2009 Blue Planet Prize
Commemorative Lectures

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THE ASAHI GLASS FOUNDATION

CONTENTS

Lord Nicholas Stern (U.K.)

Professor, The London School of Economics

Selection rationale: Having reported the economic and social impact of and actions against the colossal climate problem in "The Economics of Climate Change*"* with the approach of cutting edge natural sciences and economics, he provided a clear cut policy regarding the global warming, which has had a major impact on the world.

Education and Academic and Professional Activities

1946	Born in U.K.
	Bachelor of Arts degree in mathematics at Cambridge (1967) , and Doctor of Philosophy in economics at Oxford (1971)
1970-1978	Lecturer in Economics, Oxford University
1978-1986	Professor of Economics at University of Warwick
1986-1993	Professor of Economics at London School of Economics
1994-1999	Chief Economist and Special Counsellor to the President of the European Bank for Reconstruction and Development
2000-2003	Chief Economist and Senior Vice-President of the World Bank
2003-2007	Second Permanent Secretary at H. M. Treasury, Head of the Government Economic Service, appointed to lead the writing of the Report of the commission for Africa 2004-5, conduct a review of the economics of climate change, which led to the Stern Review 2006: The Stern Review was released on 30 October 2006
2007-	I.G. Patel Professor of Economics and Government at London School of Economics, Director of the newly created India Observatory within the Asia Research Centre at LSE, and Chair of the Grantham Research Institute on Climate Change and the Environment Lord Stern of Brentford, cross-bencher in the House of Lords

Lord Stern released the Stern Review on the Economics of Climate Change on October 30, 2006, which discusses the effect of climate change and global warming on the world economy with the aid of recent scientific data and economic models, and has since published extensivery on the subject, including the Richard Ely Lecture at the American Economic Association (American Economic Review May 2008) and his recent book (entitled The Global Deal in the USA and A Blueprint For A Safer Planet, UK) To avoid the devastating effect of global warming, the Review made it clear that the world requires urgent action to implement global policies: cooperation from all countries is crucial. The Review stresses the concept of equity, including, both the responsibility of developed countries to developing countries and intertemporal considerations, the responsibility of the current generation to provide a sustainable planet for future generations.

The Review was discussed at the Conferences of the Parties to the United Nations Framework Convention on Climate Change in 2006 and 2007 (COP12 and COP13) and received much public attention. Backed by the recent scientific data and economics, Lord Stern's work makes a significant contribution, not only through promoting the understanding of academic research, but also by informing the public about the potentially immense toll of global warming. The Review also had a significant impact on governments and policy makers by proposing viable policies to

mitigate and adapt to climate change. Lord Stern continues to take every opportunity to discuss and influence policy makers across the globe, this includes assisting concerned parties to understand the consequences of global warming and understanding of the necessity of urgent action.

From Mathematics to Development Economics

Lord Stern was born on 22 April 1946 in London UK.He earned his Bachelor of Arts degree in mathematics at Peterhouse, Cambridge, and his Doctor of Philosophy in economics at Nuffield College, Oxford. His experiences in Mexico in 1964, Turkey and Iran in 1966 and Ethiopia in 1967 generated a lifelong interest in development economics, and particularly with poverty and the study of the development process in low-income countries. From 1969, early on his career, he began research in development economics, based first in Kenya and then in India, including the Uttar Pradesh village of Palanpur which he has visited regularly since 1974, researching the economic transformation of the village and the close relationship between overcoming poverty and environmental issues and climate changes have been key issues for his work, including in the Stem Review.

He was a lecturer at Oxford University from 1970 to 1977, and served as a Professor of Economics at the University of Warwick from 1978 to 1987. He taught from 1986 to 1993 at the London School of Economics, becoming the Sir John Hicks Professor of Economics. From 1994 until 1999 he was the Chief Economist and Special Counsellor to the President of the European Bank for Reconstruction and Development. He was the Chief Economist and Senior Vice-President of the World Bank from 2000 to 2003 where continued his work on the problems of world poverty.

In 2003 Lord Stern became Second Permanent Secretary at H. M. Treasury, initially with responsibility for public finances, and head of the Government Economic Service. He led the writing of the Report of the commission for Africa 2004-5 and in July 2005 he was appointed by the UK government to conduct a review on the economics of climate change, which led to the publication of the Stern Review on 30 October 2006. The Review gained global media attention for its stark assessment of climate change and examination of comprehensive policies to prevent the likely outcomes of unmitigated climate change. Lord Stern attended COP-13 in Nairobi in Kenya in 2006 and COP-14 in Bali, Indonesia (2007 United Nations Climate Change Conference) to promote the understanding of the Review worldwide.

In June, 2007 Lord Stern became the first holder of the I. G. Patel Chair at the London School of Economics and Political Science. In 2008 he was appointed Chair of the Grantham Institute for Climate Change and the Environment, and head of the newly created India Observatory within the Asia Research Centre at LSE. Sir Nicholas Stern became Lord Stern of Brentford in December 2007, appointed to the House of Lords.

Measures proposed to deal with global warming

The Stern Review is the most comprehensive review on the economics of Climate change. The Review analyses the economic costs of climate change, the costs and benefits of actions to reduce emissions, and considers policies to address climate change. The Review provides clear conclusions concerning the consequences of unmitigated climate change: if we take no action to control emissions and continue along a business as usual (BAU) pathway, we run severe risks of a transformation of the planet which would lead to large-scale migration involving hundreds of millions of people and global conflict. This is a challenge of risk management of the highest order of importance. Expressed in more narrow cost-benefit analysis terms the Review estimated total costs over next two centuries equivalent to at least 5% (up to 20%) of world GDP each year.[*1] Moreover, given the direct impact on the environment and human health, some recent scientific evidence suggests a disproportional share of the climate change burden will fall on the poor regions of the world.

By contrast, if we act now, the cost of action to avoid the most severe impacts of climate change are estimated at around 1% to[*2] of world GDP each year. New technologies and innovation can enable the world to avoid a climate disaster

and maintain strong economic growth. Attempting to continue with high-carbon growth will not only severely damage the planet and humans and other life, it will stop or reverse growth.

To cope with the significant challenge of climate change, the Review concluded that a shared global perspective on the urgency of the climate change is required; long-term policy goals to address global warming, and an international approach based on multilateral frameworks and coordinated action, are essential to respond to the vast scale of the Challenge.

To control global warming, the Review examines national and international policies and indicates that four elements of policy are required. The first is carbon pricing policy worldwide, through taxation, emission trading or (an implicit price) regulation. The second is technology development policy, to encourage low-carbon and high-efficiency product technologies. Third is the policy to remove barriers to energy efficiency, and to inform and educate firms and individuals on possibilities. The fourth policy response is adaptation policy to deal with the climate change to which we are already committed.

An effective response to climate change will depend on creating the conditions for international collective action, for example effective policies to halt deforestation across the globe. After the release of the Review, Lord Stem has traveled extensively across the world to promote policy to curb emissions.[*3]

Lord Stern argues that developed countries are responsible for the bulk of the current stock of greenhouse gases in the atmosphere. They are also richer and have better access to technology. Therefore, they have a responsibility to lead efforts to reduce emissions and to find ways of sustaining development in a more hostile climate. They must do this directly through their own action and providing finance, directly or through trading for action in developing countries. In addition, given that developing countries will be responsible for the majority of the increase in greenhouse gas emission in the future, the sharing of low-carbon technology between developed countries and developing countries is an essential requirement of any effective policy response.

Preservation of the global environment is indispensable to sustain the development of the world economy and the future welfare of society. It is the responsibility of the current generation to hand a safe and sustainable planet to future generations. Stern's work, including in The Stern Review, clearly defines what must be achieved to fulfill our responsibility for avoiding a major climate disaster. If disastrous climate change does occur, the developing countries and the world's poorest will be hardest hit; to prevent this tragedy the world must act with urgency. The clear messages in Lord Stern's work concerning developing countries coincide with his profound understanding of the severe situation of poor people in developing counties and his serious concern over the bleak future in the case of climate inaction.

As an economist, Lord Stern has engaged in studies of economic development, economic theory, tax reform, public policy, the role of the state, and the economic transition from command to market economies. In the year 1974 and 1975, he spent 8 months in a rural village in north east India; and he wrote books about development of tea plantations in Kenya and agricultural change in India. In addition, he has written books on crime and criminal statistics in UK, financial affairs, public development, "A strategy for development" 2002, "Growth & Empowerment: Making Development Happen" 2005, "A Blueprint for a Safer Planet" 2009, and over 100 published academic papers.

Lord Stern expressed the pressing situation of climate change as following:

"There is still time to avoid the worst impacts of climate change, if we act now, we act strongly and we act internationally." Already three years have passed since the Review was made public, urgent action to combat global warming is long overdue.

Notes

*1: After the Review was published, scientists concluded that the capacity of the planet to absorb CO_2 is less that the level assumed in the Review.

Considering this fact, Lord Stern now warns that the impact of climate Change is much larger than the review predicted.

Guardian 25 March 2008

*2: Lord Stern mentioned that the evidence now shows that climate change is happening faster than had been previously thought. Therefore emissions of greenhouse gases need to be reduced even more sharply. Owing to this increase in greenhouse gases, it will cost up to 2% of global GDP each year to address climate change.

Guardian 26 June 2008, New Scientist 21 January 2009

*3: Detailed policy. Developed countries to reduce their greenhouse gas emissions by at least 80%, in order for the world to achieve an overall reduction in global emissions of 50% by 2050.

Substantial trade between countries, including rich and poor countries, in greenhouse gas emissions, to keep down costs and help finance climate investment in developing countries.

A major reform of the Clean Development Mechanism, a Kyoto protocol mechanism that allows developing countries to sell emission reductions, but does not penalize them for emissions themselves.

A programme, $10-15bn per year, could stop up to half the deforestation. Urgent promotion of technologies such as Carbon Capture and Storage (CCS) is needed to curb the emissions from coal-fired electric power generation.

Rich countries honour 0.7% GDP in aid, by 2015 to developing countries for mitigating the impact of climate change.

Guardian 29 November 2007

Creating a Global Agreement on Climate Change: Responsibilities and Opportunities

Lord Nicholas Stern

Introduction

Avoiding dangerous climate change and overcoming global poverty are the two defining challenges of the 21st century. The global responses to these challenges must be carefully designed, but if strong action is taken now, they will be both manageable and affordable.

Rich countries are largely responsible for the causes of the current climate crisis, but it is developing countries that are being hit earliest and hardest by the consequences. Thus, rich countries must take strong action now and provide significant mitigation and adaptation assistance to developing countries. Developing countries must also play a leading role in designing and implementing a global deal. However, it is reasonable that developing countries place strong conditions on the performance of rich countries both in cutting their emissions drastically and in providing financial and technological support to developing country action; with such performance they could provide a "commitment to commit" to emissions reductions. Rich country support can and should start now with substantial help with finance for the climate change action plans which developing countries are now constructing.

I begin by briefly discussing the problem of climate change and what it implies for targets to reduce emissions of greenhouse gases. This leads to a discussion and analysis of how to achieve emissions targets and the likely costs involved. I conclude with the main elements that must be part of any global deal negotiated in Copenhagen in December 2009. If that global deal is to be built and sustained it must be effective, efficient and equitable.

From people to emissions

The rate of growth of economic activity in the industrialising parts of the world accelerated dramatically from the mid-19th century onwards, while the form of that activity (the rise of industry and the relative decline of agriculture, for example) became much more hydrocarbon-intensive. These three effects - growth, industrialisation and hydrocarbon use - combined to increase greenhouse gas emissions. The second half of the 20th century saw a sharp increase in the rates of growth of emissions as the world recovered from the Great Depression and the Second World War, and more countries industrialised.

From emissions to temperature

As a result of this hydrocarbon-intensive growth, the world has been emitting carbon dioxide and other greenhouse gases at a faster rate each year than the planet can absorb, especially during the rapid and energy-intensive growth of the last 60 years.

Concentrations of greenhouse gases in the atmosphere have grown from 285 parts per million (ppm) in pre-industrial times to over 435 ppm of carbon-dioxide-equivalent (CO_2e) today, and we are adding at a rate of over 2.5 ppm per year (and if there is little or weak action this is likely to accelerate to around 3 ppm per year or higher over

the coming decades). As a result, continuing with 'business-as-usual' (BAU) is likely to take us to over 750 ppm CO_2e by the end of the century.[1]

This level of concentration, even if there were no further increase, would result in a significant probability, around 50% or more, of an eventual temperature increase of more than 5°C compared with the pre-industrial era (our benchmark for temperature increases unless otherwise stated). The planet last experienced such temperatures more than 30 million years ago, long before the appearance of humans, 100 to 200,000 years ago. The most recent warm period was around 3 million years ago when the world experienced temperatures 2°C or 3°C higher than today. Humans have never experienced temperatures anywhere near a 5°C increase.

From temperature to climate change and impacts on people

Thus 'business-as-usual' emissions of greenhouse gases would profoundly change the climate of the planet. Global sea level would rise by several metres and many low-lying coastal areas, such as much of Bangladesh, would be inundated. Many areas, probably including southern Europe would turn into deserts. The physical and thus human geography (where we can live and how we live our lives) would be transformed, leading to the migration of hundreds of millions of people, and intense competition for scarcer resources, such as water.[2] This would probably lead to intense and prolonged international and national conflicts. The stakes are immense: we are essentially gambling the planet.

The Fourth Assessment Report published by the Intergovernmental Panel on Climate Change (IPCC) in 2007 includes a review of recent research on the impacts of climate change in Japan. Average temperature in Japan increased by about 1°C in the 20th century and by 2°C to 3°C in the largest cities. This is consistent with evidence of an increase in the number of days over 35°C and a decrease in extremely low temperatures. There is also evidence of increased extreme rainfall events over the past 100 years, including serious flooding in 2004 which was the result of 10 typhoons. Migration of plants and animal species has also been reported, the flowering date of the cherry has changed and alpine flora in Hokkaido have decreased.

The IPCC also reports that heatwave conditions and extreme precipitation will increase over Japan as atmospheric moisture content increases. Significant decreases in rice production are also predicted; an atmosphere with carbon dioxide concentrations that are double those of pre-industrial times (i.e. around 560ppm CO_2e) could decrease rice yields in irrigated lowland areas of central and southern Japan by up to 40%. Sea level rise will also have powerful impacts on Japan. Over 4 million people could be at risk from a rise in sea level of 1 metre.

But remember that 'business-as-usual' will imply far higher concentrations than 550 or 560ppm CO_2e. The consequences for Japan both in terms of direct effects and migration of 550ppm CO_2e would be very unpleasant; for 650ppm CO_2e or more they are likely to be devastating.

What our emissions targets should be

In order to reduce the risk of climate change the world must act together and commit to targets for emissions reductions. Most assessments of sensible risk management imply that we should hold greenhouse gas concentrations at or below 500 ppm CO_2e, and try to reduce them from there. Holding concentrations below this level would expose the planet to a probability of global average temperature rising by 5°C or more of around 2% or

3% compared with a huge 50% or more under 'business-as-usual'.

Looking longer term, we should recognise that holding concentrations below 500ppm CO_2e and bringing down to 450 ppm or below, would still carry a serious risk of passing a number of potential tipping points, like the destruction of rainforests and the release of methane from thawing permafrost. It makes sense, therefore, to interpret 'holding concentrations below 500 ppm' as eventually allowing a very long-term stabilisation markedly below that level. The learning we have to do to hold levels below 500 ppm will tell us much about how to go further. Just where around 500 ppm CO_2e, and then lower, we should aim is a matter of balancing the costs and the avoided risks. As the scientific evidence accumulates the risks look ever larger; on the other hand the technology of emissions reductions is already moving so quickly that costs of action and the benefits of new technologies may look even more attractive.

Annual global emissions of greenhouse gases were about 40 gigatonnes (Gt) CO_2e in 1990; they are over 50 today. If the world is to hold concentrations below 500ppm CO_2e and then try to reduce from there, then we must ensure annual global emissions peak within the next 10 years and reduce to half 1990 levels, or about 20 Gt CO_2e at most, by 2050. As the global population will probably be around 9 billion in 2050, this would be equivalent to emissions of around 2 tonnes CO_2e per capita. Given that there will be very few countries with actual emissions below this level there can be very few above.[3]

At the Italy summit (L'Aquila) in 2009, G8 leaders for the first time acknowledged the importance of avoiding an increase in global average temperature of more than 2°C compared with pre-industrial times. They also agreed a goal for developed countries of reducing their annual emissions of greenhouse gases by at least 80% or more by 2050 compared with 1990. This would take actual emissions in Europe and Japan to around 2 tonnes per capita, the maximum sustainable for any major country as argued above.

In addition to these distant objectives, explicit intermediate targets for 2020 and 2030 are necessary now for the rich countries and very soon for all countries. The immediacy of the problem allows no delay, and businesses, markets and developing countries require strong signals now and powerful examples of what is possible. The longer we delay, the more difficult and more costly it will be to stay below 500 ppm CO_2e.

How to achieve the targets and costs involved

To be on a path to halve annual global emissions by 2050 from 1990, and allow eventual stabilisation at 450 ppm CO_2e, total world emissions in 2030 would have to be around 35 Gt CO_2e. Table 1 outlines six scenarios that demonstrate the extent of cuts necessary to achieve this interim 2030 target.

The scenarios focus on five nations or regional groups: USA, EU/Japan, China, India and the Rest of the World.[4] I have put the EU and Japan together since they start with similar emissions per capita and have similar emissions per unit of output. For all scenarios the overall economies grow at 2.5% for the USA and EU/Japan and 7% for each of China and India. The scenarios then look at different assumptions concerning emissions per unit of output. In the first block of 3 scenarios we have both the US and EU/Japan halving emissions per unit of output and in the second block, dividing by 4.

Within the blocks, the scenarios vary according to different assumptions concerning emissions per unit of output in India and China: India and China both constant; India constant and China halving; India halving and China dividing by 4. The assumptions concerning India relate to her much lower emissions per unit of output in 2010 (close to 2 tonnes versus around 6 for China) and to her lower standard of living (also her 'starting' emissions per unit of output are substantially lower than China's).

The table shows that only scenario 6 has any plausibility in terms of implications for the 4.3 billion people in the Rest of the World in 2030. Even that scenario would imply that the per capita emissions of the USA, EU/Japan and China would substantially exceed those of the 4.3 billion in the Rest of The World by 2030. Scenario 6 would require China to have peak emissions around 9 or 10 tonnes per capita with a peak around 2020 and India to peak at around 4 or 5 tonnes per capita well before 2030. Rich countries would have to reduce drastically starting now.

The architecture is clear: unless the USA, EU/Japan and China reduce emissions per unit of output by a factor of 4 it will not be possible to reach the goals that sensible risk management requires. The alternatives would be to cut growth or be reckless with the climate. Surely the right answer is to cut right back on emissions per unit of output. No major country, least of all a rich one, can claim to have good reason to 'contract out'. We must do this together.

Table 1: Emissions Scenarios Consistent with Global Emissions of 35 $GtCO_2e$ in 2030.

Scenario for emissions (em) change to 2030	Emissions in 2030									
	USA		EU 27 & Japan		China		India		Rest of the World	
	tCO_2e per capita	Total ($GtCO_2e$)	tCO_2e per capita	Total ($GtCO_2e$)	tCO_2e per capita	Total ($GtCO_2e$)	tCO_2e per capita	Total ($GtCO_2e$)	tCO_2e per capita	Total ($GtCO_2e$)
Scenario 1: Overall growth: India & China 7%, US, EU27 & Japan 2.5%. em/output: India & China constant; US, EU27 & Japan halving.	16.6	6.2	9.9	6.2	20.8	31.3	5.3	7.9	-3.8	-16.5
Scenario 2: Overall growth: India & China 7%, US, EU27 & Japan 2.5%. em/output - India constant; China, US, EU27 & Japan halving.	16.6	6.2	9.9	6.2	10.4	15.6	5.3	7.9	-0.2	-0.9
Scenario 3: Overall growth: India & China 7%, US, EU27 & Japan 2.5%. em/output - India halving, China decrease by factor of 4; US, EU27 & Japan halving.	16.6	6.2	9.9	6.2	5.2	7.8	2.6	4.0	2.5	10.9
Scenario 4: Overall growth: India & China 7%, US, EU27 & Japan 2.5%. em/output: India & China constant; US, EU27 & Japan decrease by factor of 4.	8.3	3.1	4.9	3.1	20.8	31.3	5.3	7.9	-2.4	-10.3
Scenario 5: Overall growth: India & China 7%, US, EU27 & Japan 2.5%. em/output - India constant, China halving; US, EU27 & Japan decrease by factor of 4.	8.3	3.1	4.9	3.1	10.4	15.6	5.3	7.9	1.2	5.3
Scenario 6: Overall growth: India & China 7%, US, EU27 & Japan 2.5%. em/output - India halving; China, US, EU27 & Japan decrease by factor of 4.	8.3	3.1	4.9	3.1	5.2	7.8	2.6	4.0	4.0	17.1

Assumptions:	**Population (bn)**		**Emissions per capita (CO_2e)**	**Total emissions ($GtCO_2e$)**
	E2010	**E2030**	**E2010**	**E2010**
China	1.4	1.5	6.0	8.1
India	1.2	1.5	1.7	2.0
USA	0.3	0.4	25.1	7.5
EU27 & Japan	0.6	0.6	12.1	7.5
Rest of the World	3.4	4.3	7.8	26.8

Source: UN 2008 World Population Prospects

Sources: Climate Analysis Indicators Tool (CAIT) & Global Carbon Budget Project.

There will of course, be other countries such as the USA, Canada, Australia which must bring emissions down much more strongly than Japan or Europe - these 3 countries are currently well over 20 tonnes CO_2e per capita. In terms of technology and geography however Japan is much closer to Europe and the fact that others have still farther to go is no excuse for major and technologically advanced countries like Europe and Japan, and Japan is the world's second largest economy, to fail to take a strong lead. If a poor country like China, with much lower emissions per capita than Japan, is likely to have to cut emissions per unit of output by a factor around 4 in 20 years, it is hard to argue that Japan cannot also cut emissions per unit of output by a factor 4 and thus halve its per capita emissions to around 5 or 6 tonnes in the next two decades.

We should not be rigid about the precise figures for annual emissions in 2030 or any other particular year. There could be a little more emissions in one year and a little fewer in another. But the limits imposed by the overall arithmetic for total emissions over the next few decades are very real and give a very powerful indication of the scale of action required.

The key areas of actions to reduce emissions will be (i) energy efficiency (ii) low-carbon technologies and (iii) halting deforestation. All will require investments which will have to start strongly now across the world in order to achieve the annual emissions reductions required by 2030. At the start of the process of stabilising atmospheric concentrations there is great scope for energy efficiency improvements. *Energy efficiency* varies across developed countries. In 2005 Japan consumed 1.94 kWh of energy per dollar of GDP, expressed in (2000) USD. The EU consumed 2.29 kWh per dollar of GDP (there is significant variation within the EU from 4.4 kWh in Bulgaria to 1.33 kWh in Ireland). In contrast, the US consumed 2.68 kWh of energy per dollar of GDP in 2005. While Japan is more energy efficient than the US and some EU states, other major developed economies have achieved similar (Germany, France) or better (UK) levels of energy efficiency.

Developing and deploying low-carbon technologies and activities will also be essential, and Japan is in an excellent position to lead. Japan has shown great technological leadership in the past; the Toyota Prius is a prominent and important example of 'green' innovation and leadership by a Japanese company. Another, less well-known, example is the development and deployment of home-use fuel cells by Tokyo Gas Company and Panasonic Corporation. The success of these technologies, especially hybrid drive technology, demonstrates the rewards and opportunities available to those who lead.

The global emissions reductions necessary require there to be many more examples like these. We need a rapid and widespread advance in the development and diffusion of a wide range of technologies. Technology policy is essential to achieve this and is a powerful stimulus. Japan has great experience in this area of policy.

As with all policy that creates the incentives to drive major change, it is important to avoid overconcentration on the many lobbyists and vested interests that will seek to delay and/or reduce the effectiveness of policy. The world needs Japan's proven track record of technological innovation. Japan has a significant opportunity to lead the world again, just as she did with the development of the semi-conductor during the 20th century.

Halting deforestation will require major advance in agricultural productivity and in other parts of the economies of the regions where the trees stand. Governance and enforcement of laws on deforestation will require

investment too. And peoples dependent on forests in various ways must have a strong and direct stake in their protection. Policies must be constructed by the countries where the trees stand but strong external support should be an obligation on us all. Japan is playing its role in helping to reduce deforestation. For example, it is an active participant in the Asia Forest Partnership (AFP) that aims to combat illegal logging and reduce forest loss and degradation. We all gain from avoided deforestation. We should be clear however that it will require substantial and sustained financial and other support.

The cost of stabilising at or below 450 ppm CO_2e (and implementing these different mitigation options), if the world acts now, is relatively small, compared to the cost of the damages avoided. Both the bottom-up and the top-down studies in the Stern Review, Chapters 9 and 10 respectively, arrived at mitigation costs in similar ranges - around 1% (between -1% and 3%) of world GDP for stabilisation below 550ppm CO_2e. With ever clearer evidence that risks from unmanaged climate change are even worse than was assumed by the Stern Review, it is clear that concentrations should be held below 500ppm CO_2e and eventually brought down to no higher than 450ppm CO_2e. The annual costs of mitigation over the next few decades might now be around 2% of world GDP.

Since the Stern Review was published there have been a number of new studies, both bottom-up and top-down. Significant examples of the former are those from McKinsey (Enkvist et al., 2007) and the IEA (2007), both of which indicated mitigation costs consistent with or lower than the Stern Review. Similar conclusions on costs of action are drawn in the Fourth Assessment Review of the IPCC (AR4, IPCC 2007).

These costs will mostly take the form of new investments and will appear, for a while, in terms of higher costs for energy to industrial and domestic consumers. But there will be potentially major savings from energy efficiency and the new low-carbon technologies, relative to those displaced, are likely to have strong benefits (energy security, cleaner air, less noise, etc.) beyond the reductions in emissions. Stopping deforestation carries great co-benefits too in terms of avoided soil erosion, silting and flooding and better watershed management, maintaining patterns of rainfall, bio-diversity and so on.

Thus, we should not see the route to the low-carbon economy merely or mostly in terms of cost and burden-sharing. There are investments and opportunities. The transition to the low-carbon economy over the next two or three decades is likely to be one of the most dynamic and exciting periods in economic history with strong discovery and growth. This will be wider and deeper in terms of technology and geography than the arrival of the railway and electricity in industrialising countries in the 19th and 20th centuries. And when low-carbon growth is achieved it will be more energy secure, cleaner, quieter, safer, and more bio-diverse than its predecessor; in other words much more attractive. High-carbon growth has no future: it will kill itself if we try to continue - first on high hydrocarbon prices and second and more fundamentally, on the very hostile physical environment it will create.

A Global Deal

The 15th Conference of the Parties (COP15) to the United Nations Framework Convention on Climate Change, to be held in Copenhagen in December 2009, will be decisive in determining the policies for the period beyond 2012 that succeed the Kyoto Protocol. The Copenhagen meeting will be the most important international gathering since the Second World War. The risks it must grapple with and the policies it agrees must be truly global. A delay in reaching an agreement would be dangerous. First, the relentless flow of emissions would continue to increase the

stock of greenhouse gases in the atmosphere, taking us into ever more difficult territory and second, delay could undermine the market confidence that will be crucial for the necessary investments in the low-carbon economy.

It is important that the agreement in Copenhagen be guided by clear principles based on rigorous analytic foundations and a common understanding of the key challenges. The following provides a brief outline of a possible global deal based on the preceding analysis.[5] It also draws on intensive public discussion during the work of the Stern Review in 2005 and 2006 and on continual interaction internationally over the last three years.

Any global deal must be based on three basic principles:

Effectiveness - it must lead to cuts in emissions of greenhouse gases on the scale required to reduce the risks from climate change to acceptable levels;

Efficiency - it must be implemented in the most cost-effective way, with mitigation being undertaken where and when it is cheapest; and

Equity - it must take account of the fact that it is poor countries, with fewer resources and technologies, that are being hit earliest and hardest by the consequences of climate change, while rich countries have a particular responsibility for the cause through their past emissions.

Effectiveness

There are several requirements for 'effective' action:

- Global annual emissions to fall by at least 50% relative to 1990 levels by 2050, to at most 20 $GtCO_2e$;
- Global average per capita emissions that will need to be around two tonnes per year by 2050 (20 Gt divided by nine billion people);[6]
- Agreement by developed countries to take on immediate and binding national targets, and to commit to reductions of at least 80% by 2050 compared with 1990;
- Well before 2020, demonstration by developed countries that they can deliver credible reductions, without threatening growth, and that they can design mechanisms and institutions to transfer funds and technologies to developing countries;
- Subject to this and to strong support with finance and the sharing of technology, a formal expectation that developing countries would make a 'commitment to commit' to take on binding national targets of their own by 2020;
- All developing countries with or without immediate formal targets would require climate change action plans;
- A commitment by all countries, regardless of targets, to develop the institutions, data and monitoring capabilities to assess progress in a transparent way, and to put in place policies to avoid the locking-in of high-carbon infrastructure.

Efficiency

Only sound, measured and coordinated policy, and timely international collaboration, can deliver strong and clean

growth for all at reasonable cost. The essence of efficiency is to get emissions reduced where the cost is lowest. If any mass sector, technology or country is left out, costs will rise. In principle, efficiency requires that the marginal cost of reducing emissions is the same everywhere.

Backed by very strong targets for cuts in emissions by developed countries, carbon prices can be maintained at levels which will provide incentives both for reductions at home and purchases from abroad, and will guide action towards the lowest cost options. The cheapest mitigation options often reside in developing countries, which should take advantage of carbon markets from the outset. The current structure of the Clean Development Mechanism (CDM) makes it difficult to create market flows to developing countries on the scale required. Moving from a project-based to a wholesale mechanism, perhaps based on sector-specific efficiency targets and credible sector decarbonisation plans, would permit scaling-up in a number of emissions and energy-intensive industries.

Equity

Any global response to climate change must be equitable; responsibilities and costs should be allocated in ways that take account of wealth, ability, and historical responsibility.

However, we start in a very difficult and inequitable position. The numbers are stark. Rich countries are responsible for around two-thirds of the existing stock of greenhouse gases in the atmosphere and their emissions per capita are much higher than those of poor countries. Therefore developing countries have a strong and understandable sense of injustice. They see rich countries having first relied on fossil fuels for their development, and thus being largely responsible for the existing stocks of greenhouse gases in the atmosphere, then telling developing countries to find another, and possibly more costly, route to development.

Given the inequities of the history of emissions, and the implications of climate change for future development, rich countries must demonstrate the feasibility of low-carbon growth and set an example for others. However, they should do much more than this. There is a strong imperative for the rich countries to provide more funds to developing countries, in addition to current development commitments, to fund the extra costs created by climate change.

Delivering additional funds on an appropriate scale is crucial. The long-standing target for development aid, set out in the Monterrey Consensus on Financing for Development in 2002 and reaffirmed in December 2008 in the Doha Declaration on Financing for Development, is for developed countries to provide at least 0.7% of GNP as Official Development Assistance (ODA). The EU gave itself, in June 2005, just before the G8 meeting at Gleneagles in the UK, until 2015 to reach the target.

Adaptation to a more hostile climate, however responsible we are in cutting emissions, will increase the burden on developing governments. Therefore the targets for support from the public budgets of rich countries are likely to be closer to 1.0% of GNP than 0.7% for the coming two decades. With the private flows that could come with them and the growth and poverty reduction they could help foster, these flows of public funds would constitute very wise investments for the world as a whole, as well as the fulfilment of our duty as citizens of the world.

Developing countries should challenge the rich countries to commit to very strong cuts in emissions. They

could place the following conditions on rich countries and, on condition of their fulfilment, the developing world should give a 'commitment to commit' to targets within 5-10 years:

(i) strong performance by the rich countries over the next decade towards meeting targets for 2020, 2025 and 2030, which are tough and fully consistent with a path to reductions in emissions of at least 80% by 2050 relative to 1990;

(ii) financial support through the markets and elsewhere for action in the developing world, and strong support in the battle against deforestation; by the 2020s the necessary flows to support reductions in emissions by developing countries are likely to be in the region of $100bn per annum.[7]

(iii) rich countries to develop new technologies for low-carbon economic growth, which should be shared with developing countries; and

(iv) substantial assistance in adaptation to those impacts of climate change which are now inevitable over the next few decades; by the 2020s the necessary additional support (over and above existing ODA countries) is likely to be in the region of $100bn per annum.[8]

This would be a framework where the developing world would explain to the rich world what is necessary and place the conditionality and performance requirements on them.

Conclusion

If the world allows climate responsibility on the one hand, and growth, development and the fight against world poverty, on the other, to become set against each other, the argument is lost from the start. The world has both the technology and the economic understanding to move forward strongly on both simultaneously. In other words the two defining challenges of our century must be tackled together. If we fail to manage climate change we will derail development and if we try to manage climate change by blocking development we will fail to build the global coalition necessary to reduce emissions.

Japan is in a strong position be in the vanguard on climate change. Japan has an enviable track record of leadership in technological innovation and the world looks to Japan to again demonstrate this leadership. Strong and effective climate change policy that sets a clear and instructive example for the rest of the world is crucial. If not the world will ask "if a country like Japan cannot do this, then how can we?" Japan is pivotal.

At Copenhagen in December 2009, leadership must come from the top; that means heads of government. The problems of climate change are too wide to be confined only to one or two individual government departments, ministries or negotiators. It is vital that united and decisive leadership is displayed by heads of government. And if we learn to collaborate on the necessary scale in this fundamental area we will surely do much better in the many other important areas of international policy.

Rich countries must recognise their responsibilities, especially to developing countries and take strong action now. Developing countries should place conditions on rich countries, and on condition of their fulfilment, 'commit to commit' to substantial cuts in emissions of their own. The arithmetic is crystal clear, only a comprehensive

agreement that involves both rich and developing countries can achieve the cuts in emissions necessary to avoid dangerous climate change.

Action is not led only from the top: it will be the individual understanding of citizens, communities, companies and NGOs that will drive forward this debate. The understanding and demands of members of the public are the most fundamental drivers of political change. It will be this voice that will carry us through to a more responsible future.

Notes

1. For references the reader may wish to consult my recent book "A Blueprint for a Safer Planet", published by Bodley Head in April 2009 (title in the USA is "A Global Deal" and published by Public Affairs), the Stern Review on "The Economics of Climate Change" published by Cambridge University Press in January 2007, or the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC).
2. Note that the effects of climate change operate mostly through water in some shape or form: storms, floods, drought, sea-level rise.
3. The base of 1990 for emissions reductions is not always stated - but it should be. The 20 Gt CO_2e upper limit in 2050 already involves substantial risk and should not be revised upwards.
4. EU refers to the 27 member countries of the European Union.
5. The reader may wish to consult my recent book "A Blueprint for a Safer Planet", for a detailed description.
6. We should note that this applies to actual emissions and there are strong arguments for rich countries to not only limit their actual emissions to these levels but also to fund emissions reductions elsewhere.
7. See, for example, "A Blueprint for a Safer Planet", Stern, 2009.
8. See, for example, the analysis of the Human Development Report 2007-08 which indicated costs around $85bn p.a. by 2015.