12. Accepting the challenge

> *"We are now faced with the fact that tomorrow is today. We are confronted with the fierce urgency of now. In this unfolding conundrum of life and history there is such a thing as being too late. Procrastination is still the thief of time. Life often leaves us standing bare, naked and dejected with a lost opportunity. The 'tide in the affairs of men' does not remain at the flood; it ebbs. We may cry out desperately for time to pause in her passage, but time is deaf to every plea and rushes on. Over the bleached bones and jumbled residue of numerous civilizations are written the pathetic words: 'Too late. . . .'"*

Reverend Dr. Martin Luther King, Jr.

> The whole history of international environmental action has been of arriving at destinations which looked impossibly distant at the moment of departure.

Tony Brenton, *The Greening of Machiavelli*.

> Taking small steps never feels entirely satisfactory. Nor does taking action without scientific knowledge. But certainty and perfection have never figured prominently in the story of human progress. Business, in particular, is accustomed to making decisions in conditions of considerable uncertainty, applying its experience and skills to areas of activity where much is unknown. That is why it will have a vital role in meeting the challenge of climate change – and why the contribution it is already making is so encouraging.

John Browne, Group Chief Executive of BP in *Foreign Affairs*, July–August 2004.

When President John F Kennedy called the United States to action in the space race, he uttered words that might apply even more convincingly to the cause of securing our civilisation from the risk of human-induced dangerous climate change. He said:

We choose to do these things not because they are easy, but because they are hard, because the goal will serve to organize and measure the best of our energies and skills, because the challenge is one we are willing to accept, one we are unwilling to postpone, and one which we intend to win.[1]

Coping with the climate change issue is in many ways a greater challenge than the space race. It is more multi-faceted, more fundamental to our civilisation, and likely to be an ongoing

challenge for this and future generations. It is a question of foresight, because it involves seeing into the future to see what is required of us today. It is a matter of risk management, because we cannot predict the future, but merely look at the possibilities, attach tentative probabilities conditional on human behaviour, and use that to decide policy today.

It is also a matter of faith – faith in science, faith in people to meet the challenge, and faith that human ingenuity and adaptability can cope with the challenge. Faith and hope, like despair, can be self-fulfilling prophecies. If people believe they can make a difference, they will act and, in so doing, *will* make a difference If, however, they despair and choose to do nothing, they will be overtaken by events: they will have abdicated their choice. People either choose and act for a sustainable future, or they contribute to a growing environmental disaster. Climate change is serious and urgent stuff, but you can make a difference.

People hate doom and gloom – it turns people off. That is not what this is about. It is about new and exciting technologies, creating new markets, making new investments and taking advantage of new opportunities. It is about solving several problems at once, co-benefits and complementary strategies. It is about enjoying our relationship with nature and creating a sustainable future. It is about making life better.

History tells us that humans are adaptable and ingenious in devising new technologies. Thus the twentieth century saw the birth and spread of many amazing new technologies such as the internal combustion engine, flight, telecommunications, medicines that have eliminated ancient scourges, and the World Wide Web. These inventions have transformed human existence.

It is therefore strange that some think we are so ingenious that we can adapt to anything, yet not be able to reduce greenhouse gas emissions at an affordable cost. And others argue the opposite – that we are so clever that we can almost instantly cut greenhouse gas emissions at acceptable cost, yet cannot adapt to even minor climate changes. We can and must do both. We can simultaneously devise new technologies to reduce greenhouse emissions thus building a low-carbon economy over the next half-century, while at the same time adapt to the changes we have not been able to prevent.

On both the mitigation and adaptation fronts there are great opportunities ahead. If we seize these opportunities we can achieve wonders, and even do so while developing our economies and simultaneously reducing poverty and inequity.

An interesting developing country perspective is provided by Jose Goldemberg, former Minister for Science and Technology, Brazil:

> *Renewable energy is inexhaustible and abundant. It is clear therefore that in due time renewable energies will dominate the world's energy system, due to their*

> *inherent advantages such as mitigation of climate change, generation of employment and reduction of poverty, as well as increased energy security and supply.*[2]

After reviewing numerous real case studies, Paul Hawken, Amory Lovins and L. Hunter Lovins of the Rocky Mountain Institute in Colorado go further:

> *In the past fifty years, the world's annual carbon emissions have quadrupled. But in the next half century, the climate problem could become as faded a memory as the energy crises of the seventies are now, because climate change is not an inevitable result of normal economic activity but an artefact of carrying out that activity in irrationally inefficient ways. Climate protection can save us all money – even coal miners, who deserve the just transition that the nation's energy savings could finance a hundred times over.*
>
> In *Natural Capitalism* (1999).[3]

Besides *Natural Capitalism*, there are many other sources of information, including case studies, on how to reduce greenhouse gas emissions. I will mention two here, but there are more in the endnotes. One good site is that of *The Climate Group*.[4] This is a group of companies, NGOs and local, regional and national governments 'committed to adopting a leadership agenda on climate protection and to reducing greenhouse gas emissions'. Another is the *International Council for Local Environmental Initiatives* (ICLEI), which has over 875 local government members, runs meetings and has specialist advisory groups.[5]

It is worth reminding ourselves that in the range of IPCC SRES scenarios for future emissions to 2100 (see Chapter 3) one scenario (B1) resulted in emissions that would lead to less than 550 ppm of CO_2 equivalent by 2100. This equilibrium concentration remains higher than the low level of greenhouse gas concentrations that may be needed, around 450 ppm as suggested in Chapter 8. Nevertheless, the B1 SRES scenario was based on a hypothetical world with an emphasis on local solutions to economic, social and environmental sustainability, but with no overt climate change policies. Thus the authors of the SRES report agree with the authors of *Natural Capitalism* that it is plausible, and maybe even desirable, to follow a relatively safe emissions pathway in the twenty-first century for reasons other than climate change. Of course, SRES also had some alternative very high emissions scenarios which SRES considered to be plausible without climate change policies.

The message is clear – we have a choice about the future, and the choice has serious consequences for future climate and for human societies. Risks associated with climate change should influence that choice. It is important here to remember that the IPCC deliberately did not attach probabilities to its SRES scenarios. However, if we examine the assumptions underlying

the B1 scenario, we see that it requires reductions in material intensity (raw materials per unit quality of life) and the introduction of clean and resource-efficient technologies, with an emphasis on global solutions, sustainability and improved equity. How probable are these developments without some deliberate policy choices, and indeed without community/government decisions, goals and incentives? The SRES scenarios say this is possible, but not that it is likely without deliberate efforts to make it happen.

Business Weekly, in a cover story on global warming on 16 August 2004, reports G Michael Purdy, Director of the Lamont-Doherty Laboratory as saying that the reasons for the present lack of urgency in reducing greenhouse gas emissions is 'not the science and not the economics', but rather 'it is the lack of public knowledge, the lack of leadership, and the lack of political will.' All that is necessary is for us to create the will to make it happen.

The situation is urgent, with both adaptation and mitigation needed. Moreover, no potential contributions to emissions reduction should be ruled out on the basis of prejudice against particular technologies or socio-economic biases. Whether it is wind power, geo-sequestration or nuclear power, mitigation options should be examined for timeliness, safety, acceptability and economic potential, rather than ruled out on the basis of some pre-existing ideological position. Infighting on an either/or basis is counter-productive, although the pros and cons of particular solutions may vary from place to place or be determined ultimately by costs and timeliness. The outcome may well be determined by a process of learning by doing. Such a process can lower costs and determine what is most appropriate in the local context.

Faced with the challenge of achieving rapid sustainable development, countries like China, India and Brazil are starting to build new low-carbon technologies (see Chapter 11), and will gain competitive advantages from doing so. They will reduce local air pollution problems, increase employment, and avoid excessive reliance on foreign sources of fossil fuels. According to The Climate Group, in a report "*China's Clean Revolution*" (2008), *China is already the world's leading renewable energy producer and is over-taking more developed economies in exploiting valuable economic opportunities, creating green-collar jobs and leading development of critical low-carbon technologies.*[4]

Developing countries are not necessarily consistent in this, as the increasing use of private automobiles in China, rather than bicycles and public transport, testifies. Yet the challenge is being faced, and these developing countries have the opportunity to adopt strategies and to design and build infrastructures that will achieve sustainability, including a stable climate.

The danger is that developing countries are being seduced by the example of highly carbon-intensive developed country lifestyles and technologies that will exacerbate the global climate

problem and lead to worse impacts of climate change on themselves. Putting development before limiting greenhouse gas emissions may have the perverse effect of stifling development through climatic disasters. Development has to be clean development if it is to succeed in the long run.

.The poorer lesser-developed countries, such as much of sub-Saharan Africa and parts of Asia, are in many cases not yet on a rapid development pathway. Instead they are struggling to cope with poverty, natural and manmade disasters such as floods, drought and civil wars, unrest and instability. For them energy policy is a matter of survival, and climate change considerations rate low on their list of priorities. Yet, as IPCC has pointed out, they are likely to be worst affected by climate change, with reduced crop yields, more climatic disasters and flooding due to sea-level rise. For these countries sustainable development needs to come first in the form of disaster preparedness, aid in developing dispersed forms of renewable energy, and efforts by the rest of the world not to make matters worse through climate change.

A special issue of *Climatic Change* in 2007 deals with the issue of climate change mitigation and its relationship to development.[6] The authors argue that rapid increases in emissions in developing countries comes mainly with increases in middle class consumption, which needs to be targeted by appliance energy standards, public transport friendly urban development and similar measures. They go on to discuss the relevance of, and problems with, the Kyoto Protocol's Clean Development Mechanism in this task.

The challenge in developed countries is in some ways greater because they have so much more already invested in inappropriate and unsustainable infrastructures. These include inefficient coal-fired power stations; hundreds of millions of polluting motor vehicles; vast road systems designed for private transport; under-utilised, run-down or even abandoned public transport systems; and highly energy-inefficient building stock. Much of this existing stock needs to be transformed and upgraded, or written off and replaced, in order to meet more sustainable standards.

Central to all these situations is how to foster rapid growth in renewable energy and energy efficiency, and how to minimise greenhouse gas emissions now. Urgent results can only be achieved through existing technologies such as greater energy efficiency (insulation, hybrid cars and so on) and proven renewable technology such as biomass ethanol, and solar and wind power. This must be backed up with new and emerging technology, including appropriate carbon removal and sequestration, and even safe and secure nuclear power. But these latter capital-expensive technologies will only achieve massive reductions in greenhouse gas emissions over the course of many decades, due to the need for research and development, large embedded energy costs and slow uptake. They are as yet largely unproven and require large long-term research, development and investment.

It is government policies that can engender a sense of urgency. This might come from mandatory targets for energy efficiency, renewable energy and reductions in emissions. And it is carbon emissions trading, tax incentives and other measures that would accelerate the development and commercialisation of low-carbon technology by internalising environmental costs. As we saw in Chapter 10, many state and local government initiatives in both the United States and Australia have been developed to fill the gaps in federal government program in these two countries. The change in government in Australia in late 2007 is generating federal initiatives also. Initiatives to reduce emissions will have maximum effectiveness only when they are implemented federally, and indeed internationally, thereby achieving economies of scale and greater planning certainty for industry.

In some developed countries, notably the European Union countries, and since 2007 in Australia, federal governments or groupings of governments, and indeed business, are accepting the challenge of developing low-carbon technology to meet necessary targets. However, there is debate about how realistic the measures being implemented are in achieving these goals, and about transitional arrangements to encourage a smooth but ongoing transition to a low-carbon economy. It is in part a process of learning by doing.[7]

As Sean Lucy, Director of Climate Change Services at PricewaterhouseCoopers stated in 2007 "*Clarity on early abatement opportunities will be eagerly awaited by business. Early adaptors of a robust carbon management strategy are likely to receive real material benefit and see a positive impact on shareholder value. The effectiveness of a company's carbon strategy is already a key metric in investor decision-making*." Later he added: "*Everyone is still learning and this is a relatively immature regulatory environment. Governments are working hard to develop models that work best and there will be, inevitably, a process of seeing what works and fine tuning it. There will be some push back from business when government oversteps, and hopefully we'll get a common sense position in the middle.*"[8]

Recognition and ownership of the climate change problem, measured in terms of real, substantial and effective action is urgent. It requires understanding, education of the population, and action by governments to set standards and create the business climate in which innovators and entrepreneurs can flourish. Markets may be efficient in achieving least-cost solutions when they recognise a problem or opportunity, but too often they are focused on the short-term and fail to recognise long-term challenges. As Sir Nicholas Stern said in his 2006 report to the UK government:

The science tells us that GHG emissions are an externality; in other words, our emissions affect the lives of others. When people do not pay for the consequences of their actions we have

market failure. This is the greatest market failure the world has seen. It is an externality that goes beyond those of ordinary congestion or pollution, although many of the same economic principles apply for its analysis.

This externality is different in 4 key ways that shape the whole policy of a rational response. It is: global; long term; involves risks and uncertainties; and potentially involves major and irreversible change.[9]

Climate change requires urgent global action in the short-term, to fulfil long-term goals. Mandatory targets, subject to revision as new information emerges, and other government carrots and sticks can and indeed must be used to stimulate this sense of urgency.

Looking beyond the Kyoto Protocol

Most of the world has accepted that the Kyoto Protocol is a good starting point in getting greenhouse gas emissions under control. Together with its parent Framework Convention on Climate Change, the Kyoto Protocol has set initial emissions targets for the developed countries, to be achieved by 2008–12, along with several principles and mechanisms. Central to the thinking in the Kyoto Protocol is the idea of differentiated responsibilities, with developed countries, who are the largest per capita emitters, taking the lead in the first commitment period, and the idea of sustainable development for all countries, especially the less developed ones.

It is important to remember that the Kyoto Protocol emissions targets, and exclusion of developing countries from them, apply only until 2012, after which a new formula must be put in place. On-going negotiations on such a formula necessarily include at least the major developing countries in one form or another. More explicit mechanisms are needed for aid to developing countries in the form of the transfer of low-carbon technologies to assist in economic development, and for aid in adapting to unavoidable climate change, including climatic disasters.

International agreements are necessary as they are more likely to create a level playing field where countries and businesses have equitable access to markets and standards and know what to expect, foster international equity and sustainable development, and discourage or penalise free-loaders. By creating truly international markets such agreements can also achieve greatest efficiency in emissions reductions, and in so doing foster a real sense of urgency.

How effective such a post-Kyoto agreement would be, and whether in fact agreement can be reached, is of course dependent on the outcome of the negotiations. Arguments over possible post-Kyoto arrangements are complex, voluminous and often highly specialised. A 2004 document from the Pew Center on Global Climate Change lists some 40 proposals and provides a succinct summary.[10] This is not the place to go into the proposals in any depth. However, I will

mention some ideas and points in the endnotes.Negotiations and academic studies of them are ongoing, and the negotiations can be followed via reports on the websites of the *Institute for Sustainable Development* and the *UN Framework Convention on Climate Change*, as well as many other websites cited in this book.[11] The IPCC 2007 Working Group III report has a whole chapter on *Policies, Instruments and Co-operative Arrangements* (Chapter 13).

Considerations in arriving at any new international agreement to reduce greenhouse gas emissions include:

- building on what has already been agreed;
- encouraging least-cost effectiveness in mitigation actions;
- promoting co-operative arrangements to cope with or adapt to unavoidable climate change via capacity building and emergency relief;
- achieving co-benefits, especially sustainable development;
- allowing for equity, relating to the agreed ideas of differentiated responsibilities and capacities;
- avoiding unwanted outcomes;
- minimising risk of failure;
- ensuring effectiveness in achieving rapid reductions in emissions;
- leaving room for adaptability as new information comes to hand regarding risks and effectiveness (including revised targets in the light of developments) and
- monitoring progress and enforcing agreements.

Whatever we may want – and the UN Framework Convention on Climate Change goal of avoiding dangerous levels of greenhouse gases seems like a reasonable objective (despite difficulties in quantifying it) – the strategy must be related to a realistic assessment of the success likely to be achieved. As Sir Winston Churchill once said:

However beautiful the strategy, you should occasionally look at the results.

A lot of thought has gone into what might follow the Kyoto Protocol. Niklas Hohne of ECOFYS, a European research and consulting company, outlined a number of possible approaches to a future mitigation agreement in work done for the German Federal Environmental Agency.[12] *The Climate Group* in a "Breaking the Climate Deadlock" initiative, and the *Pew Center on Global Climate Change* have each developed proposals.[13] Some key proposals include:

- *Continuing Kyoto.* This might include ad hoc negotiated emissions reduction targets increasing every ten years for developed countries, and increasing participation of other countries as their GDP per capita rises closer to the global average.

- *Intensity targets.* This approach would define emissions targets in terms of emissions per unit GDP (carbon intensity), and was favoured by the US Bush Administration. It allows for economic growth, but would not lead to reductions in actual emissions unless the decrease in carbon intensity is more rapid than economic growth. This is presently not the case in most countries including the US, and is, in a sense, the key problem. Expressing mitigation targets in such terms makes it difficult to define what actual reductions in emissions would be achieved, as these would depend on economic growth rates.
- *Contraction and convergence.* This proposal, originally from the Global Commons Institute in the UK, defines as the goal a target stabilised greenhouse gas concentration, assesses a global emissions pathway (variation in emissions with time) that would lead to this goal, and allocates emissions pathways to individual countries aimed at converging on the same emissions per capita at some future date such as 2050 or 2100. This would allow for some initial increase in emissions for some countries with present low emissions per capita, but greater reductions for countries with high emissions per capita.
- *Sectoral agreements.* This approach would assign different emissions reduction criteria to different sectors such as domestic, industry, electricity, agriculture and forestry. It was one basis of the formula used in the EU to share the burden between different member countries under the Kyoto Protocol. The domestic sector would require convergence of per-capita emissions, industry would require growth in energy efficiency, electricity would require a proportion of renewables, agriculture would require stabilisation at 1990 levels, and forestry would aim at zero net emissions.

One interesting variation, which potentially accommodates large differences between countries, involves negotiating a package of multi-component commitments by each country based on national circumstances, negotiated from the bottom up, as in multilateral trade agreements. How far this proposal differs from what was attempted in the Kyoto Protocol is not clear. The author, Robert Reinstein, former chief US negotiator for the UN FCCC, argues that a commitment to a target for emissions reduction must be accompanied by an illustrative package of policies and measures that might be expected to result in the target. Conversely, he argues that commitment to a package of polices and measures should be accompanied by a projection of the emissions reduction expected to result. Such estimates are a key to seeing whether the targets or policies and measures are working. He adds that government actions alone will not be sufficient to achieve results, since most investment decisions and technology dissemination are carried out by the private sector. But governments can help to create an enabling environment to encourage such private sector participation.[14]

Reinstein goes on to state that in negotiating a balanced package of commitments by all countries, it is important to distinguish between short-term and longer-term commitments. The former begin the process and send a political signal. Actions in response to short-term commitments begin to change the psychology and reinforce expectations of change, which influence market behaviour. Longer-term commitments to promote low-carbon technology and subsequent changes in capital stock and transformation of infrastructure are supported by short-term changes. Major reductions in greenhouse gas emissions will in general occur over the longer term as a result of both short-term and longer-term processes. Where I would go beyond Reinstein is to place greater emphasis on the urgency of the short-term commitments, since early reductions in emissions are crucial to reducing the risk of dangerous climate change.

To accomplish this difficult challenge, Mike MacCracken of the US *Climate Institute* proposes a reciprocal arrangement under which *"(1) developed nations move rapidly to demonstrate that a modern society can function without reliance on technologies that release carbon dioxide (CO_2) and other non-CO_2 greenhouse gases to the atmosphere; and (2) … developing nations act in the near-term to sharply limit their non-CO_2 emissions while minimizing growth in CO_2 emissions, and then in the long-term join with the developed nations to reduce all emissions as cost effective technologies are developed*." [15]

Under this approach developing nations at the outset would focus on low hanging fruit -- emissions reductions with significant ability to limit radiative forcing and that are achievable at low relative cost. These include greatly reducing emissions of methane, air pollutants that contribute to tropospheric ozone, and black soot, which blackens glaciers, in turn causing greater absorption of solar radiation and melting of glaciers that are crucial to the water supply of a large portion of humanity. Initially, the primary efforts to limit CO_2 emissions in developing nations would focus on ending deforestation and on implementing energy efficiency measures--e.g. reducing power consumption for lighting, reducing conversion loss and transmission loss, and encouraging energy recycling including combined heat and power.

A 2007 paper by Lewis and Diringer of the Pew Center argues for policy-based commitments as an avenue for developing countries to reduce emissions growth, without fixing a firm target. They suggest this could evolve from voluntary to binding commitments that other parties to any agreement would consider adequate and reliable.[16] Warwick McKibben and Peter Wilcoxen in 2002 provided another alternative that would provide a fixed number of tradeable long-term emissions permits with an elastic supply of short-term permits, which they argued would better control costs.[17]

These and many other approaches are open for discussion and have been modelled using various economic and energy sector models to see how they might work out.[18] Critical to their acceptance and usefulness is how they fit in with each country's national interests and their overall effectiveness in achieving urgent and continuing emission reductions. Substantial reductions of emissions in developed countries are necessary in all approaches, and these reductions clearly must be much larger for a 450 ppm concentration target than the emissions reductions required under the Kyoto Protocol. Early involvement of developing countries is necessary, but many approaches and variations on future actions are possible, with none being ideal. A mixture of approaches may be a good compromise, but one that ensures that tight controls or disincentives on emissions in developed countries do not lead to a transfer of polluting activities to developing countries.[19]

Addressing the Key Issues

In this book we have seen that, despite the uncertainties, there is a real and present danger that our continuing large-scale burning of fossil fuels is pushing the climate system into a situation where there is a risk of serious damage to us and our children. This danger increases with every year that we fail to take appropriate action, yet there are potential solutions out there, which we could apply.

Recent modelling of carbon budgets illustrates this point.[20] For example, Mignone and colleagues found that if the rate at which future emissions of greenhouse gases can be reduced is limited to no greater than say 1% each year, then any delay in starting to reduce emissions leads to a larger peak concentration. They found that with a decline in emissions of 1% per year starting in 2008, concentrations would peak near 475 ppm, but that for each year that reductions are postponed the eventual peak increases by 9 ppm. This greatly increases the danger of reaching some uncertain but likely "dangerous" level. Each year of delay in emissions reductions increases the risk of dangerous climate change.

Here are some key findings that should guide us:

- There is a need to achieve a *target of a stabilised concentration of about 450 ppm carbon dioxide equivalent*, or even lower if some recent results are borne out. These suggest a high risk, with concentrations around 450 ppm, of reaching a "tipping point" at which some key part of the climate system becomes unstable (such as disintegration of the Greenland Ice Sheet). Higher concentrations would lead to too great a risk of unacceptable consequences (see Chapter 6). This takes account of large uncertainties and factors them into a risk assessment.

- To achieve this, *global emissions must peak before 2050,* and then decline rapidly. This requires sizeable reductions *starting as soon as possible*.
- *If concentrations of greenhouse gases peak above about 450 ppm CO_2 equivalent they may have to be brought down later* in the 21st century, by removing greenhouse gases from the atmosphere. This may best be done by growing biomass and sequestering carbon from it as biochar or by other means.
- Effective international action requires *agreement between developed and developing countries* on emissions reduction schedules consistent with sustainable development for all. This is in everyone's interests (see Chapter 10), and probably requires eventual convergence on equal emissions per person across all countries.
- This requires that *emissions in developed countries must decrease by some 60-80% by 2050*, (see Chapter 8) and that increases in emissions in developing countries be kept as low as possible. This requires a rapid transfer to, or development of, low-carbon technology in developing countries.
- *Proven methods for reducing emissions should be applied urgently* in the next decade or two, because early emissions reductions are essential to avoid dangerous climate change.
- *Research and development should be encouraged for other potential low-carbon technologies*, at least while they seem feasible and acceptable on other grounds. They will be needed in the latter part of the twenty-first century.
- *Government intervention is necessary* to remove direct and hidden subsidies for fossil fuels and inefficient carbon-intensive activities, and to provide incentives for low-carbon technologies via the polluter pays principle. Start-up subsidies may be needed to develop new technologies, especially to achieve economies of scale.
- *Market mechanisms* should be used to achieve maximum efficiency through real competition on a level playing field.
- *National and international carbon emissions trading* looks like the best overall mechanism to internalise the environmental costs of emissions. This mechanism has proven efficient and acceptable in the US through the trading of sulfur emissions and is already being implemented for greenhouse gases in the EU and elsewhere. It is complex but difficulties can be worked through.
- *Some potential damages due to climate changes are inevitable* due to climate changes that cannot be avoided because of inertia in the economic and climate systems and where adaptation proves too expensive.

- *Adaptation measures will be necessary to minimise damages.* Adaptation has limits, will not avoid all damages, will have side effects and may be costly (see chapter 7).
- *Mitigation and adaptation measures need to be integrated into normal decision-making* on all matters of development, planning, innovation and investment.
- *Aid will be necessary* for communities and countries with low adaptive capacities, and for those suffering damages. Resettlement aid will be necessary for people displaced by sea-level rise and loss of livelihoods.

This list provides many pointers to what must be done. With a level playing field, and proper incentives, many proven low-carbon energy sources and energy saving strategies can be implemented quickly. According to the experience of many businesses, entrepreneurs and innovators, this can be done at little cost, and may even be profitable. How easy this really is will become clear only as we learn by doing. If it turns out to be easy, then targets below 450 ppm become feasible. Otherwise we may have to resort to more drastic measures.

Possibilities for mitigation were discussed in Chapter 8. Pacala and Socolow of Princeton University, among others, provide an excellent summary list.[21] Such a list (slightly expanded) might include:

Improving energy efficiency and conservation by:

- Increasing fuel economy in cars, including hybrid, fully electric and compressed air cars.
- Reducing reliance on cars, with better public transport, bike paths and urban design.
- Building or retrofitting more efficient buildings with better use of insulation, shade, cogeneration plants, and automatic controls.
- Increasing power plant efficiency.

Decreasing carbon emissions from electricity and fuels by using alternatives such as:

- Substitution of natural gas for coal and oil.
- Wind generated electricity.
- Solar photovoltaics and solar thermal power.
- Geothermal power.
- Wave and tidal power.
- Energy storage from renewables by various means including pumped hydro, hydrogen generation, efficient batteries, electrolyte generation, fuel cells and compressed air.

- Second-generation (cellulosic) biofuels, avoiding land clearing and competition with food production.
- Carbon capture and sequestration from power plants.
- Carbon capture and sequestration from synthetic fuel plants.
- Nuclear power with all safeguards.

Increasing the effectiveness of natural sinks by:

- Improving forest management, including plantations and on-farm forestry.
- Improving management of agricultural soils.
- Biochar and other means of taking greenhouse gases out of the atmosphere.

Nearly all of these options are already operating at a pilot or industrial scale, and could be massively scaled up over the next 5 to 40 years to provide large reductions in global emissions. With priority given to implementing the short-term solutions such as energy efficiency and conservation and rapid deployment of proven renewable power technologies, these options provide an excellent agenda for action.

It is absolutely crucial that options for reducing greenhouse gas emissions be pursued with a real sense of urgency. Every extra tonne of carbon dioxide placed into the atmosphere increases the very real risk of dangerous climate change, and nobody will escape the direct or indirect consequences.

We are in danger of inadvertently tripping the ‘on’ switch to disaster, with an inevitably long delay before it can be turned off again. What is done now that enhances climate change cannot be easily undone, so we should err on the side of caution.

But it is not all doom and gloom: we can save the day. As we have seen earlier in this book, the technology already exists to rapidly reduce emissions via large investments in energy efficiency (which saves money) and renewable base-load power (which will rapidly come down in price as it is scaled up). Supplemented later this century by large-scale carbon capture and sequestration and (if necessary) by safe nuclear power, the peak in greenhouse gas concentrations can be minimised and then brought down.

We need to reduce carbon emissions, and we need to do it fast. Although we are facing an emergency, with an appropriate allocation of ingenuity and resources, together we can do it. We owe that, at least, to our children.

Endnotes

1. Speech at Rice University, Houston, Texas, 12 September 1962. See www.jfklibrary.org.

2. From his speech at the 2004 Bonn Conference on Renewable Energy, quoted in *The price of power: poverty, climate change, the coming energy crisis and the renewable revolution*, New Economics Foundation, 2004 at www.neweconomics.org.

3. *Natural Capitalism* is published by Little, Brown and Co., Boston (396 pp., 1999).

4. The Climate Group website is at www.climategroup.org.

5. ICLEI's website is at www.iclei.org.

6. The special issue of *Climatic Change* on climate and development is volume **84**, no.1, September 2007, edited by A and K Michaelowa.

7. Learning by doing is discussed in a special issue of *Climatic Change*, vol.**89**, Nos.1-2, July 2008 "*Learning and Climate Change*". Climate change mitigation and development issues, including the operation of the Clean Development Mechanism, are discussed in *Climatic Change* special issue, vol.**84**, No.1, September 2007, *Climate or Development?*

8. The first quote from Sean Lucy is from a press release by PriceWaterhouseCoopers on 17 July 2007, available at www.pwc.com/extweb/ncpressrelease.nsf/. The second is from a Melbourne *Age* newspaper article, *Seeing the light*, 21 September 2007.

9. The quote from the Stern Review is highlighted in an article in *The New Economist*, 30 June 2006, available at: http://neweconomist.blogs.com/new_economist/2006/10/stern_review_2.html.

10. See: *International Climate Efforts Beyond 2012: A Survey of Approaches*, November 2004, at: http://www.pewclimate.org/global-warming-in-depth/all_reports/international_climate_efforts.

11. See http://www.iisd.ca/process/climate_atm.htm and www.unfccc.int, respectively.

12. See *Evolution of commitments under the UNFCCC: Involving newly industrialized economies and developing countries*, and *Protecting the climate after 2012,* available at http://www.umweltbundesamt.de. See also: *http://www.ecofys.com/com/publications/reports_books.asp, and http://assets.panda.org/downloads/ecofyspost2012targets20sept05.pdf*

13. The Climate Group studies are available at www.theclimategroup.org, under the "Breaking the Climate Deadlock" prompt. The Pew Center reports are at www.pewclimate.org under the "Publications and Reports" and "Climate Dialogue at Pocantico" prompts.

14. The paper by Robert Reinstein is *A Possible Way Forward on Climate Change*, in *Mitigation and Adaptation strategies for Global Change*, **9**, 295-309 (2004).

15. See http://www.climate.org/topics/climate-change/maccracken-proposal-north-south-framework.html, and a longer account is in *Journal of the Air and Water Waste Management Association*, vol.**58**, pp.735-786 (2008).

16. See "*Policy-based Commitments in a Post-2012 Climate Framework*", at www.pewclimate.org.

17. See "*Climate Change Policy After Kyoto: Blueprint for a Realistic Approach*" (2002) from The Brookings Institute in Washington DC., at www.brookings.edu.

18. Links to many other proposals and policy discussions can be found at the website of the *Future International Action on Climate Change Network*, www.fiacc.net. See also ongoing policy discussions in a number of journals, notably:

Climate Policy, (Elsevier Ltd., at www.climatepolicy.com),

Energy Policy (Elsevier Ltd, at www.elsevier.com/locate/enpol),

Environmental Modelling and Assessment (Springer, at www.springerlink.com)

Environmental Science and Policy (Elsevier Ltd., at www.elsevier.com/locate/envsci),

International Environmental Agreements: Politics, Law and Economics (Springer, as above),

Mitigation and Adaptation Strategies for Global Change (Springer, as above).

19. Other publications and websites relating to climate change policy include:

Beyond Kyoto: Advancing the International Effort Against Climate Change, Pew Center on Global Climate Change, December 2003, at www.pewclimate.org,

Climate Change Policy After Kyoto: A Blueprint for a Realistic Approach, by W. McKibben and P. Wilcoxen, Brookings Institution, see www.sensiblepolicy.com,

Climate Policy Beyond 2012: A Survey of Long-term Targets and Future Frameworks, CICERO Center for International Climate and Environmental Research, Oslo, at www.cicero.uio.no,

Climate Protection Strategies for the 21st Century: Kyoto and Beyond, German Advisory Council on Climate Change (WBGU), Special Report, see www.wbgu.de,

Contraction and Convergence – The Global Solution to Climate Change, Global Commons Institute, at www.gci.org.uk,

Dealing With Climate Change: Policies and Measures in IEA Member Countries, International Energy Agency, October 2002, at www.iea.org.

Economy-Energy-Environment Simulation: Beyond the Kyoto Protocol, ed. Kimio Uno, Kluwer Academic Publishers, 2002,

Framing Future Commitments, Benito Muller, Oxford Institute for Energy Studies (www.OxfordEnergy.org),

Overview of ongoing activities on the future design of the climate regime, Bernd Brouns, Wuppertal Institute for Climate, Environment and Energy (www.wupperinst.org),

Tiempo, for latest news and information on climate and development, at www.tiempocyberclimate.org.

These are all excellent sources of information, but even a brief summary would be exhausting and prohibitive in this book. Use them as resources for your further thinking and action.

For a useful summary of policy lessons for advancing renewable energy technologies at the national level see the thematic background paper, *National Policy Instruments*, for the Conference for Renewable Energies, Bonn 2004, by Janet Sawin at www.renewables2004.de. See also many other studies for particular countries, such as the series by *The Climate Group* at and those from various environmental and

industry groups. For example, *American Energy: The Renewable Path to Energy Security*, by the *Worldwatch Institute* and *Center for American Progress* (September 2006), at www.worldwatch.org. See also *RMI Solutions Journal*, from the Rocky Mountains Institute at www.rmi.org. See also the endotes in Chapter 8.

20. Discussion of the carbon cycle, and in particular of delays in reducing emissions, is contained in a special issue of *Climatic Change*, vol.**88**, nos.3-4, June 2008. See especially the paper by Bryan Mignone and others, *Atmospheric stabilization and the timing of carbon mitigation*, pp. 251-265.

21. See *Science*, **305**, 968-972 (2004) with supporting material at www.sciencemag.org/cgi/content/full/305/5686/968/DC1.