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"What is the economics of climate change?"

Sir Nicholas Stern, Head of the UK Government Economic Service

Summary of lecture *[Slide 2]*

1. The science of climate change

1. Climate change is a serious and urgent issue. The key elements of the role of greenhouse gases (GHGs) in the science of climate were set out in the 19th century by Fourier (1827), Tyndall (1860) and Arrhenius (1896) [*Slide 3*]. There is now an overwhelming body of scientific evidence that human activity is causing warming *[Slides 4,5]*. The climate is already changing, and we are already seeing significant impacts. The main driver of the increase in GHGs is the rise in carbon dioxide from the burning of fossil fuels – essentially we take the carbon out of the ground and put it up in the atmosphere [*Slides 5,6*]. The main sources of GHGs, in order of global importance are electricity generation, land-use changes (particularly deforestation) agriculture and transport. Those GHG emissions growing the fastest are from transport and electricity *[Slides 7,8].*

2. There remain uncertainties about the nature and scale of impacts in the longer term. We have to look at a number of scenarios [*Slide 9*]. It is clear that anything like business-as-usual takes us into dangerous territory. And the most recent science indicates that some of the risks are more serious than had first appeared. Some of the potential impacts could be irreversible and accelerate the process of global warming. Melting of permafrost could lead to the release of huge quantities of methane. Dieback of the Amazon rainforest could mean that that the region starts to emit, rather than absorb, greenhouse gases. These feedbacks could lead to warming that is at least twice as fast as current projections, leading to temperatures higher than seen in the past 50 million years.

3. The nature of the scientific evidence from climate models is different from that common in empirical economic models, with their focus on parameter estimation and curve fitting: the science models (covering a broad range of phenomena, not just temperature) are essentially based on the laws of physics and chemistry. While some of their parameters are uncertain, 'goodness of fit' is only one of the criteria used to select their values.

4. The problem is global in its cause. Greenhouse gases have broadly the same impact on the climate wherever in the world they are emitted. Some of them, including carbon dioxide, stay in the atmosphere for more than a century. And it is global in its consequences: no region will be left untouched.

5. But impacts will be unevenly felt throughout the world. Some of the most severe impacts on people will be felt at lower latitudes, often in the poorest countries that are least able to adapt to the changes. *[Slide 10].*

6. International bodies, particularly the IPCC, have been building a basis of scientific understanding to underpin international collaboration for around two decades. Scientists have been refining their assessment of the probable degree of warming for a given level of carbon dioxide in the atmosphere: for example, stabilisation at 450 or 550 ppm CO2 equivalent. You will see from the table in Slide 11 that: (i) the upper limits of the temperature ranges (corresponding to 90% confidence intervals) for all stabilisation concentrations exceed 2 deg C, (ii) the ranges from 2004 estimates are substantially above those from 2001 – science is telling us that the warming effect is greater than we had previously thought, and (iii) equilibrium temperatures are a good deal higher than temperatures at 2100, showing that we are committed to still greater warming if we look beyond this century. These numbers point clearly to the magnitude of the challenge: any of these stabilisation levels would require global emissions to peak in the next decade or two and then fall sharply.

7. The UN Framework Convention on Climate Change and the Kyoto Protocol provide a strong basis for developing an international response. However, it is clear that we will have to go beyond the action that has already been agreed at international level in terms of both the ambitions of rich countries and the participation of developing countries, if we are to stabilise GHGs at any acceptable level. *[Slides 12 – 14]*.

8. A major review of the economics of climate change under my leadership was announced at the end of July, reporting to the Chancellor of the Exchequer and the Prime Minister. It began work in autumn 2005 and will report in autumn 2006.

9. We were grateful for the more than 200 submissions to the Call for Evidence that closed in December. A discussion paper to accompany this lecture has been placed on the website at www.sternreview.org.uk. We look forward to receiving reactions.

2. The nature of the economics

10. Climate change, in common with other environmental problems, embodies an externality: the emission of GHGs damages others. But these costs are felt over a long period and over the entire globe, and their exact nature is uncertain. These and other complexities imply that the application of the theory of externalities, in simple standard form, poses many problems and questions. That standard theory, under certainty and with a single government in the community in question which represents all those involved, points to one of: taxation on the emitter equivalent to marginal social cost (Pigou); the allocation of property rights in conjunction with trading (Coase)'; and direct regulation. However, we have uncertainty, interaction with other externalities and market imperfections, global involvement, and weak representation of those most affected (future generations). Thus we have instead a complex inter-temporal international collective action problem under uncertainty.

11. This dictates the structure of the relevant economics. It is clear it must cover a very broad range, including the economics of: growth and development; industry; innovation and technological change; institutions; the international economy; demography and migration; public finance; information and uncertainty; and environmental and public economics generally.

12. We know from basic game theory that we have to promote a collaborative solution to games with 'free-rider problems': we must find a collective, global way forward. The objective must be to build clear long-term international agreements within which markets and entrepreneurs can work effectively. Building such agreements will generally require that all parties share an understanding of the consequences to them and to others of the relevant arrangements. It will also require finding incentive structures to promote 'tie in' and fostering economic, social and political processes and perspectives that can make collaboration more likely. And getting agreement will require not only a shared understanding of the issues and mechanisms but also careful attention to the complex equity issues involved.

13. In their interactions, international participants should take a broad view of ethical perspectives. The relevant ethical perspectives include consequentialism, equity, fairness, justice, freedom, rights-based approaches, sustainability and stewardship. Whilst these perspectives have some fundamental ethical differences, their application would, nevertheless, generally point to a focus on similar measurable outcomes such as incomes, forms of capital and wealth, including the environment, health, way of life and so on.

14. There is much learning to be done about both the science and the economics. But, the risks of severe outcomes and destabilising dynamics from the physical processes involved generate a powerful argument for strong and urgent action.

15. All this discussion of the nature of the economics is a consequence of the basic science of GHGs and shapes the more detailed economic analysis that follows.

3. The economics of climate change

16. The economics of climate change hitherto has been focussed on modelling the implications of growth for emissions, examining and modelling the economics of technological options, calculating 'social costs of carbon', and exploring tax, market and other structures. Many elements of the foundations have been established. We now, from the essential perspective of the international collective action problem, must focus on the analysis that individual countries will need to assess their own policy position, together with an analysis of how to generate strong international action.

17. In coming to a view on their own role, governments have an understandable focus on the growth of their economies and the health, environment and way of living of their populations. The growth story has many strands: how growth will drive the sources of greenhouse gas emissions, how climate change impacts will affect growth, both in the short run and the long run, how growth processes involve and affect people in different circumstances, and how the mitigation of greenhouse gases could affect growth.

18. Economic growth is a key factor in determining greenhouse gas emissions from energy and other uses. Current emissions are on an unsustainable path: energy-related emissions are forecast to grow, if we follow business-as-usual, by more than 2% per year over the next 30 years, compared with a

requirement to start falling within 10-20 years if GHG levels are to be stabilised at 450 or 550 ppm.

19. Existing stocks of GHGs are largely the result of past emissions from rich countries. Much of the potential emissions growth in future will be in developing countries: if they are to play their part in international action we must find a way of tackling climate change that does not undermine growth and poverty reduction in these countries.

20. We also need to understand how growth may be affected adversely by the deterioration in the environment that will occur in the absence of GHG control. Climate change has profound implications for the environment in which social and economic activity takes place, and therefore can have significant effects on prosperity and human development.

21. In human terms, developing countries are likely to be most badly affected by climate change. They will be hit not only by increasing variability (for example suffering potentially a greater incidence of both drought and flood) but also by a more adverse overall environment as temperatures rise. They will have to deal with this on despite low income levels and slim margins for adjustment. This combination presents a very serious challenge.

The importance of adaptation

22. Adaptation has the potential to reduce the impacts of climate change. Substantial climate change is already inevitable over the next 30 years – mitigation will have a limited effect on stocks of GHGs in this time frame – and thus adaptation is an essential policy response.

23. As noted above, some of the most severe and early consequences will be on developing countries; indeed, these are already occurring. The international community must find ways of supporting adaptation in the most vulnerable countries, including considering the role of technology and financing the costs of adaptation. The origins and impacts of climate change make the arguments for strong development assistance still more compelling.

24. There are limits to the ability to adapt to fundamental and rapid climate change, in the sense that the human and economic costs become very large. Adaptation is particularly difficul5t when the precise nature and incidence of impacts is uncertain. Adaptation and mitigation are not alternatives; we must pursue both. But the costs of each will influence the choice of policies for both.

Options for mitigation

25. Climate change is driven by greenhouse gas emissions from energy use, agriculture and deforestation. Effective action on mitigation is likely to require action including all three areas and in all sub-sectors of them.

26. Agriculture and deforestation are significant sources of GHG emissions. Currently together they account for around 30% of total emissions: thus reduction in GHGs is possible by changes in agriculture and reversing deforestation.

27. Energy accounts for around 2/3 of emissions. Reductions in emissions depend largely on changes in the links from economic activity to energy intensity, and from energy intensity to carbon intensity. Measures to reduce the energy required per unit of output and income include both altering the mix of economic activities and promoting energy efficiency. Reducing carbon per unit of energy will largely be down to technologies, including their mix: many are already available, and more are being developed. They are nearer in power generation than transport, and the demand for transport is growing still more rapidly than the demand for power.

28. The policy framework to manage demand and pull new technologies through to the marketplace is crucial. For the development and deployment of many or most of the relevant technologies, the private sector will play a central role. It will require market structures and incentives that are clear, long-term and credible. Innovation will be essential. The design of policy will require an understanding of the way in which fossil fuel markets work: many of them are oligopolistic and the rent from the ownership of exhaustible natural resources is a central element. Thus assessing the impact of tax and market measures is complex.

29. Key policy instruments shaping incentives include taxes, property rights and regulation. Where aggregate targets are used, they will determine the sum of property rights. Property rights can be allocated over different time horizons and in different ways. There will be different resulting distributions of wealth and income. But, if they are to be effective, they must provide the foundations for credible markets. Currently all three of these instruments play a role in most advanced countries. We will examine how these instruments should be combined. Institutional structures will be of great importance.

30. But we must go beyond incentives and the institutions that can support them and examine the possibilities for changing preferences and the behaviour they generate. This can happen through information, discussion and education. It has been a key element in a number of policy packages involving externalities, including recycling, alcohol and smoking.

31. There are market failures in the development of new clean technologies by the private sector and a challenge for government will be to design policy instruments capable of tackling these. The development and deployment of new technologies will require clear, long-term and credible signals to guide private action.

32. We must ask how quickly current patterns of energy production and use can or should be shifted – and whether this can be done in a way that strengthens, rather than weakens, economic growth. The potential effects of mitigation on growth are central to the concerns of policymakers in both rich and poor countries and thus are key concerns for those involved in international negotiations. Thus we must examine potential adjustment costs of moving towards low-carbon economies, including impacts on the competitiveness of particular industries and the overall economy along the various possible paths. We must also investigate how far a focus on energy saving and clean technologies could both cut through the many inefficiencies in the supply and use of energy and promote an era of discovery and innovation where leaders may reap advantages in the future.

33. Management of the issues of growth, pace of adjustment, and competitiveness is likely to be more successful if groups of countries act together so that their economies adjust to changes in relative prices over a similar time period; and similarly for sectors in some industries subject to global competition.

34. In deciding on their position both on how to participate in international action and on how to implement their own responsibilities, countries will bring in criteria beyond implications for growth and competitiveness. These include, in the case of energy policy, security of supply and access to energy in developing countries. Decisions are likely to vary across countries, since, inter alia, objectives, natural resource endowments and technologies may differ, as will market structures, institutions and political pressures.

35. Both for equity reasons (and see the legal principle of "common but differentiated responsibilities" in the UNFCCC) and from domestic financial pressures, developing countries are likely to seek external finance for the investments involved in their contribution to mitigation. The magnitude of the challenge and limits to overseas aid indicate that scaling up market mechanisms for promoting such investments is likely to play a central role. These will be likely to involve a broad range, including not only power generation but also transport, agriculture and deforestation. Rights to technology will also be an important issue.

The role of uncertainty

36. Uncertainty and risk are key elements of most aspects of climate change. The criteria by which decisions are assessed must take careful account of the degree of uncertainty, the long time horizons and the range of possible outcomes. Such outcomes, which include major irreversible change to the climate, are likely to involve possibilities considerably beyond human experience hitherto.

37. Given the uncertainty over the scientific, economic and social consequences of climate change, it is a challenge for international collective action to agree on GHG emission targets.

38. The pervasiveness of uncertainty will influence the choice of instruments (whether 'prices' or 'quantities' are more appropriate policy instruments in face of uncertainty and asymmetric information) in terms of taxes, markets, property rights and regulation. It will influence an understanding of the pace and degree of action in the face of learning, irreversibility of some effects and the 'sunk costs' of some infrastructure investments. And it will influence approaches to the promotion of technological discovery and development.

4. Responding to the global challenges: the basis for international action

39. Any effective response to the challenge of climate change must be based on an international understanding that its origins, impact, scale and urgency require global collective action.

40. In order to make sensible choices in building international agreement, all countries will need to understand the implications for them of adaptation to

and mitigation of climate change in terms of their growth, competitiveness, security, public finances and environment. Most countries will, and should be, concerned also about the implications for others. The UK is no exception.

41. Thus analysis of these implications is crucial to providing a basis to inform and underpin international negotiations and agreements. It must offer a clear and, where possible, quantitative understanding of the likely impacts on different countries, regions and generations arising from different courses of action. Whilst it will take some time to produce a strong body of research on some of these issues given their complexity, some broad directions and 'orders of magnitude' are already emerging. It is important for this economic and social analysis to proceed side-by-side with the science.

42. It will be important to find ways to sustain agreements, given the potential damage free riding can inflict on mitigation by others. A combination of methods is likely to be appropriate, including: international standards; treaty obligations supported by emissions quotas and/or taxes; technological lock-ins via infrastructure and other investments; making climate change a central element in the whole set of international engagements; public pressure nationally and internationally; and the education of current and future generations.

43. The Review will consider these issues, and will also look at how individual countries and regions, particularly the UK and EU, can play an effective role in fostering and promoting cooperation within this wider international context. International action requires both leadership and a collaborative spirit.

44. In conclusion, a response to the great challenge of climate change must, given the scientific structure of the problem, be based on international collective action. Building on the science, the economic analysis must, therefore, provide shared understanding of the nature of the economic problems it generates, inform the international participants of the implications for them, and other parties, of different arrangements and find ways of sustaining a collaborative response to the challenge.