CAMBRIDGE

Cambridge University Press
978-0-521-70080-1 - The Economics of Climate Change: The Stern Review
Nicholas Stern
Frontmatter
More information

The Economics of Climate Change

The Stern Review

NICHOLAS STERN
Cabinet Office – HM Treasury

There is now clear scientific evidence that emissions from economic activity, particularly the burning of fossil fuels for energy, are causing changes to the Earth's climate. A sound understanding of the economics of climate change is needed in order to underpin an effective global response to this challenge.

The Stern Review is an accessible, independent, and comprehensive analysis of the economic aspects of this crucial issue. It has been conducted by Nicholas Stern, Head of the UK Government Economic Service, and a former Chief Economist of the World Bank.

The Review considers all aspects of the issue, including the nature of the economics and the science; the impact of climate change on growth and development in both rich and poor countries; the economics of cutting emissions and stabilising greenhouse gas emissions in the atmosphere; the components of policy on both mitigation and adaptation; and the challenges of achieving sustained international collective action. *The Review* will help to promote a greater understanding of the impact and effectiveness of national and international policies and arrangements in reducing emissions in a cost-effective way, and promoting a dynamic, equitable and sustainable global economy.

The Economics of Climate Change: The Stern Review will be invaluable for anyone interested in the economics and policy implications of climate change, and students, economists, scientists and policy makers involved in all aspects of climate change.

Sir Nicholas Stern is Adviser to the UK Government on the Economics of Climate Change and Development, reporting to the Prime Minister. As well as being Head of the *Stern Review on the Economics of Climate Change*, he is Head of the Government Economic Service, and previously Second Permanent Secretary to Her Majesty's Treasury and Director of Policy and Research for the Prime Minister's Commission for Africa. He is also a former Chief Economist for the World Bank and Special Counsellor to the President of the European Bank for Reconstruction and Development. His research and publications have focused on economic development and growth, economic theory, tax reform, public policy and the role of the state and economies in transition. He is a Fellow of the British Academy and a Foreign Honorary Member of the American Academy of Arts and Sciences. His most recent book is *Growth and Empowerment: Making Development Happen* (2005, MIT Press).

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-70080-1 - The Economics of Climate Change: The Stern Review
Nicholas Stern
Frontmatter
More information

Comments on *The Economics of Climate Change: The Stern Review*

'Nicholas Stern's review will be seen as a landmark in the struggle against climate change. It gives a stark warning, but also offers hope. It proves comprehensively that tackling climate change is a pro-growth strategy. The economic benefits of strong early action easily outweigh the costs. The framework for action laid out by the Review is both ambitious and realistic. Climate change is a global problem and Stern's conclusions are a wake-up call not just for the UK, but for every country in the world.'
Rt Hon Tony Blair MP, UK Prime Minister

'*The Stern Review* on the *Economics of Climate Change* is the most comprehensive analysis yet, not only of the challenges, but also of the opportunities from climate change. Stern makes clear that climate change is a global challenge that demands a global solution. Above all, environmental policy is economic policy. It is my hope that this Review is discussed and understood as widely as possible, throughout the world, not just by Governments, but also by business leaders, NGOs, international institutions and society as a whole.'
Rt Hon Gordon Brown MP, UK Chancellor of the Exchequer

'*The Stern Review* shows us, with utmost clarity, while allowing fully for all the uncertainties, what global warming is going to mean; and what can and should be done to reduce it. It provides numbers for the economic impact, and for the necessary economic policies. It deserves the widest circulation. I wish it the greatest possible impact. Governments have a clear and immediate duty to accept the challenge it represents.'
James Mirrlees, recipient of the Nobel Prize for Economics, 1996

'The stark prospects of climate change and its mounting economic and human costs are clearly brought out in this searching investigation. What is particularly striking is the identification of ways and means of sharply minimizing these penalties through acting right now, rather than waiting for our lives to be overrun by rapidly advancing adversities. The world would be foolish to neglect this strong but strictly time-bound practical message.'
Amartya Sen, recipient of the Nobel Prize for Economics, 1998

'*The Stern Review* of *The Economics of Climate Change* provides the most thorough and rigorous analysis to date of the costs and risks of climate change, and the costs and risks of reducing emissions. It makes clear that the question is not whether we can afford to act, but whether we can afford not to act. ... And it provides a comprehensive agenda – one which is economically and politically feasible – behind which the entire world can unite in addressing this most important threat to our future well being.'
Joseph Stiglitz, recipient of the Nobel Prize for Economics, 2001

' ... the world is waiting for a calm, reasonable, carefully argued approach to climate change: Nick Stern and his team have produced one.'
Robert M. Solow , recipient of the Nobel Prize for Economics, 1987

'I very much welcome *The Stern Review*, which provides a much needed critical economic analysis of the issues associated with climate change ...'
Paul Wolfowitz, President of the World Bank

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-70080-1 - The Economics of Climate Change: The Stern Review
Nicholas Stern
Frontmatter
More information

'*The Stern Review* of *The Economics of Climate Change* is a vital step forward in securing an effective global policy on climate change. Led by one of the world's top economists, the *Stern Review* shows convincingly that the benefits of early global action to mitigate climate change will be far lower than the costs. The report establishes realistic guidelines for action ... . *The Stern Review* will play an important role in helping the world to agree on a sensible post-Kyoto policy.'
Professor Jeffrey D. Sachs, Director of the Earth Institute at Columbia University and Special Advisor to UN Secretary General

'*The Economics of Climate Change* sends a very important and timely message: that the benefits of strong, early action on climate change outweigh the costs. ... Congratulations to Sir Nick Stern and his team for producing a landmark review which I have no doubt will strengthen the political will to change of governments around the world.'
Claude Mandil, Executive Director of the International Energy Agency

'The scientific evidence of global warming is overwhelming but some commentators and lobby groups have continued to oppose offsetting actions on economic and competitiveness grounds. This comprehensive and authoritative report demolishes their arguments, explaining clearly the complex economics of climate change. It makes plain that we can cut emissions radically at a cost to the economy far less than the economic and human welfare costs which climate change could impose.'
Adair Turner, Former Director of UK Confederation of British Industry and Economic Advisor to the Sustainable Development Commission

'When the history of the world's response to climate change is written, the *Stern Review* will be recognized as a turning point. ... Sir Nicholas and his team have provided important intellectual leadership as humanity engages with its greatest challenge. ... While the details will be debated, the main thrust of the report is clear and compelling – the expected benefits of tackling climate change far outweigh the expected costs.'
Cameron Hepburn, Elizabeth Wordsworth Junior Research Fellow in Economics, Oxford University

'Pay now to fix global warming or risk a worldwide economic depression later ... The [Stern] report moves economic discussion of how humanity should deal with global warming to center stage ...'
USA Today

'The overwhelming message of ... [the] Stern review on the economics of climate change is that it is now time to move on from arguing about statistics to taking drastic action at an international level. ... Even if Stern is only half right then ... the consequence of doing nothing is still so dreadful that it ought not to be contemplated.'
The Guardian

'[The report's] basic point seems unassailable: failure to act now will exact much greater penalties later on ... If people and industries are made to pay heavily for the privilege, they will inevitable be driven to develop cleaner fuels, cars and factories...'
The New York Times

'The Stern review makes two invaluable contributions. The first is that it recasts environmentalism as economics ... Stern's second serious contribution is to provide a formula for durable environmentalism, one which binds business and government.'
The Times

© Cambridge University Press www.cambridge.org

'The [Stern] report argues that environmentalism and economic growth can go hand in hand in the battle against global warming ... The report by Sir Nicholas Stern, a senior government economist, represents a huge contrast to the U.S. government's wait-and-see policies.'
Chicago Tribune

'... a comprehensive overview of the threat posed by climate change – and how we should respond to it. ... Sir Nicholas Stern spells out a bleak vision of a future gripped by violent storms, rising sea-levels, crippling droughts and economic chaos unless urgent action is taken to tackle global warming. ... a heavyweight review ... Sir Nicholas Stern's review of the economic impact of global warming is a watershed. The former World Bank chief economist has put a price-tag on saving the planet. ... Sir Nicholas is a sober and respected economist, which makes his findings all the more chilling.'
The Daily Telegraph

'Future generations may come to regard the apocalyptic report by Sir Nicholas Stern ... as the turning point in combating global warming, or as the missed opportunity. ... what Sir Nicholas Stern has done with his report on the economics of climate change is remarkable; he has ripped up the last excuse for inaction. ... one wouldn't want to exaggerate, but it does feel like one of those moments that are truly historic ... the first really comprehensive review of the economics of climate change. For nearly 20 years if has been the *science* of climate change that has made all the headlines ... We've heard a thousand calls to action, to stop global warming happening. But what would that *cost* the world? And what would doing nothing cost us? ... now Sir Nicholas Stern and his team have come up with concrete numbers.'
The Independent

CAMBRIDGE

Cambridge University Press
978-0-521-70080-1 - The Economics of Climate Change: The Stern Review
Nicholas Stern
Frontmatter
More information

The Economics of Climate Change

The Stern Review

NICHOLAS STERN
Cabinet Office – HM Treasury

CAMBRIDGE
UNIVERSITY PRESS

© Cambridge University Press www.cambridge.org

CAMBRIDGE UNIVERSITY PRESS
Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, São Paulo, Delhi

Cambridge University Press
The Edinburgh Building, Cambridge CB2 8RU, UK

Published in the United States of America by Cambridge University Press, New York

www.cambridge.org
Information on this title: www.cambridge.org/9780521700801

The Stern Review Report © Crown copyright 2006

The Economics of Climate Change: The Stern Review © Cambridge University Press 2007

First published 2007
Fourth printing 2008

Printed in the United Kingdom at the University Press, Cambridge

A catalogue record for this publication is available from the British Library

ISBN 978-0-521-70080-1 paperback

The text in *The Stern Review* reproduced in this document (excluding the Royal Coat of Arms and departmental logos) may be reproduced free of charge in any format or medium providing it is reproduced accurately and not used in a misleading context. The material must be acknowledged as Crown copyright and the title of the document specified.

The Report and supporting materials can be found on the HM Treasury website at: www.hm-treasury.gov.uk.

Any enquiries relating to the copyright in this document should be addressed to: The Information Policy Team, HMSO, St Clements House, 2–16 Colegate, Norwich, NR3 1BQ. Fax: 00-44-(0)1603 723000 or e-mail: licensing@opsi.x.gsi.gov.uk.

For general enquiries about HM Treasury and its work, contact: Correspondence and Enquiry Unit, HM Treasury, 1 Horse Guards Road, London, SW1A 2HQ, UK, Tel: 00-44-(0)20 7270 4558, Fax: 00-44-(0)20 7270 4861, Email: public.enquiries@hm-treasury.gov.uk.

Printed on 100% recycled paper

CAMBRIDGE

Cambridge University Press
978-0-521-70080-1 - The Economics of Climate Change: The Stern Review
Nicholas Stern
Frontmatter
More information

Contents

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-70080-1 - The Economics of Climate Change: The Stern Review
Nicholas Stern
Frontmatter
More information

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-70080-1 - The Economics of Climate Change: The Stern Review
Nicholas Stern
Frontmatter
More information

Preface

This Review was announced by the Chancellor of the Exchequer in July 2005. The Review set out to provide a report to the Prime Minister and Chancellor by Autumn 2006 assessing:

- the economics of moving to a low-carbon global economy, focusing on the medium to long-term perspective, and drawing implications for the timescales for action, and the choice of policies and institutions;
- the potential of different approaches for adaptation to changes in the climate; and
- specific lessons for the UK, in the context of its existing climate change goals.

The terms of reference for the Review included a requirement to consult broadly with stakeholders and to examine the evidence on:

- the implications for energy demand and emissions of the prospects for economic growth over the coming decades, including the composition and energy intensity of growth in developed and developing countries;
- the economic, social and environmental consequences of climate change in both developed and developing countries, taking into account the risks of increased climate volatility and major irreversible impacts, and the climatic interaction with other air pollutants, as well as possible actions to adapt to the changing climate and the costs associated with them;
- the costs and benefits of actions to reduce the net global balance of greenhouse gas emissions from energy use and other sources, including the role of land-use changes and forestry, taking into account the potential impact of technological advances on future costs; and
- the impact and effectiveness of national and international policies and arrangements in reducing net emissions in a cost-effective way and promoting a dynamic, equitable and sustainable global economy, including distributional effects and impacts on incentives for investment in cleaner technologies.

Overall approach to the Review

We have taken a broad view of the economics required to understand the challenges of climate change. Wherever possible, we have based our Review on gathering and structuring existing research material.

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-70080-1 - The Economics of Climate Change: The Stern Review
Nicholas Stern
Frontmatter
More information

Submissions to the Review were invited from 10 October 2005 to 15 January 2006. Sir Nicholas Stern set out his initial views on the approach to the Review in the Oxonia lecture on 31 January 2006, and invited further responses to this lecture up to 17 March 2006.

During the Review, Sir Nicholas and members of the team visited a number of key countries and institutions, including Brazil, Canada, China, the European Commission, France, Germany, India, Japan, Mexico, Norway, Russia, South Africa and the USA. These visits and work in the UK have included a wide range of interactions, including with economists, scientists, policy-makers, business and NGOs.

The report also draws on the analysis prepared for the International Energy Agency publications "Energy Technology Perspectives" and "World Energy Outlook 2006".

There is a solid basis in the literature for the principles underlying our analysis. The scientific literature on the impacts of climate change is evolving rapidly, and the economic modelling has yet to reflect the full range of the new evidence.

In some areas, we found that existing literature did not provide answers. In these cases, we have conducted some of our own research, within the constraints allowed by our timetable and resources. We also commissioned some papers and analysis to feed into the Review. A full list of commissioned work and links to the papers are at www.sternreview.org.uk

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-70080-1 - The Economics of Climate Change: The Stern Review
Nicholas Stern
Frontmatter
More information

Acknowledgements

The team was led by Siobhan Peters. Team members included Vicki Bakhshi, Alex Bowen, Catherine Cameron, Sebastian Catovsky, Di Crane, Sophie Cruickshank, Simon Dietz, Nicola Edmondson, Su-Lin Garbett, Lorraine Hamid, Gideon Hoffman, Daniel Ingram, Ben Jones, Nicola Patmore, Helene Radcliffe, Raj Sathiyarajah, Michelle Stock, Chris Taylor, Tamsin Vernon, Hannah Wanjie, and Dimitri Zenghelis.

We are very grateful to the following organisations for their invaluable contributions throughout the course of the Review: Vicky Pope and all those who have helped us at the Hadley Centre for Climate Prediction; Claude Mandil, Fatih Birol and their team at the International Energy Agency; Francois Bourguignon, Katherine Sierra, Ken Chomitz, Maureen Cropper, Ian Noble and all those who have lent their support at the World Bank; the OECD, EBRD, IADB, and UNEP; Rajendra Pachauri, Bert Metz, Martin Parry and others at the IPCC; Chatham House; as well as Martin Rees and the Royal Society.

Many government departments and public bodies have supported our work, with resources, ideas and expertise. We are indebted to them. They include: HM Treasury, Cabinet Office, Department for Environment Food and Rural Affairs, Department of Trade and Industry, Department for International Development, Department for Transport, Foreign and Commonwealth Office, and the Office of Science and Innovation. We are also grateful for support and assistance from the Bank of England and the Economic and Social Research Council, and for advice from the Environment Agency and Carbon Trust.

We owe thanks to the academics and researchers with whom we have worked closely throughout the Review. A special mention goes to Dennis Anderson who contributed greatly to our understanding of the costs of energy technologies and of technology policy, and has provided invaluable support and advice to the team. Special thanks too to Halsey Rogers and to Tony Robinson who worked with us to edit drafts of the Review. And we are very grateful to: Neil Adger, Sudhir Anand, Nigel Arnell, Terry Barker, John Broome, Andy Challinor, Paul Collier, Sam Fankhauser, Michael Grubb, Roger Guesnerie, Cameron Hepburn, Dieter Helm, Claude Henry, Chris Hope, Paul Johnson, Paul Klemperer, Robert May, David Newbery, Robert Nicholls, Peter Sinclair, Julia Slingo, Max Tse, Rachel Warren and Adrian Wood.

Throughout our work we have learned greatly from academics and researchers who have advised us, including: Philippe Aghion, Shardul Agrawala, Edward Anderson, Tony Atkinson, The Auto Project (Vance

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-70080-1 - The Economics of Climate Change: The Stern Review
Nicholas Stern
Frontmatter
More information

Wagner and Alex Whitworth), Paul Baer, Philip Bagnoli, Hewson Baltzell, Scott Barrett, Marcel Berk, Richard Betts, Ken Binmore, Victor Blinov, Christopher Bliss, Katharine Blundell, Severin Borenstein, Jean-Paul Bouttes, Richard Boyd, Alan Budd, Frances Cairncross, Daniel Cullenward, Larry Dale, Victor Danilov-Daniliyan, Amy Davidsen, Angus Deaton, Michelden Elzen, Richard Eckaus, Jae Edmonds, Jorgen Elmeskov, Paul Epstein, Gunnar Eskeland, Alexander Farrell, Brian Fender, Anthony Fisher, Meredith Fowley, Jeffrey Frankel, Jose Garibaldi, Leila Gohar, Maryanne Grieg-Gran, Bronwyn Hall, Jim Hall, Stephane Hallegate, Kate Hampton, Michael Hanemann, Bill Hare, Geoffrey Heal, Merylyn Hedger, Molly Hellmuth, David Henderson, David Hendry, Marc Henry, Margaret Hiller, Niklas Hoehne, Bjart Holtsmark, Brian Hoskins, Jean-Charles Hourcade, Jo Hossell, Alistair Hunt, Saleem Huq, Mark Jaccard, Sarah Joy, Jiang Kejun, Ian Johnson, Tom Jones, Dale Jorgenson, Paul Joskow, Kassim Kulindwa, Daniel Kammen, Jonathan Köhler, Paul Krugman, Sari Kovats, Klaus Lackner, John Lawton, Tim Lenton, Li Junfeng, Lin Erda, Richard Lindzen, Björn Lomborg, Gordon MacKerron, Joaquim Oliveira Martins, Warwick McKibbin, Malte Meinshausen, Robert Mendelsohn, Evan Mills, Vladimir Milov, James Mirrlees, Richard Morgenstern, Mu Haoming, Robert Muir-Wood, Justin Mundy, Gustavo Nagy, Nebojša Nakicenovic, Karsten Neuhoff, Greg Nimmet, J.C Nkomo, William Nordhaus, David Norse, Anthony Nyong, Pan Jiahua, John Parsons, Cedric Philibert, Robert Pindyck, William Pizer, Oleg Pluzhnikov, Jonathon Porritt, Lant Pritchett, John Reilly, Richard Richels, David Roland-Holst, Nick Rowley, Cynthia Rosenzweig, Joyashree Roy, Jeffrey Sachs, Mark Salmon, Alan Sanstad, Mark Schankerman, John Schellnhueber, Michael Schlesinger, Ken Schomitz, Amartya Sen, Robert Sherman, Keith Shine, P. R. Shukla, Brian Smith, Leonard Smith, Robert Socolow, David Stainforth, Robert Stavins, David Stephenson, Joe Stiglitz, Peter Stone, Roger Street, Josuè Tanaka, Evgeniy Sokolov, Robert Solow, James Sweeney, Richard Tol, Asbjorn Torvanger, Laurence Tubiana, David Vaughnan, Steven Ward, Paul Watkiss, Jim Watson, Martin Weitzman, Hege Westskog, John Weyant, Tony White, Gary Yohe, Ernesto Zedillo, Zhang Anhua, Zhang Qun, Zhao Xingshu, and Zou Ji.

We are grateful to the leaders, officials, academics, NGO staff and business people who assisted us during our visits to: Brazil, Canada, China, the European Commission, France, Germany, Iceland, India, Japan, Mexico, Norway, Russia, South Africa and the USA.

And thanks to the numerous business leaders and representatives who have advised us, including, in particular, John Browne, Paul Golby, Jane Milne, Vincent de Rivaz, James Smith, Adair Turner, and the Corporate Leaders Group.

Also to the NGOs that have offered advice and help including: Christian Aid, The Climate Group, Friends of the Earth, Global Cool, Green Alliance, Greenpeace, IIED, IPPR, New Economics Foundation, Oxfam, Practical Action, RSPB, Stop Climate Chaos, Tearfund, Women's Institute, and WWF UK.

Finally, thanks also go to Australian Antarctic Division for permission to use the picture for the logo and to David Barnett, for designing the logo.

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-70080-1 - The Economics of Climate Change: The Stern Review
Nicholas Stern
Frontmatter
More information

Introduction

The economics of climate change is shaped by the science. That is what dictates the structure of the economic analysis and policies; therefore we start with the science.

Human-induced climate change is caused by the emissions of carbon dioxide and other greenhouse gases (GHGs) that have accumulated in the atmosphere mainly over the past 100 years.

The scientific evidence that climate change is a serious and urgent issue is now compelling. It warrants strong action to reduce greenhouse gas emissions around the world to reduce the risk of very damaging and potentially irreversible impacts on ecosystems, societies and economies. With good policies the costs of action need not be prohibitive and would be much smaller than the damage averted.

Reversing the trend to higher global temperatures requires an urgent, world-wide shift towards a low-carbon economy. Delay makes the problem much more difficult and action to deal with it much more costly. Managing that transition effectively and efficiently poses ethical and economic challenges, but also opportunities, which this Review sets out to explore.

Economics has much to say about assessing and managing the risks of climate change, and about how to design national and international responses for both the reduction of emissions and adaptation to the impacts that we can no longer avoid. If economics is used to design cost-effective policies, then taking action to tackle climate change will enable societies' potential for well-being to increase much faster in the long run than without action; we can be 'green' and grow. Indeed, if we are not 'green', we will eventually undermine growth, however measured.

This Review takes an international perspective on the economics of climate change. Climate change is a global issue that requires a global response. The science tells us that emissions have the same effects from wherever they arise. The implication for the economics is that this is clearly and unambiguously an international collective action problem with all the attendant difficulties of generating coherent action and of avoiding free riding. It is a problem requiring international cooperation and leadership.

Our approach emphasises a number of key themes, which will feature throughout.

- We use a consistent approach towards **uncertainty.** The science of climate change is reliable, and the direction is clear. But we do not

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-70080-1 - The Economics of Climate Change: The Stern Review
Nicholas Stern
Frontmatter
More information

know precisely when and where particular impacts will occur. Uncertainty about impacts strengthens the argument for mitigation: this Review is about the economics of the management of very large risks.

- We focus on a quantitative understanding of **risk**, assisted by recent advances in the science that have begun to assign probabilities to the relationships between emissions and changes in the climate system, and to those between the climate and the natural environment.
- We take a systematic approach to the treatment of inter- and intra-generational **equity** in our analysis, informed by a consideration of what various ethical perspectives imply in the context of climate change. Inaction now risks great damage to the prospects of future generations, and particularly to the poorest amongst them. A coherent economic analysis of policy requires that we be explicit about the effects.

Economists describe human-induced climate change as an 'externality' and the global climate as a 'public good'. Those who create greenhouse gas emissions as they generate electricity, power their factories, flare off gases, cut down forests, fly in planes, heat their homes or drive their cars do not have to pay for the costs of the climate change that results from their contribution to the accumulation of those gases in the atmosphere.

But climate change has a number of features that together distinguish it from other externalities. It is global in its causes and consequences; the impacts of climate change are persistent and develop over the long run; there are uncertainties that prevent precise quantification of the economic impacts; and there is a serious risk of major, irreversible change with non-marginal economic effects.

This analysis leads us to *five sets of questions* that shape Parts 2 to 6 of the Review.

- What is our understanding of the risks of the impacts of climate change, their costs, and on whom they fall?
- What are the options for reducing greenhouse-gas emissions, and what do they cost? What does this mean for the economics of the choice of paths to stabilisation for the world? What are the economic opportunities generated by action on reducing emissions and adopting new technologies?
- For mitigation of climate change, what kind of incentive structures and policies will be most effective, efficient and equitable? What are the implications for the public finances?
- For adaptation, what approaches are appropriate and how should they be financed?
- How can approaches to both mitigation and adaptation work at an international level?

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-70080-1 - The Economics of Climate Change: The Stern Review
Nicholas Stern
Frontmatter
More information

Summary of Conclusions

There is still time to avoid the worst impacts of climate change, if we take strong action now.

The scientific evidence is now overwhelming: climate change is a serious global threat, and it demands an urgent global response.

This Review has assessed a wide range of evidence on the impacts of climate change and on the economic costs, and has used a number of different techniques to assess costs and risks. From all of these perspectives, the evidence gathered by the Review leads to a simple conclusion: the benefits of strong and early action far outweigh the economic costs of not acting.

Climate change will affect the basic elements of life for people around the world – access to water, food production, health, and the environment. Hundreds of millions of people could suffer hunger, water shortages and coastal flooding as the world warms.

Using the results from formal economic models, the Review estimates that if we don't act, the overall costs and risks of climate change will be equivalent to losing at least 5% of global GDP each year, now and forever. If a wider range of risks and impacts is taken into account, the estimates of damage could rise to 20% of GDP or more.

In contrast, the costs of action – reducing greenhouse gas emissions to avoid the worst impacts of climate change – can be limited to around 1% of global GDP each year.

The investment that takes place in the next 10-20 years will have a profound effect on the climate in the second half of this century and in the next. Our actions now and over the coming decades could create risks of major disruption to economic and social activity, on a scale similar to those associated with the great wars and the economic depression of the first half of the 20th century. And it will be difficult or impossible to reverse these changes.

So prompt and strong action is clearly warranted. Because climate change is a global problem, the response to it must be international. It must be based on a shared vision of long-term goals and agreement on frameworks that will accelerate action over the next decade, and it must build on mutually reinforcing approaches at national, regional and international level.

Climate change could have very serious impacts on growth and development.

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-70080-1 - The Economics of Climate Change: The Stern Review
Nicholas Stern
Frontmatter
More information

If no action is taken to reduce emissions, the concentration of greenhouse gases in the atmosphere could reach double its pre-industrial level as early as 2035, virtually committing us to a global average temperature rise of over 2°C. In the longer term, there would be more than a 50% chance that the temperature rise would exceed 5°C. This rise would be very dangerous indeed; it is equivalent to the change in average temperatures from the last ice age to today. Such a radical change in the physical geography of the world must lead to major changes in the human geography – where people live and how they live their lives.

Even at more moderate levels of warming, all the evidence – from detailed studies of regional and sectoral impacts of changing weather patterns through to economic models of the global effects – shows that climate change will have serious impacts on world output, on human life and on the environment.

All countries will be affected. The most vulnerable – the poorest countries and populations – will suffer earliest and most, even though they have contributed least to the causes of climate change. The costs of extreme weather, including floods, droughts and storms, are already rising, including for rich countries.

Adaptation to climate change – that is, taking steps to build resilience and minimise costs – is essential. It is no longer possible to prevent the climate change that will take place over the next two to three decades, but it is still possible to protect our societies and economies from its impacts to some extent – for example, by providing better information, improved planning and more climate-resilient crops and infrastructure. Adaptation will cost tens of billions of dollars a year in developing countries alone, and will put still further pressure on already scarce resources. Adaptation efforts, particularly in developing countries, should be accelerated.

The costs of stabilising the climate are significant but manageable; delay would be dangerous and much more costly.

The risks of the worst impacts of climate change can be substantially reduced if greenhouse gas levels in the atmosphere can be stabilised between 450 and 550 ppm CO_2 equivalent (CO_2e). The current level is 430 ppm CO_2e today, and it is rising at more than 2 ppm each year. Stabilisation in this range would require emissions to be at least 25% below current levels by 2050, and perhaps much more.

Ultimately, stabilisation – at whatever level – requires that annual emissions be brought down to more than 80% below current levels.

This is a major challenge, but sustained long-term action can achieve it at costs that are low in comparison to the risks of inaction. Central estimates of the annual costs of achieving stabilisation between 500 and 550 ppm CO_2e are around 1% of global GDP, if we start to take strong action now.

Costs could be even lower than that if there are major gains in efficiency, or if the strong co-benefits, for example from reduced air pollution, are measured. Costs will be higher if innovation in low-carbon

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-70080-1 - The Economics of Climate Change: The Stern Review
Nicholas Stern
Frontmatter
More information

technologies is slower than expected, or if policy-makers fail to make the most of economic instruments that allow emissions to be reduced whenever, wherever and however it is cheapest to do so.

It would already be very difficult and costly to aim to stabilise at 450 ppm CO_2e. If we delay, the opportunity to stabilise at 500-550 ppm CO_2e may slip away.

Action on climate change is required across all countries, and it need not cap the aspirations for growth of rich or poor countries.

The costs of taking action are not evenly distributed across sectors or around the world. Even if the rich world takes on responsibility for absolute cuts in emissions of 60-80% by 2050, developing countries must take significant action too. But developing countries should not be required to bear the full costs of this action alone, and they will not have to. Carbon markets in rich countries are already beginning to deliver flows of finance to support low-carbon development, including through the Clean Development Mechanism. A transformation of these flows is now required to support action on the scale required.

Action on climate change will also create significant business opportunities, as new markets are created in low-carbon energy technologies and other low-carbon goods and services. These markets could grow to be worth hundreds of billions of dollars each year, and employment in these sectors will expand accordingly.

The world does not need to choose between averting climate change and promoting growth and development. Changes in energy technologies and in the structure of economies have created opportunities to decouple growth from greenhouse gas emissions. Indeed, ignoring climate change will eventually damage economic growth.

Tackling climate change is the pro-growth strategy for the longer term, and it can be done in a way that does not cap the aspirations for growth of rich or poor countries.

A range of options exists to cut emissions; strong, deliberate policy action is required to motivate their take-up.

Emissions can be cut through increased energy efficiency, changes in demand, and through adoption of clean power, heat and transport technologies. The power sector around the world would need to be at least 60% decarbonised by 2050 for atmospheric concentrations to stabilise at or below 550 ppm CO_2e, and deep emissions cuts will also be required in the transport sector.

Even with very strong expansion of the use of renewable energy and other low-carbon energy sources, fossil fuels could still make up over half of global energy supply in 2050. Coal will continue to be important in the energy mix around the world, including in fast-growing economies. Extensive carbon capture and storage will be necessary to allow the continued use of fossil fuels without damage to the atmosphere.

Cuts in non-energy emissions, such as those resulting from deforestation and from agricultural and industrial processes, are also essential.

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-70080-1 - The Economics of Climate Change: The Stern Review
Nicholas Stern
Frontmatter
More information

With strong, deliberate policy choices, it is possible to reduce emissions in both developed and developing economies on the scale necessary for stabilisation in the required range while continuing to grow.

Climate change is the greatest market failure the world has ever seen, and it interacts with other market imperfections. Three elements of policy are required for an effective global response. The first is the pricing of carbon, implemented through tax, trading or regulation. The second is policy to support innovation and the deployment of low-carbon technologies. And the third is action to remove barriers to energy efficiency, and to inform, educate and persuade individuals about what they can do to respond to climate change.

Climate change demands an international response, based on a shared understanding of long-term goals and agreement on frameworks for action.

Many countries and regions are taking action already: the EU, California and China are among those with the most ambitious policies that will reduce greenhouse gas emissions. The UN Framework Convention on Climate Change and the Kyoto Protocol provide a basis for international co-operation, along with a range of partnerships and other approaches. But more ambitious action is now required around the world.

Countries facing diverse circumstances will use different approaches to make their contribution to tackling climate change. But action by individual countries is not enough. Each country, however large, is just a part of the problem. It is essential to create a shared international vision of long-term goals, and to build the international frameworks that will help each country to play its part in meeting these common goals.

Key elements of future international frameworks should include:

- *Emissions trading:* Expanding and linking the growing number of emissions trading schemes around the world is a powerful way to promote cost-effective reductions in emissions and to bring forward action in developing countries: strong targets in rich countries could drive flows amounting to tens of billions of dollars each year to support the transition to low-carbon development paths.
- *Technology cooperation:* Informal co-ordination as well as formal agreements can boost the effectiveness of investments in innovation around the world. Globally, support for energy R&D should at least double, and support for the deployment of new low-carbon technologies should increase up to five-fold. International co-operation on product standards is a powerful way to boost energy efficiency.
- *Action to reduce deforestation:* The loss of natural forests around the world contributes more to global emissions each year than the transport sector. Curbing deforestation is a highly cost-effective way to reduce emissions; large-scale international pilot programmes to explore the best ways to do this could get underway very quickly.

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-70080-1 - The Economics of Climate Change: The Stern Review
Nicholas Stern
Frontmatter
More information

- *Adaptation:* The poorest countries are most vulnerable to climate change. It is essential that climate change be fully integrated into development policy, and that rich countries honour their pledges to increase support through overseas development assistance. International funding should also support improved regional information on climate change impacts, and research into new crop varieties that will be more resilient to drought and flood.

© Cambridge University Press www.cambridge.org