



Bjerknes Centre
for Climate Research



The Stern review on the economics of climate change

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Introduction

- On 30 October 2006, the UK government published a review report on the economics of climate change.
- Review commissioned by the UK Chancellor of the Exchequer (finance minister) in July 2005
- Carried out by Sir Nicholas Stern, Head of the Government Economic Service
- The report reviews research by climate scientists on past, present, and potential future climate, which indicates a substantial risk that the near-future climate will cause a serious deterioration in living standards on Earth, if current trends (BAU, 'Business as usual') continue

- The report discusses the 'cost' of such changes, relative to the cost of either adapting to the climate changes or taking measures to ameliorate them, and makes recommendations on what steps may and/or should be taken.

Preview of cost estimates

- Approximate cost of Business As Usual (BAU): 20% of global GDP
- Approximate cost of avoidance measures: 1% of global GDP
- Approximate Social Cost of Carbon: 85 USD per 1000 kg CO₂

Figure 6.5d. Combined scenarios.

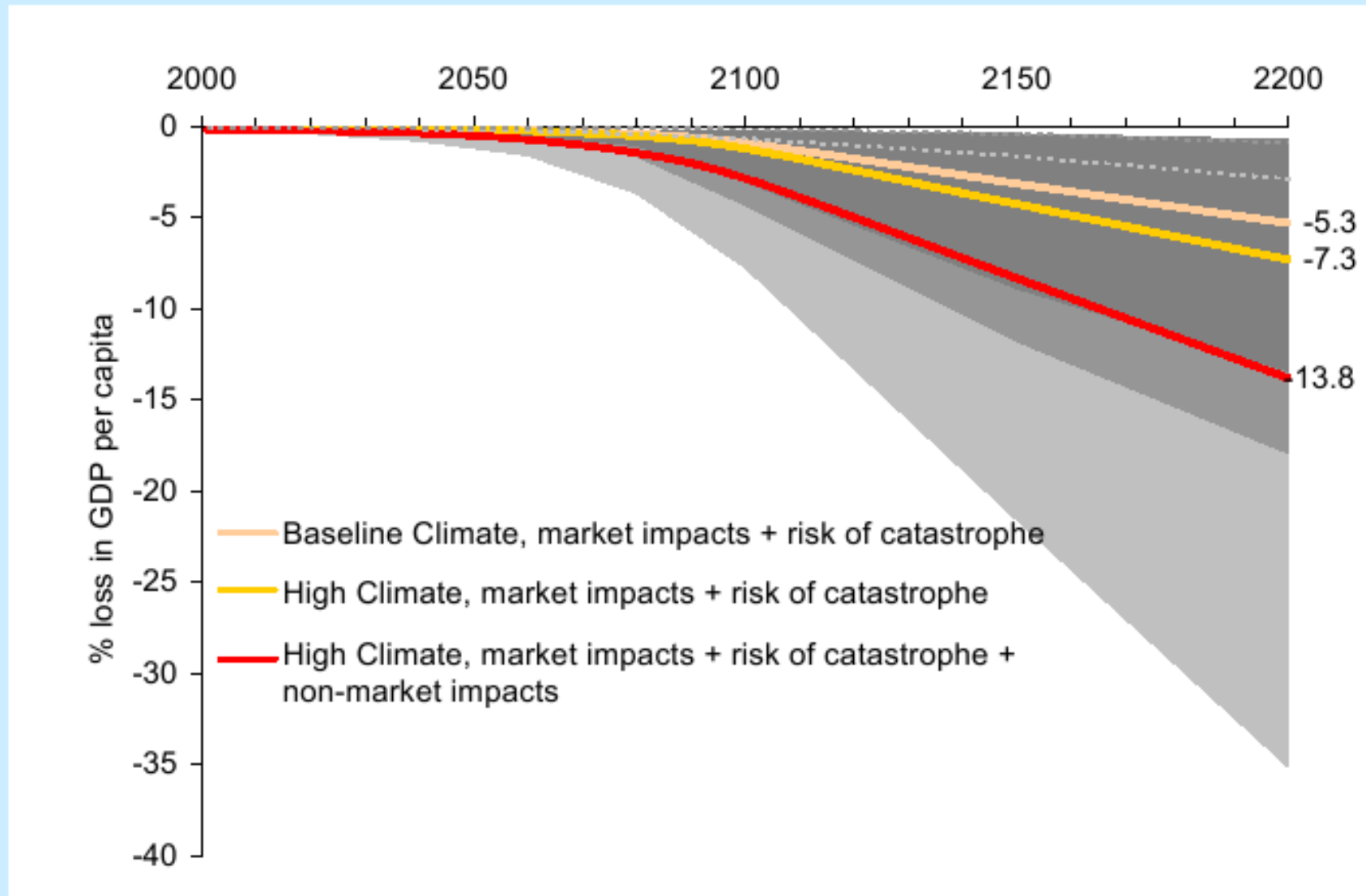
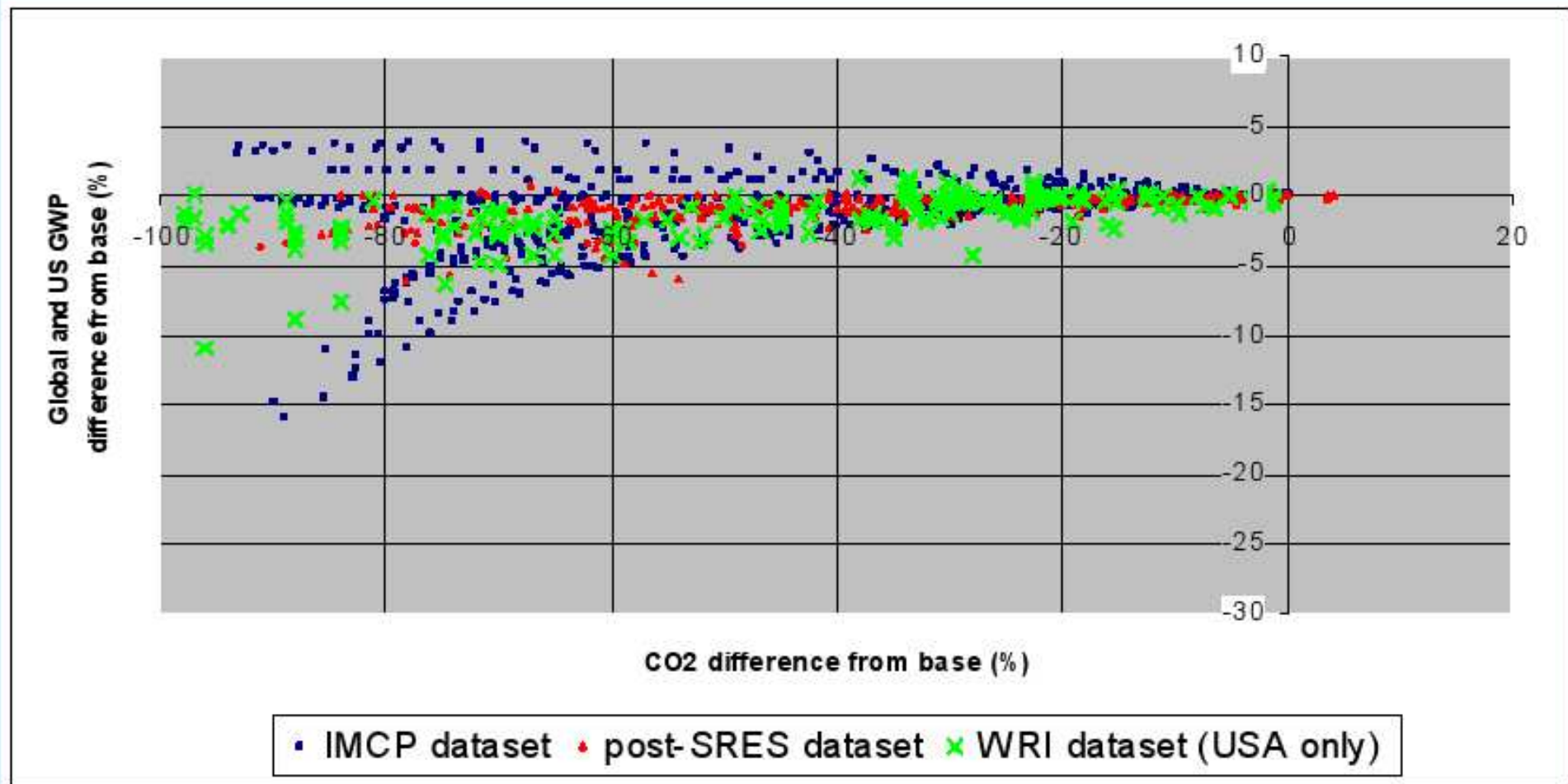


Figure 4 Model cost projections scatter plot
Costs of CO₂ reductions as a fraction of world GDP against level of reduction



Source: Barker, T., M.S. Qureshi and J. Köhler (2006): 'The costs of greenhouse-gas mitigation with induced technological change: A Meta-Analysis of estimates in the literature', 4CMR, Cambridge Centre for Climate Change Mitigation Research, Cambridge: University of Cambridge.

UK government approach

- The UK Chancellor, Gordon Brown, has so far commissioned 39 reviews by outside experts on a variety of policy issues.
- Such reviews should have substantial credibility, being commissioned by the government department which *provides* the money that other government departments *spend*.
- The Stern Review is one of those policy reviews.
- Of course, the government response to a policy review depends on the circumstances:
 - Some reviews may look like an excuse to do what was to be done anyway
 - Other reviews may have no apparent influence
 - We hope the Stern review is an *intermediate* case

Where to find the Stern Review

- Downloadable PDF files from `www.sternreview.org.uk`, or search `www.treasury.gov.uk`.
- ≈ 30 GBP + postage from Cambridge University Press (ISBN 0-521-70080-9, published January 2007).



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30 October 2006

Stern Review on the Economics of Climate Change

Publication of the Stern Review's final report

Sir Nicholas Stern, Head of the Government Economics Service and Adviser to the Government on the economics of climate change and development, is delighted to present his report to the Prime Minister and the Chancellor of the Exchequer on the Economics of Climate Change:

Full report

[Executive Summary](#)

[Other language versions of the Executive Summary](#)

[Postscript](#) and [Technical Annex to Postscript](#)

[Press notice: Publication of the Stern Review on the Economics of Climate Change](#)

[PDF file of comments on the Stern Review by leading economists](#)

[PDF files of Sir Nicholas Stern's launch presentation](#) and [speaking notes](#)

My personal view of the problem

- It has been suspected for many years that CO₂ and other substances released into the atmosphere from industrial and other anthropogenic sources may lead to substantial changes in the Earth's climate
- Recent research, including:
 - state-of-the art analyses of current, historical, and pre-historical climate observations;
 - state-of-the art models for climate prediction;

drives us to the conclusion that if current trends continue:

- Within the current century, and certainly within the next few hundred years, a substantial climate change will occur, causing a serious deterioration in living conditions on Earth;
- But if major changes are made in current industrial and economic policies, the severity of the climate change should be substantially reduced.
- *However, we must consider the following:*

... And it ought to be remembered that there is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success, than to take the lead in the introduction of a new order of things. Because the innovator has for enemies all those who have done well under the old conditions, and lukewarm defenders in those who may do well under the new.

Niccolò Machiavelli, *Il Principe*, Chapter VI.

Engl. transl. by W. K. Marriott, *The Prince*,
available from www.gutenberg.org,
EBook #1232, 2006.

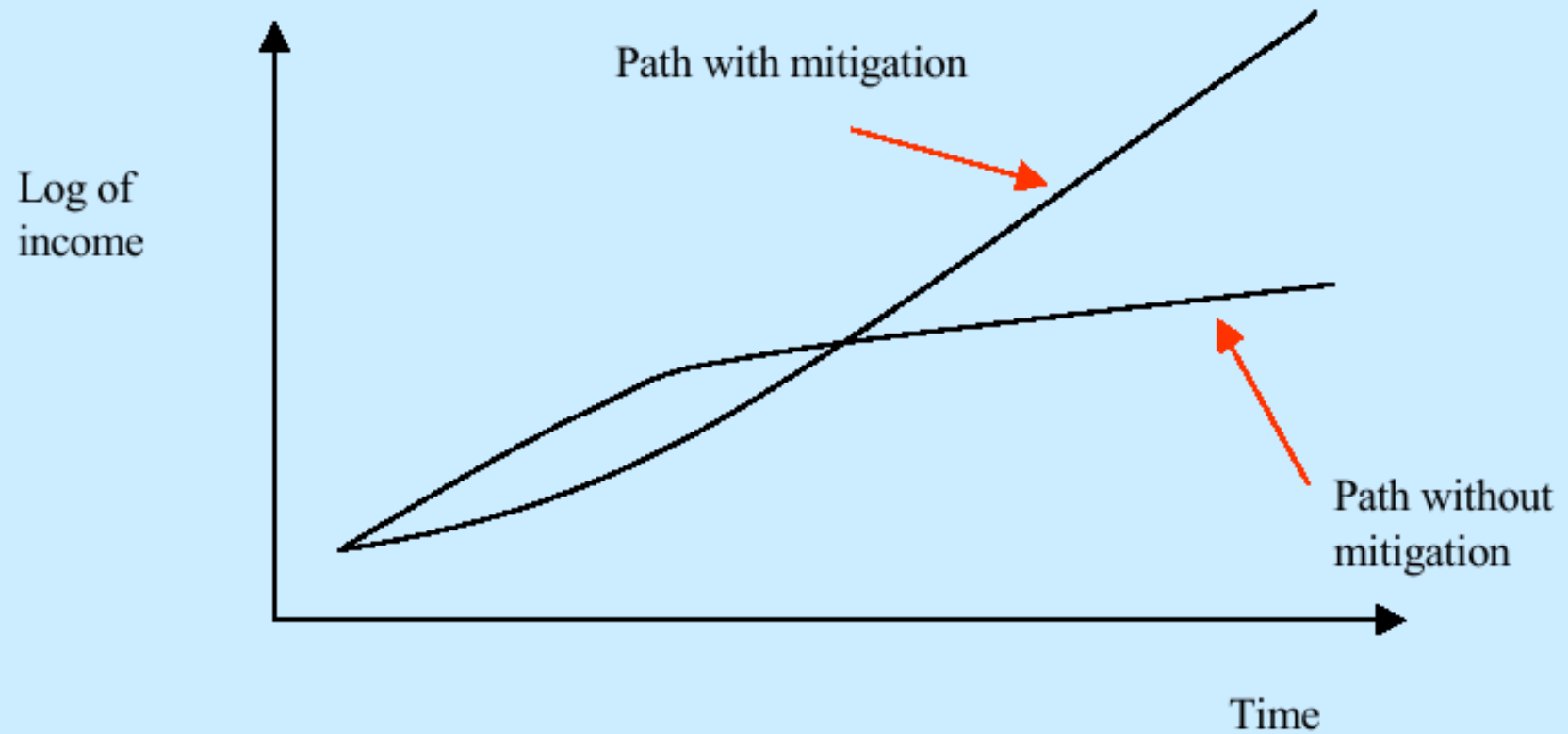
- So if we want to ameliorate climate change and its effects, we must start now, before the changes have become evident, **and**:
 - We must put great effort into convincing people that it is in their interest to do so;
 - We must use arguments which are convincing for people of many different professional, social, and educational backgrounds. Not only scientists and engineers, but also:
 - * Politicians of all hues
 - * Administrators, business ‘leaders’ and ‘followers’
 - * Journalists
 - * Voters of all persuasions
 - * Representatives and members of all social groups
 - * Members of the workforce, unemployed, pensioners, ...

- And since almost everybody needs money or its equivalent, we need to take account of the views of **economists**.

Terminology of economists

- Economists assume that individuals generally act in (in some sense) *their own self-interest*
- This may be formulated mathematically by stating that they act to maximize a *utility* function
- Utility is *not* money. In fact, it is generally assumed to be a *nonlinear* function of money (or amount of other goods etc.).
- This nonlinear function increases *more slowly than* linearly, in fact the utility function is often assumed to be a *logarithm*, decreasing to $-\infty$ as the 'monetary' asset $\rightarrow 0$.
- The Stern report employs a utility given by the logarithm of the per capita consumption.

Figure 2.3 Conceptual approach to comparing divergent growth paths over the long-term



- Economists also like *economic growth*, where total wealth and/or economic activity tends to increase continually (never mind that the Universe is finite ...)
- If one assumes that one's wealth will increase in the future, the utility of a fixed amount of money will then decrease with time, even if one does not assume a 'pure time' **discount rate** where the inherent value of economic resources decreases exponentially with future time.
- This argument is used in the Stern report to justify the use of a much smaller discount rate than is normally used when evaluating commercial investment projects.

Commissioning of the Stern review

- Announced in July 2005, and aimed to assess:
 - Economics of moving to a low-carbon global economy
 - Approaches for adaptation to changes in climate
 - UK-specific lessons
- Terms of reference included:
 - energy demand and economic growth, including developing countries
 - economic, social and environmental consequences, including risks of increased climate volatility
 - costs and benefits of reducing greenhouse gas emissions
 - national and international policies, including investment in cleaner technologies

- Mostly a review of existing research, but some commissioning of new research where information was not available in the literature.
- Team led by Siobhan Peters, with over 20 members
- Contributing organizations include Hadley Centre, IPCC, Royal Society, IEA, OECD, World Bank, EBRD, IADB, and UNEP.
- Large 'supporting cast' of UK and international government and public bodies, academics, public and business officials, and NGOs.

Frequently asked questions

- A list of frequently asked questions about the Stern Review, and replies to them, is given in
http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/sternreview_faq.cfm
- The topics covered include
 - The scientific basis
 - Estimates of climate change impacts including damage estimates
 - The economic *discount rate*
 - Cost of mitigation
 - International action

- A useful brief summary of the scientific basis for the analysis, and of the economic and policy criteria used in the review, are given in a response by Stern to criticism by Byatt et al., published in *World Economics* (2006), available from http://www.hm-treasury.gov.uk/media/5E1/FB/stern_reply_worldeconomics.pdf

Table of contents

Title: Stern Review: The Economics of Climate Change

- Executive Summary
- Preface & Acknowledgements
- Introduction to Review
- Summary of Conclusions

Part I Climate change: our approach

- Introduction
- 1 The science of climate change:
- 2 Economics, ethics and climate change
- 2A Technical annex: ethical frameworks and intertemporal equity

Part II The Impacts of climate change on growth and development

- Introduction
- 3 How climate change will affect people around the world
- 4 Implications of climate change for development
- 5 Costs of climate change in developed countries
- 6 Economic modelling of climate change impacts

Part III The economics of stabilisation

- Introduction
- 7 Projecting the growth of greenhouse gas emissions
- 7A Annex: Climate change and the environmental Kuznets curve
- 8 The challenge of stabilisation
- 9 Identifying the costs of mitigation

- 10 Macroeconomic models of costs
- 11 Structural change and competitiveness
- 11A Annex: Key statistics for 123 UK production sectors
- 12 Opportunities and wider benefits from climate policies
- 13 Towards a goal for climate change policy

Part IV Policy responses for mitigation

- Introduction
- 14 Harnessing markets to reduce emissions
- 15 Carbon pricing and emission markets in practice
- 16 Accelerating technological innovation
- 17 Beyond carbon markets and technology

Part V Policy responses for adaptation

- Introduction
- 18 Understanding the economics of adaptation
- 19 Adaptation in the developed world
- 20 The role of adaptation in sustainable development

Part VI International collective action

- Introduction
- 21 Framework for understanding international collective action for climate change
- 22 Creating a global price for carbon
- 23 Supporting the transition to a low carbon global economy
- 24 Promoting effective international technology co-operation
- 25 Reversing emissions from land use change
- 26 International support for adaptation
- 27 Conclusions
- STERN REVIEW Acronyms and Abbreviations

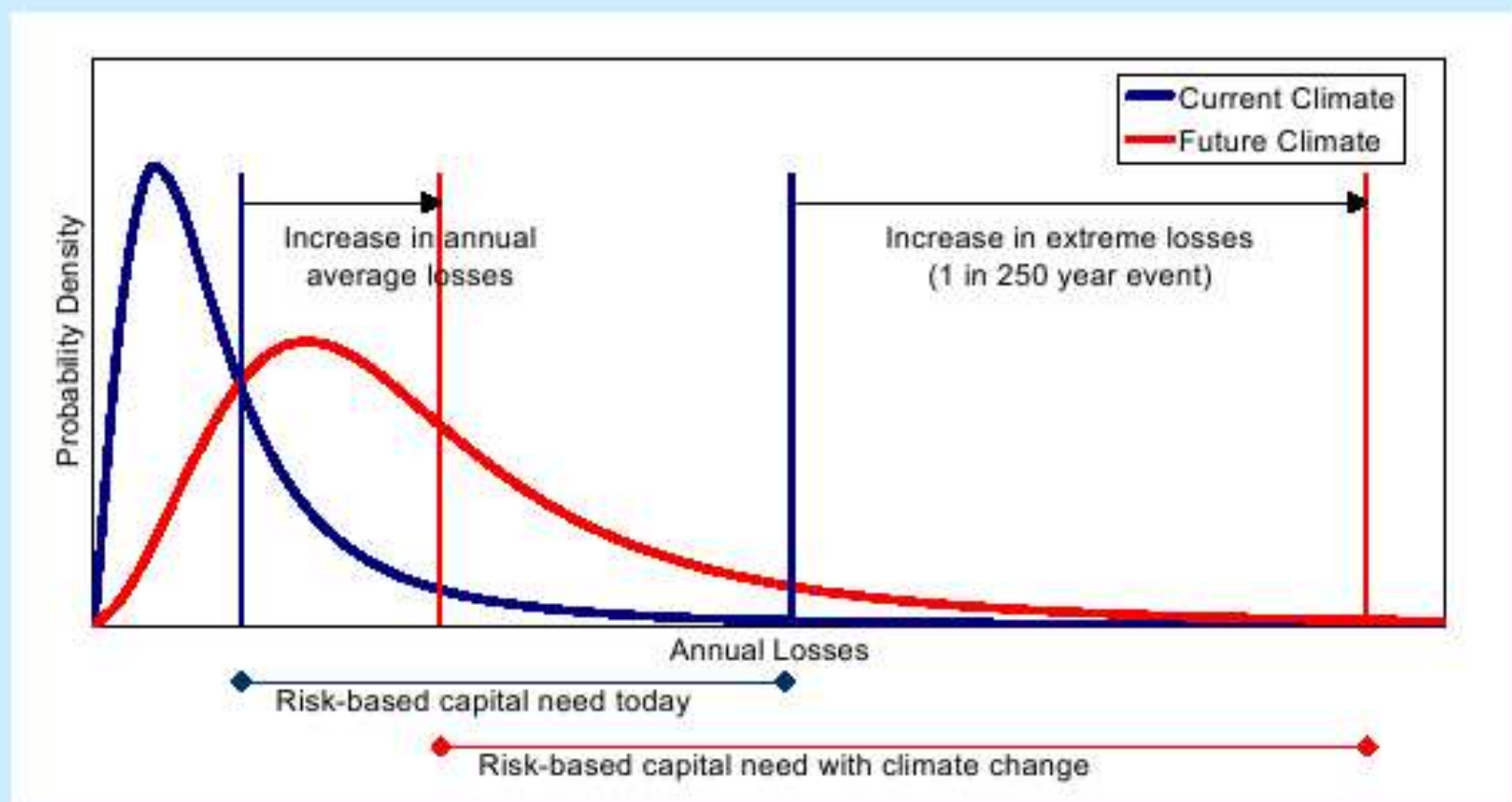
Terminology

- In the Stern review, greenhouse gas concentration is measured in ppm CO₂e (e = 'equivalent', incorporating the effects of other greenhouse gases).
 - Pre-industrial: 280 ppm CO₂e
 - Present day (2005): 430 ppm CO₂e
 - The level of 550 ppm CO₂e could be reached as early as 2035
 - At 550 ppm CO₂e, probability of a global average temperature rise > 2°C is **0.77–0.99**.

Main themes and conclusions

- **Climate change is the greatest market failure the world has ever seen**
- Use a consistent, quantitative approach to uncertainty and risk (probability theory). Uncertainty is an argument for a **more** (not less) demanding emission reduction goal: this is *consistent* with normal 'prudent' government policies in such areas as defence, financial stability, flood protection, etc.

Climate change is likely to lead to a shift in the distribution of losses towards higher values, with a greater effect at the tail.⁴⁷ Average annual losses (or expected losses) will increase by a smaller amount than the extreme losses (here shown as a 1 in 250 year event), with the result that the amount of capital that insurers are required to hold to deal with extremes increases.



If storm intensity increases by 6%, as predicted by several climate models for a doubling of carbon dioxide or a 3°C rise in temperature, this could increase insurers' capital requirements by over 90% for US hurricanes and 80% for Japanese typhoons – an additional \$76 billion in today's prices.

Source: Association of British Insurers (2005a)

- 'Climate-related shocks have sparked violent conflict in the past, **and conflict is a serious risk in areas such as West Africa, the Nile Basin, and Central Asia.**'

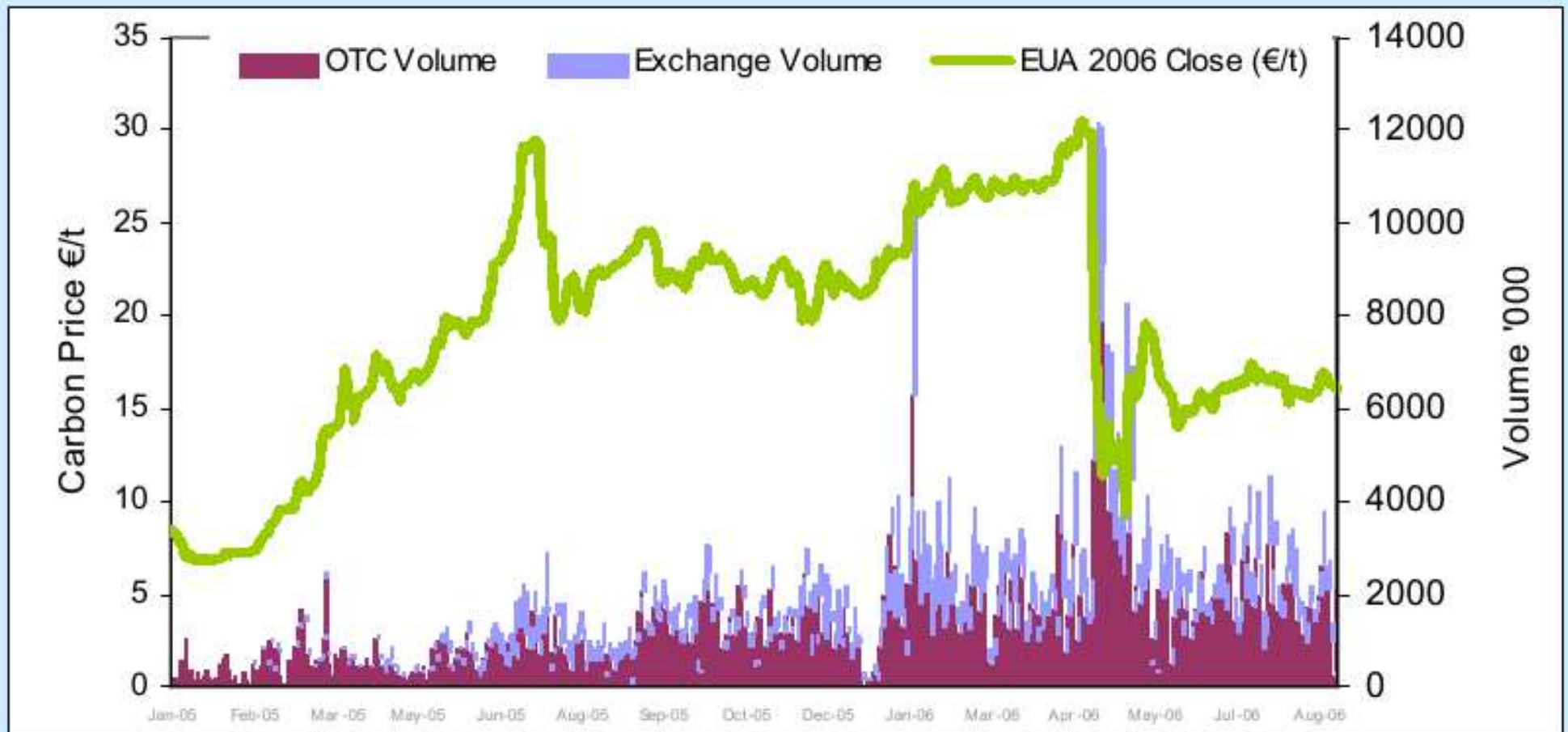
- Results from new risk based assessments suggest that there is a significant chance that the climate system is more sensitive than originally thought.

- Systematic treatment of inter- and intra-generational *equity*
- Climate change will have serious impacts within the lifetime of most people alive today. Future generations will be even more strongly affected, although they lack representation in present-day decisions

- Standard cost-benefit analysis techniques are limited as they focus on *marginal changes* (i.e., they linearize assuming small perturbations).
- Standard treatments of *discounting* (e.g., depreciation at a fixed percentage per year) are inappropriate since we are considering *large* (highly nonlinear) potential changes with very long-term impacts.

- The social cost of carbon (BAU) is of the order of 85 USD per tonne (1000 kg) of CO₂

The market for EU allowances (EUAs) –prices and volumes



Source: Data taken from Point Carbon, www.pointcarbon.com

Table 24.1 Implicit cost of carbon in existing deployment support⁵²

Country	Application	Imputed carbon price, \$ per tonne CO₂
Germany	Onshore wind	73
	Offshore wind	146
	Solar	1048
	Electricity from biomass	146
Austria	Wind	122
	Electricity from biomass	171
Spain	Wind	73
	Solar	804

Figure 6.5d. Combined scenarios.

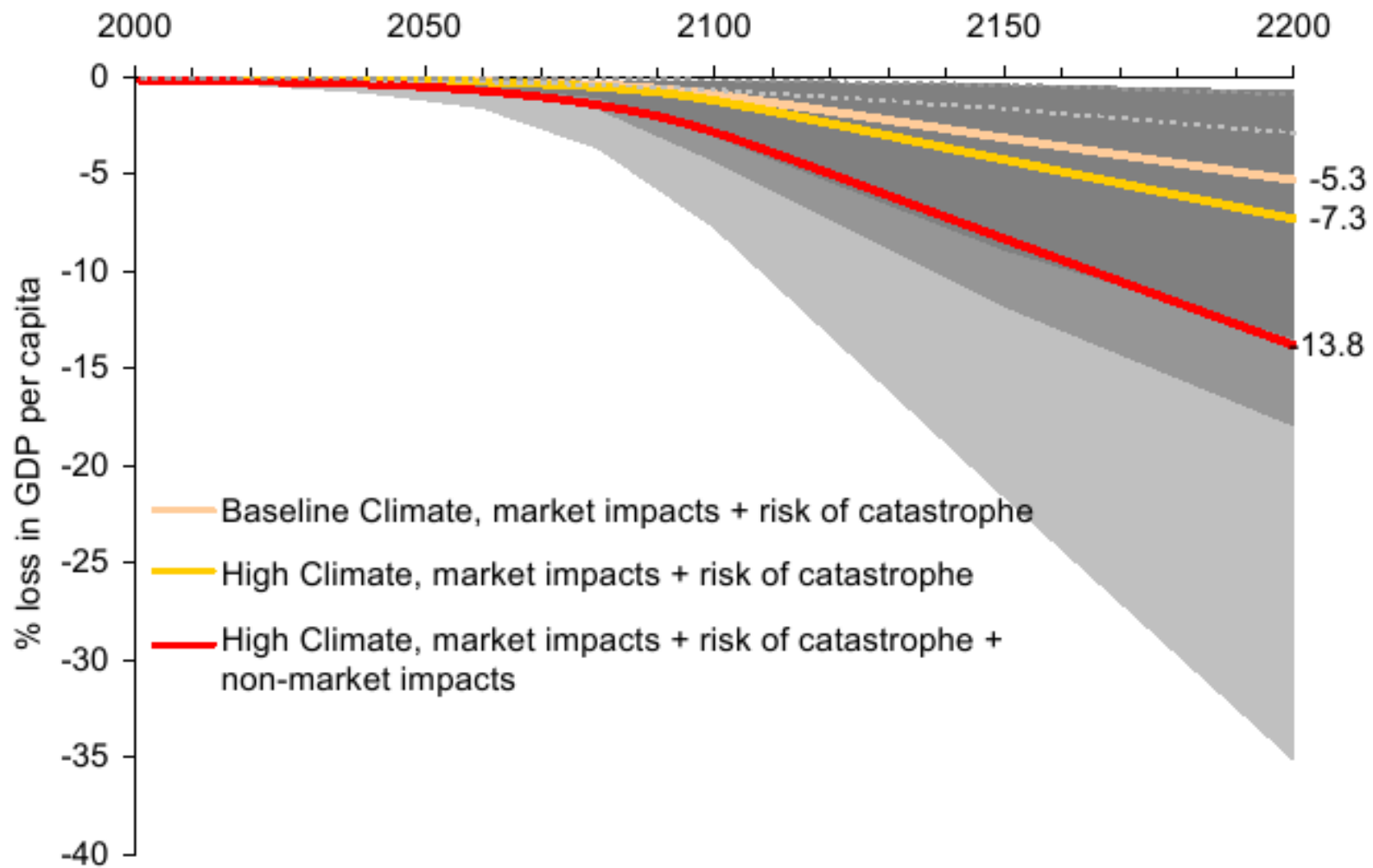
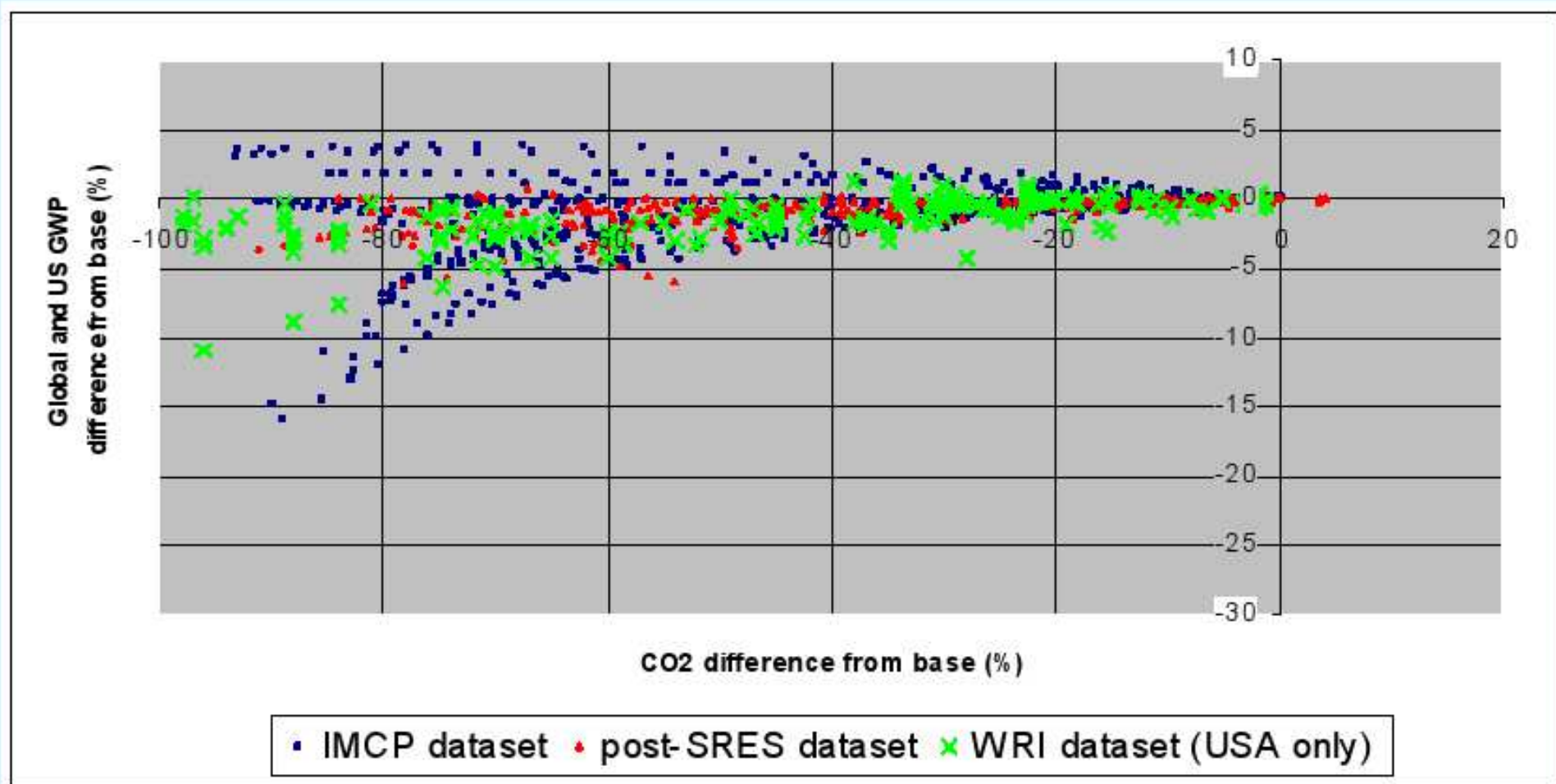


Figure 4 Model cost projections scatter plot

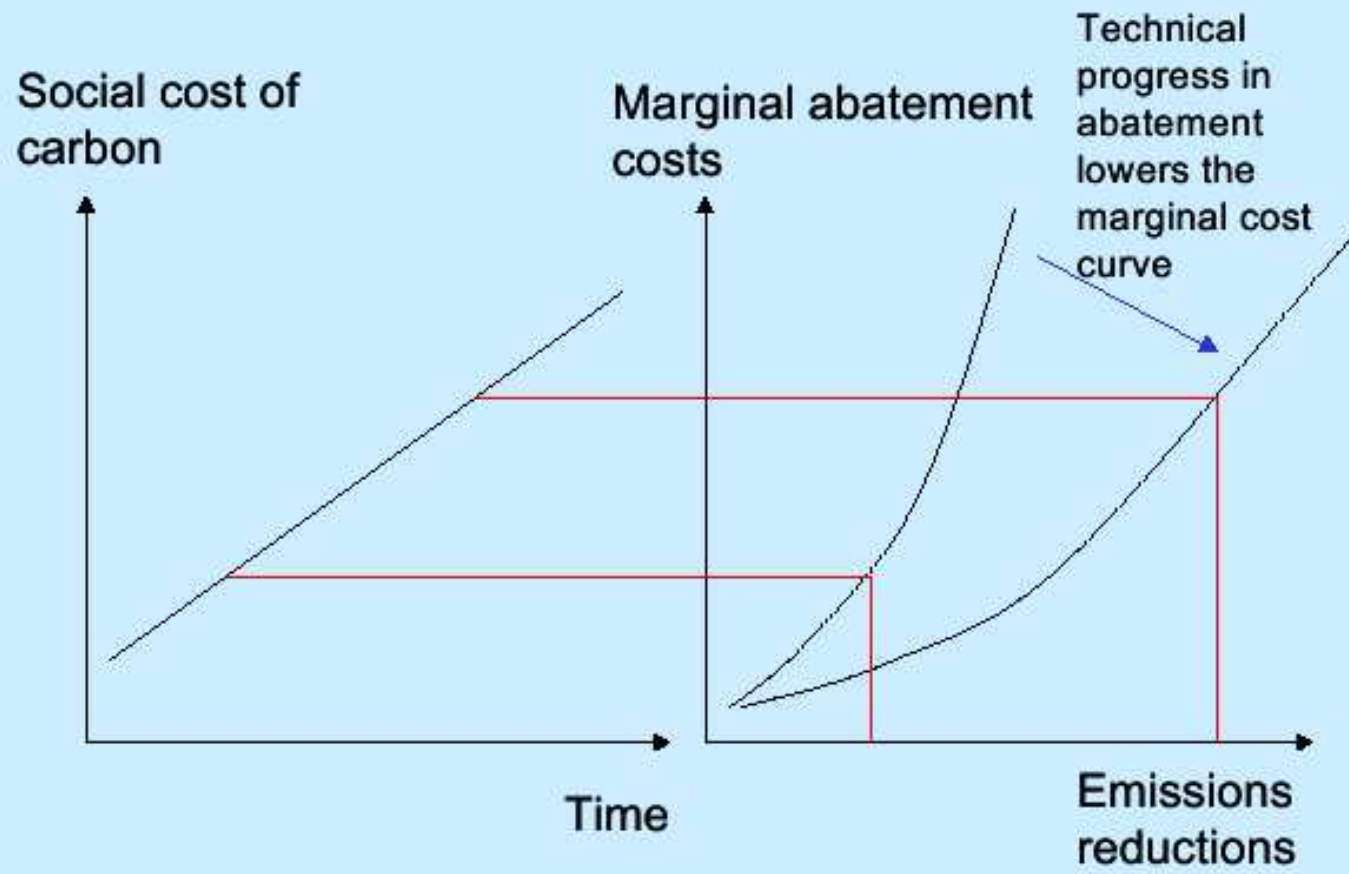
Costs of CO₂ reductions as a fraction of world GDP against level of reduction



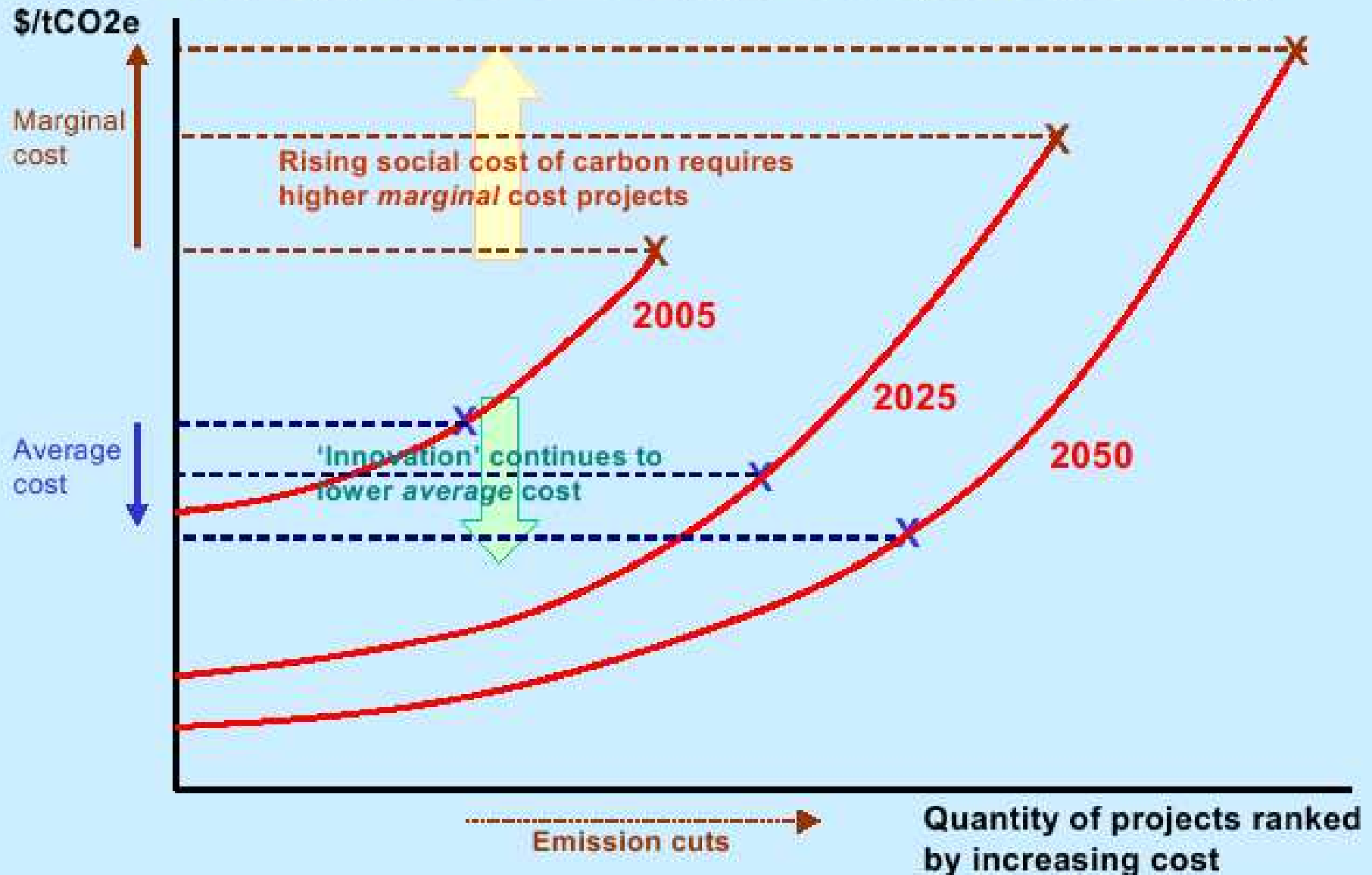
Source: Barker, T., M.S. Qureshi and J. Köhler (2006): 'The costs of greenhouse-gas mitigation with induced technological change: A Meta-Analysis of estimates in the literature', 4CMR, Cambridge Centre for Climate Change Mitigation Research, Cambridge: University of Cambridge.

- If and when damages occur it will be **too late** to reverse the process. Thus we must **look a long way ahead**.
- There is still time to avoid the worst impacts of climate change, if we take strong action now. **The benefits of strong, early action on climate change outweigh the costs.**

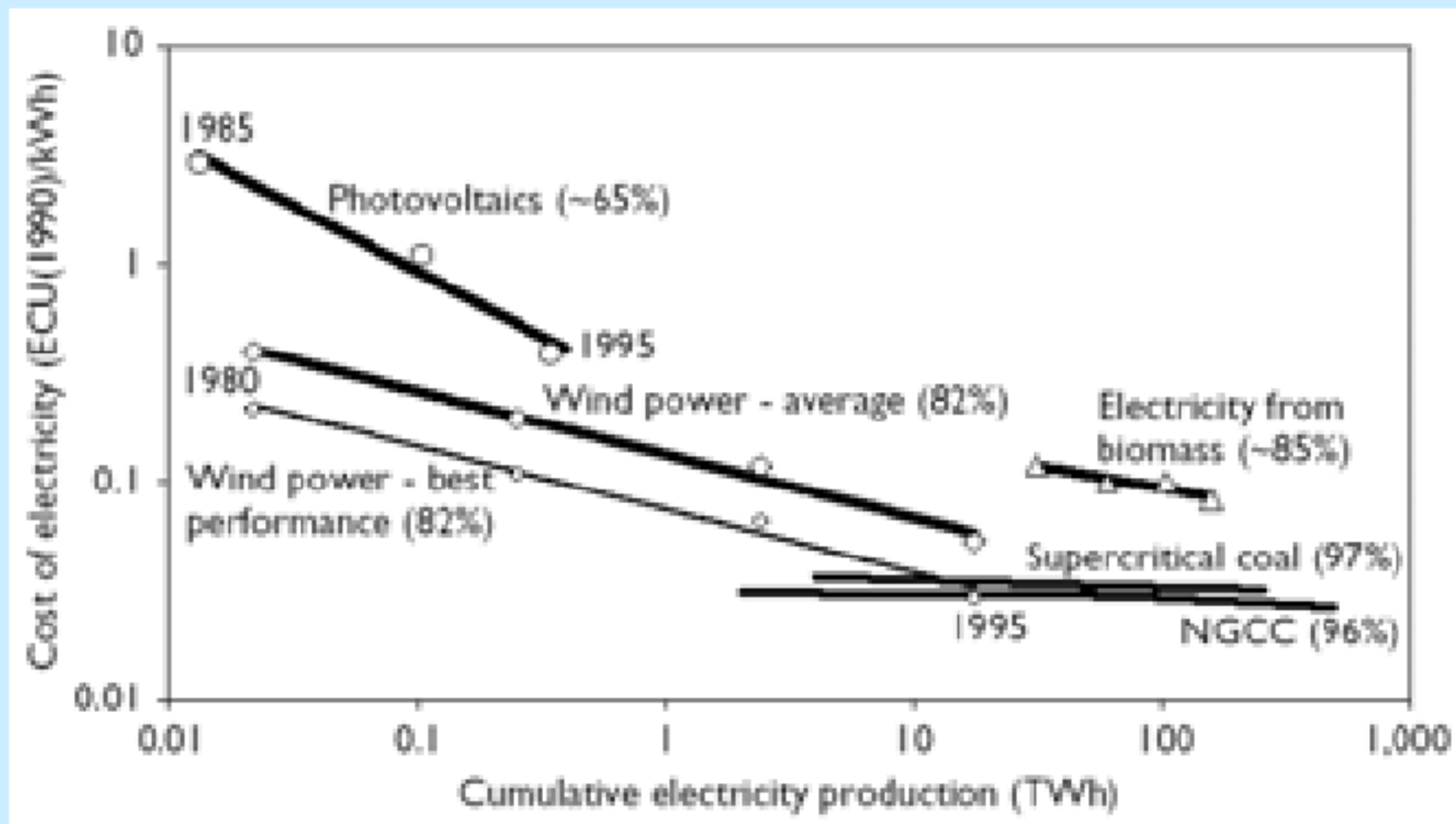
Figure 2.2 How the path for the social cost of carbon drives the extent of abatement



Illustrative cost per unit of GHG abated for a specific technology



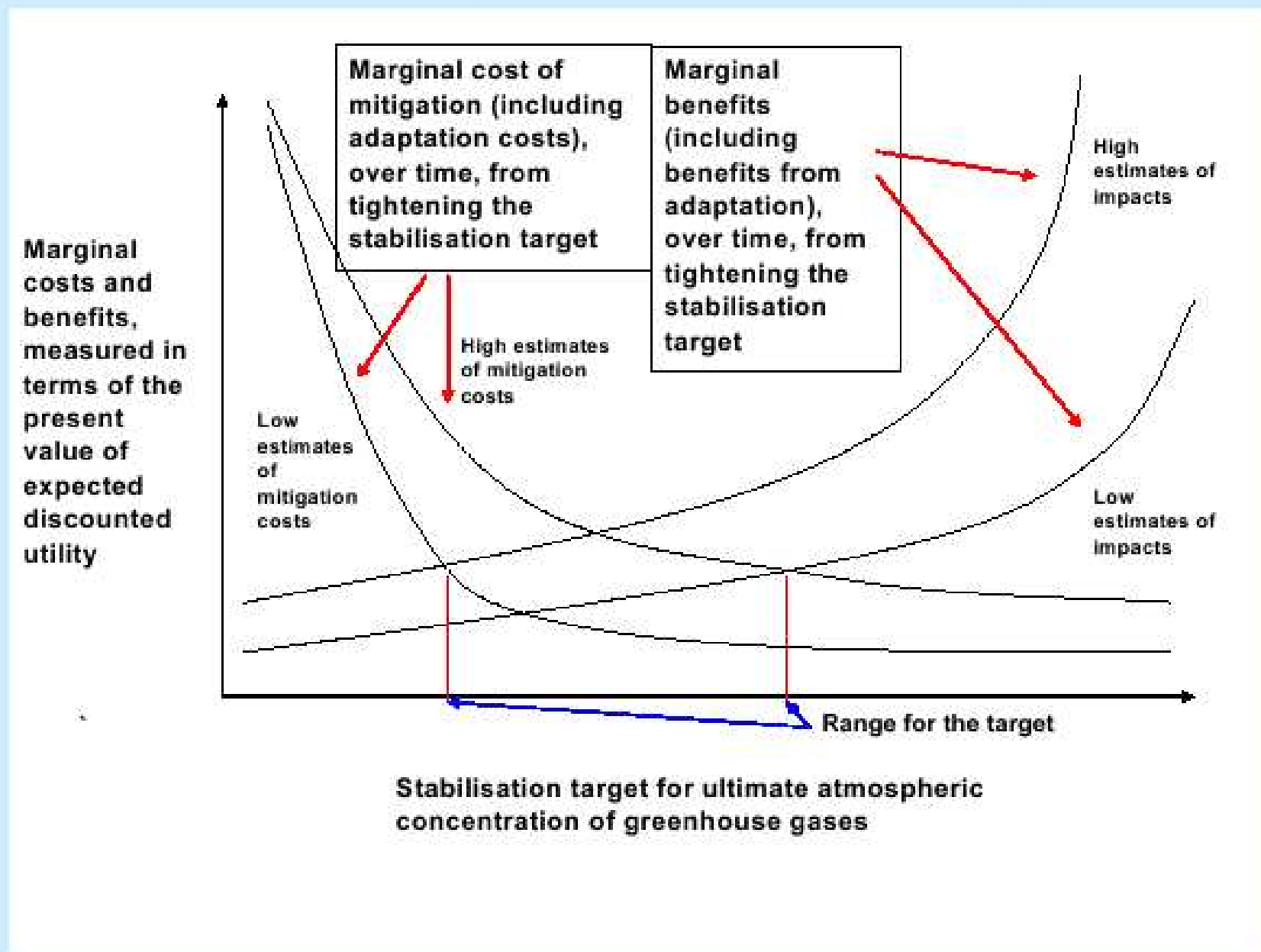
Cost evolution and learning rates for selected technologies



Source: IEA (2000) pp21

- Stabilisation of greenhouse-gas concentrations in the atmosphere is feasible and consistent with continued economic growth. Achieving the necessary cuts in greenhouse-gas emissions will cost around 1% of GDP by 2050—a level that is significant but manageable
- Stabilisation at 450 ppm CO₂e is now out of reach. **Weak action in the next 10–20 years will make stabilisation at 550 ppm CO₂e impossible.**

Figure 13.3 Schematic representation of how to select a stabilisation level



- The power (electricity) sector will have to be 60–75% decarbonised by 2050. Extensive carbon capture and storage will be necessary to allow the continued use of fossil fuels.

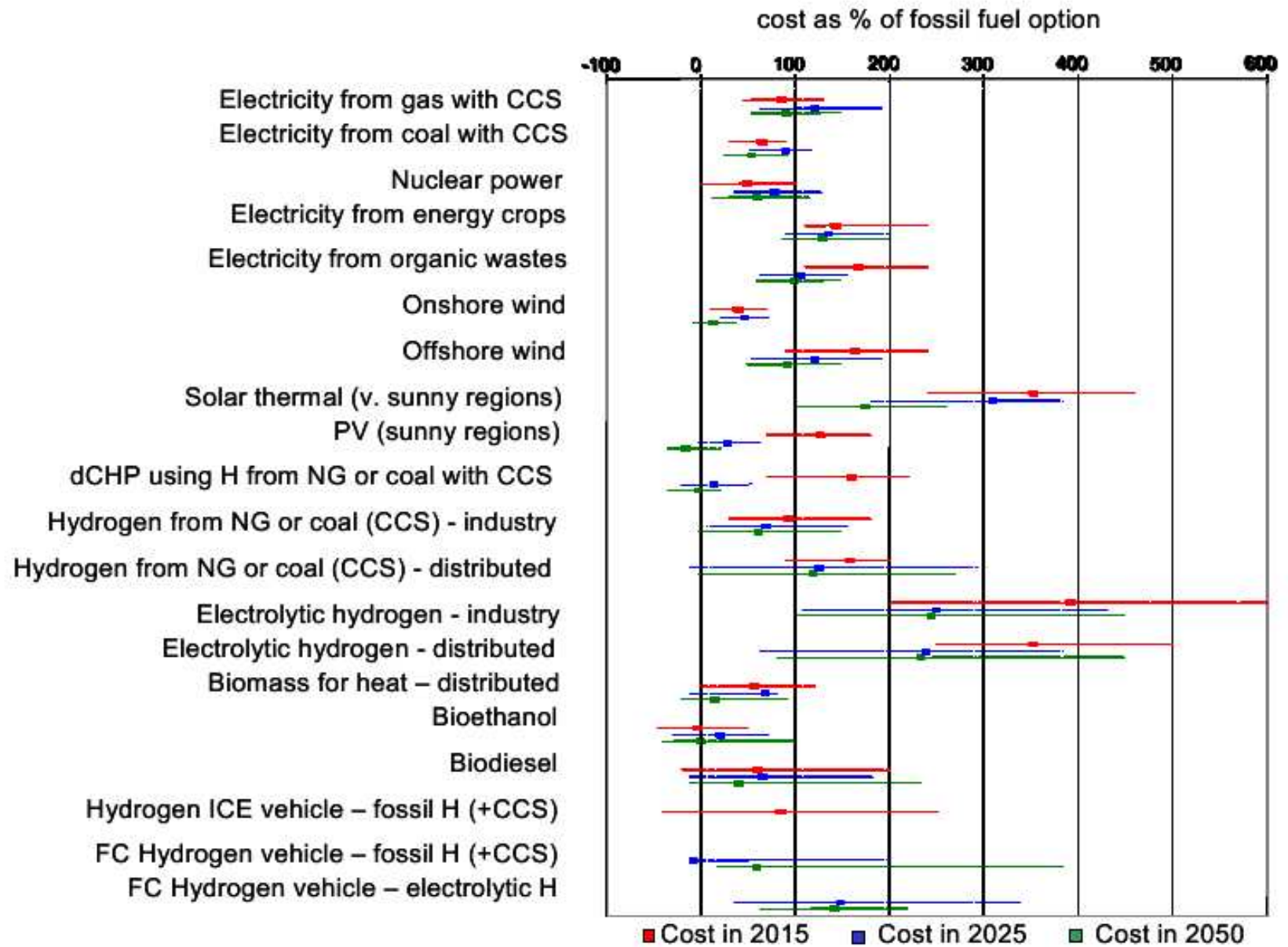
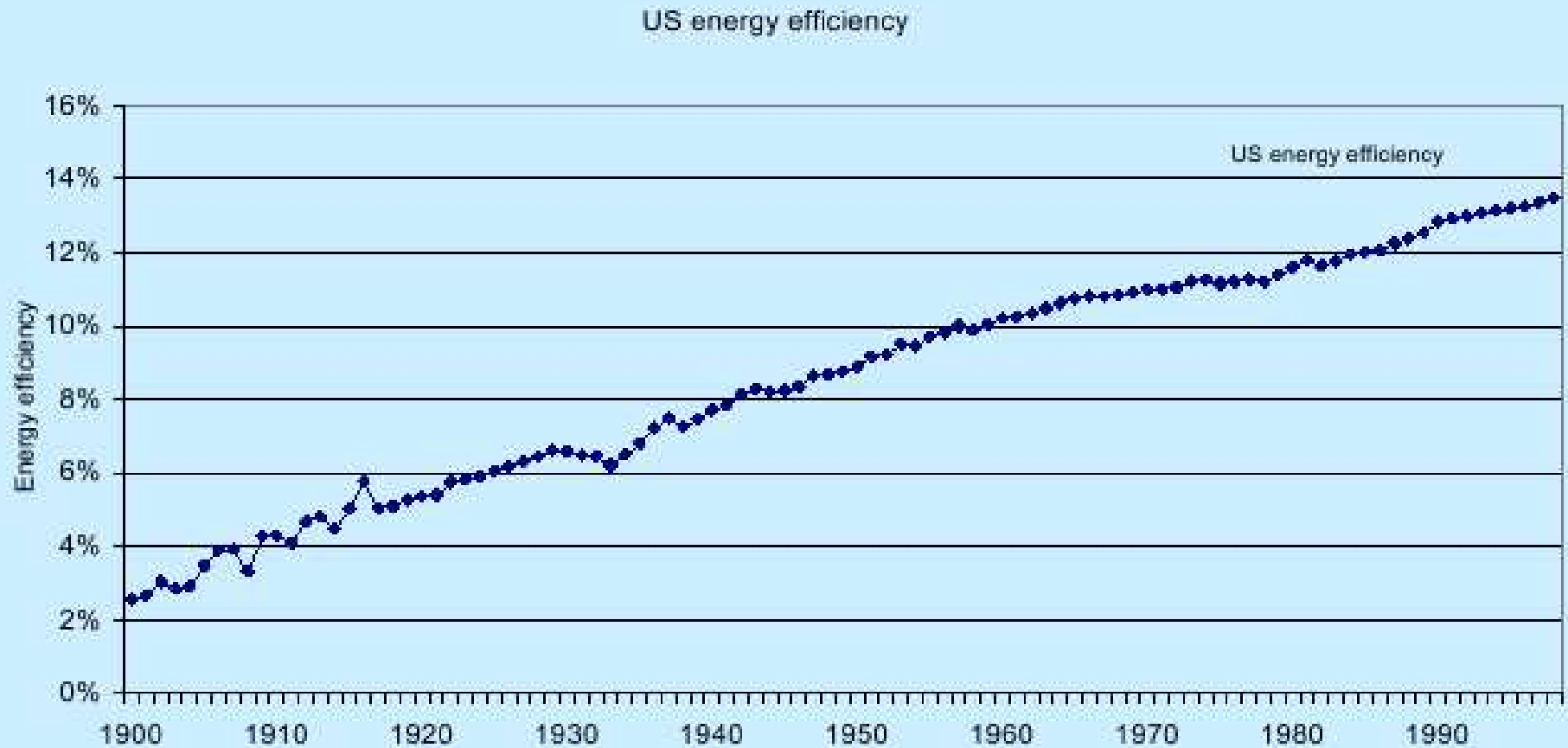


Figure 7.5 Energy conversion efficiencies, USA, 1900–1998

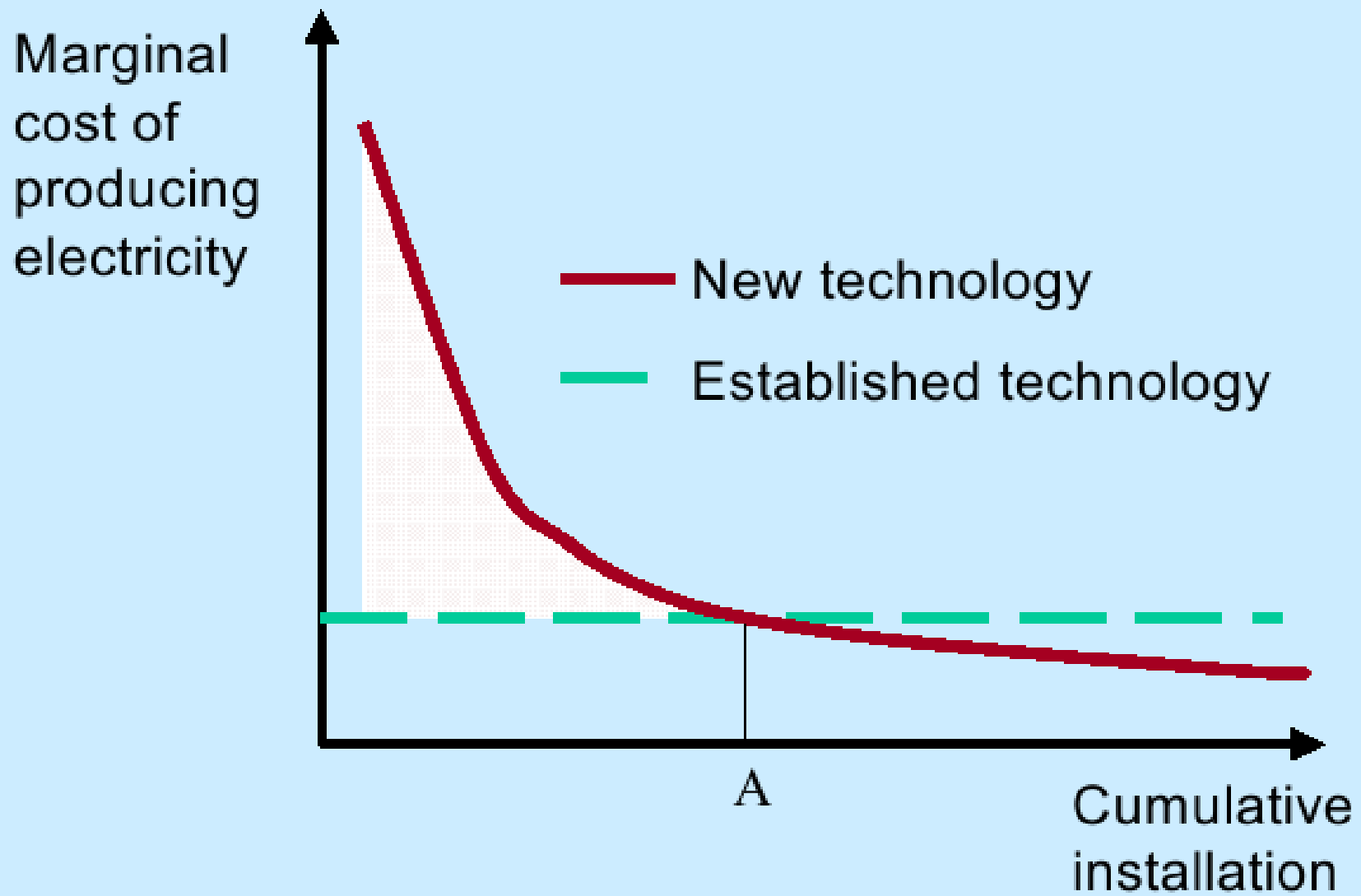


Source: Ayres et al (2005) and Ayres and Warr (2005) This graph shows the efficiency with which power from fossil-fuel, hydroelectric and nuclear sources is converted into useful energy services. The percentages reflect the ratio of useful work output to energy input.

- Deep emission cuts in the transport sector will ultimately be needed.

- Transition to a low-carbon economy will bring opportunities for growth (new markets, new technologies).

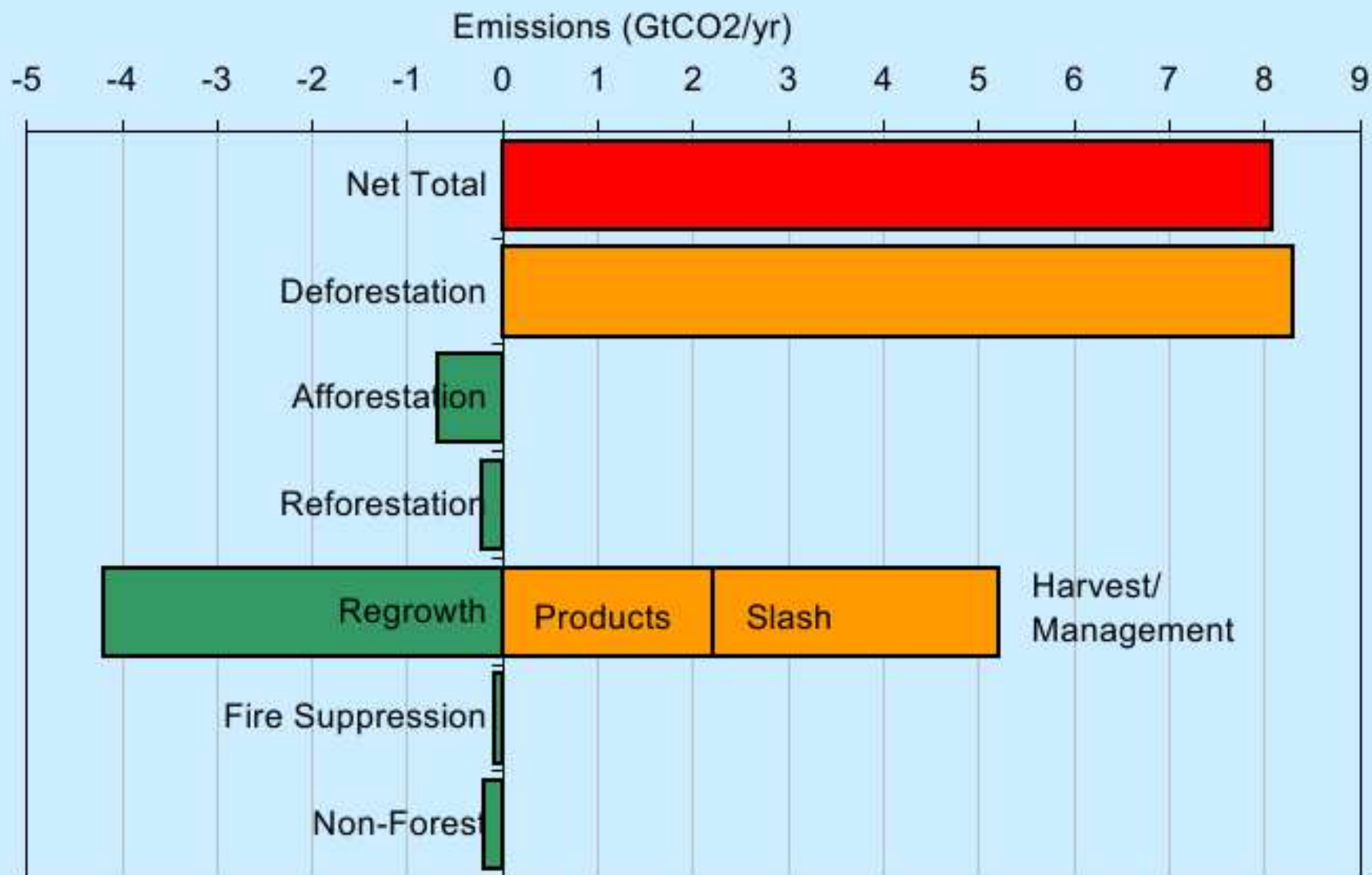
Figure 16.2 Illustrative experience curve for a new technology



- It is important to educate the public and stakeholders so that they may all be able to participate in policy discussions on climate change and amelioration techniques. This type of ‘government by discussion’ was put forward by John Stuart Mill in the 19th century (‘On Liberty’).
- The **removal of barriers to behavioural change** is essential
 - It is necessary to foster a shared understanding of the nature of climate change and its consequences. *Evidence, education, persuasion, and discussion* are necessary.
- Climate change demands an international response, based on a shared understanding of long-term goals and agreement on frameworks for action.

- Key elements of future international frameworks should include:
 - Emissions trading
 - Technology cooperation
 - Action to reduce deforestation
 - Adaptation (rich countries should assist the poorest countries)

Figure 25.1 Sources of emissions from global land use change 2000



Source: Reproduced from Baumert et al (2005)

- **Conclusion:** there is still time to avoid the worst impacts of climate change **if strong collective action starts now.**