Towards A Global Deal on Climate Change

Lord Nicholas Stern

The Third Annual
Richard H. Sabot Lecture

June 2008

The center for Global Development

The Richard H. Sabot Lecture Series

The Richard H. Sabot Lecture is held annually to honor the life and work of Richard "Dick" Sabot, a respected professor, celebrated development economist, successful Internet entrepreneur, and close friend of the Center for Global Development (CGD) who died suddenly in July 2005. As a founding member of CGD's Board of Directors, Dick's enthusiasm and intellect encouraged our beginnings. His work as a scholar and as a development practitioner helped to shape the Center's vision of independent research and new ideas in the service of better development policies and practices.

Dick held a Ph.D. in economics from Oxford University; he was Professor of Economics at Williams College, and he taught at Yale University, Oxford University, and Columbia University. He made numerous scholarly contributions in the fields of economics and international development, and he worked for ten years at the World Bank.

The Sabot Lecture series hosts each year a scholar-practitioner who has made significant contributions to international development, combining, as did Dick, academic work with leadership in the policy community. We were pleased in 2007 to have Ngozi Okonjo-Iweala, Managing Director of the World Bank, deliver the Second Annual Richard H. Sabot Lecture. In 2006, the Sabot Lecture was delivered by Lawrence Summers, Charles W. Eliot University Professor of Economics at Harvard University. We are grateful to the Sabot family and to CGD board member Bruns Grayson for support to launch the Richard H. Sabot Lecture Series.

Lord Nicholas Stern

Lord Nicholas Stern is the IG Patel Professor of Economics and Government at the London School of Economics. He was previously advisor to the UK Government on the Economics of Climate Change and Development. His work in that position led to the publication of the *Stern Review* on the economics of climate change in October 2006. He is Vice Chairman of the Idea Global Group and Special Adviser to HSBC's Chairman on Economic Development and Climate Change. He is responsible for advising HSBC on economic development issues and the implications of climate change on the Group and its clients.

From 2003 to 2007, Stern held many positions in the UK government, including Head of the Government Economic Service (2003–2004), Second Permanent Secretary to Her Majesty's Treasury (2003–2007), and Director of Policy and Research for the Prime Minister's Commission for Africa (2004–2005). From 2000 to 2003, he was Chief Economist and Senior Vice President for Development Economics at the World Bank. Stern was knighted in 2004 and introduced to the House of Lords in December 2007.

The Stern Review measures the economic impacts of climate change and the impacts of efforts to stabilize greenhouse gas emissions. The review finds that climate change poses serious global risks that require quick responses in order to avoid the worst effects of climate change. Stern writes that the cost of enacting policies now to stabilize greenhouse gas emissions—about 1 percent of global GDP per year—must be considered a wise investment with returns that will far outweigh the costs of doing too little.

Towards a Global Deal on Climate Change

Thank you very much. It is a great pleasure to be back at CGD. I admire what everyone here has been creating over the years—it is really tremendous. You are changing the way in which people see things—not only in the United States, but much farther afield. It is a special privilege for me to be giving the Richard H. Sabot lecture.

I knew Dick for more than 30 years in various incarnations—in Kenya, where I was working on tea; in Oxford where I taught for eight years and Dick was a frequent visitor; and in and around the World Bank over a few decades. He was a man of extraordinary wisdom, great friendship, great scholarship, and entrepreneurship. So it is a special privilege for me to be asked to give this lecture, and I thank Dick's family and Nancy for the invitation.

Climate and Development: Two Great Issues of the Twenty-First Century

Development and climate change are the two great issues of the twenty-first century, and unless we tackle them together, we will fail on both. Climate change, if it goes on unmanaged, will undermine development. Conversely, any response to climate change that appears to stall development will fail. It will fail politically and it will deserve to fail. Unless we tackle them both together, we are not going to be successful on either. This point is absolutely crucial. I underline it because sometimes you get into a horse race: should we do one or the other? To frame the debate in this way is analytically and ethically confused. We should be emphasizing the ways in which they come together.

I am going to cover some ground fairly rapidly because climate change is a huge subject. I know that CGD is highly selective in its audience, so I'm sure that covering this ground quickly is not going to be a problem. I won't be too heavy on the economics. There is an awful lot of economics in this topic. It is actually as difficult a subject in economics as you could imagine. I realize that there are some people here who are not economists. That is your fault; you have taken your own decisions on your training! But, nevertheless, I don't want to get too

heavy on the economics. Those of you who are economists will notice that I am sometimes sliding over difficulties, but I think the foundations are sound. I would be happy to address specific economics points during questions.

So, I will have to go fairly fast. Groucho Marx asked: "I have a long version and a short version and why should I let you off so lightly?" I'm going to give you the long version fairly rapidly. At the end of the talk I want to address something that has been concerning me—particularly since I left government a year ago. That is, how do we put a global deal together, and what would a global deal on climate change look like?

CLIMATE CHANGE STARTS WITH PEOPLE AND ENDS WITH PEOPLE

How does all of this work? There are several links in the chain. Climate change starts with people and it ends with people. People cause emissions. The emissions generated by the ordinary activities of life—consumption and production—are not fully absorbed by the planet. So these emissions result in an increase in the stock of greenhouse gases. It is this stock that is the problem. The flow-stock process is absolutely fundamental, because it is the stock that traps the heat and causes global warming. And global warming produces climate change. Most of the problems of climate change operate through water in some shape or form—storms, floods, droughts, and sea level rise. Of course, heat itself is part of the story too. In many cases, these effects disrupt and undermine people's lives, their consumption and production activities, how and where they can live.

That in brief is the story, the risks and the dangers. Every link in that chain of climate change is stochastic, or has randomness in it. So, we can't predict any of these things with certainty. But we can start to talk about the language of probabilities, and the science has told us quite a lot about probabilities. I will focus on one link in the chain to illustrate.

Chart 1

Probabilities (in percent) of exceeding a temperature increase at equilibrium

Stabilisation level (in ppm CO_2e)	2°C	3°C	4°C	5°C	6°C	7°C
450	78	18	3	1	0	0
500	96	44	11	3	1	0
550	99	69	24	7	2	1
650	100	94	58	24	9	4
150	100	99	82	47	22	9

Source: Hadley Centre: From Murphy et al., "Quantification of Modelling Uncertainties in a Large Ensemble of Climate Change Simulations," Nature *430:768-772.*

Chart 1 shows the probability, expressed as a percentage, that a given level of greenhouse gases in the atmosphere will lead to various temperature increases. The chart shows temperature changes in Centigrade; to convert to changes in Fahrenheit, multiply by nine over five. So, for example, an increase of 2 degrees centigrade is the same as an increase of 3.6 degrees Fahrenheit or 5 degrees centigrade is 9 degrees Fahrenheit.

The atmosphere currently has about 430 parts per million of CO_2 equivalent; that is, CO_2 and other greenhouse gases measured in terms of their CO_2 heat-trapping potential. We are a little above 430 ppm, but we are increasing the concentrations at about 2.5 ppm per year—and that number is rising.

If we went on with business as usual, not changing our ways much for a century, that 2.5 ppm would go up quite quickly. Over the century, the concentrations could rise at an average rate of at least 3 ppm or 4 ppm per year. Over that time period then, we would be adding 300–400 ppm of CO_2. That 430 ppm where we are now would rise to 750, 800, or even 850 ppm. Well, 750 ppm is plenty bad enough. Let's just focus on 750 ppm.
Of course, you can't stop this train in its tracks. But what if you did stop right there, at 750 ppm? What would the world be like? We would have close to a

50-50 chance of being above 5°C sometime early in the next century. That is enormous. Five degrees centigrade is not just the difference between Edinburgh and Madrid, or Maine and Florida; it transforms the planet. Last time we were 5°C above where we are now was during the Eocene period, or 30 to 50 million years ago. The world was largely covered in swampy forest and there were alligators near the North Pole.

Now, it is not the alligators at the North Pole that worry me so much. The point here is that this kind of temperature change rewrites where species are and it rewrites where humans could be. The last time we were 5°C below where we are now was much more recently—about 10,000 years ago, or during the last ice age. The ice sheet came down just north of London and just south of New York. When it melted, the UK separated from Europe. Now you might regard that as a wholly beneficial outcome! But my point is that this kind of change profoundly recasts where people can live. If you change the physical geography of the world on such a scale, then you change the human geography of the world. On a comparable scale, some parts would be inundated, others would become deserts, others uninhabitable because of hurricanes; snow caps and glaciers would disappear, rivers would be re-routed, monsoons disrupted and so on. Massive population movements would result because we have made our settlements on the basis of an existing climate, and existing sea levels. We have developed as a species in relation to that climate. It is all about change, huge and deeply damaging change. And if we've learned one thing in the last few hundred years, it is that massive movements of people involve conflict and serious loss of life. It wouldn't just be like a world war that goes on for a few years; this kind of disruption of the climate and population movement would go on for a very long time. Given the potential magnitude of these changes, the language of global warming and climate change is I think, inadequate. This is about global overheating and destruction.

THE COSTS OF INACTION

This is a very big phenomenon. If we just talk about the consequences of temperatures rising by one or two degrees, as many economists do, we are missing the point. If we take strong action now—holding at 500 ppm, say, and not going to 750 ppm—we can keep an increase of 5˚C down to a 3 percent probability, and an increase of 4˚C can be held down to an 11 percent probability. And look how fast that probability goes up as you increase the concentrations of CO_2—this is the cost of inaction. The 3 percent probability of a 5˚C increase at 500 ppm becomes a 47 percent probability at 750 ppm. The cost of inaction entails huge risks with devastating consequences. If we raise CO_2 levels under business as usual, there will be massive change. If we hold below much lower levels, we are buying down that probability in a very substantial way. We should ask ourselves, "Are we prepared to pay the 1 or 2 percent of GDP per annum that it would cost to bring down that probability in that way?" I think most people thinking carefully about that for just a few minutes would say, "Yes, that sounds like a reasonable deal to us." And we are likely to find that there are real benefits beyond managing climate change which come through more quickly—a cleaner, quieter, more secure, more biodiverse and prosperous way of living.

CARBON STOCKS AND CARBON FLOWS

So, broadly, the structure of my argument is that we need to hold CO_2-equivalent levels below 500 parts per million. I will show you very quickly how powerful that observation is because it leads you very strongly in the direction of what policies should look like and, ultimately, what the global deal should look like. It would be nice to be able to hold below 450 ppm CO_2 equivalent, but I think we've missed that target. We are already at 430 and we are adding 2.5 ppm a year. In eight years, we will be there; it is very hard to get this stuff out once it is in the atmosphere. This is the flow-stock problem, which has a clear ratchet effect.

If we aim to hold below around 500 ppm, we can work out very quickly what kind of policy measures and economic instruments will be needed. To hold

below this level, you would need to cut annual global emissions roughly by 50 percent by 2050 from 1990 levels, and keep on going down from there. I will come back to the question of the reductions that rich countries should make. You are going to see fairly quickly that they should be 80 percent from 1990 to 2050. But I will keep that for when I talk about the global deal.

The cost of achieving a 50 percent reduction in emissions for the world as a whole by 2050, from 1990 levels, would probably be 1 to 2 percent of GDP. There is some uncertainty there, which I will discuss a little later.

THE PRICE OF CARBON

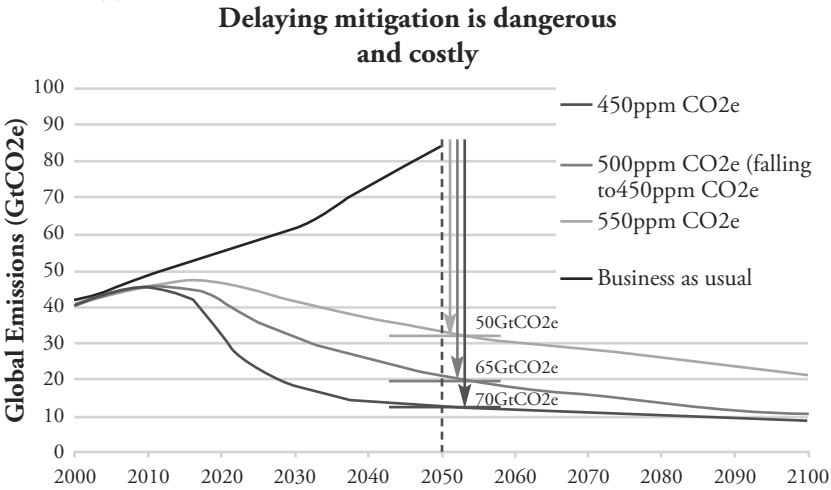
So, we have looked at the stocks we should aim for, the emissions reductions needed, and roughly what it costs. That is the basic structure of the first part of the argument. The next step concerns what type of economic instruments are most appropriate in getting us there and in particular what price for carbon we should have. There is a marginal cost associated with each moment of time and the levels of cuts that need to be made. So, the simple story of 500 ppm upper limit on concentrations and 50 percent reductions in emissions by 2050 tells you the path—roughly speaking—of marginal abatement cost. If the price of carbon over time follows this path, and if markets work well, the urge to minimize costs will, in principle, lead to the right level of emissions.

You can go back and check just how closely that marginal cost of carbon, or the cost of cutting back on carbon dioxide, compares with the marginal social cost of having a bit more carbon dioxide. I tell the story in this way, from risk, to path, to marginal cost, to price, because it is very difficult to calculate the marginal social cost of "a bit more carbon dioxide." Just think about it. You put a little extra up there and it stays in the atmosphere for a very long time. So, you have to look at the integral over the indefinite future. That integral will be different according to which path of carbon you happen to be on. You then have to think about how to model and value those consequences. If you give me a path for the marginal social cost of carbon, I can probably invent a moderately plausible emissions path, set of consequences, and intertemporal

values could give you that cost. That is why I prefer to go the way I have, which is to work through a target and then exercise marginal abatement costs. It gives you much greater clarity of logic and of results, but do not misunderstand me: one should indeed check on the marginal social cost—or the social cost of carbon, as it is sometimes called—and see that it is roughly in the right range.

I will come back to the equity side of the global deal in just a moment, but let's remember that this is deeply inequitable. The rich countries are responsible for about 70 percent of current concentrations of greenhouse gases, but the poor countries are hit earliest and hardest. The emissions per capita of most of sub-Saharan Africa is a good deal less than one ton; India is at two tons per capita; China, at about five; Europe at ten to fourteen. Japan is in a similar range, and the United States, Canada, and Australia are over 20. The difference is even bigger if you look at stocks, since the rich countries industrialized far earlier than the poorer.

CHART 2



Source: Nicholas Stern, The Economics of Climate Change: The Stern Review *(Cambridge, 2007).*

Let us now look at the possible flow paths for emissions a little more closely and think about the costs of achieving the necessary reductions. Chart 2 gives you a feel for various emissions reductions paths relative to business as usual. The vertical axis represents the flow of emissions, and the horizontal axis, time. The top line represents business as usual, with the flow of global emissions increasing from year to year. The second line represents a flow of emissions which can stabilize the stock of greenhouse gases at 550 ppm of CO_2 equivalent; the third line represents a flow which can stabilize at 500 ppm; and the fourth line, at 450 ppm. You can stabilize at a given level over a number of paths (e.g., do a little more reduction earlier and a little less later), but stabilization paths for the given level would look roughly as drawn.

Now do a fast piece of mental arithmetic here. If you go to 2050, business as usual would have global emissions around 85 gigatons of CO_2 equivalent; to stabilize the stock of greenhouse gases around 500 or 550 ppm (the yellow or red line), we'd have to cut emissions by 50, 60, 65 gigatons. Take a price of carbon around $30 a ton and multiply it by 50, 60, or 65 gigatons and you get a number that is essentially $1.5–2 trillion. World GDP in 2050 may be around $100 trillion; it's probably at $50 trillion now. That gives you a feel for where the 1 or 2 percent of GDP comes from. If you do those sums, you realize that you are in the right ballpark.

We did these cost estimates largely from the bottom up, looking in some detail at individual technological possibilities. Others have developed fairly fancy models of the world economy as a whole, in particular its energy sector, which we can think of as "top-down." Since publication of the *Stern Review*, there has been quite a lot of bottom-up analysis—such as from the International Energy Agency, McKinsey, and the Nobel Prize–winning Intergovernmental Panel on Climate Change (IPCC). Ottmar Edenhofer at the Potsdam Institute, for example, has done both bottom-up and top-down work. Basically, people have been pointing to the kind of numbers that we came up with—although a little bit lower in some cases.

But a great deal depends on good policy. There are lots of ways of messing this up if we get into more expensive ways of cutting back on flows: such policies could lead to costs of more than the 1 or 2 percent that I described. Good policy and sound economic analysis matter enormously.

You have to take the cheapest options before the more expensive ones, and of course price mechanisms—here for greenhouse gases—are designed to do exactly that. Without such policy connections, we have market failure: you do not pay for the costs you inflict on others from emitting greenhouse gases. It is the biggest market failure the world has ever seen. We are all involved and the consequences are potentially enormous.

So what do you do? You fix the market failure. And you fix it first through the price mechanism—taxes, or quotas and trading. The policy response to market failure is not to drop back into central planning. The right thing to do is to fix the market failure by setting a price for carbon. There has been much public discussion about this approach. If you are a neurotically narrow, neoclassical economist, you would say "just set the price to fix the market failure and let the entrepreneurship and glorious competition of the market sort out all the rest." A price for carbon is, indeed, fundamental, but it isn't quite as simple as that. There are lots of other market failures out there, such as market failures associated with ideas, capital markets, and buildings and land. There is a very important argument for going beyond carbon prices and supporting accelerated technological development—essentially fixing other relevant market failures. I will say a little bit more about that in a minute.

THE RISKS OF INACTION

Looking back at the *Stern Review*, I think that we probably got the costs of reducing emissions about right. But, 18 months on, I think that we probably underestimated the risks of inaction. Emissions are growing faster than we thought. The absorptive capacity of the earth looks weaker than we thought, the probability of high temperatures from given stocks of greenhouse gases looks a bit higher than we thought, and the rapidity of the entire set of

processes seems to be greater than we thought. So, broadly speaking, the *Stern Review* underestimated the risks.

The argument that seems most persuasive to me about the cost of inaction, the one sketched above, consists of describing as best we can the types of risks that occur from business as usual or delayed action, in terms of physical perils, forced migrations, conflicts, and so on. Economists, however like to do their overall aggregations and compress diverse elements into single numbers. The *Stern Review* worked mostly in terms of describing risks as well as possible but did succumb to aggregation in just one chapter. In order to aggregate across space and time and outcomes, you have to do averaging. When we take averages to assess relative costs and risks for different paths, we generally try to quantify using expectations of utility. This is analogous to what we do when we average across regions of the world, usually by adding social utilities, where utility functions express some aspects of distributional values.

If you average over time, you also have to think about discounting. The discussion of discounting in many contributions to the literature on climate change has been truly awful. You will find a vast array of errors and confusion, but I am not going to bore you with too many of the details. I addressed my fellow economists when I gave the Richard Ely lecture to the American Economic Association in January 2008. These remarks were published in May in the *American Economic Review*. I tried to set out the key generic ways in which the discussions of discounting in the climate change literature had gone so badly wrong. Let me just give three examples of the types of confusion and error which arise when an attempt is made to "read off" discount rates for climate change from market data or interest rates or rates of return.

(i) Discount rates are usually defined in terms of marginal changes around a given path. But with climate change we are examining very different paths and risks: we are clearly dealing with non-marginal changes.

(ii) Markets for intertemporal transactions rarely cover more than 20 or 30 years and are for individual decision. There are no markets that can tell us how we should act in terms of discounting over a hundred years for collective decisions. Even if there were such markets, you would have to think carefully about their ethical relevance.

(iii) Most importantly, this isn't a single-good problem; it's a multi-good problem. You might consider postponing action on climate change and invest in something else and say, "I'll buy off the damages caused by climate change farther down the track and invest in other things for now." But, with a multi-good problem like this, the relative price of the environment shoots up against you over time, and it is much more expensive to buy down later on.

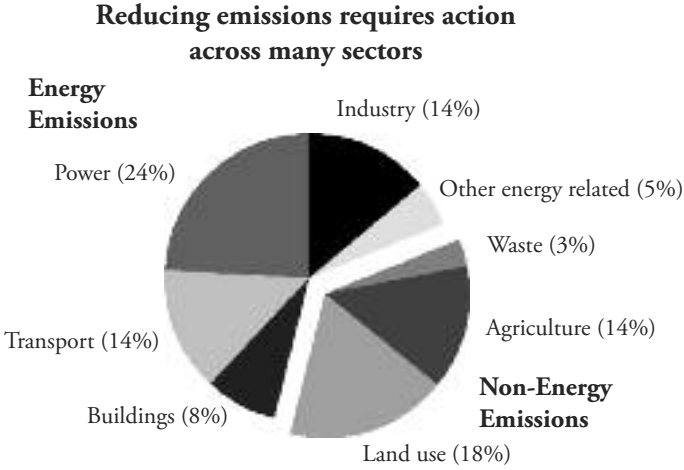
All the mistakes I have just described (and many more) have been made in the discussion of this literature. That discussion and how it goes wrong is for the nerdy economists amongst you, and I'll spare you the rest of it! Those of you who like that sort of stuff can read my article in the *American Economic Review* that came out in May 2008.

ENERGY POLICY

I'm going to go pretty rapidly through the policy story, that is how we can efficiently and equitably foster the necessary reductions in emissions, because I want to focus a little bit more on development and the global deal. Carbon emissions, carbon dioxide emissions, and greenhouse gas emissions come from a huge array of activities and sectors, which means that policy has to be effective across the board (see Chart 3). Power, transport, buildings, and industry are all very important; so too are the emissions from changes in land use, associated particularly with deforestation, forest degradation, and peat fires. Agriculture itself emits greenhouse gases.

Because there are some activities for which the reduction in emissions are more difficult or will move more slowly than others, reductions where actions are potentially easier or quicker will have to move more strongly. Reducing global

Chart 3



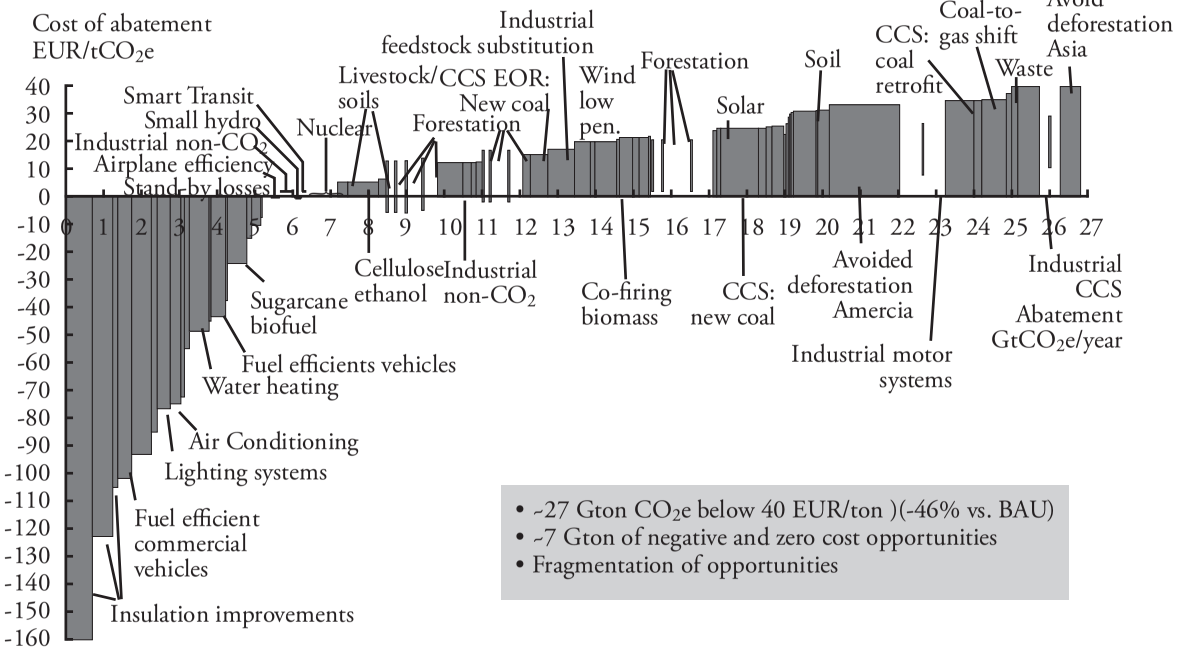
Total emissions in 2000: 42 $GtCO_2e$.

emissions by 50 percent by 2050 relative to 1990 will require a massive shift to carbon-free power and road transportation, but we'll have to do much more than that. The quicker wins are increasing energy efficiency and stopping deforestation, with the right policies and sensible incentives. Further increasing energy efficiency generally saves resources, and halting deforestation has a broad range of environmental benefits, for example water and bio-diversity, which can appear fairly soon—years not decades. In fact, there is a great deal that we can do in all of these areas with existing technologies and much more that we will be able to do with future technologies.

Some of the options are illustrated in Chart 4. Amounts of reductions are on the horizontal axis and the cost (in euros) on the vertical axis. Notice the big chunks below the axis; they correspond to energy-efficiency measures that actually save resources. As you move toward bigger emissions cuts, however, it is necessary to adopt, measures that will cost resources. If you are aiming for 20 or 25 gigaton cuts by 2030, which is roughly the necessary magnitudes on the path that I am suggesting you get to a cost of 30 or 40 euros a ton by 2030. [These figures are equivalent to $38–52 a ton at current exchange rates.]

Many options: policy matters and prices crucial

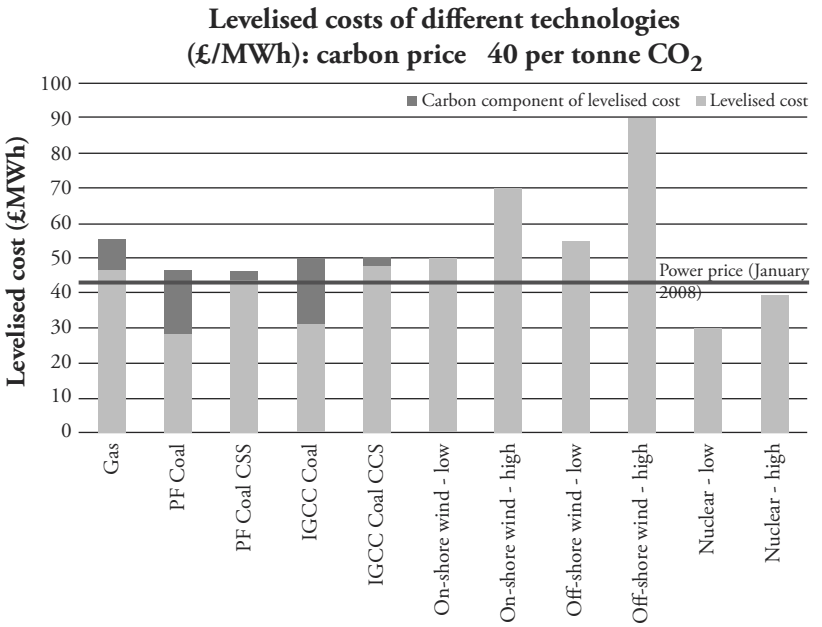
2030



- ~27 Gton CO_2e below 40 EUR/ton)(-46% vs. BAU)
- ~7 Gton of negative and zero cost opportunities
- Fragmentation of opportunities

Source: McKinsey & Co., Reducing U.S. Greenhouse Gas Emissions: How Much at What Cost, *U.S. Greenhouse Gas Abatement Initiative (2007).*

Chart 5

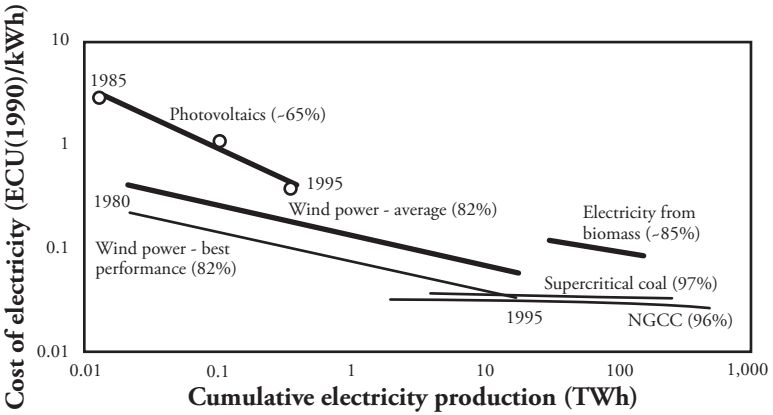


Source: Department of Trade and Energy (UK), The Energy Challenge: Energy Review Report 2006. *(Fossil fuel price assumes price of oil of $70/barrel.)*

Chart 5 shows the costs per megawatt hour of several sources of electric power (the data are from the UK and are expressed in pounds Sterling). The first five are carbon-intensive and have a 40-euro-per-ton carbon price added to their cost. The cost of oil is taken in this chart to be $70 per barrel, somewhat lower than the International Energy Agency estimate of $100 for the next two decades, the horizontal line is the electricity price in the UK for January 2008. Nuclear energy already looks profitable relative to UK prices, but these estimates may be a little optimistic. Coal looks pretty attractive at current prices, but not if you put that shaded box (or the carbon price) on top of it. What we are seeing now is that the carbon price makes many zero-carbon energy alternatives quite attractive, especially if you push up the dollars per ton.

CHART 6

Technology needs more than a carbon price



Source: International Energy Agency, Experience Curves for Energy Technology Policy *(OECD/IEA, 2000) and* Stern Review *(2006).*

Chart 6 illustrates the learning process in electricity generation. The horizontal axis shows cumulative electricity production and the vertical axis shows how fast costs come down during various periods from 1980–2000. What this chart is telling us is that we can learn by doing things ourselves and by watching others, in summary, the collective experience in the sector—and this is true across technologies. This provides an argument for supporting technology directly and it explains why we need a price for carbon and a technology policy at the same time. We should always be cautious in thinking that we can pick the winners. Nevertheless, as policies are set, you can't avoid some knowledge of the time scales, and features of technologies which must be of relevance in making policies.

THE GLOBAL DEAL

Let us for the last third of this lecture turn to development and the structure of a global deal.

I've already argued, and argued strongly, that we have to take these two issues of climate change and development together. What are the threats?

Well, I think they are pretty obvious now. All of the dimensions of development that we worry about—health, income, dislocation, and so on—are going to be affected by climate change. You could add education to this story because we all know that, for example, the conditions for water have a profound effect on the ability of girls to go to school, since in many societies they have particular responsibilities for fetching water. Unreliable or rapidly changing water (whether it be droughts, floods, storms, or sea levels) will affect all parts of the development story. That is why it is so important that mitigation (reduced emissions) moves strongly and urgently so that risks can be managed and reduced. Nevertheless the climate is changing and will change, even if we act responsibly, and adaptation will be essential.

Let us take a closer look at adaptation and development. I have time here only for painting with a broad brush and there is a lot to discuss underneath all of this. The first point that I would like to emphasize is that development is a key part of adaptation. Development diversifies economic activities and strengthens your capital. It increases income and allows investment in more defensive activities. We must not put adaptation and development into separate boxes with separate resources or funding streams for each. You should not waste time and energy in asking what fraction of the foundations of the bridge is far more resilient to droughts and floods, and which fraction for crossing the river.

If we decomposed every development project into two versions, one with climate change and one without, you'd divert your attention and undermine your sources of finance and analysis. It simply doesn't make sense. We have to treat both climate and development together. So, it is crucial to think of the funding for adaptation as being absolutely interwoven with the funding for

development. They are not separate topics. Both development and the process of funding for development are endangered if we try to separate them.

We must recognize that development in a hostile climate is much more expensive. A number of people in the room today, including myself, were involved in the UN Conference on the Millenium Development Goals financing for development in Monterey in 2002; I was there as Chief Economist of the World Bank. Before I wrote the Review on the Economics of Climate Change, I also wrote the report on the Commission for Africa. We had strong promises at the G-8 Gleneagles Summit in 2005 to double aid for Africa from 2005 to 2010.

When we had those discussions in Monterrey in 2002 and at Gleneagles in 2005, I don't think we—as development economists—adequately factored climate change into the story. My view now is that if we had considered the impact of climate change, we would have come back with bigger numbers for external financing required to achieve the Millennium Development Goals. The UNDP's Human Development Report estimates that, by 2015, the additional costs of climate change relative to development will be around $85 billion per annum. Now, you can fuss about precisely how those numbers were calculated, but the point is that there are scores of billions of extra dollars that will be needed as a result of climate change. We didn't factor that into the story when we were discussing aid.

Our first challenge will be to deliver on our promises for 2015. In June 2005, through its Finance Ministers, Europe committed to raise its Official Development Assistance (ODA) relative to GDP to 0.7 percent by 2015. Europeans should challenge themselves to meet that goal. (I'd rather not comment on the ratio of ODA to GDP in this country!) The first thing then is to deliver on the promises that we have made. But, as we go to the period after the date for Millennium Development Goal 2015, we must factor climate change into the development challenge and the development funding story. Our goals for 2015 are challenging enough, but let's both keep our ambitions high and be realistic about climate change as we get closer to 2015 and think about the period beyond.

There obviously has to be a global deal if we are to manage effectively the risks of climate change. The emissions in Johannesburg, London, Los Angeles, Beijing, or Delhi have the same effect on the climate. So what does a global deal which is effective, efficient, and equitable look like? I have already gone through most of the basic elements of a global deal, so let us assemble them now.

We've discussed 50 percent global cuts by 2050 relative to 1990. But what about targets for rich countries? Here's a little bit of mental arithmetic again. In 1990, global emissions flows were a little over 40 gigatons per annum of CO_2 equivalent (they were similar in 2000). World population was around 6 billion in 1990 (but it is about 6.7 billion now). Cutting global emissions by 50 percent means that, by 2050, we should be emitting only around 20 gigatons of CO_2 equivalent (40 divided by 2 is 20). How many of us will there be on the planet? Probably around nine billion. Twenty billion divided by nine billion is just over two, that is, two tons CO_2 equivalent per person. So, as a world, we'd need to be around two tons per capita on average by 2050. Given that few are below that, and that the average is the average, then actual emissions will have to be fairly equal across the world in per-capita tons. That means rich-country actual emissions would need to be cut by 80 percent; that is not a magic number out of nowhere.

Europe is emitting 10 to 12 tons per capita. To get that down to two, Europe would need to cut per-capita emissions by a factor of 5 or about 80 percent (Japan's per-capita emissions are similar to Europe). The United States, Australia, and Canada are currently emitting over 20 tons per capita. To get that down to two tons per capita would require a cut of 90 percent. Given the calculations and that the world emissions should be cut by at least 50 percent, rich-country cuts should be at least 80 percent.

What about developing countries? Developing countries are in a different position in terms of a historical responsibility. They have more worries about the economic risks of moving to low-carbon growth. I've just been having long discussions with the government in India. Many in this room have close friends

in senior positions in the government there. Wherever you ask developing countries—including in China, Indonesia, and Brazil—they say, "Look, the problem was largely created by rich countries." But the developing world's population is going to be eight billion out of the nine billion in 2050. You don't get an average of two tons per capita over nine billion if you aren't pretty close to the two tons per capita over the eight billion. They and the developing world as a whole face a major challenge in reducing emissions per capita.

So there is an increasing realization in the developing world that, whilst the starting point may be very unfair, we all have to be involved. Developing countries are recognizing this challenge but also its magnitude. Thus, they are also asking the question, "What do we need from rich countries to help us get down to two tons per capita by 2050?" China is already at five or possibly six tons per capita and they should and will, in my view, require four things of the rich world:

- the 80 percent target for cuts in the rich world and credible targets along that path for 2020
- demonstration that low-carbon growth is really possible, clear examples of what such growth entails and how it can be achieved
- a flow of finance through carbon markets and in other ways
- the development and sharing of technology

My own view is that all should participate in framing of the global deal but the developing world should describe the deal to the rich world in the above terms. They should describe the deal to us and they should say to us, "This is the deal. You take on those 80 percent targets for reductions and we will commit to two tons per capita by 2020. But we will look to you for these four things." That is the kind of glue and understanding that will hold this global deal together.

I want to make three last points on the global deal and then I will stop.

First, deforestation is a crucial part of the story. Depending how you do the sums, it accounts for 15 or 20 percent of the emissions. I would guess that for

$10 or $15 billion per annum we could cut deforestation in half. Such a program does have to be a global approach. Otherwise, you just shift the deforestation around. The country programs should be designed by the countries where the trees stand: it is their trees, their countries, their economies, and their local communities who are involved with the forests. These programs will and should be orientated around raising incomes and opportunities, together with saving the forests. But the outside world will be a great beneficiary of avoided deforestation and should provide the majority of financing for such endeavors. Since much of the activity will be about the basic elements of the development story, diversify activities, capacity, governance, and so on, much of the external funding will have to come from development support. The carbon markets will have this role to play but cannot be the whole funding story.

Second, on the demonstration and sharing of technologies, I think we should have a broad view of sources: hydro, nuclear, wind, or solar energy—we are going to need the lot. Carbon capture and storage for coal will be of particular importance. World electricity is roughly 50 percent from coal at the moment. India and China's electricity is expected to be 80 percent coal-fired over the next 30 or 40 years. Without carbon capture and storage for coal, meeting the targets will be much more difficult and costly. Thus, it is extremely important to demonstrate that carbon capture and storage works on scale over the next 10 years or so.

We need at least 30 up-and-running commercial plants so that we can sort out the problems and show that it really works. If it doesn't work, we have a bigger problem on our hands. The overall cost won't be 1 or 2 percent of GDP; it will be more. But, I think it would still be worth paying. That is the only technology I would highlight—not because I like it especially, but because coal is going to be there and we have to learn how to deal with it.

Finally, I have emphasized the importance of the overseas development aid commitments. The rich world must meet its responsibilities and commitments.

That is my description of a global deal. We can see the analytics and the quantities that are involved. The important thing is to get there. We don't have very long. We have to get this global deal together with its key elements agreed at the United Nations Framework Convention on Climate Change Conference in Copenhagen at the end of 2009. If it is to be a treaty, we have to have the words well ahead of time. If we are to have the words, we have to have the principles. We don't have very much time to put this deal together. That's why it is so important to get it clear about the principles now.

It is also very important to understand that this is not like negotiations at the WTO where nobody does anything until everybody agrees to everything. We have to have a framework in which, as we put it together, each country can get on with the job of finding low-carbon growth. And delay in negotiations makes the starting point ever more difficult as concentrations rise.

What is going to drive this? What will the sanctions be for people who misbehave? I do not believe in a global government model in which, if people misbehave in terms of emissions, an institution comes and whacks them on the head with a big stick. That kind of sanction is not going to work here. The sanction will be what the people want and the pressures they put on their leaders to be serious about climate change.

In a number of countries now, the direct pressure from the bottom is starting to take effect. But that won't work fast enough in all countries. It is going to need leadership as well so that, over time, you get recognition of the severity of the problem around the world. It will be the people in the countries who are the enforcement mechanisms. That is partly happening now, but it needs to be much stronger and it needs stronger leadership.

If we throw up our hands and say, "Wow, this is all too difficult and nobody will agree," then we'll simply have to face up and say that we are ready to go to 650 or 700 parts per million, or whatever the weaker target is that we want to argue for. We would have to face up to the great risks that such a decision will

involve for our children and grandchildren. It will be difficult. But cynicism to the point of saying it is all impossible will be self-fulfilling. And it would require the honesty to describe the risks that follow from that and to recognize the severity of the implications of our inability to act.

Thank you all very much.

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