in the Intergovernmental Panel on Climate Change (IPCC) concluded in November 2007 that “warming of the climate system is unequivocal” and human activity was “very likely” responsible.
- Recent research indicates that we need to limit warming to approximately 2°C; the indications are that moving beyond this level of warming will greatly increase the risks of irreversible and potentially catastrophic changes to the climate.
- In 2005 the atmosphere had a concentration level of carbon dioxide equivalents (CO<sub>2</sub>e, a measure of greenhouse gases) of 455 parts per million by volume (ppmv). When the impact of aerosols is taken into account the effective concentration is 375 ppmv.
- To have a reasonable chance of limiting warming to approximately 2°C, we would need to peak concentrations at around 475-500 ppmv CO<sub>2</sub>e (including aerosols), and then reduce emissions to stabilise concentrations at 400-450 ppmv by the 23rd century.
- The scientific consensus is that in order to meet such a concentration path for CO<sub>2</sub>e, we need to peak global annual emissions no later than 2020 and then cut global annual emissions by at least 50 percent versus 1990 levels by 2050 (1990 is the base year for the UN Framework Convention on Climate Change (UNFCCC) – though there is political contention over the use of this base year). However, peaking globally by 2020 requires rapid, major emissions reductions by developed countries, and there is doubt, today, whether this can be achieved.
- In 1990 the world emitted around 40 billion tonnes of CO<sub>2</sub>e. Today the figure is estimated to be 55 billion. Without action this would rise to 60 billion by 2030 and 85 billion by 2050. In order to meet the 50 percent reduction, we need to take it down to less than 20 billion tonnes by 2050.
- If, as projected, the world population rises to 9 billion people, this would mean an average of approximately 2 tonnes of CO<sub>2</sub>e per person per year by 2050. Today the average is 8 tonnes, with over 20 tonnes for the US, 10 tonnes for Europe and Japan, 6 for China and 2 for India.
- The implications of all of this are transformative for the world economy; in order to cut carbon to this degree and maintain current levels of economic growth, carbon productivity (GDP per tonne of carbon) needs to increase tenfold over the next four decades. This cannot happen without profound behavioural and technological change.

## B The challenge can be met

- We can meet approximately 70 percent of the abatement required over the next two decades with existing or near-commercial technologies.
- Energy efficiency alone could cut energy demand by 20-24 percent and save hundreds of billions of dollars per year.
- There are low-carbon energy sources already in large scale use today that can be expanded, e.g., wind, nuclear, and solar.
- Biofuels, particularly sugarcane-based and next generation lignocellulosic biofuels, offer significant potential in transport, but strict policies and incentives are needed to ensure they are sustainable, with less impact on food and land use.
- There are new technologies that are near to deployment: carbon capture and storage (CCS); new transport technologies; new forms of solar; and the use of information technologies to monitor energy use. All offer the potential for huge reductions in emissions.
- Preserving the world’s natural carbon sinks, i.e., forests, has massive benefits. Deforestation now accounts for 15-20 percent of CO<sub>2</sub>e emissions.

## **C** The challenge can be met without damaging the economy

- Various estimates indicate that abatement will have an impact on the economy, but both the IPCC and the Stern Review have found that it is likely to be relatively low – significantly less, for example, than the recent oil price rise.
- Costs would likely be financed by private sector and government borrowing over time, and are modest compared to normal capital replacement cycles; thus the actual impact on GDP growth in a given year is likely to be minimal or even positive.
- There will be major investments, creating jobs and business opportunities, in the move to a new low-carbon economy. For example, over 2 million people are today employed in renewable energy; investment in new environmental technologies rose from \$10 billion to \$66 billion from 1998 to 2007.
- Trade will be a sensitive issue, but evidence indicates that the impact on trade flows is likely to be modest.
- Experience from past environmental issues such as acid rain and CFCs indicates that costs are often overstated; costs in both cases turned out to be less than a third of original estimates.

## **D** Addressing climate change leads to energy security

- Around 50 percent of potential abatement actions – energy efficiency, renewables, biofuels, nuclear – result in increased energy security. Other abatement actions are mostly energy security neutral and less than 3 percent of potential abatement runs counter to energy security.
- Pursuing energy security without consideration for climate could, however, lead to negative climate effects; notably from increased use of coal and energy-intensive sources of oil such as tar sands.
- However, pursuing climate and energy security together would create far more diverse energy supplies, greater scope for local energy production, and reduced dependence on imported oil and gas.
- Not addressing climate and energy security increases the risk of future conflict resulting from climate effects and resource scarcity.

## **E** Adaptation will be a necessity, not a choice

- Climate change is already occurring and will continue to occur even with strong action.
- Over a billion people live in coastal regions prone to flooding, and will likely be affected even if radical action is taken.
- Droughts, shifting agricultural patterns, greater storm intensity, and spread of disease areas are all effects that will need to be addressed – particularly for the poorest and most vulnerable nations.
- Insurance will become a major issue, to provide effective safety nets through local insurance and global reinsurance systems. New forms of micro-insurance will be needed for low-income families.

## **F** Waiting is risky and expensive

- The science has become more, not less, alarming on the dangers of climate change as time has passed.
- The longer we wait, the more expensive the reduction will be, the more painful and abrupt the economic transformation, and the more we will be required to spend on adaptation. Recent US reports have shown that delaying the start of emissions reductions from 2010 to 2020 will almost double the annual rate of reductions required.
- China and India and developing countries will make many of their major energy investments over the coming decade. We have a short window of opportunity to make that power infrastructure as energy efficient as possible; it will be far more expensive to achieve this later.
- Deforestation has to be reversed – otherwise we will deplete carbon sinks irreversibly, requiring us to take more expensive actions elsewhere.

Given the above, a global deal on climate change is essential. Without it, individual countries can act, but the cumulative impact will be much less than concerted action within a framework that accelerates the process of change in both developed and developing nations. The Bali Action Plan agreed in December 2007 under the UN Framework Convention on Climate Change (UNFCCC) provides the overall direction for the post-Kyoto treaty negotiations that will occur in Copenhagen in December 2009. The purpose of this report is to describe the building blocks that need to be in a global deal and the research necessary to broaden and deepen our understanding of them and how they interrelate. A future report for the 2009 G8 will then try to show how these elements could be put together in a coherent deal.

We have identified ten core building blocks for a global deal.

## [1 The global target](#)

From this, all else flows. There has to be a clear direction given by a global target. There is a growing consensus that we need a cut in CO<sub>2</sub>e emissions of at least 50 percent by 2050. There are however different views as to what the baseline should be. The UNFCCC has been working off a 1990 baseline, which is the baseline specified in the Kyoto treaty; but there are those who want to work off a more recent baseline. The key is that annual emissions should be reduced to below 20 billion tonnes by 2050.

### **Further work**

- How should such a target be expressed? As a percentage versus a baseline or as an absolute amount?
- If a percentage, should the baseline year be 1990, or more recent? What are the implications of the baseline year for national targets?

## [2 An interim target](#)

Leaving it all to 2050 doesn't allow us to describe the pathway to change or prevent a rise in emissions that becomes irreversible. The science says it is critical to constrain the date by which global emissions peak.

### **Further work**

- For which date should the target be set – 2020 or later?
- What should the target for reductions be by that date? What does this require from developed nations?
- Should the target be expressed as an absolute amount? A percentage reduction? A peaking date?

## [3 Developed world commitments and carbon markets](#)

The developed world needs to start peaking and reducing emissions soon. The primary mechanism for achieving this should be a set of binding emissions caps and an international carbon market for trading emissions permits. Developed countries should also put forward national action plans as to how they will meet their emission cap obligations. An important question is what the baseline year should be for the caps. 1990 was agreed as the baseline year for the UNFCCC, but much has changed since then.

### **Further work**

- What overall level of reductions should developed countries target?
- What should the process be for determining national caps?
- How should the national caps be expressed? Absolute reductions or percentage off of baseline? If baseline, what year?
- How should existing and planned national/regional carbon markets be integrated into a global market?
- How should the Kyoto Clean Development Mechanism (CDM) be reformed as a part of a carbon market developed at Copenhagen?
- How should the international carbon market be regulated?

## 4 [Developing world contributions](#)

Bali agreed there should be “common but differentiated” contributions toward meeting the global goal from developing nations. There need to be obligations: to work to national action plans to abate emissions as far as possible consistent with growth; to peak at a certain point; and thereafter to reduce emissions. Meeting these obligations will require technology and funding to support them. Developing world mechanisms may also include a reformed CDM and “no lose” incentives for energy efficiency and carbon productivity improvements at the industry sector level.

### Further work

- How are the national action plans to be formed?
- When should developing country emissions peak?
- What reductions are then possible?
- What additional obligations, with the availability of technology and funding support, should developing nations undertake?
- How to distinguish between rapidly industrialising, less rapidly industrialising and very poor nations?
- What sector-level schemes might provide incentives and investment for deeper and more rapid action?
- What other ways might developing nations participate in the carbon market?

## 5 [Sectoral action](#)

A carbon price will be necessary to drive the needed changes but may not be sufficient. Action at the industry sector level may also prove an important tool for driving transformation. Developed countries may use sector targets as a part of their national policies, and one-sided sector-based incentive schemes may help developing countries accelerate their efforts. Where similar opportunities exist in many countries, sectoral approaches may benefit from international cooperation, and enhance the delivery of national targets.

### Further work

- How can sectoral schemes be most effectively used by developed nations to deliver cap commitments?
- How might one-sided sector-based incentive schemes be designed for developing countries?
- In which cases might international cooperation on sectors help countries take on and deliver more ambitious targets?
- Are sector-specific schemes needed for sectors currently outside of national caps, e.g., international aviation and shipping (so-called “bunker fuels”)?

## 6 [Financing](#)

The world has a much stronger chance of hitting global targets, and the overall mitigation of emissions will ultimately be less costly, if developed nations provide significant funding to support accelerated action by developing nations; for technology development and deployment; for adaptation; and for halting deforestation. The size of the flows required is comparable or larger than current overseas development aid (ODA) flows and will thus be challenging to deploy and manage effectively. Some of the funding is needed immediately, some over time.

### Further work

- What institutional structures are required to manage large new climate funding flows? New institutions versus existing? How can we ensure effectiveness and accountability?
- How can we maximise funding for key technologies, especially CCS, by major contributor countries?
- Can we auction developed country permits as a way of raising money to accelerate developing nation action?
- How can we ensure that financing for climate issues is incremental to, but integrated with, ODA?

## 7 Technology

There are certain key technologies that require rapid development to offer medium term reductions. The principle one is CCS – without this technology, achieving the targets described, will either be unfeasible or significantly more costly. A broad portfolio of technology investments is required, including solar, nuclear, sustainable biofuels, IT and “smart grid” technologies, as well as basic R&D for the third generation of low-emissions technologies. New mechanisms are required to encourage low-emissions technology diffusion in developing countries and to reduce barriers to intellectual property access.

### Further work

- How do we accelerate CCS? How do we engage governments and the private sector to make the investments required to get CCS to commercial viability and widely deployed?
- For countries committed to nuclear, how do we expand nuclear capability?
- How do we create incentives for and support a broad portfolio of technology innovation?
- How do we integrate technology diffusion in developing countries with overall economic development?
- What is the best intellectual property rights regime for encouraging low-emissions technology development and transfer?

## 8 Forests

There will need to be a specific plan for tackling deforestation. This plan should differentiate between the forestry needs of different nations; should have a proper system of monitoring; and should develop the incentives to encourage the action necessary to stop deforestation.

### Further work

- What are the incentives/obligations necessary to prevent deforestation?
- Are market-based incentives feasible and under what circumstances? Where is programmatic funding required?
- What is the right system of monitoring?
- How will funding be raised to support necessary in-country action?
- How can in-country capabilities be built to support forestry efforts?
- What can be done to encourage economic development that is compatible with forest preservation and expansion?

## 9 Adaptation

Climate change is occurring today and adaptation is required, particularly for the most vulnerable countries. Estimates on funding required vary, but it will be significant. We should also look at innovative ways in which the private sector can play a role through the global insurance market.

### Further work

- What funding will be needed for adaptation by which countries, for what applications, and over what time frames?
- What should the sources of this funding be?
- What institutional mechanisms are required to deliver funding, integrate it with development agendas, and ensure effectiveness?
- What role might the insurance industry play?

## 10 Institutions and mechanisms of action

It is apparent that the scale, complexity, and range of action will require effective institutional structures and mechanisms. These can be existing institutions. They can be created. They can be partnerships between the private and public sector. We should attempt to construct non-traditional and non-bureaucratic means of acting.

### Further work

- What overall governance structures are required for the actions arising out of a new Copenhagen treaty? How can we strengthen the UNFCCC?
- How centralised should the governance structures be versus a principle of subsidiarity? Should there be different, customised solutions to each aspect, or one over-arching body?
- What is the best way of informing and monitoring the overall performance of the treaty and its various mechanisms (e.g., carbon markets)?
- What is the best way of encouraging continued research and development of our knowledge base? How can we ensure that growing knowledge is incorporated in future target setting and other mechanisms?
- What is the role of the World Bank, the International Energy Agency (IEA), and other multilateral institutions?
- What role can the private sector play and how can public/private partnerships be an instrument of action?

In order to have productive negotiations in Copenhagen, we must be actively working on these questions now.

The G8 Hokkaido Toyako Summit – with the +5 and others in attendance – and the Major Economies Meeting (MEM) chaired by the US offer the chance to agree:

- That these elements should indeed be the building blocks of the global deal.
- To take certain key decisions now, e.g., the global target of at least 50 percent ; funding for CCS development and deployment; and actions to advance the concepts of carbon markets and equitable contributions by developing nations.
- To put in place a process for developing these building blocks in the run-up to the Maddalena G8.
- To commission further work.

In that way, the UNFCCC meeting at Poznan at the end of 2008 can move the process forward, and the Maddalena Summit in 2009 will be a major opportunity for the G8 to build on progress in Hokkaido, provide leadership and create positive momentum in the months leading to Copenhagen.

If the G8 nations are committed to take action themselves, transform their economies, lead in new technologies, and support the nations of the developing world, then the chances of a successful and perhaps even historic outcome in Copenhagen will be greatly increased.

# Chapter 1

## Achieving Climate Security in an Interdependent World

This year and next, the leaders of the world will make fundamental choices as to how they will address the risks of climate change. Those choices will be reflected in the international treaty that emerges out of the post-Kyoto negotiations in Copenhagen in December 2009. That treaty, and the national policies that are committed to as a part of it, will play a major role in determining whether or not the world gets onto a path that reduces and stabilises greenhouse gas (GHG) emissions in the coming decade.

The case for action is urgent and clear:

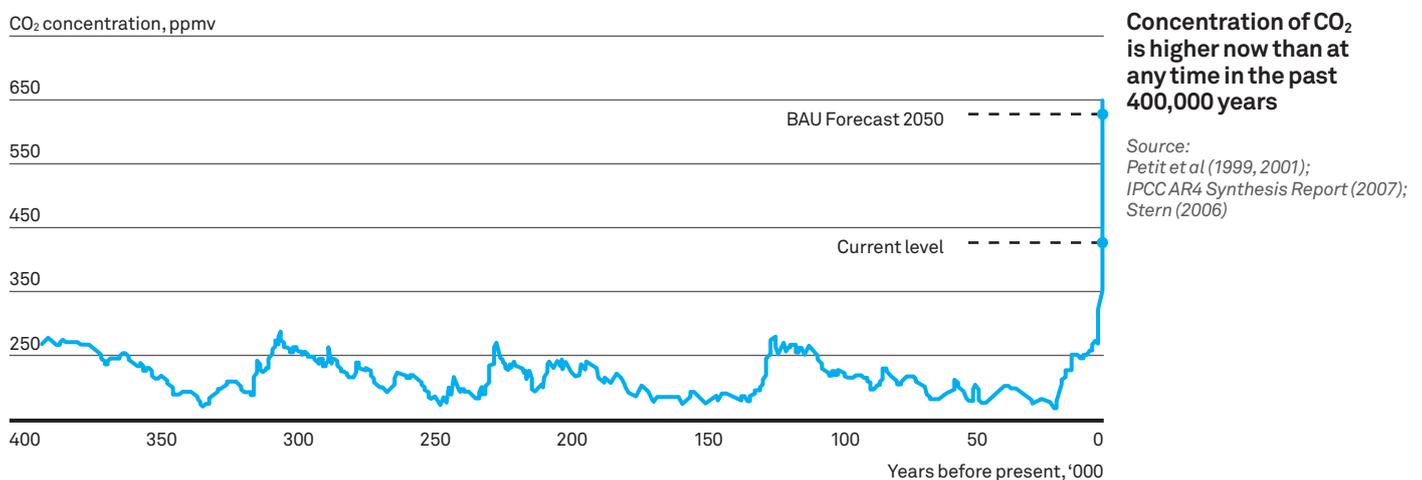
- There is strong and growing scientific evidence that the risks from unchecked emissions are high and potentially irreversible.
- The evidence is also strong that we can address climate change without damaging our economies – we can reduce emissions and grow in both the developed and developing world.
- Addressing climate change will help increase energy security, and ultimately international security.
- We must also begin to adapt to climate change already under way.
- Delaying or taking too little action to reduce emissions will ultimately cost more and increase risks.

### Emissions growth creates irreversible risks

In November 2007, over 2,500 leading scientists from more than 100 nations participating in the Intergovernmental Panel on Climate Change (IPCC) warned that “warming of the climate system is unequivocal”.<sup>1</sup> The IPCC also concluded that it is “very likely”<sup>2</sup> that most of the observed increase in global average temperatures since the mid-20th century is due to the increase in GHG concentration caused by human activities. As one prominent scientist has put it, the evidence base is now sufficiently strong that those who continue to deny the connection between human activity and climate change are in a scientifically similar position to those who deny the link between smoking and lung cancer.<sup>3</sup>

Concentrations of carbon dioxide (CO<sub>2</sub>), which is the largest category of GHG emissions, have generally remained in a relatively narrow range for the past 400,000 years, but have spiked sharply since the Industrial Revolution (Exhibit 1). The atmosphere we are creating now is one that humans as a species have never experienced before.<sup>4</sup>

### Exhibit 1



BAU = business as usual

Climate change is not a distant future risk, but is a phenomenon occurring today.<sup>5</sup> Eleven of the last twelve years have been the warmest since instrumental records began in 1850. Around the world sea levels are rising, glaciers are melting, habitats are shifting, and weather patterns are changing. Even if we could hold GHG concentrations constant at present levels (which would require abrupt and infeasible reductions in emissions), the climate would still warm at about 0.1°C per decade for a few decades, and more slowly after that for many decades to come.<sup>6</sup>

Without action to curb emissions, temperatures could rise anywhere between 2°C and 6°C above pre-industrial levels within the lifetime of children being born today (temperatures are now about 0.8°C above pre-industrial).<sup>7</sup> While these differences in temperature may seem small, their impact is likely to be far-reaching. The last time the world was 4 to 6°C cooler, much of the northern hemisphere was buried under ice and sea levels were 120 metres lower than today. When the world was 3 to 4°C warmer, sea levels were some 25 metres higher.<sup>8</sup>

At temperatures around 2°C warmer, the likely impacts on humans include reduced water access for hundreds of millions, major shifts in agricultural production, increased damage from storms, coastal flooding, more frequent heat waves causing loss of life, the spread of tropical diseases, and 20-30 percent of species at increased risk of extinction.<sup>9</sup> One only needs think of recent events such as the 2001 droughts in Central America, the 2002 floods in Russia, the 2003 heat wave in Europe, the 2004 monsoons in south Asia, the 2005 Katrina hurricane in the US, and the 2008 record snows in China to imagine the potential human and economic costs of more extreme weather patterns from a changed climate.<sup>10</sup>

Furthermore, warming may lead to “tipping points” being crossed which could cause abrupt, irreversible or large-scale changes in the climate system.<sup>11</sup> At a 1.5 to 2.5°C increase in temperature above pre-industrial levels, there is an uncertain but increasing risk of the irreversible melting of the Greenland ice sheet and the partial or complete disintegration of West Antarctic ice sheet.<sup>12</sup> This could raise sea levels anywhere from 5 to 13 meters over the coming centuries, flooding most of the world’s coastal cities.

Higher temperatures and drought could also cause the collapse of the Amazon rainforest, reducing one of the world’s largest terrestrial carbon sinks, leading to a major loss of biodiversity and a massive additional increase in atmospheric carbon dioxide.<sup>13</sup> Higher temperatures could further lead to the release of some of the estimated 500 billion tonnes of GHGs currently locked in permafrost at northern latitudes as either carbon dioxide or more importantly methane.<sup>14</sup> Siberia has already seen a seven times increase in carbon release as well as methane bubbling through lakes five times faster than previously assumed. A number of studies indicate a high sensitivity to warming and the process could become self-reinforcing as temperatures rise, melting more permafrost and releasing more GHGs.<sup>15</sup>

Finally, warming will also inhibit the ability of the oceans to absorb CO<sub>2</sub> over time, reducing the effectiveness of the planet’s largest carbon sink, as well as acidifying the oceans and causing significant damage to marine life.<sup>16</sup>

There is a risk that these and other tipping points could cause an acceleration in warming to greater than 4°C. If this occurs we are in uncharted territory. One has to go back over 65 million years to find a period when the Earth was that warm. The IPCC estimates that above 3.5°C, 40 to 70 percent of species on the planet are at risk of extinction.<sup>17</sup>

## Mitigating climate risk by stabilising greenhouse gases

Predicting the future of a system as complex as the climate is inherently uncertain. There are wide ranges on many of the scientists' estimates of future effects. But given the existence of significant risks of highly negative and irreversible outcomes, the appropriate response is to seek to mitigate those risks as effectively and cost efficiently as possible.

The evidence shows that climate risk increases significantly when temperatures exceed 2°C above preindustrial levels.<sup>18</sup> The European Union has adopted a target of limiting warming to 2°C.<sup>19</sup> If we use this as an approximate benchmark, we can then ask what GHG concentration level we need to reach to stabilise around the 2°C threshold.

The relationship between temperature and concentrations of GHGs in the atmosphere is complex, and GHG levels are not the only factor that drive temperature change. But as the IPCC found, most of the observed increase in global average temperature since the mid-20th century are very likely due to human-caused increases in atmospheric GHG concentrations.<sup>20</sup>

Concentrations of GHGs are a stock. Emissions flowing into the atmosphere raise the level of the stock, while absorption by the oceans, forests, and other carbon sinks lower the level – just as water pouring into a bathtub raises the level, while water flowing down the drain lowers it. Currently, the inflows from emissions are much greater than the outflows from absorption. Thus the concentration level is rising. In order to stop the rise and cause concentration levels to peak, we need to reduce the emission inflows sharply, down to the approximate level of absorption outflows.<sup>21</sup> In order to go further and actually bring concentration levels down from their peak, we will need to cut still more steeply, and have a period where the emissions inflows are less than the absorption outflows. The goal of policy then should be to use a combination of emissions cuts and strategies for preserving or expanding carbon sinks to create a path for stabilising atmospheric concentrations at a level that reduces climate risk to an acceptable level.

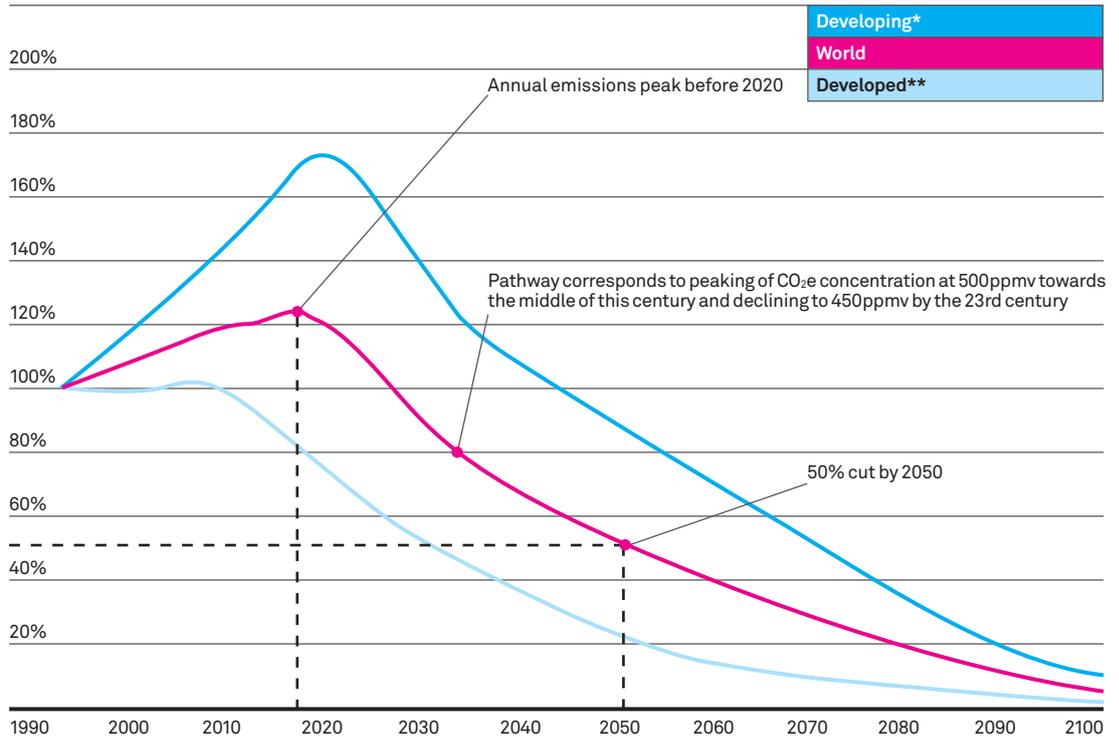
Research estimates that we would have a good chance of staying below 2°C if we were to peak concentrations of CO<sub>2</sub>e (carbon dioxide equivalents, a standard measure of greenhouse gases) at approximately 475 ppmv (parts per million by volume, taking into account the impact of aerosols and other effects) by around 2050, and then decline to 400 ppmv in the 23rd century.<sup>22</sup> Unfortunately, however, we are fast approaching the point beyond which we would be unable to achieve this with current technologies and without excessive costs. The IPCC's best estimate is that CO<sub>2</sub>e concentrations were at 455 ppmv in 2005, although when the impact of aerosols are taken into account, then the effective concentration is 375 ppmv.<sup>23</sup> The implications of the scientific evidence are that if we take urgent action now, we might be able to achieve a path of atmospheric concentrations peaking at around 475-500 ppmv by 2050 and then gradually declining to 400-450 ppmv by the 23rd century.<sup>24</sup> Under such a scenario, we would have an increased risk of exceeding 2°C versus a 400 ppmv stabilisation path, but it would still give us a reasonable chance of avoiding the worst effects of climate change.

If we take a long-term stabilisation path of 450 ppmv as the upper limit of acceptable risk, then global annual CO<sub>2</sub>e emissions will need to peak no later than 2020 and then drop at least below 50 percent of 1990 levels by 2050 (targets are often expressed versus 1990, the base year for the UN Framework Convention on Climate Change – UNFCCC). If annual emissions do not peak by 2020, it would not be possible to find a 450 ppmv emission pathway without far more radical cuts (or even negative net emissions) in the future.<sup>25</sup> Exhibit 2 illustrates a potential pathway consistent with these guidelines.<sup>26</sup>

## Exhibit 2

### Potential pathway to stabilise greenhouse gases GHG annual emissions relative to 1990

Source:  
Meinshausen (2007)



\* Developing = UNFCCC Non Annex 1 \*\* Developed = UNFCCC Annex 1

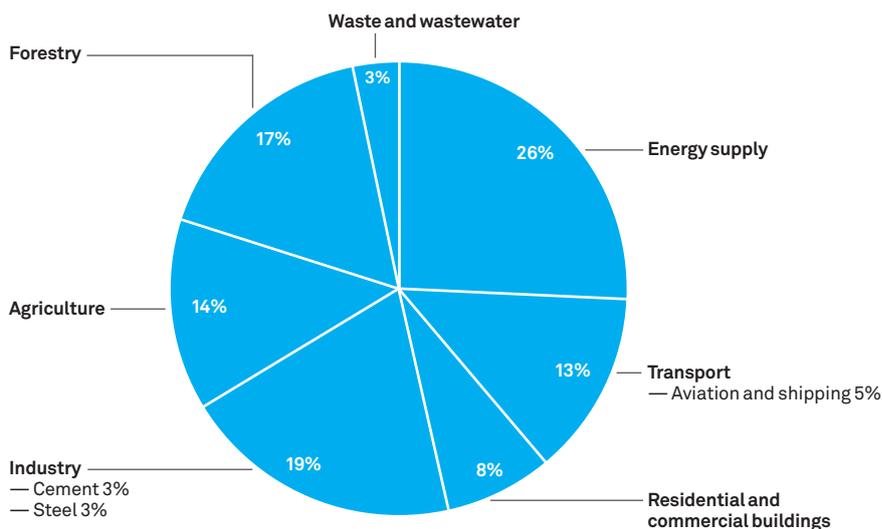
We can then translate these percentage reductions into annual emissions figures. Today, the world emits approximately 55 billion tonnes of CO<sub>2</sub>e per year (billions of tonnes are also sometimes referred to as “gigatons”).<sup>27</sup> The power sector accounts for the biggest share at around 26 percent according to IPCC estimates, with industry at 19 percent, forestry 17 percent, agriculture 14 percent and transport 13 percent (Exhibit 3).

## Exhibit 3

### GHG emissions by sector

Source:  
IPCC, AR4 Synthesis Report, 2007,  
p.36; Kahn et al., 2007, pp.325, 333;  
Bernstein et al., 2007, pp.461, 467

Anthropogenic CO<sub>2</sub>e emissions 2004, 100% = 49 billion tonnes



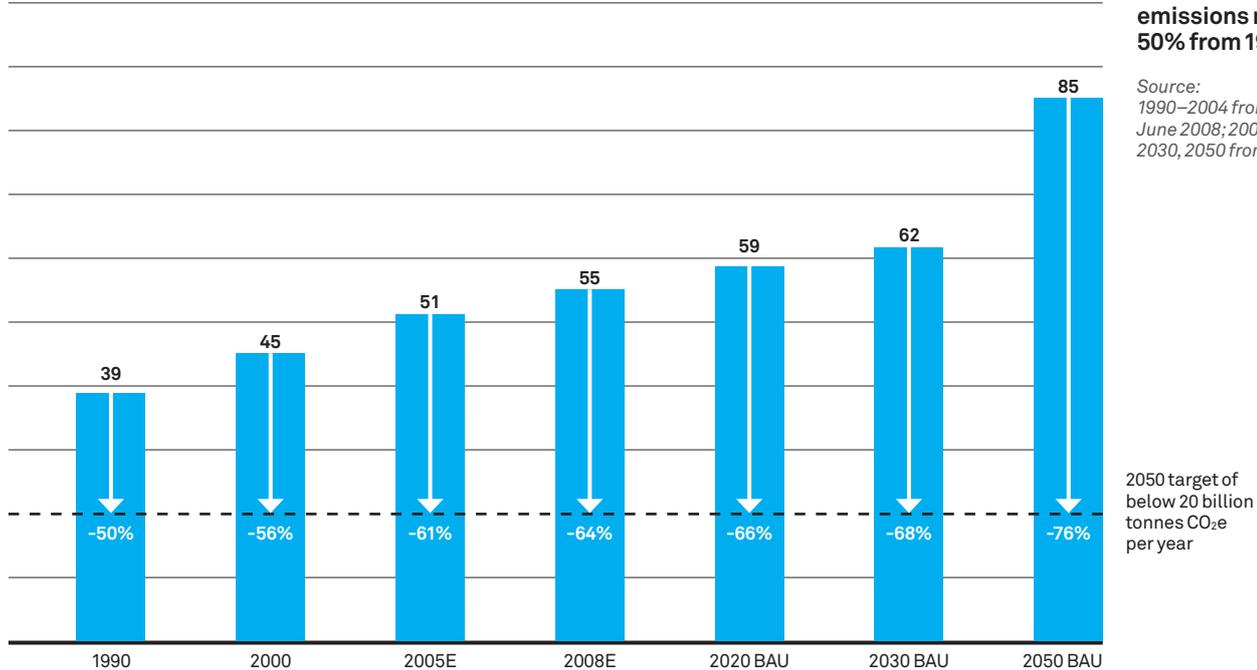
At the country level, a recent Dutch study of CO<sub>2</sub> emissions puts China as the world’s biggest emitter accounting for around 24 percent of the global total, with the US at 21 percent, the EU-15 at 12 percent, India 8 percent and the Russian Federation 6 percent.<sup>28</sup> Together these regions make up more than 70 percent of the world’s CO<sub>2</sub> emissions.

Without action, global GHG emissions are likely to grow to over 60 billion tonnes by 2030 and to 85 billion tonnes by 2050 (Exhibit 4).<sup>29</sup> If we are to move onto the stabilisation pathway described above, then at a global level we need to:

- By 2020 – peak CO<sub>2</sub>e emissions.
- By 2030 – cut annual emissions to below 35 billion tonnes.
- By 2050 – cut annual emissions to below 20 billion tonnes.<sup>30</sup>

### Exhibit 4

Global GHG emissions, billion tonnes CO<sub>2</sub>e



### Greenhouse gas emissions need to fall 50% from 1990 level

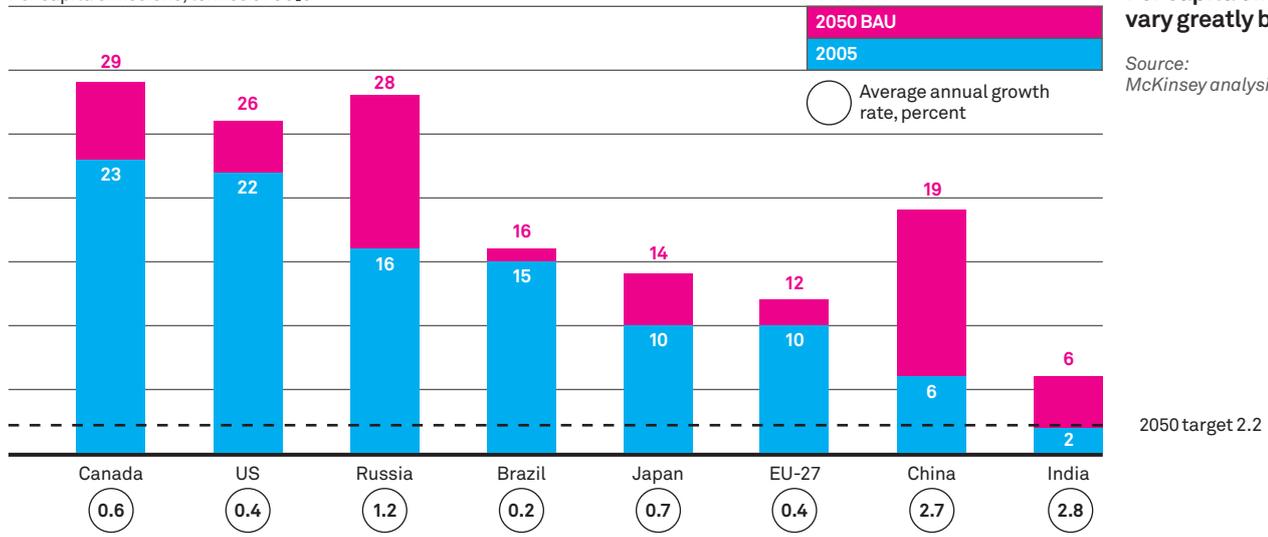
Source: 1990–2004 from IPCC data as of June 2008; 2005–2020 estimates; 2030, 2050 from Stern (2006)

BAU = business as usual

Another way to think about this is that in 2005 emissions were about 8 tonnes per person per year. Advanced economies ranged from 10 tonnes per person for Japan and the EU, to 23 for Canada (Exhibit 5). Developing countries range from very small amounts for the poorest countries to under 2 tonnes per person for India and 6 for China. Assuming the emissions cuts above and world population growth to 9 billion people, such a scenario implies a world average of approximately 2 tonnes per person by 2050.<sup>31</sup>

### Exhibit 5

Per capita emissions, tonnes of CO<sub>2</sub>e



### Per capita emissions vary greatly by country

Source: McKinsey analysis

BAU = business as usual

## Abating carbon and pursuing economic growth

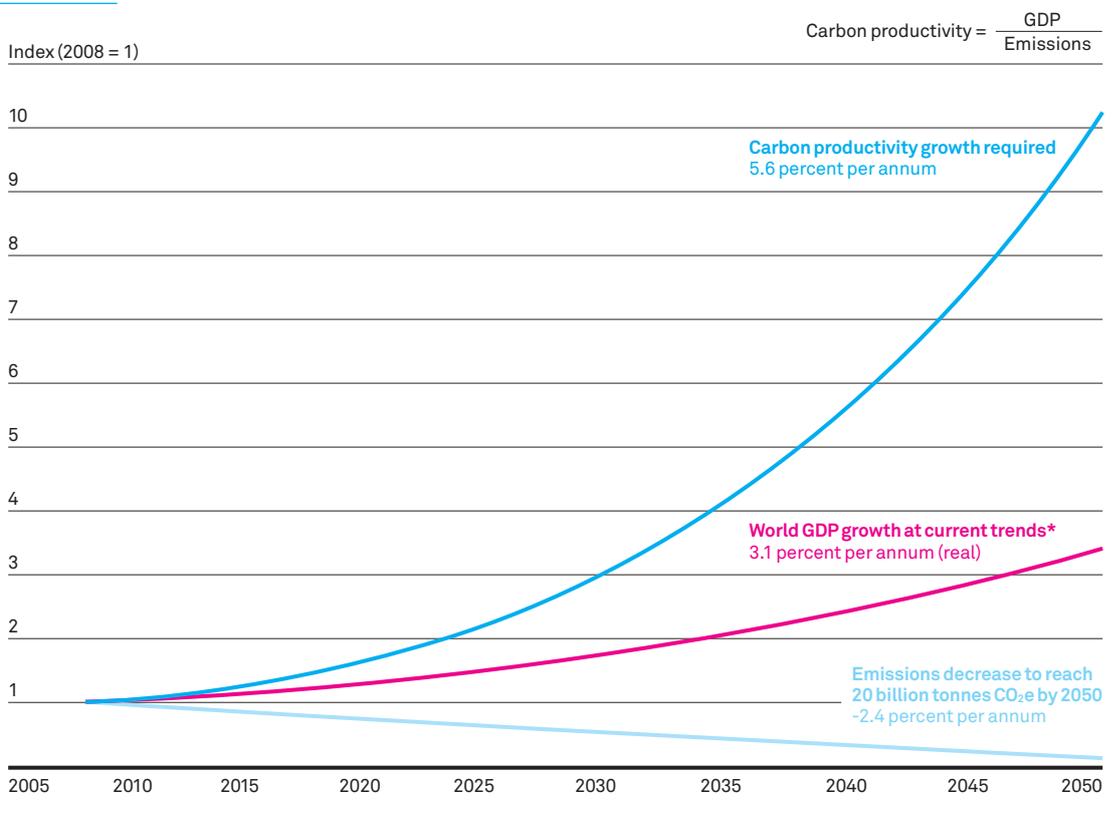
Just as there is a large body of evidence on the risks of climate change, there is also a large body of evidence on what we can do about it. There is a growing consensus that emissions can be reduced without damaging prosperity in either the developed or developing world. Reducing emissions will require a transformation of our economies, but not giving up on growth.

The challenge is to transform our energy sources, technologies, infrastructure, institutions and behaviours, in ways that dramatically increase the carbon productivity of the economy. Carbon productivity is the amount of GDP produced per tonne of carbon emitted. Carbon productivity can be thought of in a similar way as labour productivity (GDP per hour worked) or capital productivity (GDP per amount of capital). The world's carbon productivity today is about \$740 per tonne of CO<sub>2</sub>e. If we are to keep world economic growth on its current course of 3.1 percent per year in real terms and meet a 450 ppmv stabilisation goal, carbon productivity needs to increase by 5.6 percent per year to \$7,300 per tonne of CO<sub>2</sub>e by 2050 – a tenfold increase over the next four decades (Exhibit 6).<sup>32</sup> The question is: how do we achieve this goal?

### Exhibit 6

#### Carbon productivity must increase by ten times

Source:  
Beinhocker et al. (2008)



\* Global Insight GDP forecast to 2037, extrapolated to 2050.

### Finding the largest and lowest cost sources of emissions reduction

A first step to answering this question is to look at all of the possible options for abating carbon with existing technologies, or with near-commercial technologies whose performance can be assessed, and ask how much carbon can be abated and at what cost. The potential actions can then be stacked up from least cost to highest cost creating a “cost curve” for CO<sub>2</sub>e abatement (Exhibit 7).<sup>33</sup> The horizontal axis shows the abatement opportunities, ordered from least cost on the left to higher cost on the right, with the width of the bars showing the amount of potential abatement, and the height the average cost per tonne. The lowest cost options are then the ones most likely to increase carbon productivity and thus should be the top priorities for action.



### **Capturing the energy efficiency opportunity**

Analysis by the McKinsey Global Institute suggests that by 2020 energy use could be cut by 20 to 24 percent, and 7.9 billion tonnes of CO<sub>2</sub>e could be saved, through energy efficiency investments that would more than pay for themselves. Large untapped efficiency opportunities exist in the residential and commercial buildings sectors (e.g., building insulation, lighting, appliances, heating and air conditioning), industry (e.g., more efficient motors and manufacturing processes), and transport (e.g., vehicle fuel efficiency – see below). Capturing these opportunities globally would require additional annual investments of \$170 billion, but annual energy savings would ramp up over time to generate over \$900 billion in annual savings by 2020 – a 17 percent annual rate of return.<sup>38</sup>

The prospect of permanently higher energy prices is already strengthening private and public sector incentives for greater energy efficiency (Box 1). High energy prices create an opportunity for governments to accelerate the transition to a more energy efficient economy.

#### **Box 1**

##### **Companies cut carbon and save \$11.6 billion in energy costs**

In 2005 a combined \$11.6 billion in energy cost savings was reported by 43 companies, achieved largely through energy efficiency measures. Four of these companies – Bayer, BT, DuPont and Norske Canada – achieved absolute GHG emissions reductions of more than 60 percent while saving \$4 billion in energy costs. A further 21 companies achieved GHG cuts of 25 percent. Johnson & Johnson, for example, cut its CO<sub>2</sub> emissions by 22 percent from 2003 to 2006 due largely to energy efficiency measures, while growing annual revenues by 27 percent – an improvement in carbon productivity of 64 percent.<sup>39</sup>

##### **Woking Borough (UK) cuts energy use in half**

Between 1990 and 2004, Woking Borough Council achieved a 77 percent reduction in CO<sub>2</sub> emissions and a 51 percent reduction in energy consumption in council buildings. These dramatic reductions were achieved through a range of initiatives, including building a combined heat and power energy station, introducing energy-efficient lighting, setting up energy management systems in buildings, and using solar energy to power pay-and-display parking meters. The Council is also helping local residents and businesses to reduce emissions through a public-private energy service company (ESCO).<sup>40</sup>

##### **Japan's Top-Runner Programme Increases Energy Efficiency**

Japan's "Top-Runner" programme has delivered impressive energy efficiency improvements in a number of product categories ranging from computers to fluorescent lights. Within each product category, the best-in-class is used to construct an efficiency standard which all manufacturers must meet. During the first phase, energy efficiency improved well above expectations in many product categories, with the energy efficiency of petrol-fueled passenger vehicles improving by 23 percent, refrigerators by 55 percent, and room air conditioners by 68 percent.<sup>41</sup>

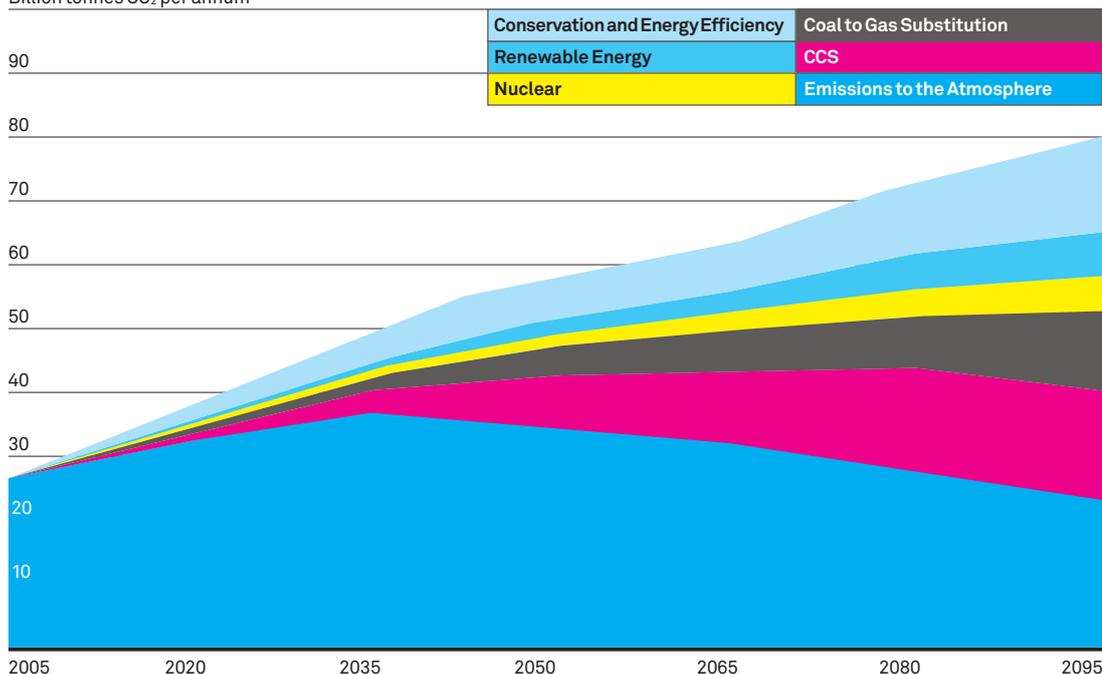
## De-carbonising energy supplies

Overall, low-emissions sources account for only 19 percent of total energy provision today, and most of that is from nuclear, hydro, and waste-to-energy sources. While renewables and biofuels have been growing quickly, they still only account for 1 percent of global power generation and 1 percent of transport fuel demand, respectively.<sup>42</sup>

If the world continues to grow at recent levels, end-use energy demand will increase by 55 percent by 2030 – with 74 percent of the increase from developing countries.<sup>43</sup> Under virtually all credible scenarios, coal will still be a major part of the global energy supply mix for decades to come.<sup>44</sup> In addition to energy efficiency, there are four further critical areas for action if the world is to decarbonise energy sources at the required pace over the next 20-30 years (Exhibit 8) – a period during which there will be massive new-build in the power sector around the world:

### Exhibit 8

Potential global emission reductions for power sector  
Billion tonnes CO<sub>2</sub> per annum



CCS could achieve a substantial share of emissions reductions needed in the power sector

Source: IPCC (2005), (MiniCAM model)

- ### Carbon Capture and Storage

A critical and urgent priority is accelerating the development of carbon capture and storage (CCS) for coal-fired power plants and other carbon-intensive industrial processes. The largest and fastest growing source of CO<sub>2</sub> emissions in the coming decades will be emissions from coal-fired power stations in China, India and the US.<sup>45</sup> For example, the IEA projects that between now and 2030 China will invest in 1,312 gigawatts of new electricity capacity, 70 percent of which will be based on coal.<sup>46</sup> Under optimistic assumptions, this new coal-based capacity alone will commit China to 5 billion tonnes of increased annual CO<sub>2</sub> emissions by 2030 – more than today's total EU CO<sub>2</sub> emissions.<sup>47</sup> It will be very challenging, if not impossible, to hit significant abatement targets without CCS. The Zero Emissions in Power (ZEP) group in Europe has highlighted the need for 10-12 demonstration plants to be running before 2015 in order to prove the technology at full operational scale. ZEP have estimated the cost of such a project at €6-10 billion.<sup>48</sup> If the technology is proven at scale, Massachusetts Institute Of Technology estimates that it should then be economic at a carbon price above \$30 per tonne.<sup>49</sup> Widespread deployment will then involve massive infrastructure investments – the pipelines required to transport gaseous or liquefied carbon dioxide to sequestration would rival the existing natural gas and oil transport infrastructure.

- ### Renewables

There is significant potential to expand the supply of renewable energy sources (e.g., wind, solar, biomass, tidal). Overall, the IEA estimates that under a mitigation scenario with reduction of CO<sub>2</sub> emissions by 50 percent from current levels by 2050, renewables would account for 46 percent of global power generation, primarily

from wind, solar and biomass.<sup>50</sup> However, achieving this level of penetration will require investment incentives to drive scale, lower costs, and improve performance. High oil prices and carbon pricing would help make renewable technologies cost-competitive. For example, at an oil price of \$80 per barrel and a carbon price of \$30 per tonne, on-shore wind becomes cost competitive with combined cycle gas turbine plants and could multiply its installed capacity five times to 354 gigawatts by 2015, or 8 percent of the world total.<sup>51</sup> Likewise, a number of solar technologies become cost competitive with sufficiently high energy and carbon prices.

- **Nuclear**  
Nuclear currently provides about 7 percent of global energy demand and about 17 percent of total electricity generation. It is an established low emissions technology capable of producing large amounts of base-load power. Nuclear costs are in many circumstances competitive with coal today at about \$48 to \$58 per MWh for nuclear, versus about \$41 to \$59 for coal.<sup>52</sup> If a carbon price is introduced, raising the costs of coal, then nuclear will become even more relatively competitive. However, nuclear remains controversial in many countries and there are uncertainties around long-term de-commissioning and waste disposal costs, as well as concerns over nuclear proliferation and security issues.
- **Coal to gas substitution**  
Modern combined cycle gas turbine (CCGT) plants emit 60 percent less carbon per MWh than coal-fired power. In regions with access to secure gas supplies, this provides another avenue for emissions reduction that could amount to 310 million tonnes of CO<sub>2</sub>e per year in aggregate.<sup>53</sup> However, the economics depend on the price of natural gas relative to coal, the existence of a credible long term carbon price, and the cost of CCS for coal and gas plants. The emissions from CCGT, while lower than coal, are higher than coal combined with CCS, nuclear, and renewables.<sup>54</sup>

Overall, it is clear that there will be no single answer to de-carbonising energy supplies. However, with the right combination of incentives (e.g., carbon price, feed-in tariffs, renewable subsidies) and with substantial investments in development and deployment over the coming decades, it will be possible to create a portfolio of energy supplies that cuts power-sector CO<sub>2</sub> emissions by 71 percent compared to 2005 by 2050, while increasing electricity production by 132 percent – an eightfold reduction in emissions intensity.<sup>55</sup>

### Reducing emissions from transport

Overall the transport sector accounted for 13 percent of total CO<sub>2</sub>e emissions in 2004.<sup>56</sup> There are three strategies for reducing transport emissions:

- **Demand reduction**  
Strategies include improved mass transport and better urban planning (Box 2), road pricing schemes, reducing weight of shipped goods, redesign of supply chains to account for a carbon price (less goods transported and shorter distances), video conference substitution for business travel, and other measures.
- **Fuel efficiency**  
For vehicles, strategies include reducing weight, more efficient engines, and better aerodynamics. Using these techniques, prototypes for one popular model reduced emissions from 176 g/km to 99 g/km, a 44 percent reduction.<sup>57</sup> Hybrid vehicle technology also continues to advance. For shipping there is potential from more efficient engines and hull designs, as well as supplementary power from wind (e.g., rigid, composite sails) and solar sources. Aviation has already seen significant fuel efficiency gains of 20 percent over the past decade<sup>58</sup>, due to high fuel costs as a percentage of operating costs. More efficiencies are possible, though fewer breakthroughs are likely.
- **Biofuels and other fuel substitution**  
Biofuels have an important immediate role in tackling GHG emissions, but they are unlikely to displace the entire global fuel supply. The IEA estimates that biofuels will deliver 6 percent of transport fuels by 2030, although targets of 10 percent by 2020 in several countries will accelerate their use.<sup>59</sup> They must therefore be combined with the policies above as well as technologies such as electric and hydrogen vehicles where low-carbon energy sources are available. Not all biofuels are sustainable – their environmental, social and economic impacts depend on how

and where they are grown and produced. Policies to promote their development and use must incentivise production methods with the lowest GHG emissions across the supply chain and end use. In addition policies are needed to reduce wider environmental and social impacts such as water availability, biodiversity, food prices. Current food-based biofuels can deliver significant reductions in GHG emissions, particularly sugarcane and wheat ethanol. Future biofuels offer greatly improved performance, with higher yields per hectare and lower environmental and social impacts. Such biofuels include ethanol and biodiesel from lignocellulose sources such as agricultural and forestry residues, and fast growing grasses that can be grown on marginal land. However, these are still early in their commercial development with the first plants currently being built.

## Box 2

### Sustainable Urban Planning in Curitiba (Brazil)

The city of Curitiba has used integrated urban planning to develop into an environmentally sustainable city. The city government has focused particularly on planning transport, housing and land-use to cut pollution and improve the environment. Since 1970, residents have planted 1.5 million trees along city streets. Curitiba now has the lowest per capita gasoline consumption in Brazil, thanks to the popularity of its public transport network. Since 1974, traffic in the city has declined by 30 percent while population has doubled.<sup>61</sup>

### Changing behaviours and decisions

To a large extent, carbon emissions are the product of billions of decisions made by individual managers and consumers around the world every day. Shifting to a low-carbon economy will require that consumers change what they buy, and managers what they sell and how they provide their goods and services. As carbon has historically been free, neither consumers nor producers have taken it into account in their decision making. A combination of a carbon price and other measures such as energy efficiency standards, feed-in tariffs, and renewable incentives will be required to start ensuring that carbon impact enters into those decisions. Better information and product labelling will be required to help consumers make low-carbon choices. Both governments and the private sector can also help change social norms around carbon use, just as social norms have changed around smoking.

Behavioural changes can make a significant difference. For example, a major retailer and several consumer goods companies have worked together to shift consumers to “concentrated” laundry detergents with the same cleaning function, but a lower environmental impact. The initiative has thus far saved 400 million gallons of water, 95 million pounds of plastic resin, and 125 million pounds of cardboard, and such products have 20 percent lower CO<sub>2</sub> emissions through their lifecycle.<sup>62</sup> These companies have also educated consumers to lower washing temperatures, saving further energy and emissions. All of this has been achieved with no loss for consumers or the companies – only a reduction in wasted energy and carbon.

### Preserving and expanding the world's natural carbon sinks

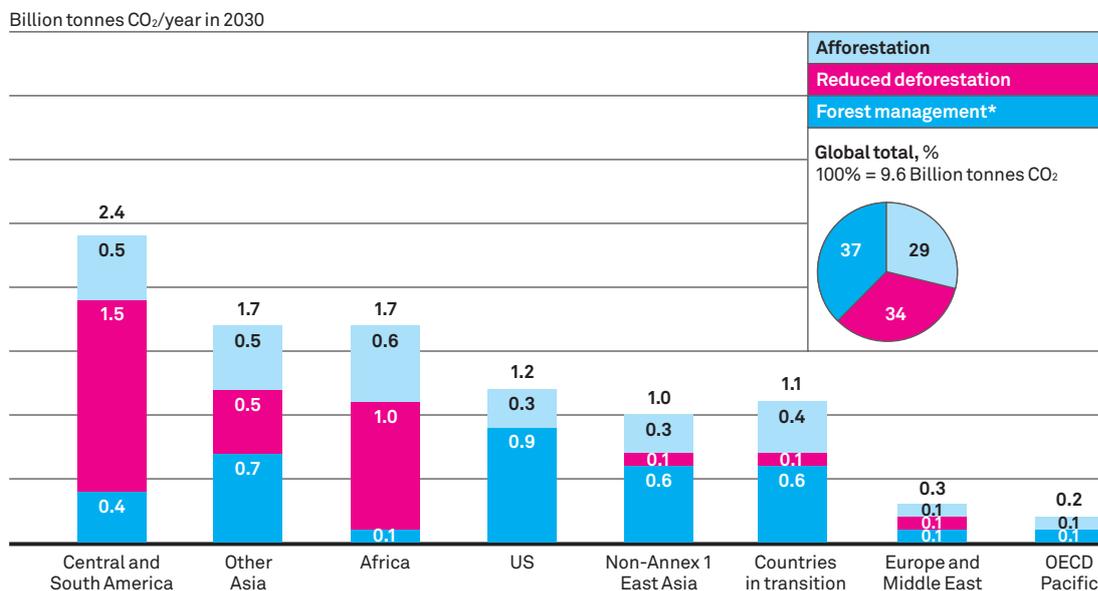
Every year, about 13 million hectares of forests – an area equivalent to the size of Greece – are destroyed. In addition, another 2.4 million hectares are affected by degradation in tropical regions.<sup>63</sup> Brazil and Indonesia alone account for about 35 to 40 percent of net forest area lost in 2000 to 2005.<sup>64</sup> Forecasts of deforestation rates vary, but according to the Millennium Ecosystem Assessment scenarios, 200 to 490 million hectares of forest area could be lost in the developing world by 2050, some 5 to 12 percent of the current total.<sup>65</sup> Deforestation causes significant GHG emissions – an estimated 7.6 billion tonnes of CO<sub>2</sub> per year in 2000, about 15 to 20 percent of all GHG emissions.<sup>66</sup>

There is still much debate about the abatement potential from forests – through reduced deforestation, afforestation, and forest management – though even the low end of the range is large. Regional bottom-up estimates for forestry mitigation potential range from 1.3 to 4.2 billion tonnes of CO<sub>2</sub> per year by 2030 at a carbon price of up to \$100 per tonne CO<sub>2</sub>, with half of that potential achievable at a price of under \$20 per tonne CO<sub>2</sub>. Global top-down models estimate a mitigation potential of 9 - 14 billion tonnes CO<sub>2</sub> per year (Exhibit 9).<sup>67</sup>

## Exhibit 9

**Some estimates put forestry mitigation potential as high as 10 billion tonnes CO<sub>2</sub> by 2030**  
Forestry mitigation potential with costs up to \$50/tonne CO<sub>2</sub>

Source:  
Results of three global forest sector modelling studies as reported in Nabuurs et al. (2007)



\* Maintaining or increasing the carbon stocks of a forest, while producing an annual sustained yield of timber, fibre or energy from it.

There are some encouraging examples of forest preservation. Brazilian pulp and paper company Grupo ORSA has for five years managed the world's largest private tropical forest, just over half the size of Belgium. One-third of the forest is harvested just under the natural regeneration rate and trees are felled and transported so as to cause minimal harm. The efforts are certified by the Forest Stewardship Council every six months.<sup>68</sup>

### Accelerating the development and deployment of next generation technologies

The technologies discussed thus far and included in the cost curve are all either commercially available today or “near-commercial”. With the appropriate incentives, in particular a carbon price, and investment from both public and private sector sources, one can fully expect that improvements in existing technologies would accelerate and new technologies would be developed. In the first quarter of 2008, even without a global carbon price and limited incentives, venture capitalists from around the world put more than \$1 billion of investment into clean energy technologies.<sup>69</sup> Investment in renewable energy went up from \$10 billion to \$66 billion from 1998 to 2007.<sup>70</sup> Although the pace of development and ultimate impact is inherently unpredictable, there is a “next generation” of technology under development today with significant potential (Box 3).

## Box 3

### Promising Technologies

#### Combining carbon capture and biofuel production with algae

Algae can potentially be used in carbon capture and biofuels. Unlike some biofuel sources, it can be cultivated without competing with food crops for agricultural land, and generates high yields per hectare. Yields are enhanced when algae is fed with carbon dioxide emissions from power stations or factories, generating over 100,000 litres of fuel per hectare each year compared to 6,000 litres per hectare from sugarcane, and 3,000 litres per hectare from corn. In pilot installations algae has absorbed up to 40 percent of CO<sub>2</sub> from emissions. Algae can also be grown in non-agricultural environments such as artificial ponds, tubes and on flat plates, thus avoiding competition for land with crops or forests. In addition to government-funded research, a significant number of companies are investing in algae including BP, ENI, Shell, E.ON, Chevron, Honeywell Aerospace and Greenfuel Technologies Corporation.<sup>71</sup>

### **Concentrated solar power (CSP)**

CSP installations covering just 1 percent of the world's deserts, if appropriately linked to demand centres, could theoretically meet the entire world's electricity demand in 2030.<sup>72</sup> This technology uses reflectors to concentrate sunlight and generate heat, which drives steam or gas turbines to generate electricity. The heat can also be stored more efficiently than electricity; CSP installations can therefore generate power at night as well as day. But before CSP can be deployed at scale, the costs need to come down substantially – current forecast electricity costs for plants under construction is \$125-\$225 per MWh. The US Department of Energy has set a goal of CSP becoming cost competitive by 2020, versus high-carbon base-load power. The industry sees this as achievable if 5,000 MW of capacity is built globally. CSP also has other uses, ranging from direct heating and cooling for buildings, to water desalination and hydrogen fuel cell production.<sup>73</sup>

### **Smart grids**

“Smart grid” systems could substantially reduce energy losses across the transmission network (accounting for about 7 percent of all power generation in OECD countries and for 10 percent or more in other regions), enable a more distributed and intermittent (i.e., renewables-friendly) approach to power generation, and facilitate the cross-border integration of power markets (making it easier to export low-carbon energy from sources such as solar and off-shore wind).<sup>74</sup> Smart grids combined with smart meters also have the ability to smooth demand by switching off water heaters and other non-time-critical loads for short periods, in return for a lower tariff.

### **Information and communications technologies (ICT)**

ICT could enable emission abatements of 7.8 billion tonnes of CO<sub>2</sub>e by 2020, mostly through improved energy efficiency. ICT can enable energy efficient building design through modelling and simulating energy consumption.<sup>75</sup> Buildings are being constructed with smart “Building Management Systems” which improve energy efficiency by continuously monitoring the building (e.g., movements, weather) and adapting lighting, heating and air-conditioning in real time. Other examples of ICT-enabled abatement include road charging and traffic flow monitoring, automation of industrial processes, teleworking, and video-conferencing.

## **A new model of growth**

The science tells us what the risks are. Economists, technologists, and business leaders tell us what can be done. The key question then is the cost of transition to this new low-carbon economy, and the wider economic and social impacts. Specifically:

- 1 What will be the impact on growth?
- 2 What will be the impact on jobs?
- 3 What will be the effect on international competitiveness?
- 4 Who will the winners and losers be, and how can we treat the losers fairly?

Clearly, the answers to these questions will be different from one country to the next, depending on the stage of industrialisation, the starting position in terms of the carbon-intensity of their power sector, and population density. Some countries, such as Japan, have built a comparative advantage in energy efficiency programmes, which could be exported to the world. Others, such as Sweden, benefit from low-carbon power sectors and could (in principle) be pioneers in electric transport. Russia and France continue to develop new nuclear power technologies. Brazil, on the other hand, has built up the world's leading biofuels economy. Germany has the world's largest concentration of wind power. While Costa Rica has taken on the task of creating a growth model which preserves rainforests and increases afforestation. All of these “national experiments” are building the evidence base for how to accelerate the transition to a low-carbon economy. But the questions about growth, jobs, competitiveness and costs are still all on the table.

### **Impact on Growth**

The IPCC surveyed a broad range of studies on the costs of mitigation and found estimates ranging from a 1 percent gain to a 5.5 percent decrease in global GDP by 2050.<sup>76</sup> Stabilisation at 445 – 535 ppmv slowed GDP growth by 0.12 percent per year. Such a difference in annual growth rates is in the “noise level” for most economic

forecasts – that is, other general economic factors such as interest rates, inflation, and the ups and downs of the business cycle are likely to play a far greater role in future economic performance than even an aggressive programme of emissions reduction.

It is also important to note that of the scenarios surveyed by the IPCC, the majority were assessed before the recent run-up in energy prices and make assumptions about future energy costs that look low by current standards. Thus on a relative basis, the impact on growth may be even lower than shown by these studies.

To put these costs into perspective:

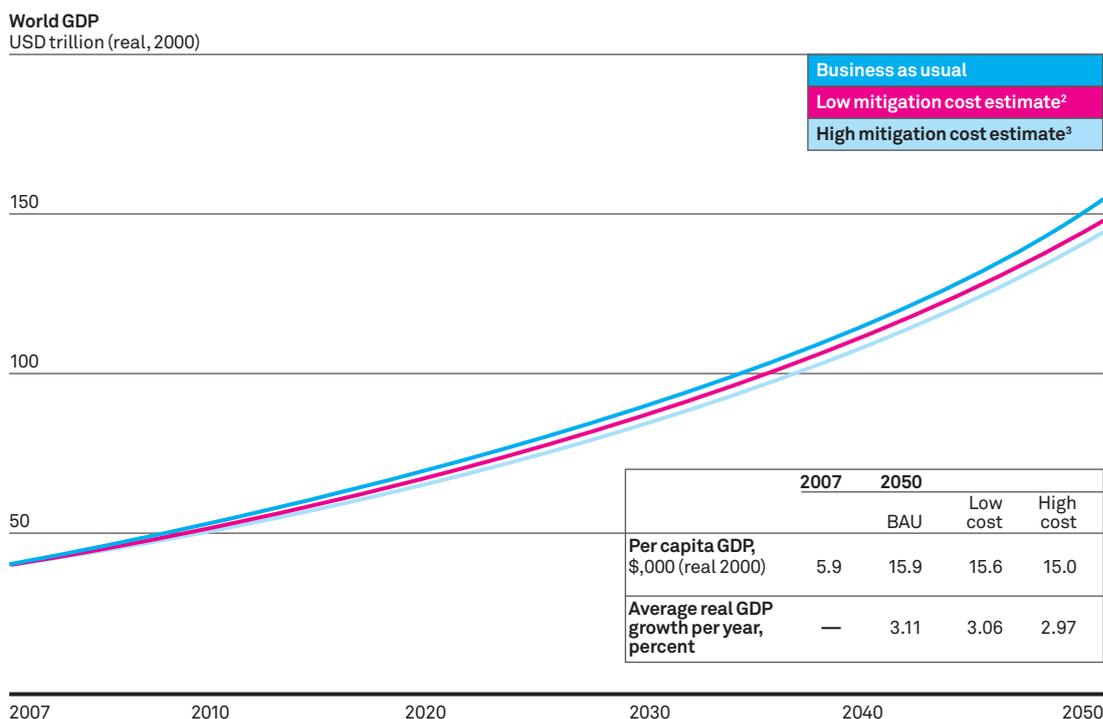
- On average, the US spent about 6 percent of GDP per year on defence during the Cold War (1950-1990)<sup>77</sup>
- Today, the world spends about 3 percent of GDP per year on insurance.
- The estimated global cost of the US sub-prime crisis for the financial sector is potentially up to 2 percent of GDP.<sup>78</sup>
- The estimated global cost of oil increasing from \$40 bbl to \$130 bbl from June 2004 to June 2008 is about 5 percent of GDP.<sup>79</sup>

If one looks at these cost scenarios over time, one sees that there is very little overall difference in economic performance between a business-as-usual economy and an economy transitioning to a low-carbon path (Exhibit 10). Under business-as-usual assumptions world GDP per capita will grow from \$5,900 today to \$15,900 by 2050. Estimates for a low-carbon scenario in 2050 range from \$15,000 to \$15,600 GDP per capita. Thus even in a low-carbon world, people would likely be 2.5 times richer than they are today.

### Exhibit 10

#### GDP costs for mitigation are low relative to overall growth

Source:  
IPCC, AR4 Synthesis Report, 2007;  
Barker and Jenkins, 2007,  
McKinsey analysis



<sup>1</sup> Global Insight GDP forecast to 2037, extrapolated to 2050

<sup>2</sup> 1% of GDP in 2030, 1.8% in 2050

<sup>3</sup> 3% of GDP in 2030, 5.5% in 2050

The impact will differ country by country, but there is no significant evidence that a low-carbon economy is a barrier to growth. For example, US GDP per capita would multiply by 1.74 times between now and 2040 under a low-carbon scenario versus 1.78 under business as usual.<sup>80</sup> China would see its GDP per capita multiply by 6.9 times by 2040 under a low-carbon scenario versus 7.2 times under business as usual.<sup>81</sup> The key message is that for most families in most countries, the costs of transitioning to a low-carbon economy will be modest compared to the impact of other economic factors such as energy prices, interest rates, food and healthcare costs, and the ups and downs of the business cycle.<sup>82</sup> What these families will notice, however, is the impact of storms, flooding, higher food prices, and the spread of disease if we do not take action.

## Why costs are less than feared

There are four reasons why the costs of transition to a low carbon economy are lower than might be imagined. First, the energy and capital infrastructure of the world economy turns over and is replaced every few decades. The world spends \$10.6 trillion per year on capital investment. Shifting this infrastructure to low-carbon technologies will involve some incremental costs, but much of the money would be spent anyway in the course of normal investment – the incremental costs relative to total infrastructure costs are not large. For example, McKinsey estimates that the incremental cost for the US would be \$1.1 trillion through to 2030 – while this sounds large, it is only 1.5 percent of the \$77 trillion in projected real investment during this same period.<sup>83</sup> Second, as noted before, many mitigation actions have positive economic returns due to energy cost savings. Third, also as mentioned before, most of the technologies are commercial or near-commercial today: it is largely a matter of creating incentives through a carbon price and other measures to encourage their development and deployment. And fourth, many changes require shifts in consumer and management behaviour, but little actual cost.

Furthermore, most of the above scenarios make a stringent assumption that mitigation costs are paid for in the year they are incurred. More realistically, much of the incremental cost will be financed over time. This is appropriate given that much of the investment would be in long-lived assets. A power company investing in a new CCS or solar power plant would likely borrow the money to pay for it, just as it borrows to pay for coal plants today. The amounts involved for developed countries would be easily financeable. The US, for example, would have no difficulty financing the \$50 billion per year in incremental investment required through its \$56 trillion capital market.

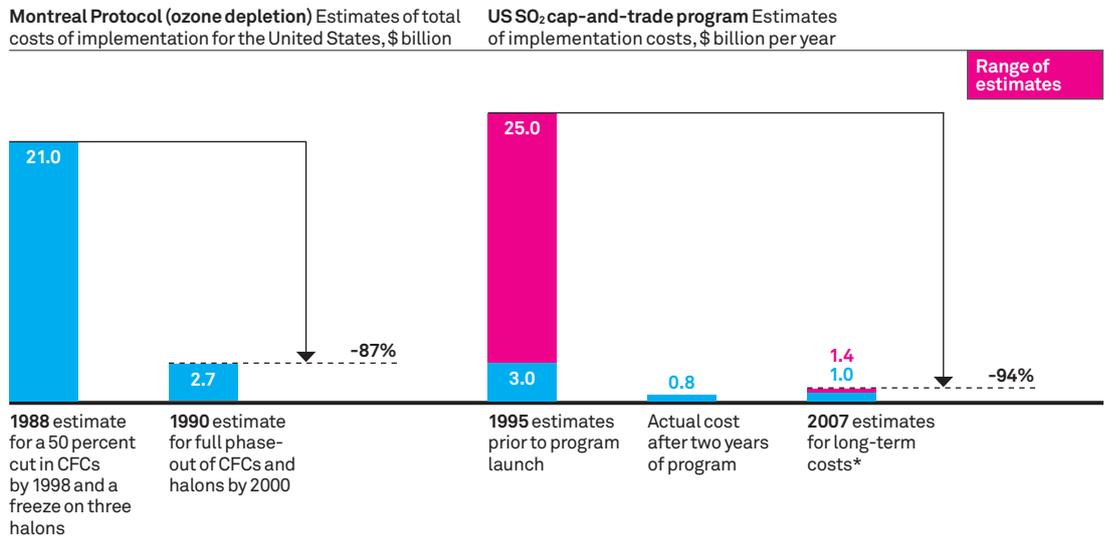
If the transition to a low-carbon economy is financed over time, then GDP growth may actually accelerate, not slow. The new investment to build CCS power plants, renewable energy sources, energy efficient buildings, low-carbon vehicles, and so on, would all boost output and create jobs. If the incremental costs are financed, then there would be little offsetting reduction in consumption of other goods and services; overall GDP would therefore increase.

Finally, history suggests that the costs predicted today are likely to overestimate the actual costs.<sup>84</sup> This is because it is very difficult to predict the response to changed incentives such as a carbon price, and the pace of technological innovation. For example, in 1988 economists estimated the cost to the United States of a 50 percent cut in chlorofluorocarbons (CFCs) at \$21 billion (Exhibit 11). By 1990, after two years of operation under the Montreal Protocol, the estimated cost for a 100 percent cut dropped to \$2.7 billion – 87 percent less than the original estimate for double the abatement. Similarly, estimates for the annual costs of the US SO<sub>2</sub> (acid rain) cap-and-trade program prior to launch in 1995 ranged from \$3 billion to \$25 billion. As of 2007, estimates for the actual long-term costs range from \$1 billion to \$1.4 billion – between 53 percent and 94 percent less than the original projection. CFC and US SO<sub>2</sub> abatement were significantly smaller-scale problems than global carbon abatement. But the same principle – that it is impossible to see all of the innovation and cost reduction opportunities in advance – is likely to hold for carbon as well.

## Exhibit 11

### The Montreal Protocol and the US SO<sub>2</sub> cap-and-trade scheme reduced emissions at lower-than-expected cost

Source:  
Barrett (2003); Burtraw et al. (2005);  
Environmental Defense Fund



\* Long-term costs are higher than short-term costs because in Phase I (1995–99) the program covered only the most SO<sub>2</sub> emission-intensive power generating units, whereas in Phase II (2000–) the program was broadened to cover almost all units.

### Impact on Jobs

There is an argument that the low-carbon economy will cost the world jobs. The evidence suggests that the low-carbon economy is likely to create more jobs than it will destroy. Clearly, there are some high-carbon industry sectors that will be adversely affected. However, there are also many examples of companies growing and creating employment in low-carbon sectors (Box 4):

- 1 Renewables already employ at least 2.3 million people globally and 170,000 jobs were created in 2006 alone.<sup>85</sup>
- 2 In China, it is estimated that the renewables sector already employs almost a million people, over 60 percent of them in solar thermal manufacturing and services.<sup>86</sup>
- 3 In India, biomass gasification is estimated to have potential for creating about 900,000 jobs by 2025 in gasifier stove manufacturing, biomass production and processing, supply chain operations, and after-sales services.<sup>87</sup>
- 4 In Germany, 25,000 jobs were created and 116,000 more saved during the first half of this decade in a home retrofit project by the German Alliance for Work and the Environment, a collaborative effort by the government, unions, NGOs and employer federations.<sup>88</sup>

The crucial question, however, is the net effect on employment, and there is evidence that this can be positive. A research group at the University of California, Berkeley modelled a scenario where 20 percent of US electricity demand in 2004 was covered by renewables (solar, biomass, and wind) by 2020 and found that this would lead to the net creation of 78,000 to 102,000 additional jobs (depending on the shares of different renewables) – an increase of 91 to 119 percent compared to a situation where that demand was covered by coal or natural gas.<sup>89</sup>

### Box 4

#### Broad Air Conditioning (China)

As incomes rise in the developing world, the demand for air conditioning is exploding, creating a new source of GHG emissions. Broad Air Conditioning, a Chinese company, sells air conditioning units that result in less CO<sub>2</sub> emissions than conventional units and are up to twice as energy-efficient. The technology behind this is “nonelectric refrigeration”, in which a liquid is heated, boiled and then cooled so the vapours condense and cool their surroundings. The unit can be fuelled by local energy sources such as natural gas, avoiding increasing peak loads on the electricity grid. Broad Air Conditioning has had significant success in China and other developing countries achieving sales of \$300 million in 2006; it employs 2,000 people, and is growing globally. The company estimates that over the years, it has helped save over 18 million tonnes in CO<sub>2</sub> emissions – an amount comparable to Bahrain’s emissions in 2005 – and over \$12.5 billion of investment in power stations.<sup>90</sup>

## Impact on International Competitiveness

A third concern relates to the risk that some high-carbon, traded sectors such as steel, plastics, cement, glass or aluminium will be unfairly affected by carbon regulation that would be stricter for developed economies than in middle- or low-income countries. Differential carbon regimes would not only distort competition, but could result in production and jobs leaking to low-carbon regimes, thus undermining both economic and climate policy goals.

In some cases, this is a legitimate concern, and any global carbon regime will have to find a way to address it. It is, however, worth noting that:

- 1 The most likely affected sectors represent a small share of global GDP and of jobs – in the US, for example, 3 percent of GDP and less than 2 percent of jobs.<sup>91</sup>
- 2 Only a relatively small share of imports is likely to be affected. For example in the aluminium and steel sectors, only 3 percent and 7 percent respectively of imports to the US come from China. Canada and Europe are the largest source of carbon intensive imports into the US, and would likely be covered similarly under any climate treaty.<sup>92</sup>
- 3 There are other factors (such as technology development, changing consumption patterns, access to primary resources, primary energy costs) which may have a much bigger impact on industry structure and competitive dynamics than the precise specification of the carbon regime.

Also, other studies have found that differences in environmental regulations are a relatively minor factor in production location decisions compared with factors such as access to skilled labour, technology, and customers. Detailed country-by-country and industry-by-industry studies have found little evidence that a carbon price could trigger potential major shifts in production.<sup>93</sup>

This is not to say that there will be no trade impact from an international regime on GHG emissions. Rather, that the impact of any such regime is likely to be modest compared to general trade and economic issues, and can be managed through existing or modified trade adjustment mechanisms.

## Encouraging winners, helping those displaced

There will be some losers, as well as winners, from the low-carbon economy, just as there have been from the much bigger economic dislocations resulting from technology change, globalisation, and the recent sharp rise in energy prices. Given the ongoing restructuring of the global economy over the past 30 years, much is known about the best interventions to help smooth adjustments to new economic realities. They involve targeted interventions to stimulate new uses for existing assets, to accelerate skills retraining for affected workers, to stimulate R&D, and to encourage the creation of new growth engines rather than protecting sunset industries. There is every reason to believe that such approaches can be adapted to the transition challenges of adjusting to a low-carbon economy.

We may also need to adjust our perceptions of who is likely to “win” and who is likely to “lose”. Consider just one example. The introduction of carbon capture and storage technology in the US will require the investment in a pipeline and storage infrastructure, roughly the size of the existing oil and gas sector. Not only will steel companies benefit hugely from a sustained phase of increased investment demand, but the oil and gas sector may find opportunities too. Many of the same core skills used to extract and transport oil and natural gas would be used to transport and store carbon. In fact, it may be that the “high-carbon sectors” of our economy, with their experience with energy technologies and infrastructure construction and management, end up benefitting rather than losing from the transition.

In many ways, the transition to a low-carbon economy would be similar to other major economic transformations. Both the Industrial Revolution and the Information Technology Revolution were “expensive” in that they involved lots of new investment in infrastructure and technology – but they both also drove growth and major improvements in people’s lives. When we look back in 25 years time, there is a good chance that we will see the low-carbon revolution in much the same way as we see the internet today – creating entire new industries and enhancing the rate of productivity growth across the economy as a whole.

## [Increasing energy security and international security](#)

With rapidly growing global demand for energy, questions about the long-term future of supplies, and the concentration of oil and gas deposits in some of the most politically unstable parts of the world, increasing energy security has risen to the top of many national agendas. We now have an enormous opportunity to align the energy security and climate security agendas.

If one looks at the changes to the energy sector that GHG abatement requires, 97 percent of carbon mitigation either supports greater energy security, or at worst is neutral on energy security.<sup>94</sup> About 50 percent of potential abatement actions such as energy efficiency measures, increased renewables, use of domestic biofuels, nuclear, and biomass power generation result in increased energy security. Approximately 47 percent of abatement, including CCS, forestry, agriculture, and imported biofuels, is neutral to energy security concerns. The only significant abatement lever that would decrease energy security is substituting natural gas for coal, but that accounts for only 3 percent of potential abatement.

Addressing climate change would thus be overwhelmingly positive for increasing energy security. However, the logic does not work in reverse – pursuing energy security is not automatically good for climate change. If domestic coal is substituted for imported oil and gas, that could increase annual CO<sub>2</sub>e emissions by 0.6 billion tonnes globally. Likewise, if more coal is liquefied, again to substitute for oil and gas imports, that could increase emissions a further 0.6 to 1.2 billion tonnes.<sup>95</sup>

It is critical, therefore, that the energy security and climate security agendas are pursued together. Energy security pursued in isolation could result in accelerated climate change. But thoughtful policies to address climate change will result in greater energy independence, greater diversity of supply, and less economic exposure to volatile oil and gas prices – a win-win for both climate and energy security.

Greater energy independence would have particular benefits for the developing world, whose citizens are often the most negatively affected by energy price increases. A transition to a low-carbon economy could significantly enhance developing world access to energy, especially in rural areas where over 2 billion of the world's poorest people live and work. Many of the new energy technologies (e.g., wind, solar, biofuels, combined heat and power) can be deployed in a much more decentralised, “local energy loop” fashion. This decentralisation of energy could provide the basis for a profound increase in rural productivity, helping to alleviate poverty and, at the same time, to slow down urbanisation to a more manageable pace.

Finally, we can view addressing climate change as a priority to improve international security. Military planners are increasingly beginning to see climate change as a potential source of national security risks. A panel of eleven of the most senior retired generals and admirals in the US recently concluded that “global climate change presents a serious national security threat which could impact Americans at home, impact United States military operations and heighten global tensions”.<sup>96</sup> This is not a theoretical future threat – the UN estimates that all but one of its emergency appeals for humanitarian aid in 2007 were climate related.<sup>97</sup> Some have called Darfur the world's first climate war.

In a recent report on climate change and international security, the European High Representative and European Commission concluded “climate change is best viewed as a threat multiplier which exacerbates existing trends, tensions, and instabilities.”<sup>98</sup> The report identified seven specific security threats presented by climate change:

- 1 Conflict over resources
- 2 Risk to coastal cities and infrastructure
- 3 Loss of territory and border disputes
- 4 Environmentally-induced migration
- 5 Situations of fragility and radicalisation
- 6 Tensions over energy supply
- 7 Pressure on international governance

If we do not take action on climate change, it is almost certain that part of the adaptation cost we will have to pay will be increased defence and other national security expenditures, as well as the human costs of climate-related conflict.

## [Adapting to existing and future climate change](#)

While the agenda outlined in this chapter would drive substantial mitigation, even if the world was to take radical action now, ongoing temperature rises and momentum in the climate system mean that we will almost certainly see significant, adverse climate change over the coming decades.<sup>99</sup> We must develop and implement a programme to systematically begin adapting to the changes that are likely to come.

Billions of people will be affected by climate change. Studies show that it will be the poorest and most vulnerable people who will bear the brunt of the impact, but wealthy countries will not be immune either.<sup>100</sup> More than a sixth of the world's population live in glacier or snowmelt-fed river basins, where water supplies are likely to become more erratic. Over a billion people currently live in coastal regions, a population which could grow to over 5 billion by 2080 and will be significantly threatened by rises in sea level. While water availability may increase in higher latitudes and wet tropics, semi-arid areas like the Mediterranean Basin, western US and southern Africa are likely to become drier, and droughts will increase.<sup>101</sup>

A whole range of strategies from building improved coastal defences to developing drought-resistant crops will be needed to help the people and communities affected by climate change already under way. There must be much more serious consideration of the risks involved in building on flood plains, and of the need to halt deforestation to prevent flooding. Communities most at risk from extreme weather must be helped to put in place systems to warn their citizens, as is happening in Bangladesh. Effective safety nets must be provided through both local insurance systems and global reinsurance models. In addition we need new forms of “micro-insurance” for lower-income families.

There is still a wide range of estimates of the costs of adaptation – from tens to hundreds of billions of dollars per annum in additional investment that is incremental to “business as usual” financial flows and existing overseas development aid.<sup>102</sup> One thing is certain – the longer we fail to address the challenge of reducing carbon emissions, the higher the costs of adaptation will be, and we will face more changes in climate that cannot be adapted to.

## [Waiting is both risky and expensive](#)

Critics in the climate change debate have noted that while the scenarios described in this chapter are indeed sobering, there is much uncertainty about the future evolution of the climate and our impact on it. They maintain that it is also possible that while the planet will get warmer, the changes will not be nearly as dramatic as those described.

Forecasting the future of a system as complex as the climate is an inherently uncertain exercise. The reports of the IPCC are couched in appropriately cautious terms and note where there is debate over evidence and key uncertainties in forecasts. Critics argue that the costs of addressing climate change will be expensive, certain, and near-term, while the risks are uncertain and longer-term. Therefore, they argue, we should wait to act until we have more certainty over climate effects and until the costs of low-emissions technologies are lower. There are six problems with this argument, however:

First, the science so far has tended to err on the side of conservatism. In general, as scientists have learned more about this issue, the results have become more concerning, not less. For example, the 2007 IPCC report significantly raised the threat level from the previous 2001 report.<sup>103</sup>

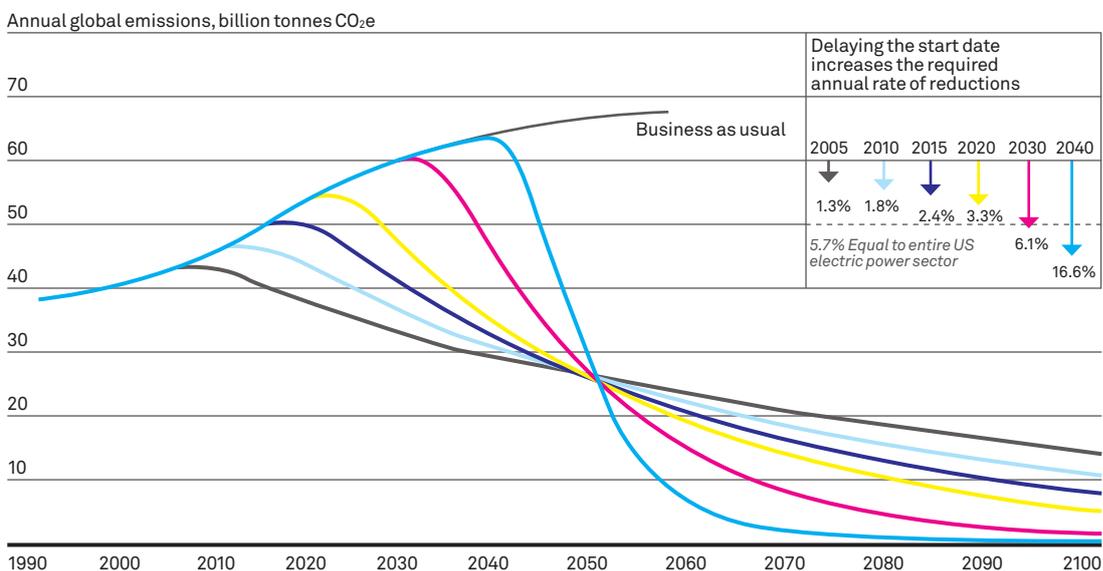
Second, by the time we have certainty it will be too late. By the time temperatures rise above 2°C and we begin to see the impact of such warming, it may be too late to reverse it. The climate system has significant momentum to it, and the tipping points described before are such that we cannot wait until they are reached.

Third, the longer we wait, the more expensive reducing emissions will be. There will be less time for businesses and consumers to adjust; more infrastructure must be changed out before the end of its lifecycle; and the abatement path will have to be steeper. For example, studies have shown that delaying the start of emissions reductions from 2010 to 2020 could almost double the annual rate of reductions required (Exhibit 12).<sup>104</sup> Furthermore, delaying action will reduce the incentives to develop and deploy new technologies, thus raising the overall costs of mitigation.

### Exhibit 12

**Urgent action is needed to avoid deeper cuts in the future**  
 Pathways for global emissions that would yield at least a 50 percent chance of avoiding 2°C warming

Source:  
 Keohane and Goldmark (2008)



Fourth, as emerging markets in China, India, Russia, Brazil, and the Middle East enjoy rapid growth, they will make major investments in power generation, transport systems, industry, buildings, and other infrastructure over the coming decade. Once it is built, much of that infrastructure will have a long lifetime and be expensive to replace. The world has a short window of opportunity to determine whether that infrastructure is built using low- or high-emissions technologies. These countries already account for one third of emissions today and their emissions are growing at 4.3 percent per year.<sup>105</sup> If that infrastructure is built with high-emissions technology, then a significant overshoot is more likely and returning to a 450 ppmv path will be far more expensive, if possible at all.

Fifth, it is important to note that waiting may require steeper and more expensive reductions because of degradations in the world’s carbon sinks. As temperatures rise, the ability of the oceans to absorb CO<sub>2</sub> declines, and the world is also losing a large amount of forest cover each year. As carbon sinks decline, the amount of annual reduction will have to increase by an equivalent amount.

Sixth, and finally, the longer we wait, the greater and more expensive the adaptation challenge will be. Almost all studies show that “an ounce of prevention is worth a pound of cure”. The potential damage from climate change and costs of adaptation rise significantly the longer we delay action on mitigation.

Waiting to take action on climate change will neither reduce the uncertainties nor reduce the costs of acting. Delay will only increase risks and costs. It is prudent to act now.

\* \* \*

Necessity is often the mother of invention. The world needs to develop and implement a new model of low-carbon growth. This will require new technologies, institutions, incentives, and cultural norms – at the community, national and global level. There is real change needed and real costs involved. However, the costs are manageable and the potential benefits are huge – new sources of economic growth, increased energy and international security, new opportunities for both the developed and developing world, and a healthier, cleaner planet.

But realising these benefits and managing the costs will require a concerted global effort through well designed policies. There is a risk that poorly designed climate policies will either be insufficient to address the problem, or impose excessive economic costs, particularly on those least able to afford it. The challenge – addressed in the next chapter – is how to get those policies right and to create the basis for effective collective action.



# Chapter 2

## Developing the Framework for a Global Deal

When negotiators sit down in Copenhagen in December 2009, they will face one of the most formidable political challenges in recent history. They must build on the strengths, as well as address the weaknesses of the Kyoto Protocol, to create a successor treaty that will be agreed to, ratified, and enacted by 191 countries to take firm and decisive joint action on climate change. That is why this year's G8, under the leadership of Japan, is so important.

Over the past 15 years, the UNFCCC (United Nations Framework Convention on Climate Change) and its Kyoto Protocol have established a number of precedents that will inform the Copenhagen negotiations. Furthermore, in December 2007 in Bali, Indonesia, the member nations of the UNFCCC agreed on a roadmap to prepare for the negotiations. Taken together, the UNFCCC, Kyoto Protocol, and Bali roadmap establish four principles that provide a starting point for Copenhagen. First, the recognition that countries should take action "on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities". In other words, developed countries need to lead by committing to binding absolute emission reductions, while developing countries also need to make equitable contributions to help reduce global emissions. Second, a commitment to market mechanisms for abating carbon – specifically to a "cap-and-trade" system that creates a global carbon market. Third, that finance needs to flow from developed to developing countries to support mitigation and adaptation efforts. And fourth, that actions should be "measurable, reportable and verifiable," and for binding commitments for developed countries, enforcement mechanisms are required. In deepening our application of these principles, we must learn from both the strengths and weaknesses of the existing treaties and protocols.

But beyond these general principles, much will be on the table in the months leading up to Copenhagen.

### What success in Copenhagen would look like

In Copenhagen negotiators will undoubtedly walk into the room influenced by the wider global economy, their interpretation of the lessons from Kyoto, their view on the science, perceptions of fairness, their domestic political processes, and beliefs about inter-generational equity.

But despite the natural diversity of these starting points, there is a common set of interests that will bind all of the participating nations together. At the highest level, there are the shared goals of abating global carbon emissions while preserving economic growth. Building on these two over-arching objectives, we can outline a set of more specific goals. A successful outcome in Copenhagen would:

- Launch actions that lead to tangible changes in energy production, industry, and consumer behaviour, rapidly putting the world on a path to peak emissions within the next 10–15 years at the latest, followed by deep reductions consistent with scientific evidence about the maximum "safe" concentrations of CO<sub>2</sub>e.
- Begin the process of adapting the world's infrastructure, human systems, and institutions to climate change already under way, particularly in the most vulnerable nations.
- Enable all member nations to fulfill their aspirations for economic prosperity and energy security.
- Reflect the differential starting positions of countries which, because they are at varying stages of development, are likely to have (a) radically different economically viable pathways to stabilising and then reducing CO<sub>2</sub>e emissions; (b) different potential costs of carbon abatement; (c) different levels of financial resources to make the transition; (d) different abatement challenges in the context of their wider development goals; (e) different levels of institutional capability; and

- (f) different levels of historic responsibility for the current level of CO<sub>2</sub>e concentration.
- Provide strong incentives for countries to stretch their level of commitment over time and join a widening circle of nations pursuing low-carbon growth.
- Create opportunities for effective global action through expanded international flows of financial resources, technology, trade in low-carbon goods and services, and scientific, technical, and policy expertise.
- Respond to new evidence from scientists, economists, technology experts, policy specialists, and others on the risks, costs, and effectiveness of responses – above all, Copenhagen should not be a static treaty, but rather one that creates institutions and policies that evolve as our knowledge of this hugely complex issue evolves.

The remainder of this chapter will consider how policy leaders can, over the coming 18 months, reconcile the agenda of Copenhagen with this vision for success. Given the political and technical complexities of the issues, this is not very much time. Thus the goal of this chapter is to build on the Bali roadmap to help governments focus their deliberations on the key issues, as well as support the academic, NGO, business, and policy communities in their efforts to inform this debate.

We will discuss ten building blocks for the Copenhagen agenda that will be fundamental to achieving an effective, economically efficient, and fair treaty:

- 1 The global target
- 2 An interim target
- 3 Developed world commitments and carbon market mechanisms
- 4 Developing world contributions
- 5 Sectoral action
- 6 Financing
- 7 Technology
- 8 Forests
- 9 Adaptation
- 10 Institutions and mechanisms for action

## 1 The global target

A global long-term 2050 target provides an essential context for discussing the other elements of the global climate deal and serves as a yardstick for setting policies and assessing the success of efforts to cut greenhouse gas emissions.

### Issues

As discussed in the previous chapter, there is a strong scientific consensus that the world needs to cut GHG emissions by at least 50 percent relative to 1990 by 2050, though this baseline remains an issue of significant political contention.<sup>1</sup> This would translate into annual emissions of less than 20 billion tonnes of CO<sub>2</sub>e in 2050 – a 64 percent reduction from today's estimated level of 55 billion tonnes. In principle, such a reduction, if combined with emissions peaking by 2020 and further reductions beyond 2050 for a century or more, would put emissions on a path to significantly reduce the risks from climate change versus the path we are on today.

It is important to note, however, that even though such a target would significantly reduce our risks, it would far from eliminate them. A 50 percent cut in emissions is at the lower end of the 50 to 85 percent range that the IPCC suggests would be needed. At that target level there is still a sizeable chance that temperatures would rise more than 2°C, leaving the potential for far more catastrophic risks.

### Further work and choices

Bearing in mind that the global target will shape other items under negotiation, amongst the key issues that governments will have to resolve before final agreement can be reached in Copenhagen are:

- How should the target be expressed (e.g., percentage versus base year, absolute reduction, temperature, concentration level)?
- If a percentage, should the baseline year be 1990 or more recent? What are the implications of the baseline year for national targets?
- Should the target make any reference to distributional equity? For example, 20 billion tonnes globally could also imply approximately 2 tonnes per capita by 2050.<sup>2</sup>

- What are the institutional mechanisms necessary to create confidence that the target will be met, so helping reduce uncertainty for governments and businesses making long-term decisions?
- What is the process for adjusting the target if scientific or economic knowledge changes significantly?

## 2 An interim target

While a long-term target sets the overall context, an interim target, or targets, will ensure that we are on the right pathway and will send clear short- and medium-term investment signals.

### Issues

Given there will be almost four decades between the treaty going into effect and 2050, there obviously needs to be a pathway to 2050. This raises the question of an interim target. As discussed in the previous chapter, most long-term emissions reduction scenarios show emissions rising in the near-term, peaking, then falling. Thus one approach is to call for emissions to peak by a certain date. For example, Exhibit 2 (shown in chapter 1) portrays a scenario where global emissions peak by 2020 and then fall to 50 percent versus 1990 by 2050.

Some might say that a big cut in emissions by 2020 by the developed world is too steep a prospect – it is too soon. The problem with an alternative that sets a less demanding interim goal is that it might not sufficiently constrain peak emissions. If the peak is higher and/or later (e.g., 2025), then to keep temperatures from rising too high, emissions would have to be cut more steeply later (e.g., deeper than 50 percent by 2050).

Another approach would be to use a series of five year commitment periods (a Kyoto mechanism), e.g., 2013-2017, 2018-2022, and so on, measuring average emissions during those periods. An initial global path could be established in Copenhagen and then reviewed at the end of each five year commitment period based on performance and current science and economic evidence.

The key is to set a path to the global 2050 target that is both realistic and consistent with climate risks at an acceptable level, and then to create a set of institutional and interim targeting mechanisms to constrain the parties to that path.

### Further work and choices

The interim target will have to combine a series of factors:

- What is the right interim target date – 2020 or later?
- How should the interim target be expressed? Percentage versus baseline year? Which year? Absolute reduction?
- What are the implications of the interim target for other provisions of the deal (e.g., developed country reductions, evolution of developing country commitments)?
- What are the further interim targets that should be examined?
- As with the long-term goal, what is the process that can update target(s) as progress is made and more knowledge is gained?

## 3 Developed world commitments and carbon market mechanisms

It is widely accepted that industrialised countries will have to take the lead by committing to absolute emissions reductions beyond those agreed under Kyoto, linked to the contributions made by developing countries. Essential to delivering on these commitments will be the role of carbon market mechanisms backed by national action plans. Many countries will have national markets, all will participate in the global market.

### Issues

#### Setting developed country caps

Given that developed countries are largely responsible for the climate problem (approximately 70-80 percent of the cumulative stock of CO<sub>2</sub> created between 1850 and 2002 was emitted by the developed world)<sup>3</sup> and have the most financial and technological resources to address it, the UNFCCC established the principle

that they should take the lead in reducing emissions. In the Kyoto Protocol, developed countries committed to national binding emissions caps aggregating to 5 percent below 1990 levels by 2012. Individual country caps ranged from +10 percent to -8 percent.

It is also expected that in Copenhagen, developed countries will commit to binding national caps assessed over five year commitment periods. However, the developed country reductions recommended by the IPCC are now significantly steeper than those agreed in Kyoto – 25 to 40 percent versus 1990 by 2020, and 80 to 95 percent by 2050 (Exhibit 2, shown previously, provides an illustration of what the less-aggressive end of this range might look like).<sup>4</sup> Such targets would require a significant and rapid deviation from current rates of emissions growth. For example, US emissions have grown 16 percent over the past fifteen years, and to meet this target range they would have to fall by 35-48 percent over the next 12 years.<sup>5</sup> Likewise, Japanese emissions have risen 7 percent over the past 15 years and would have to fall 30-44 percent over the coming 12 years.<sup>6</sup>

Thus the same questions about defining and setting long-term and interim global targets also apply to the cap for the group of developed countries. Specific national caps would then be determined through an assessment of the mitigation potential, costs, and capabilities for each country, and ultimately through negotiation.

### **Developed country action plans**

It will also be essential for the credibility of these targets that they are backed up by national action plans that lay out specific strategies for meeting cap commitments. Such plans are usually discussed in the context of developing countries, but could also be a valuable tool in helping developed countries assess their mitigation strategies, and would provide further transparency and information to participants in the carbon market. The plans, for example, would show what mechanisms are being employed in pursuit of reductions (e.g., national cap and trade system, national sector plans), what efforts are being made to develop and deploy technologies, emissions projection scenarios, and so on.

### **Defining “developed countries”**

There is a further question as to which countries should be included in the “developed” group. The world has clearly changed since the Annex I list of developed countries was established in 1992, and the Kyoto Annex B list in 1997. Thus a critical question will be which countries, and by what criteria, will be assuming binding national caps under a Copenhagen agreement.

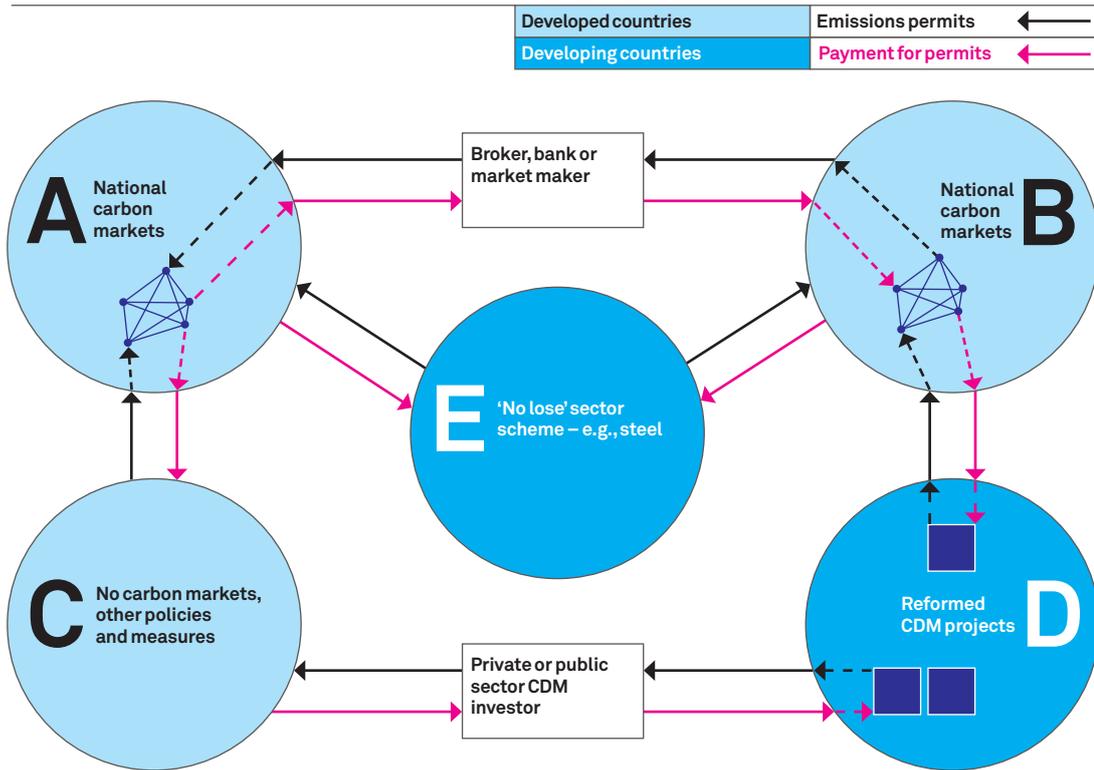
### **Establishing carbon markets**

A key feature of the Kyoto Protocol is that it enables countries under cap commitments to trade emissions permits with each other. Thus a country over its cap can buy permits from a country under its cap. Such a cap-and-trade system significantly reduces mitigation costs by enabling countries to seek emission reduction opportunities wherever they are least expensive. It is likely that Copenhagen would build on and extend this system.

Exhibit 13 provides an illustration of how such a system might work, with trading of emissions permits between developed countries (denoted A, B, and C). In the diagram country A is a net buyer of permits because such purchases from other countries are less expensive than taking the same mitigation domestically. Some of the developed countries in the system may have national carbon markets as well (A and B), while some may not (C). Developing countries also participate in the market. For example, country D is participating in an updated version of the Clean Development Mechanism (CDM – see below), while country E is participating in a “no lose” sectoral scheme (see section 5). Intermediaries such as brokers, banks, and market makers might also participate, as could private and public sector investors.

A growing number of national governments and regions have or are considering national cap and trade systems, e.g., the EU ETS, proposed systems in the US and Australia, and Japan’s recently announced “Fukuda Vision” to launch an emissions trading scheme by autumn 2008. Such systems have the potential to be a highly effective policy tool for achieving national targets; however, a critical question is how they might be integrated into a global carbon market. Studies estimate that a truly global carbon market could cut abatement costs by 50 percent.<sup>7</sup>

Source: McKinsey analysis



A further question is whether international trading should remain country-to-country, or whether the global system should evolve to company-to-company trading (company-to-company trading currently occurs within national or regional systems). International company-to-company trading would create a more liquid market and reduce costs, but would also reduce government control over meeting cap commitments. There is an analogy to the evolution of the global currency markets. Until the 1970s, currency trades were largely carried out country-to-country. With the fall of capital controls in many economies, currency trading between companies and individuals grew rapidly. This created a truly global market and greatly increased economic efficiency, but reduced national control over exchange rates and reserves. Just as international currency markets have needed to develop national and international institutional structures and regulatory regimes as they have globalised, so too would carbon markets.

**Reforming the Clean Development Mechanism**

Finally, another key element of the Kyoto market is a feature that enables developed countries to obtain emissions credits by investing in abatement projects in developing countries – the “Clean Development Mechanism” (CDM). As the cost curve in the previous chapter showed, over 40 percent of low-cost abatement opportunities are in the developing world. The CDM is a win-win in that developing countries benefit from investment flows while developed countries get access to lower cost abatement opportunities than they might have in their domestic markets alone.

The complexities of administering the CDM have, however, limited its ability to scale up and the investment flows it has stimulated have been a modest \$7.4 billion to date.<sup>8</sup> This is a small fraction of the financial flows that are needed. There have also been questions about the quality of the avoided emissions it generates. Thus another key issue for Copenhagen is whether and how to reform CDM to enable it to scale better and ensure quality.

**Further work and choices**

There is a complex negotiation under way to determine the level of developed country targets, the comparability of targets, and the means to achieve those targets. This negotiation includes carbon market mechanisms, the inclusion of land-use change and forestry within each country, and other technical issues. In Bali, Kyoto Party developed countries decided to use the 25 to 40 percent reduction range (by 2020), identified in the IPCC, as guidance for the level of ambition of the group.

The most important choices are:

- What is the level of effort that each developed country is prepared to undertake within the 2020 timeframe? There is a range of linked issues including the base year and the end date of the target. While five year commitment periods are useful to ensure countries are on track, longer periods, out to 2020 and beyond, are important to send clear signals to the markets.
- What is the basis for determining caps, given different levels of carbon productivity across those countries?
- Might national action plans be a useful tool for helping developed countries ensure delivery against their commitments? What would be in such plans? Would they be required or simply encouraged? How would they be reviewed and by whom?
- How should the carbon markets work? How can we ensure national schemes are compatible with a Copenhagen market and together evolve into a truly global market?
- How should we define “developed countries”? By what criteria? Should the list evolve as countries progress to “developed” status?
- What is the extent to which countries can meet their targets through purchasing carbon reductions from developing economies?
- How should the CDM mechanism be reformed? How can investment flows and emissions reductions be scaled up dramatically without diluting the quality of emissions credits?
- What are the enforcement mechanisms that would be most effective in the case of non-compliance?
- What is the mechanism to review targets and set future targets beyond 2020, noting the rapid developments in climate science and speed of transition to a low carbon economy?

## 4 Developing world contributions

Alongside emissions reductions by industrialised countries, developing countries will need to contribute to slowing the growth of, and cutting, emissions. These contributions – and their timeframe – will need to reflect differential shares of emissions and capacities, and the incentives that can be provided. Undertakings to make these contributions should be specified in national action plans.

### Issues

While the principle that developed countries must lead is generally accepted, it is also clear that dangerous levels of climate change will not be avoided without strong action by developing countries. Over half of current emissions come from developing countries and are growing rapidly. As illustrated in Exhibit 2, if developed countries begin cutting immediately, developing countries can continue to grow emissions for another decade, but then would need to see emissions peak in order for global emissions meet a target of 50 percent by 2050. The IPCC has said that developing countries, particularly in Latin America, the Middle East, and East Asia, need to achieve “substantial deviations from baseline” by 2020.<sup>9</sup>

At present, national caps are not on the table for developing countries as they would be viewed as an unfair burden on countries which have less historical responsibility for the problem; poorer citizens who aspire to the living standards of the developed world; and fewer financial and other resources to transform their economies. Nonetheless, most developing countries recognise the role they must play to help address the climate issue, and the risks they run if climate change is not addressed – it is the poorest countries who would likely suffer the most. Thus other tools are required to help developing countries make equitable contributions to emissions mitigation.

The approach envisioned in the Bali roadmap is “Nationally appropriate mitigation actions by developing country Parties in the context of sustainable development, supported and enabled by technology financing and capacity-building, in a measurable, reportable and verifiable manner.”<sup>10</sup> One could imagine that such “nationally appropriate actions” could be specified in national action plans. Such plans would detail specific investments and actions for a given country to increase carbon productivity and develop sustainably. The plans would provide a basis for partnership between a developing country (where emissions reductions will take place) and the industrialised countries that will be providing financial, technological, capacity-building and other support for those

reductions. The plans would be eligible for significant levels of co-funding (or in the case of the poorest countries, complete funding) over and above current overseas development aid (ODA).

One of the critical debates is whether the group of developing countries should be segmented in some way with gradations of effort. It is clear that a middle income country such as Chile is in a different position from a large, rapidly developing country such as China, which in turn is in a different position from a small impoverished nation such as Burkina Faso. There are various proposals for segmenting countries where the least developed nations would not be required to take on any efforts to reduce emissions as they neither contribute greatly to the problem nor have the resources to reduce emissions. At the other end of the spectrum there is a group of rapidly industrialising nations that would be expected to do more, although with financial and technological support from developed countries.<sup>11</sup>

A related issue is whether, how, and when middle income and rapidly industrialising countries might move from making “equitable contributions” to undertaking binding national caps. Some have proposed schemes whereby countries automatically graduate if they reach certain development criteria. Others have proposed that developing country contributions become commitments over time to encourage emissions peaking by 2020-2030. But some developing countries believe it is inappropriate for them to take on firm commitments until the developed countries deliver on their commitments between now and 2020.

In addition to national action plans, many developing countries would likely participate in the CDM (see section 3) and some countries might participate in sector incentive schemes (see section 5). An important question is what other mechanisms and funding flows need to be created to encourage and support ambitious action by developing countries. The goal is to create a set of incentives to unleash creativity, competition and ambition, transforming developing countries into innovators for a low carbon economy.

### Further work and choices

In the area of developing country contributions, the most important choices are:

- How to differentiate between developing countries in both level of effort and type of contribution?
- What is the appropriate level of effort that each rapidly developing country undertakes in its national action plan? Countries could include national policies and measures such as renewable energy and energy efficiency targets or sectoral commitments.
- How do we implement the measurable, reportable and verifiable clauses of the Bali Action Plan? What might this mean in the context of national action plans?
- What are the types of mechanisms and funds that will best support developing country efforts and increase the level of ambition of those efforts – i.e., that will accelerate their transition to a low-carbon economy?
- In which year and by what criteria do countries graduate from contributions to commitments, in particular into a regime of binding caps? What is the monitoring, measuring and review system needed for developing countries, coupled with the support to develop and implement such systems?

## 5 Sectoral actions

The term “sectors” is used in a variety of ways in the Copenhagen context. Some developed countries might choose to use sectoral approaches as a part of their national policies to help them deliver on their commitments under a carbon cap. There are also proposals for one-sided “no-lose” incentive schemes for developing countries to achieve energy efficiency or carbon productivity targets for high emitting sectors (e.g., power). Finally, questions have been raised as to whether international agreements might make sense for certain sectors.

### Issues

National-level strategies on sectors may be a useful tool for ensuring abatement performance, particularly for countries with strong industrial planning traditions, or for highly regulated sectors (e.g., again, power). However, it is important that these be seen as a policy for supporting national caps (not a replacement) and are used as a complementary tool for achieving those caps, along with carbon markets and other mechanisms.

One-sided “no-lose” sector incentives for developing countries offer the potential to scale up investment flows and abatement beyond what can be achieved with project-based CDM. Such incentives could reward improvements in energy efficiency, carbon productivity, or actions to de-carbonise energy sources; they could take the form of emissions credits to be sold on the carbon market, or cash payments. A sectoral scheme based on emissions credits would in effect create incentives for developing country sectors to “join” the global carbon market. The key issues are (a) administering such schemes; (b) ensuring that achieving the targets translates into real emissions reductions; and (c) ensuring the flow of credits does not become so large that the price in the carbon market collapses.

The idea of international sector agreements is more controversial. International sector agreements have been discussed as a vehicle for ensuring comparability of effort between developed and developing countries and creating a level playing field for trade. For example, an international agreement might set some common goals for energy efficiency or carbon productivity in steel, aluminium, or cement. This would help ensure some degree of convergence on low-carbon production methods, even though each sector is spread across developed and developing countries. Some developed countries, however, express concern that international sector agreements could be used as a substitute for or to weaken national caps. Some developing countries, on the other hand, express concern that such agreements would in effect put much of their economies under a binding cap before it is fair or practicable to do so.

There may, however, be benefits if countries pursuing sector schemes (either as national policy or as part of an incentive mechanism) have some degree of international coordination. Examples might include sharing data on sector performance, cooperating on industry best practice, or sharing technologies that enable sector targets to be met. There is, however, one sector that may be a candidate for a specific international agreement. International aviation and shipping (so-called “bunker fuels”) are not currently covered under Kyoto. The fact that their emissions occur in international skies and waters makes them challenging to include in a national cap and trade scheme.

#### Further work and choices

- How might national sector schemes be used by some developed countries to support delivery of their national cap commitments?
- How might a scheme for one-sided sector incentives work for developing countries? What would be the criteria for eligibility? What would the incentives be? How would such a scheme be administered? How would we address potential impacts on the carbon price?
- What types of international cooperation might be beneficial for sector schemes?
- What should be the plan for bunker fuels?

## 6 Financing

There will need to be funding for developing country action plans, technology diffusion, deforestation and for adaptation .

### Issues

In addition to the financial flows towards GHG abatement that will be stimulated by carbon markets, CDM, sector schemes, and other policies designed to drive private sector investment, there are a number of areas where additional investments will be needed, largely in developing countries. A successful outcome in Copenhagen will depend on the ability to create mechanisms that enable these investments to take place in a predictable way at the scale needed.

There is increasing work to estimate the scale of these flows, though there remain significant uncertainties around them. The UNFCCC recently estimated that by 2030 developing countries would need \$19 billion a year for building upgrades, \$14 billion for low-carbon industrial production, \$36 billion for transport, \$28 billion for agriculture, plus an additional sum for research and development.<sup>12</sup> Forestry is estimated to require \$20 billion (see section 8 below), and adaptation up to \$67 billion (section 9).<sup>13</sup> These flows would be in addition to the investments stimulated by carbon markets – though the faster carbon markets expand and the higher the price of carbon, the less non-

market funding will be required. The funding would also be over and above existing Overseas Development Assistance (ODA).

The critical questions are how such funds are to be raised and disbursed. There are three options for sources of funds. First, a portion of the developed country cap could be carved out and the permits auctioned. Auctioning a small proportion of the permits would potentially cover the above funding needs, be linked to the emissions that cause climate change, and not be a direct drain on government budgets. The EU ETS and US legislation are both considering carbon auctions as a method for raising funds. The second option is a levy on developed country emissions or carbon trading transactions (Kyoto currently has such a levy on CDM transactions). Finally, countries could simply increase their ODA budgets, though the required amount makes this unlikely to be feasible on its own. In all likelihood, a mix of all three sources will be required.

The flows envisioned are significantly larger than those handled by multilateral institutions today. New institutions will need to be created to handle the flows, close partnerships forged with existing institutions, and new creative mechanisms developed for working with the private sector. Furthermore, many countries lack the institutions and capabilities to handle the large financing flows required and ensure they are effectively used. National institution and capability building will thus be critical prerequisites for effective funding use.

### Further work and choices

- What are the funding levels required by country and application (e.g., mitigation, adaptation)?
- What is the potential for each of the three funding options and issues associated with each?
- What institutional structures are required for collecting and distributing funds (e.g., a general fund for all Copenhagen monies or multiple funds), as well as funding governance and accountability?
- Would the funding impact be maximised by flows through new institutions, versus partnering with existing institutions, versus private sector institutions?
- How do we create vehicles for national capability building to make effective use of funds?

## 7 Technology

Innovation and technology are crucial for achieving low-carbon development. A new approach to innovation is required in order to develop and deploy new technologies and business models within a given timeframe to avoid carbon lock-in. Action should be centred on harnessing the power of markets to drive innovation, but international cooperation will also be needed to capture the global public good aspects of low carbon innovation and enhance the diffusion of low-carbon technologies to developing countries. Governments must also accelerate the development of critical technologies, in particular carbon capture and storage.

### Issues

The vast majority of technology investments will be made by the private sector and the critical policy for stimulating those investments will be a robust carbon price. As discussed in the previous chapter, at a carbon price above \$30, a number of low-emissions technologies begin to become cost competitive. But carbon markets alone will not be enough. There are four areas where complementary policies and international cooperation in Copenhagen could potentially further accelerate technology development and diffusion.

#### 1 Market expansion

Policies such as energy efficiency standards, utility feed-in tariffs, and government purchasing policies can all expand markets for low-carbon technologies, helping drive them down learning curves and reducing their costs. The Copenhagen process should consider how international coordination on such policies could accelerate technology development (e.g., an international energy efficiency effort modelled on the Japanese “Top-Runner” programme).

## 2 R&D funding

International funding could be applied to technologies that need to be accelerated to meet mitigation goals (e.g., CCS, solar CSP), that require significant public infrastructure investments (again CCS), or public regulatory involvement (e.g., nuclear), as well as funding for basic R&D that private sector companies have less incentive to invest in.

## 3 Diffusion funding and assistance for developing countries

Provide assistance in acquiring technologies on a commercial basis and building capabilities to use those technologies; studies of technology diffusion in developing countries show that such efforts need to be tightly integrated with broader development efforts.<sup>14</sup> Recent examples include the launch by US, UK, and Japan of what is intended to become a \$30 billion fund to support deployment of low-emissions technologies in developing countries.<sup>15</sup> India has also proposed a collaborative network of R&D institutes from developed and developing countries for research on energy efficiency and clean technologies (Cleanet initiative).<sup>16</sup>

## 4 Removal of barriers to diffusion

For example, subsidies for high-emissions technologies, tariffs on low-emissions technologies, and anti-competitive intellectual property (IP) practices (e.g., discriminatory pricing).

On the issue of IP, there are some who would go further than just removing anti-competitive barriers and have proposed an international “protect and share” arrangement. Under such a framework, there would be government-to-government commitments to “protect and share” low carbon technologies and encourage joint-ventures and public-private partnerships. Support would be made available under the R&D and diffusion funds to strengthen IP protection measures in developing countries. Any countries that were found to not robustly protect low-carbon IP would risk having their access to the R&D and diffusion funds blocked. Such a framework would use technology roadmaps to identify critical technologies and establish licensing criteria that encourage rapid diffusion.

### Further work and choices

- What is the feasibility of creating an international energy efficiency programme modelled on principles similar to Japan’s Top-Runner programme (see chapter 1)?
- How do we identify priority technology funding needs and establish funding mechanisms to meet those needs?
- What is the best way of providing diffusion funding and assistance that is closely integrated with overall sustainable development agendas?
- What is the potential impact of IP schemes such as “protect and share” on technology diffusion and IP creator incentives?

## 8 Forests

A separate and discrete action plan will be required to reverse deforestation and to build carbon sinks.

### Issues

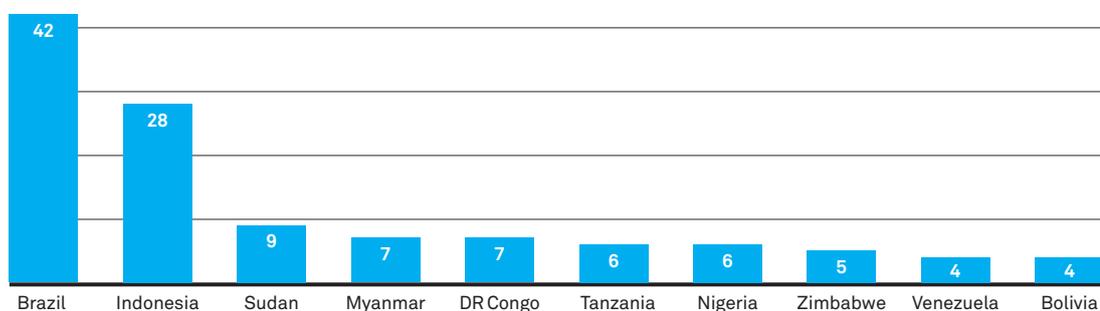
As discussed in the previous chapter, deforestation is responsible for 15-20 percent of all GHG emissions. Reducing emissions from deforestation and degradation (referred to as REDD), together with afforestation, offers significant abatement potential. Indeed a global climate deal will not be successful without strong action on forests.

There are a variety of proposals for addressing forests. These range from including forests in emissions trading thus creating economic incentives to avoid deforestation, to funding programmes to support reforestation, to better forest management, to alternative livelihoods for current forest-users.

The challenge is that the world's largest forests are concentrated in developing countries populated by some of the world's poorest people (Exhibit 14). Forest management involves complex economic challenges in providing incentives to preserve forests and creating alternative economic opportunities, as well as complex institutional challenges in monitoring and enforcing forestry regimes over immense areas.

## Exhibit 14

Millions of hectares of forest loss 1990–2005



**Tropical countries with greatest loss of forest cover**

Source:  
FAO (2005); McKinsey analysis

Few countries have the capacity to measure and monitor their emissions, let alone the ability to enforce laws to reduce deforestation. It will thus be essential to craft these systems to create “investment ready” forest projects. If investors are not able to document the results clearly, it will be difficult to attract the necessary funds. Proposals also need to be developed and pilots created to show how new funding from a forestry programme might be successfully applied. Both national and international institutions need to be built and strengthened to support such forestry efforts.

### Further work and choices

- Should forests be included in market mechanisms? What would be the likely effectiveness for forests, and the impact on the broader carbon market (e.g., quality, price of emissions permits)?
- What is the right programme-based funding mechanism, and what are the likely funding needs, sources, and institutional structures?
- How do we determine country-by-country institutional and capability needs and create mechanisms to provide funding and support?
- What is the best way to review global measuring and monitoring capabilities? What support is necessary?

## 9 Adaptation

As the IPCC has concluded, climate change is occurring now, and will likely continue even with urgent action to cut emissions. Some degree of adaptation will thus not be a choice but a necessity. The IPCC has further identified developing countries as the most vulnerable to climate risks, in particular due to likely impacts on food security and water security. Adaptation has not received the attention it should have, yet it will be a large part of the deal in Copenhagen. While the Adaptation Fund of the Kyoto Protocol is now becoming operational and funded by a levy on the CDM, it is clear that its scale is far too small.

### Issues

The Bali Action Plan envisions action on adaptation as an integral part of the Copenhagen deal. The Adaptation Fund in the Kyoto Protocol is a first step to address the issue. However, up until this point, the issue of adaptation is split across the UNFCCC and the Kyoto Protocol, with no overarching framework to pull those programmes, small as they currently might be, together with some of the larger needed efforts in the areas of disaster relief, health and food security. The Adaptation Fund, under the Kyoto Protocol, is only now getting up and running. There is, however, as yet no plan for how to coordinate or manage the massive issues that emerge from adaptation; and very little capacity, particularly in developing countries, for thinking through what this means practically for development planning and implementation. There is also currently little confidence amongst the donor community that if the billions are raised, the funds will be applied to the most urgent and critical needs.

While developing countries point out that action on adaptation needs to be integrated with development agendas, they note that adaptation should be viewed as incremental to development assistance (e.g., assistance in recovering from flooding induced by climate change should not detract from support for development). They worry that they will be facing reduced overseas development aid at the same time as having to find the funds to cope with the increased floods and droughts that are forecast. Overall funding requirements have been estimated at \$28–\$67 billion per year in financing to developing countries by 2030.<sup>17</sup> But, as the range of the estimate shows, significant work remains in determining detailed funding requirements. Work remains, too, on the institutional arrangements for distributing funding and ensuring it is most effectively used.

Further effort is required to flesh out bolder proposals such as a global insurance programme, both on the micro and macro level. Least developed countries are the most at risk from climate impacts, due to limited infrastructure and resources. Financial risk instruments help pool and share risk and can either be applied as stand-alone financing instruments that provide effective risk coverage, or as elements of micro-credit products that bring far greater access to financing. Scaling up such insurance-based approaches could complement more traditional weather-related disaster strategies and financial mechanisms.

### Further work and choices

- What is the level of funding needed for adaptation and what should be the mechanisms for raising that funding?
- What are the institutional arrangements required to distribute and create accountability for funds? For example, it might make sense to create a Global Adaptation Framework that incorporates the range of institutions currently working on the various areas included in the adaptation debate (developing country governments, Food and Agriculture Organisation, World Health Organisation, Red Cross, etc.) and devises a plan for how to respond in real time to real needs. These needs can be identified in National Adaptation Plans of Action.
- What are the measures to ensure that capacity exists on the ground to identify the risks and plan ahead? The Framework should include regional centres of excellence, including national universities and research centres in developing countries, to study the potential impacts on the regional, national and local scale and advise governments.
- What is the potential to create global insurance and micro insurance schemes, and how might they work?

## 10 Institutions and mechanisms for action

It is clear that there will need to be new institutions and mechanisms to make a global deal work. But they need not be centralised, and they need not be conventional bureaucracies. There is real scope for public/private partnerships.

### Issues

One of the most significant challenges, both in Copenhagen, and for the wider implementation of a comprehensive international climate policy framework, will be to strengthen the UNFCCC, and design and agree on the institutional arrangements that will carry out the treaty's policies and deliver on its objectives. The scale of financial flows, the need for monitoring, reporting and verification, and the complexity of the network of policies, measures, markets and incentives require these arrangements to be agile, efficient and well-resourced. Likewise, it is crucial that these institutions allow the framework to evolve without requiring major political interventions and potential logjams at every step.

It is clear that a framework based exclusively on current UN and Bretton Woods institutions is unlikely to be able to meet this challenge. While the UNFCCC will continue to have a core role, new institutions will need to be developed for areas such as carbon market oversight, and funding for technology, forestry and adaptation. It will also be important to make use of the academic community, NGOs, local governments and other decentralised structures; and to draw on successful applications of public-private partnership approaches and of delegation of responsibility to the private sector. The Copenhagen agreement will also need to establish principles of subsidiarity to ensure that decisions are devolved to the lowest level (e.g., city, state, country)

as much as possible, and to minimise the build-up of new, bureaucratic international institutions.

Finally, the agreement will need mechanisms to ensure that its institutions and policies evolve and respond over time to developments in the science and economics of climate change, as well as to the changing circumstances of its participating countries. But at the same time, these institutions must be viewed as strong and credible over long time horizons.

#### Further work and choices

- What is the right framework for the post-Copenhagen institutions and mechanisms, detailing decision rights, governance, and accountability structures?
- How do we assess what should be the lowest level to which decisions can be devolved?
- What is the role of the private sector in these mechanisms?
- What are the best existing institutions that can play a role?

\* \* \*

Stepping back from all of the detail, what will success in Copenhagen look like? At its core, a successful agreement will: set a high-level direction through a 2050 target; get the world on a path to that target through deep developed world cuts and equitable developing world contributions, with appropriate interim targets and waypoints; create a set of effective enabling mechanisms and institutions; and create a process that enables the deal to be improved over time as more is learned.

The test will be whether the deal generates the investments, decisions, and financial flows that set the 21st Century on a new low-carbon path.

The complexity of achieving such a successful outcome is immense and will require leadership at the highest levels – starting with the G8.



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# Chapter 3

## Creating the Conditions for a Successful Agreement: Leadership by the G8

Success in Copenhagen will depend on the actions taken over the next eighteen months as national leaders, negotiators, and experts from around the world prepare for the UNFCCC process. It is essential that momentum starts to build now towards a positive outcome and that leaders engage in discussions at the highest levels, so that detailed proposals can be worked out for negotiation. The G8+5 is not the only forum where the climate issue will be discussed; there will also be the Major Economies Meeting process (MEM) and other forums. But the world will look to the largest and most developed countries to show leadership on this issue. The G8 has a particularly important opportunity to create the political dynamic that will lead to success for the world in Copenhagen.

### Leadership at the G8 in Hokkaido Toyako

The vital first step at Hokkaido would be for the G8 to reaffirm its commitment to achieving a robust long-term global agreement in Copenhagen. While there have been useful discussions and assessment of the many hypothetical options for putting the Bali Action Plan into practice, there is a pressing need for concrete proposals to push these discussions forward and drive the analysis that will underpin them. The G8 leaders can help make this a reality.

Chapter 2 described a set of further work and critical choices that negotiators will need to address over the next 18 months and conclude in Copenhagen. In Hokkaido, the G8 leadership can set the frame and momentum for this journey by providing direction on each of the ten building blocks of a global deal.

#### **1 Setting the global target**

In order to make detailed decisions on a global deal, the world needs a clear vision. First and foremost this implies recognising that a low-carbon, climate resilient world is essential for energy security, national security and sustainable economic development; and that all relevant actors (governments, businesses and civil society), and resources (technologies, finances and policies) need to be mobilised to make this world possible.

Putting this vision into practice means, in turn, building on the statements agreed in Gleneagles and Heiligendamm and establishing the long-term global emissions target that will drive these actors and resources in the right direction. As this report makes clear, the evidence shows that if we are to have a reasonable chance of achieving the goal enshrined in the UNFCCC's founding document of avoiding the dangerous effects of climate change, this firm target needs to be that:

*Global GHG emissions are cut by at least 50 percent by 2050.*

While the specific base year used has implications for how national caps would be calculated, what matters for the global target is that whichever base year and percentage are used, annual emissions in 2050 are no higher than 20 billion tonnes of CO<sub>2</sub>e.

#### **2 An interim target**

2050, however, is a long way off. The science strongly suggests that in order to meet the 50 percent target we need put ourselves quickly on a path that sees global emissions peak by 2020. It is also important, however, that the target be met and achieved without unnecessary economic and social dislocation. The G8 leaders meeting in Hokkaido must find a way to balance these objectives and commit to ensuring that:

*There is an agreed global peaking date for carbon emissions.*

This will set the context for the complex task in Copenhagen of determining who should cut emissions, by how much, and when.

### 3 Developed world commitments and carbon market mechanisms

The G8 countries, with their greater share of historical emissions and greater technological and financial ability to make major improvements in carbon productivity, will have to be the pacesetters in the race to cut emissions. This requires them to create the conditions and incentives to encourage both their private and their public sectors to lead the world in developing and adopting low-carbon solutions. In Hokkaido it would send an important signal if the G8 leaders were to:

*Reaffirm the principle that the G8 and other countries of the developed world must lead in efforts to reduce GHG emissions, and are committed to using carbon markets to achieve this.*

Carbon markets are likely to play a central role in creating the price for carbon that will be necessary to help drive the adoption of low-carbon technologies and to change production and consumption decisions in favour of low-carbon alternatives. It is therefore crucial that the emissions trading schemes currently in operation or being planned do not preclude evolution towards an efficient and transparent global market. Therefore, an invaluable component of the Hokkaido communiqué would be an agreement in principle to:

*Ensure that domestic carbon markets are consistent with the rules adopted in Copenhagen, and set as a goal the integration of G8 member carbon markets with the international carbon market over time.*

### 4 Developing world contributions

Securing the commitment of the developed countries will be necessary but not sufficient to achieving the level of carbon emissions reductions required. In addition, the major emerging markets will also need support to achieve significant increases in carbon productivity over the next decade. It would be a significant step in Hokkaido if the full G8+5 could agree to a text which would acknowledge:

*The equitable contributions of all countries towards meeting the global reduction targets on the basis of national plans and the importance of developed country support to accelerate investment by developing countries in low-carbon technology and infrastructure.*

### 5 Sectoral action

National sectoral approaches, sector incentives for developing countries, and international cooperation on sectors may be useful complements to carbon markets and national policies and measures. However, much work remains to be done on sectors. The G8 leaders could encourage progress on sectors by commissioning for review at the 2009 G8 in Maddalena, Italy:

*A report on the potential for sector-based approaches to complement national policies and carbon markets in effective delivery of mitigation targets.*

### 6 Financing

While the carbon markets would likely provide a significant and increasing flow of capital to support low-carbon growth in developing countries, they will not be able to cover the full costs. Developing countries will need assistance in financing national action plans, technology acquisition and development, and sustained investments in forestry and climate-resilient development. As already acknowledged by many developed countries, this will require funding that is clearly additional to existing ODA flows. To this end:

*The G8 should agree to investigate different sources and methods of funding, including the auctioning of emissions permits.*

### 7 Technology

G8 countries can stimulate the development and deployment of the major technological options for mitigating climate change. The IEA technology roadmaps show that CCS and solar energy together have the potential to achieve 15 percent of the annual emission

reductions needed by 2050, so accelerating their commercial viability is an absolute priority, particularly given projected rises in coal use.<sup>1</sup> To bring this about, full scale CCS demonstration plants are needed in all the major countries where coal generation is likely to play a significant role in future electricity generation; and large-scale solar plants are needed where there are significant solar energy resources. A key signal from G8 leaders in Hokkaido, in partnership with their emerging economy counterparts, would be to commit to having:

*A significant number of coal-fired power stations with fully functioning carbon capture and storage and large scale solar electricity generation demonstration plants in operation by 2015 in a range of industrialised and developing countries.*

The G8 could also provide significant acceleration of existing and new low-energy technologies by launching a major programme of energy efficiency improvement. Such a programme would increase energy security and generate high returns on investment:

*G8 leaders should commit to the full implementation of all the sixteen IEA energy efficiency recommendations presented to and discussed at the St. Petersburg and Heiligendamn summits in 2006 and 2007.*

The G8 could take a bold step further in its commitment to energy efficiency and build on the successful experience of its Japanese hosts by:

*Investigating the case for an institutional framework modelled on Japan's Top-Runner programme to coordinate the setting and updating of international energy efficiency standards for appliances, vehicles, industrial plants, buildings, and other appropriate sectors.*

## **8 Forests**

Given the major role that reducing the loss of forest will have in cutting CO<sub>2</sub> emissions and the multiple benefits that accompany it, the G8 should:

*Explicitly recognise the central importance of forests as critical carbon sinks and sources of potential carbon abatement, and as such, the need to create strong incentives to reduce deforestation and encourage afforestation; and*

*Launch a programme to develop pilot projects in partnership with major forest nations aimed at testing different approaches to reducing deforestation and encouraging afforestation.*

## **9 Adaptation**

The G8 countries can demonstrate their recognition of the importance of adaptation by beginning to implement the recommendations that have come out of the Nairobi Work Programme adopted under the UNFCCC in 2006. The funding commitments already being discussed could be used to:

*Provide funding for one priority project in each of the National Adaptation Plans of Action. To send a clear signal about the importance of adaptation, this funding would ideally be in place by the 2009 G8 Summit.*

In addition, Hokkaido could provide the setting for a bold new initiative around a global reinsurance scheme that would provide, through a mix of public and private funding, a safety net for some of the world's most vulnerable people. While there are many details that would need to be worked through, it would be entirely feasible to call upon the finance ministries of the G8 to:

*Work with the global insurance industry to establish how the insurance industry can play its part in the climate change question, in particular to design a safety net for low-income people across the world who are exposed to climate change risk*

G8 member nations could also benefit from coordinated action and sharing of practices and plans for adaptation, as well as signal commitment to the need for climate preparedness by:

*Asking G8 environment ministers to review G8 adaptation needs and assess opportunities for cross-G8 coordination.*

## **10 Institutions and mechanisms of action**

An effective global climate regime needs a high-quality, trusted set of institutions to monitor performance, allocate funds, transfer know-how, influence market and technology development, and feed improved scientific understanding into updated targets. A global climate regime provides a critical opportunity to build on the world's collective experience of multilateral institutions over the past 50 years – and to translate that learning into a network of high-performing, open (and at times, competing) institutions for managing the global climate regime.

The G8 leaders could accelerate progress on this imperative by asking their respective governments to:

*Develop proposals for ensuring that a global climate deal (a) has appropriate monitoring and reporting mechanisms; (b) is flexible in responding to new scientific and economic evidence; (c) has mechanisms for ensuring an effective carbon price; (d) is capable of adjustment based on performance versus targets and commitments; (e) engages government, multilateral, social sector and private sector institutions in its delivery mechanisms; and (f) has a governance structure that is accountable for institutional performance and fairly represents both the developed and developing world.*

### **From Hokkaido and the 2008 MEM Leaders' Meeting to the 2009 G8 in Maddalena**

In addition to the agreements and actions outlined above, chapter 2 has shown that there are a number of aspects of the agreement in Copenhagen that will need decisions at the highest level of government, but for which the best options are still not clear. It is also obvious from all that has been discussed so far that there is a vast amount of detailed technical work and research to be done in support of the political negotiation process. The IPCC and the UNFCCC continue their excellent work. But they need help.

While all nations will ultimately have to agree to a climate deal, agreement amongst the world's major economies is a critical precursor to a successful outcome in Copenhagen. The G8+5 was formed at Gleneagles in 2005 precisely to do this – to create an informal gathering of the major countries so that common areas of agreement could be reached. The MEM process, led by the US, is working toward that same end.

It is surely sensible that some form of co-ordination between the major economies continues after Hokkaido and then onto the Maddalena G8.

The process initiated by the G8 Summit in Gleneagles in 2005, and due to conclude at Hokkaido, set in motion a number of activities that have increased understanding of the potential solutions – the IEA energy efficiency recommendations, the IEA technology roadmaps and the World Bank's Clean Energy Investment Framework. The process has also brought different actors together to support consensus – through the GLOBE Legislators Dialogue and the World Economic Forum's CEO process.

Establishing a similar process in Hokkaido to run through to the 2009 Summit in Maddalena, would have significant value in directing research efforts and further honing the options facing political leaders over the next 18 months. This process would be significantly strengthened through the establishment of a small secretariat to co-ordinate key workstreams over the next 12 months, and to ensure alignment with the UNFCCC process and expert networks. As described in chapter 2, there are key technical and policy issues that still need to be analysed – each of which has very considerable implications for the likely costs and benefits of adjustment to a low-carbon economy. By the time of Maddalena, it would be of immense value if the G8+5 leadership were able to agree on key outstanding issues and make specific proposals, for example on:

- 1 The date at which global emissions need to peak and the implications for the pace and depth of developed nation emissions cuts.
- 2 The process and mechanisms for linking domestic carbon markets and scaling up international carbon finance flows through these markets.
- 3 An assessment of the financial flows from developed countries to developing countries that will be required in the Copenhagen agreement, and their potential sources.
- 4 A progress report on G8 efforts to pilot CCS and large-scale solar.
- 5 A progress report on implementation of IEA energy efficiency recommendations and a proposal for a G8-led international energy efficiency framework.
- 6 A G8 assessment of options for forestry and a progress report on pilots.
- 7 A proposal from G8 finance ministers on how a global insurance mechanism could be created to provide a safety net for the world's poor, who are most exposed to climate change risk.
- 8 A review of G8 preparedness for adaptation challenges.
- 9 A review of proposals on the institutional arrangements for supporting the Copenhagen treaty.
- 10 An assessment of key outstanding issues that would benefit from G8 leader or ministerial discussion after Maddalena and before Copenhagen.

\* \* \*

The G8 is meeting at a crucial moment in time. The scientific case for moving to a low-carbon economy is clear. The economic case says it can be done by transforming our economy in ways that will create new sources of growth, new jobs, energy security, and greater equity and opportunity in the world. But the political complexities of gaining agreement from 191 countries to travel this path are immense. By providing clear and decisive direction, the Hokkaido Toyako G8 Summit has the opportunity to make 2008 the year the world began this historic journey.



# Endnotes

## Chapter 1 endnotes

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- <sup>4</sup> IPCC, AR4 Synthesis Report, 2007, Topic 2.
- <sup>5</sup> IPCC, AR4 Synthesis Report, 2007, Topic 1.
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- <sup>16</sup> Denman et al., 2007, op. cit.
- <sup>17</sup> IPCC, AR4 Synthesis Report, 2007, p. 54. On the relationship between GHGs and mass extinction events, see also Ryskin, "Methane-driven oceanic eruptions and mass extinctions," *Geology*, 2003, Number 31, pp. 741-744; Riccardi et al., "Sulfur isotopic evidence for chemocline upwater excursions during the end-Permian," *Geochimica et Cosmochimica Acta*, 2006, Number 70, pp. 5740-5752; Mayhew et al., "A long-term association between global temperature and biodiversity, origination and extinction in the fossil record," *Proceedings of the Royal Society B.*, 2008, Number 275, pp. 47 – 53.
- <sup>18</sup> IPCC, AR4 Synthesis Report, 2007, p. 51. Also see Meinshausen, "What Does a 2°C Target Mean for Greenhouse Gas Concentrations? A Brief Analysis Based on Multi-Gas Emission Pathways and Several Climate Sensitivity Uncertainty Estimates," in Schnelnhuber (ed.) *Avoiding Dangerous Climate Change*, Cambridge University Press, 2006.
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- <sup>20</sup> IPCC, AR4 Synthesis Report, 2007, p. 39.
- <sup>21</sup> This is a simplification. See IPCC, AR4 WGI, 2007, for a more complete explanation of atmospheric GHG concentrations and their impact on temperature, absorption, and gas lifetime in the atmosphere.
- <sup>22</sup> With the Hadley estimates of uncertainty in climate sensitivity there would be around a 30% chance of exceeding 2°C. Murphy et al., "Quantification of modelling uncertainties in a large ensemble of climate change simulations," *Nature*, 2004, Volume 430, Number 7001, pp. 768-772.
- <sup>23</sup> Atmospheric CO<sub>2</sub> concentrations were 379ppm and the estimate of total CO<sub>2</sub>e concentration in 2005 for all long-lived GHGs was about 455ppm CO<sub>2</sub>e, which was offset by the effects of aerosols mainly to give an equivalent concentration of 375ppm.
- <sup>24</sup> Uncertainties are large here: with the Hadley centre estimates of climate sensitivity this would have about an 80% chance of exceeding 2°C. Murphy et al., 2004, op. cit. Also see den Elzen & Meinshausen, "Multi-gas emission pathways for meeting the EU 2°C climate target," in Schnelnhuber (ed.) *Avoiding Dangerous Climate Change*. Cambridge University Press, 2006, pp. 299-309.
- <sup>25</sup> Gupta et al., "Policies, Instruments and Co-operative Arrangements," in *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Metz et al. (eds.)), Cambridge University Press, 2007, Chapter 13, Box 13.7 (volume hereafter referred to as IPCC, AR4 WG III, 2007); IPCC, AR4 Synthesis Report, 2007, Topic 5, Table 5.1.

- <sup>26</sup> Pathways from Meinshausen, "Stylized emission path," Background note prepared for the UNDP Human Development Report, 2007 ([http://hdr.undp.org/en/reports/global/hdr2007-2008/papers/meinshausen\\_malte.pdf](http://hdr.undp.org/en/reports/global/hdr2007-2008/papers/meinshausen_malte.pdf)).
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- <sup>28</sup> Netherlands Environmental Assessment Agency, June 2008.
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- <sup>32</sup> Beinhocker et al., *The Carbon Productivity Challenge: Curbing Climate Change and Sustaining Economic Growth*, McKinsey Global Institute, June 2008 ([www.mckinsey.com/mgi](http://www.mckinsey.com/mgi)).
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- <sup>35</sup> The oil price assumed in this analysis was \$40 per bbl. Higher energy prices would increase the positive economic opportunities on the left side of the curve.
- <sup>36</sup> See Beinhocker et al., 2008, *op. cit.*
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- <sup>43</sup> IEA, WEO, 2007.
- <sup>44</sup> See, for instance, the alternative policy scenario in IEA, WEO, 2007, p. 594.
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- <sup>68</sup> "Managed forestry offers hope of saving Amazon," WBSCD newsletter, February 2008.
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## Chapter 2 endnotes

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## Chapter 3 endnotes

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## Exhibit Sources

**Exhibit 1:** Historic data from Petit et al., *Vostok Ice Core Data for 420,000 Years*, IGBP PAGES/ World Data Center for Paleoclimatology Data Contribution Series #2001-076. NOAA/NGDC Paleoclimatology Program. See also Petit et al., "Climate and Atmospheric History of the Past 420,000 Years from the Vostok Ice Core, Antarctica," *Nature*, 1999, Number 399, pp. 429-436. Current and forecast values from IPCC, *Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Core Writing Team et al. (eds.)), IPCC, 2007 (hereafter referred to as IPCC, AR4 Synthesis Report, 2007), p. 67; Stern, *The Economics of Climate Change. The Stern Review*, Cambridge University Press, 2006.

**Exhibit 2:** Pathways from Meinshausen, *Stylized emission path. Background note prepared for the UNDP Human Development Report*, 2007 ([http://hdr.undp.org/en/reports/global/hdr2007-2008/papers/meinshausen\\_malte.pdf](http://hdr.undp.org/en/reports/global/hdr2007-2008/papers/meinshausen_malte.pdf)).

**Exhibit 3:** IPCC, AR4 Synthesis Report, 2007, p. 36 (Figure 2.1 (c) Share of different sectors in total anthropogenic GHG emissions in 2004 in terms of CO<sub>2</sub>-eq; reformatted for printing and used with permission of the IPCC); Bernstein et al., "Industry," in *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Metz et al. (eds.)), Cambridge University Press, 2007, pp. 461, 467; Kahn Ribeiro et al., "Transport and its infrastructure," in *ibid.*, pp. 325, 333.

**Exhibit 4:** 1990-2004 from IPCC data as of June 2008; 2005-2020 estimates; 2030, 2050 from Stern, 2006, *op. cit.*

**Exhibit 5:** McKinsey analysis based on a combination of sources, including IEA, *World Energy Outlook*, OECD/IEA, 2007; Environmental Protection Agency, *Global Anthropogenic Non-CO<sub>2</sub> Greenhouse Gas Emissions: 1990-2020*, 2006; UNFCCC, *Greenhouse Gas Inventory Data*, 2007.

**Exhibit 6:** Beinhocker et al., *The Carbon Productivity Challenge: Curbing Climate Change and Sustaining Economic Growth*, McKinsey Global Institute, June 2008 ([www.mckinsey.com/mgi](http://www.mckinsey.com/mgi)).

**Exhibit 7:** Enkvist et al., "A cost curve for greenhouse gas reduction," *The McKinsey Quarterly*, 2007, Number 1 ([www.mckinseyquarterly.com](http://www.mckinseyquarterly.com)). The carbon abatement cost curve was developed jointly with Vattenfall.

**Exhibit 8:** IPCC Special Report on Carbon Dioxide Capture and Storage. Prepared by Working Group III of the Intergovernmental Panel on Climate Change (Metz et al. (eds.)), Cambridge University Press, 2005 (© Intergovernmental Panel on Climate Change 2005), *Summary for Policymakers*, p. 13 (Figure SPM.7 (c) Emissions (MtCO<sub>2</sub> yr-1) (MiniCAM); reformatted for printing and used with permission of the IPCC).

**Exhibit 9:** Results of three global forest sector modeling studies as reported in Nabuurs et al., "Forestry," in *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Metz et al. (eds.), Cambridge University Press, 2007).

**Exhibit 10:** Business as usual: Global Insight GDP forecast to 2037, extrapolated to 2050, not taking into account potential costs caused by climate change; High-cost scenario: high ends of GDP reduction estimates for 445-535ppm CO<sub>2</sub>e stabilisation levels as in IPCC, AR4 Synthesis Report, 2007, p. 69: 3% for 2030 and 5.5% for 2050; Low-cost scenario: costs of 1% of GDP in 2030, 2050 costs as the same share of 2030 costs as in the high-end estimate. For instance according to a meta-analysis of different modeling studies by Barker & Jenkins, the global costs of a 450ppm CO<sub>2</sub>e stabilization level are by 2100 about 1 to 2% of GDP in 2030, assuming international emission permit trading. *The Costs of Avoiding Dangerous Climate Change: Estimates derived from a meta-analysis of the literature. Final draft for a briefing paper for the Human Development Report 2007/2008, 2007* (a study undertaken by members of the Cambridge Centre for Climate Change Mitigation Research); Population data from *World Population Prospects: The 2006 Revision and World Urbanization Prospects: The 2005 Revision*, Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (<http://esa.un.org/unpp>).

**Exhibit 11:** Barrett, *Environment and Statecraft: The Strategy of Environmental Treaty-Making*, Oxford University Press, 2003; Burtraw et al., *Economics of Pollution Trading for SO<sub>2</sub> and NO<sub>x</sub>*, Resources for the Future Discussion Paper, 2005; Environmental Defense Fund.

**Exhibit 12:** Environmental Defense Fund calculations using the MAGICC climate model and IPCC assumptions, published in Keohane & Goldmark, *What Will it Cost to Protect Ourselves from Global Warming? The Impact on the U.S. Economy of a Cap-and-Trade Policy for Greenhouse Gas Emissions*, Environmental Defense Fund, 2008. © 2002 Environmental Defense. Used by permission

**Exhibit 13:** McKinsey analysis.

**Exhibit 14:** Food and Agriculture Organization of the United Nations (FAO), "Global Forest Resources Assessment 2005. Progress towards sustainable forest management," *FAO Forestry Paper*, 2006, Number 147; McKinsey analysis.



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