Towards a Low-Carbon Energy Future: Policy Imperatives and Economic Implications

Presentation to the Royal Society's Fast-Track Discussion
'Towards a Low-Carbon Energy Future'

Paul Ekins
Professor of Energy and Environment Policy
King's College London, Department of Geography

Monday 17th November, 2008
Royal Society, London

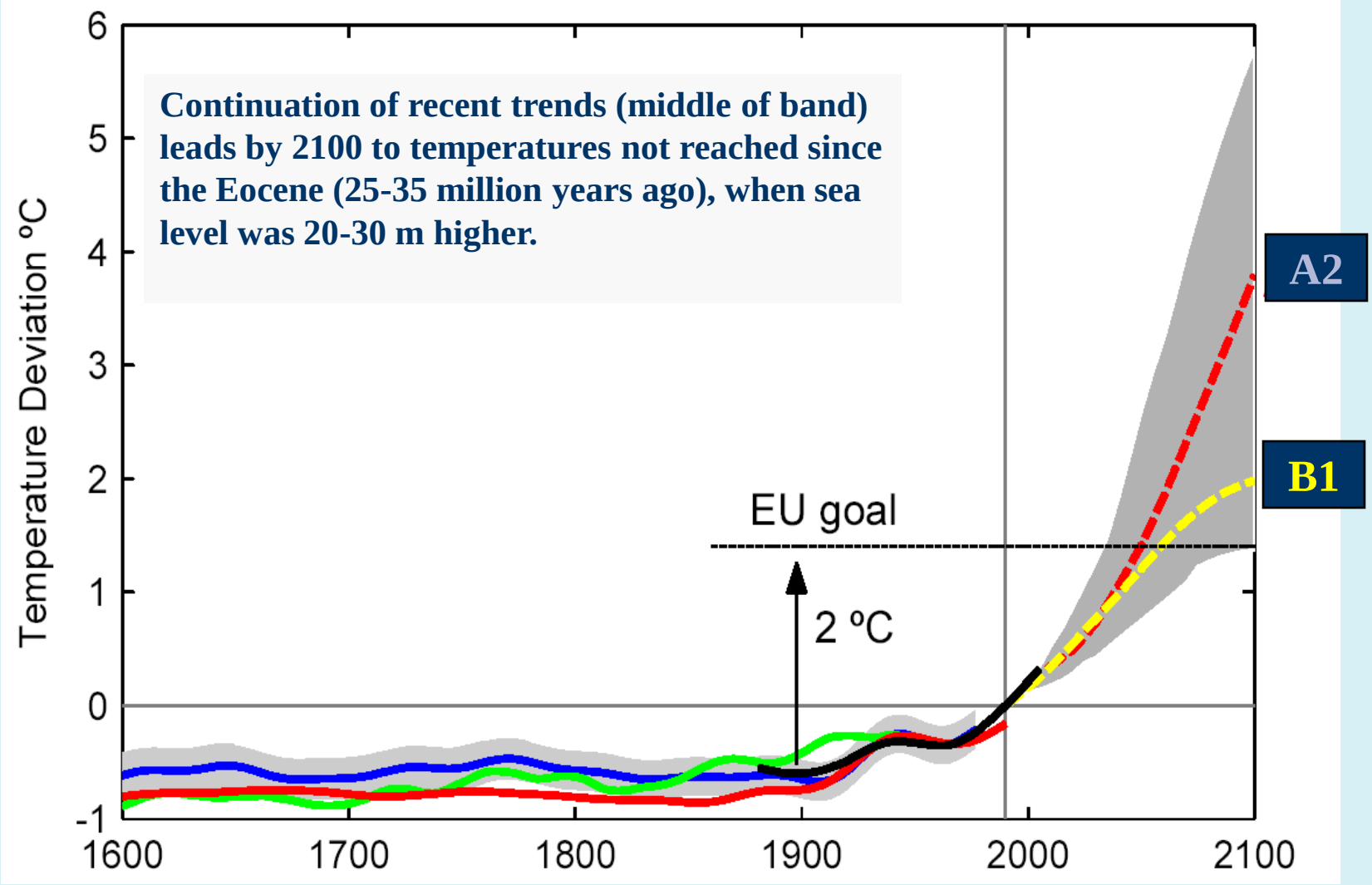
Structure of presentation

- The necessary improvements in energy/carbon productivity for climate stabilisation
- Policy framework for making those improvements
- Implications for the macro-economy
- Conclusions, implications (opportunities and risks) for investment and business

‘Dangerous anthropogenic climate change’

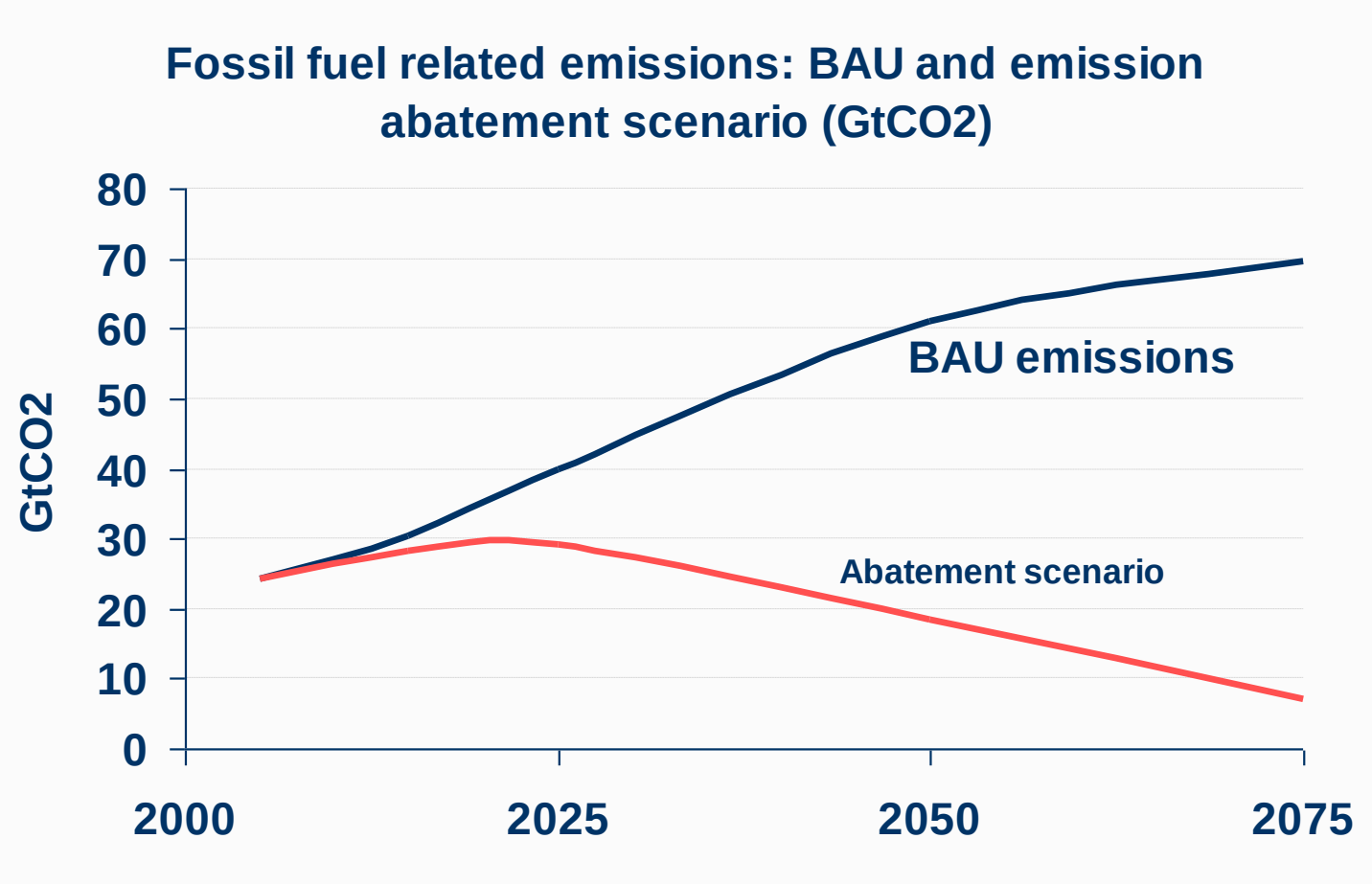
- **Pre-industrial CO2 concentrations : 280 ppm**
- **Current CO2 concentrations: 380 ppm**
- **Current GHG (CO2e) concentrations: 430 ppm**
- **Rate of GHG concentration increase: 2.5 ppm p.a.**
- **Current global average temperature increase since 1900: 0.7^{o}C**
- **Target temperature increase for ‘acceptable’ climate change: 2°C**
- **Probability that this will be exceeded at 450ppm: 80%**

The climate implications of where we're headed: The next 100 years compared to the last 400



Source: Professor John Holdren, Harvard University

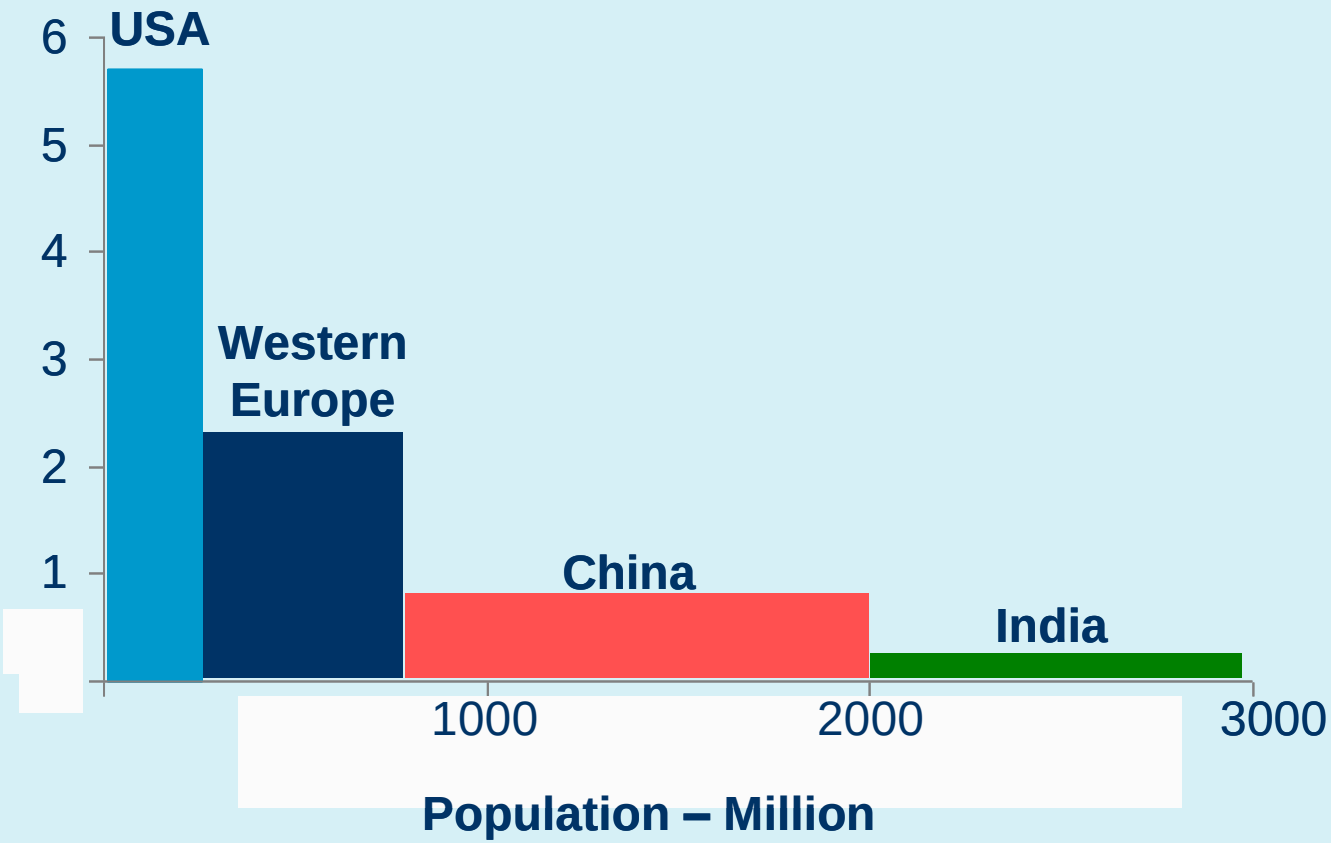
Emissions scenario to limit temperature change



Source: Stern Review, Part III, Chapter 9

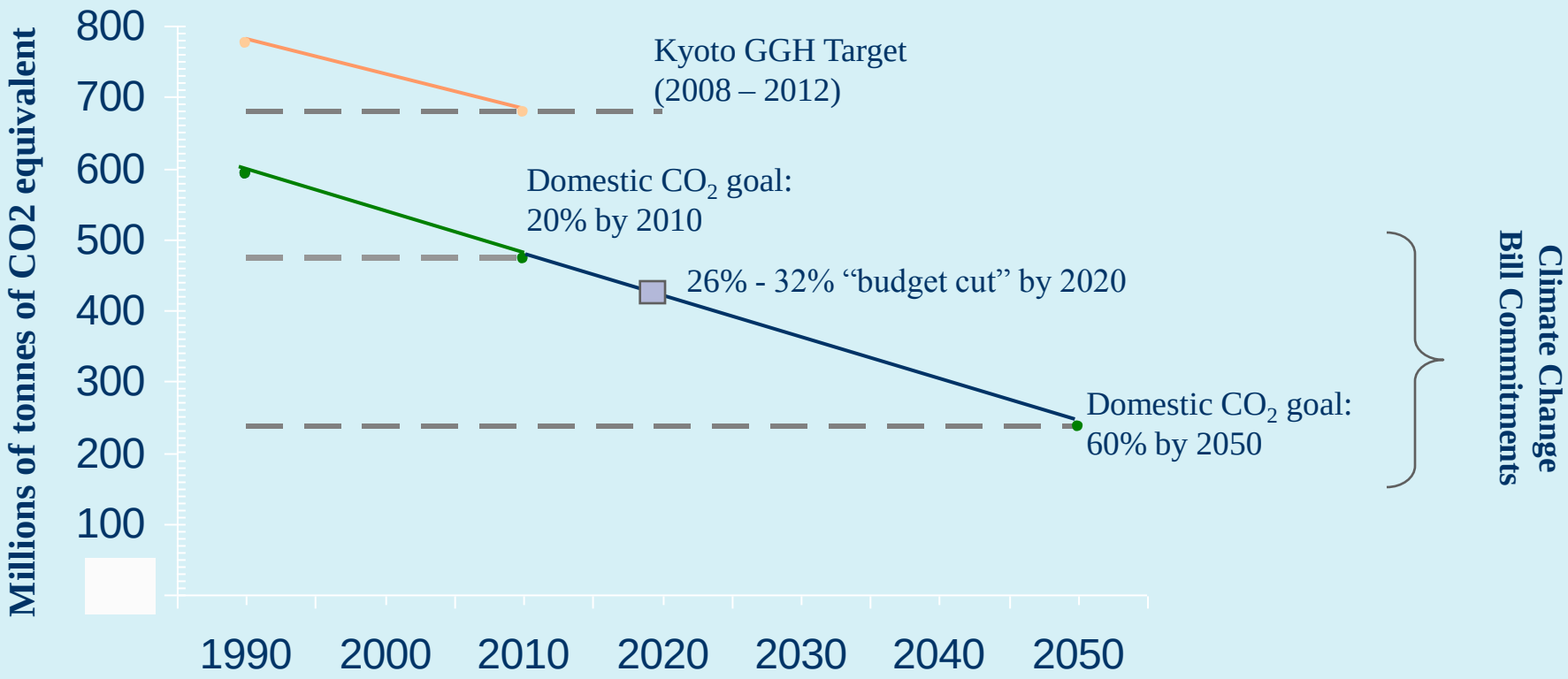
CO_2 emissions per capita

Tonnes of Carbon



Source: Carbon Trust "The Climate Change Challenge", March 2005

UK emissions targets



The necessary improvements in energy productivity

- **Energy productivity = GDP/energy; energy intensity = energy/GDP**

- **Carbon productivity = GDP/carbon; carbon intensity = carbon/GDP**
- **Carbon intensity of energy = carbon/energy**

- **Carbon emissions = Population * GDP/capita * energy/GDP * carbon/energy**
- **Carbon emissions = Population * GDP/capita * carbon/GDP**

- **To achieve 450ppmv atmospheric concentration of CO_2, assuming ongoing economic and population growth (3.1% p.a. real), need to increase carbon productivity by a factor of 10-15 by 2050, or approx. 6% p.a.**

- **Compare current increase in carbon productivity of 0% p.a. over 2000-2006, i.e. global carbon emissions rose at 3.1% p.a.; also**
- **Compare 10-fold improvement in labour productivity in US over 1830-1955, must achieve the same factor increase in carbon in 42 years**

An unprecedented policy challenge

The Stern Review Policy Prescription

- **Carbon pricing: carbon taxes; emission trading**
- **Technology policy: low-carbon energy sources; high-efficiency end-use appliances/buildings; incentivisation of a HUGE investment programme**
- **Remove other barriers and promote behaviour change: take-up of new technologies and high-efficiency end-use options; low-energy (carbon) behaviours (i.e. Less driving/flying/meat-eating/lower building temperatures in winter, higher in summer)**
- **To what extent does behaviour change need to be driven by price (e.g. The results of the fuel price increases over the past two years)?**

Key elements of a global deal (Stern)

- Emissions targets
- Involvement of developing countries in mitigation and trading
- International emissions trading – cap and trading (generates financial flows to developing countries)
- Financing emissions reductions from deforestation
- Technology (existing, near-commercial, breakthrough)
- Adaptation
- Implementation and institutions

Categorisation of environmental policies

- *Market/incentive-based (also called economic) instruments*: include emissions trading, environmental taxes and charges, deposit-refund systems, subsidies (including the removal of perverse subsidies), green purchasing, and liability and compensation.

- *Regulation instruments*, which seek to define legal standards in relation to technologies, environmental performance, pressures or outcomes. Can also include imposition of obligations, e.g. renewable and energy efficiency obligations in the UK.

- *Voluntary/self-regulation (also called negotiated) agreements* between governments and producing organisations. Economic actors may enter into these in order to forestall the introduction of market-based instruments or regulation.

- *Information/education-based instruments* e.g. Eco-labels, 'smart' meters, may be mandatory or voluntary.

Policies for carbon decoupling (1)

- Huge policy innovation over the last ten years; we know what to do
- Limited results from these policies; we don’t apply the policies hard enough
- Many policies need local implementation/enforcement

- Economic instruments: importance of resource and emission prices, driver of efficient use, emission and waste reduction
  - Energy taxes: climate change levy (carbon reduced by 3.5 mtc by 2010), fuel taxes (EU emissions half what they would have been at US prices)
  - Emissions trading: EU ETS; Carbon Reduction Commitment

Policies for carbon decoupling (2)

- Regulation
  - Renewables Obligation
  - Energy Efficiency Commitment (Carbon Emissions Reduction Target)
  - Integrated Pollution Prevention and Control (control of non-carbon emissions may *increase* carbon emissions)
- Voluntary agreements
  - Climate change agreements
  - EU fuel efficiency agreements (targets will not be met; targets will be mandatory in future, i.e. Regulation)
- Information/education
  - Energy efficiency labels for appliances (e.g. A-rated fridge freezers 0-80% market share in 6 years)

Combinations of policy instruments

- Market transformation
  - Result of the combination of a number of policy measures affecting different actors, including: EU energy labelling; marketing campaigns (e.g. Energy Efficiency Recommended branding and advertising) by the Government and its agencies (e.g. EST); consumer advice from Energy Efficiency Advice Centres; media coverage on climate change; retail staff training and point of sale material from the EST; EU Minimum Performance Standards; EEC funding for incentives for consumers to purchase the energy-efficient models.
- EU Integrated Product Policy
  - SCP; state aid; voluntary agreements; standardisation; environmental management systems; eco-design; labelling and product declarations; greening public procurement; encouragement of green technology; and legislation in areas including waste and chemicals.
- SCP (see next slide)

UK SCP Strategy

Products	Strengthening domestic and international measures to improve the environmental performance of products and services, including improved product design
Production	Improve resource efficiency and reduce waste and harmful emissions across business sectors
Consumption	Influence consumption patterns, including proposals for new advice for consumers
Procurement	Sustainable procurement in the public sector, to make the UK a leader within the EU by 2009
Innovation	Support for innovation to bring through new products, materials and services
Sustainable business	Increase transparency, corporate responsibility and skill in business and other organisations
Waste	Increased emphasis on reducing waste at source and making use of it as a resource

Policies for deploying renewables (IEA, 2008)

- For UK biggest opportunities in on- and offshore wind, biomass for electricity and heat, biogas, marine (tide, tidal currents, wave), solar thermal and geothermal heat): UK potential is nearly 400TWh by 2020, or 23% of year 2000 Final Energy Demand
- Most of these opportunities will need to be realised for the UK to meet its 15% EU renewables target. Policies:

- Removal of non-economic barriers (administration, planning, grid access, skills, social acceptance
- Minimum level of remuneration (USD 0.07-08/kWh for onshore wind, biomass electricity)
- Predictable, transparent policy framework to support investment
- Technology-specific incentives based on technological maturity
- Transition incentives to foster innovation and get across the ‘valley of death’
- System considerations (e.g. of intermittency)

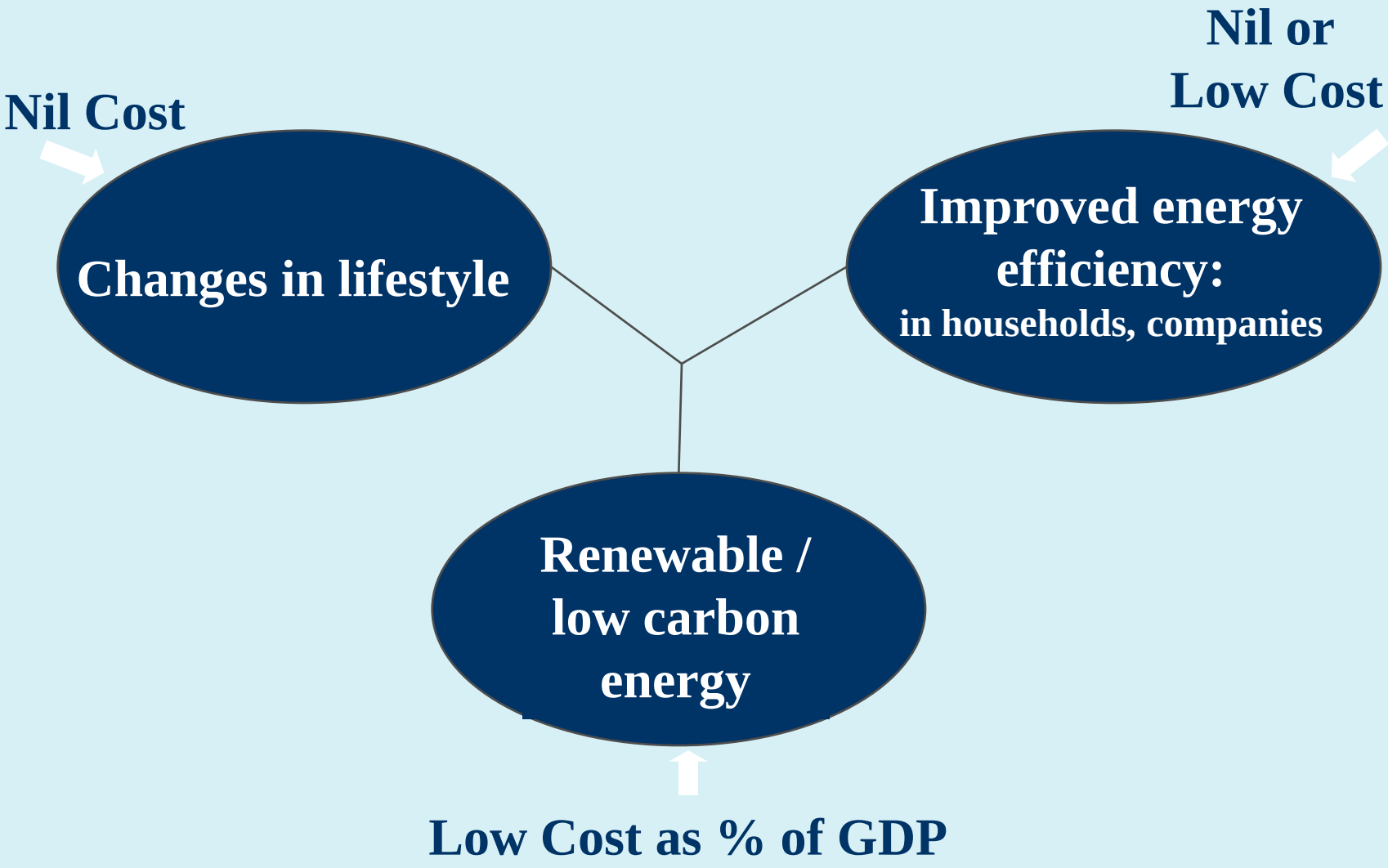
Policy effectiveness

- Relative, but not absolute, carbon decoupling (carbon emissions have risen in UK since 1997, despite Climate Change Programme policies)
- (Much) More stringent application of policy instruments (especially price-based to avoid rebound effects)
- Political feasibility
- Implications for economic growth

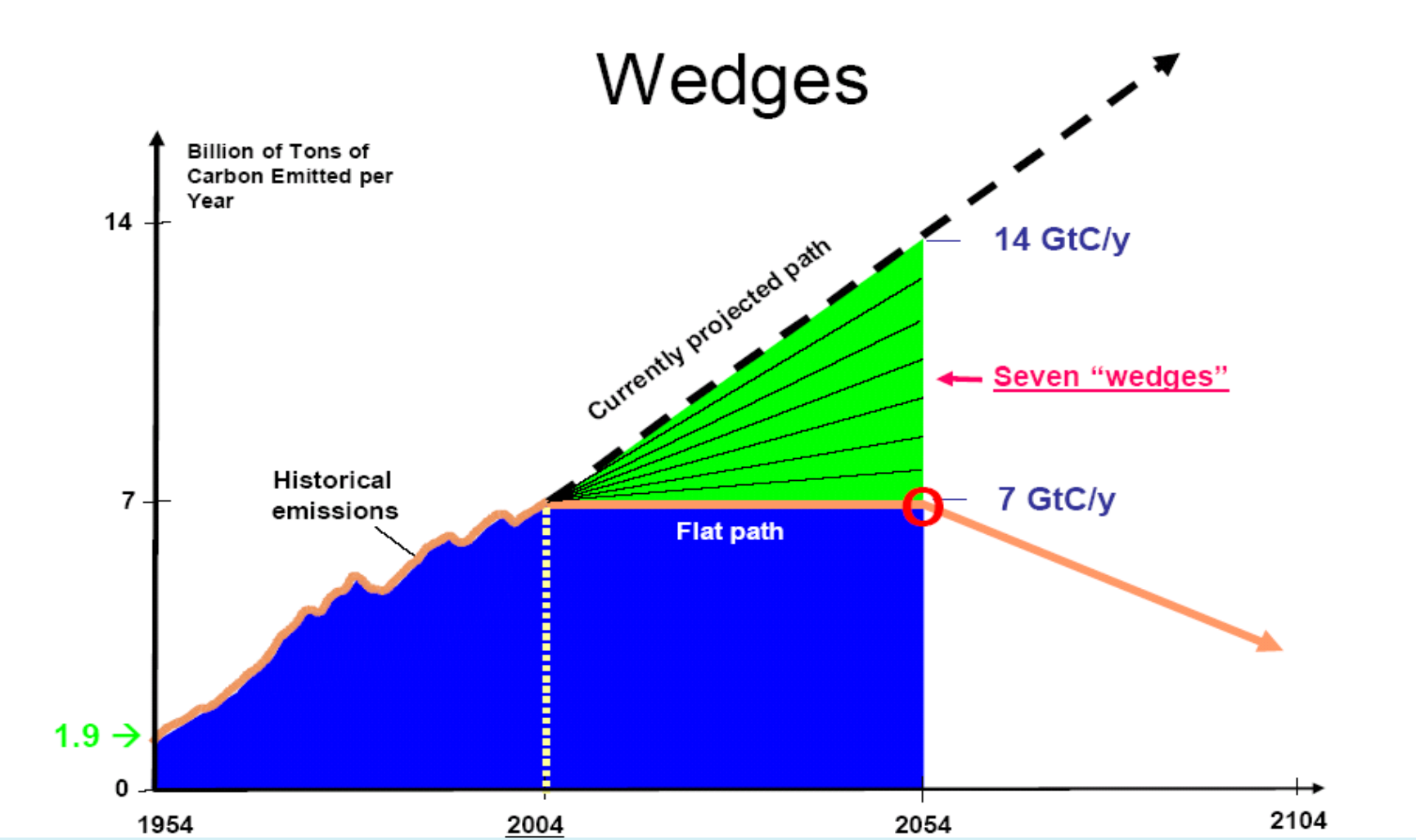
The macro-economic costs of climate change mitigation

- Optimists:
  - ‘Costs’ are really investments, can contribute to GDP growth
  - Considerable opportunity for zero-cost mitigation
  - A number of low-carbon technologies are (nearly) available at low incremental cost over the huge investments in the energy system that need to be made anyway
  - ‘Learning curve’ experience suggests that the costs of new technologies will fall dramatically
  - Climate change policies can spur innovation, new industries, exports and growth
- Pessimists:
  - Alternative energy sources are more expensive, are bound to constrain growth
  - Cheap, concentrated energy sources are fundamental to industrial development

The hope for affordable economic cost



Technological potential: the Socolow Wedges



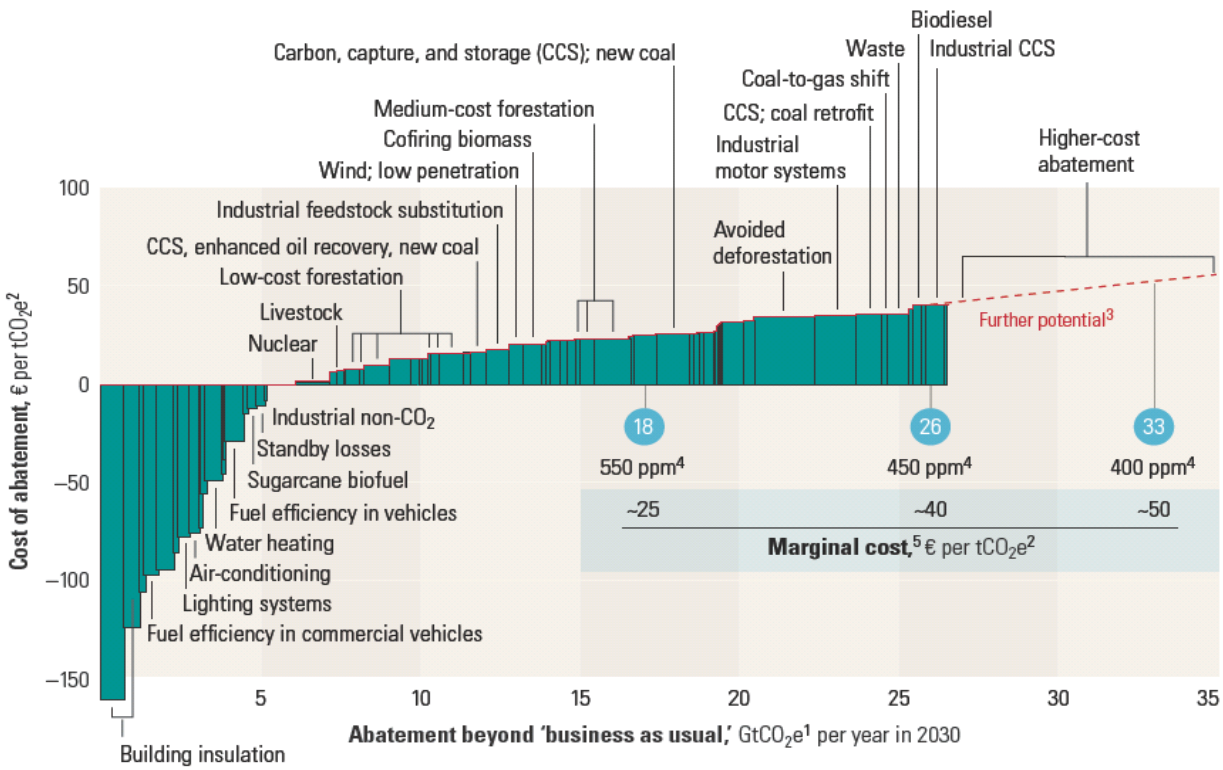
Source: Professor Robert Socolow "Stabilisation Wedges", Met Office Symposium, 3rd February 2005

Potential “wedges”: cuts of 1Gt of carbon per year in 2054

- **Efficient vehicles:** *Increase fuel economy for 2 billion autos from 30 to 60 mpg.*
- **Nuclear:** *Tripling of capacity to 1050 Gwatts.*
- **Gas for coal substitution:** *1400 Gwatts of electricity generation switched from coal to gas.*
- **Carbon capture and storage:** *Introduce CCS at 800 Gwatt coal stations*
- **Wind power:** *50 times as much wind power as at present.*
- **Solar PV:** *700 times 2004 capacity*
- **Hydrogen:** *Additional 4000 Gwatts of wind capacity or additional CCS capacity*
- **Biomass fuel:** *100 times the current Brazilian ethanol production*

Source: Professor Robert Socolow “Stabilisation Wedges”

The (micro)economic cost: global cost curve for greenhouse gas abatement

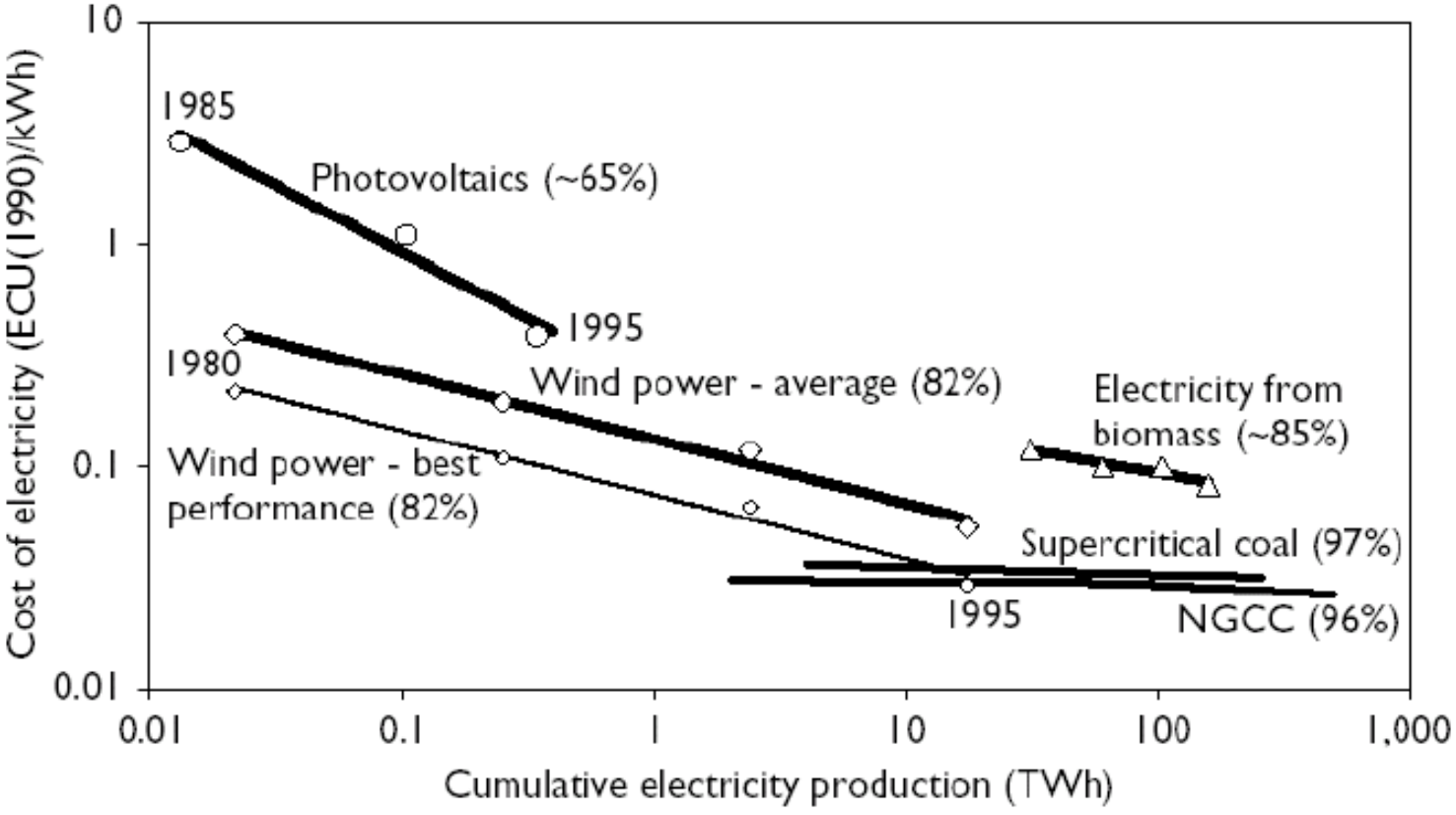


[1]$GtCO_2e$ = gigaton of carbon dioxide equivalent; "business as usual" based on emissions growth driven mainly, by increasing demand for energy and transport around the world, and by tropical deforestation.
[2]tCO_2e = ton of carbon dioxide equivalent.
[3]Measures costing more than €40 a ton were not the focus of this study.
[4]Atmospheric concentration of all greenhouse gases recalculated into CO_2 equivalents; ppm = parts per million.
[5]Marginal cost of avoiding emissions of 1 ton of CO_2 equivalents in each abatement demand scenario.

Copyright © 2007 McKinsey & Company

Source: A cost curve for greenhouse gas reductions, The Mckinsey Quarterly, February 2007

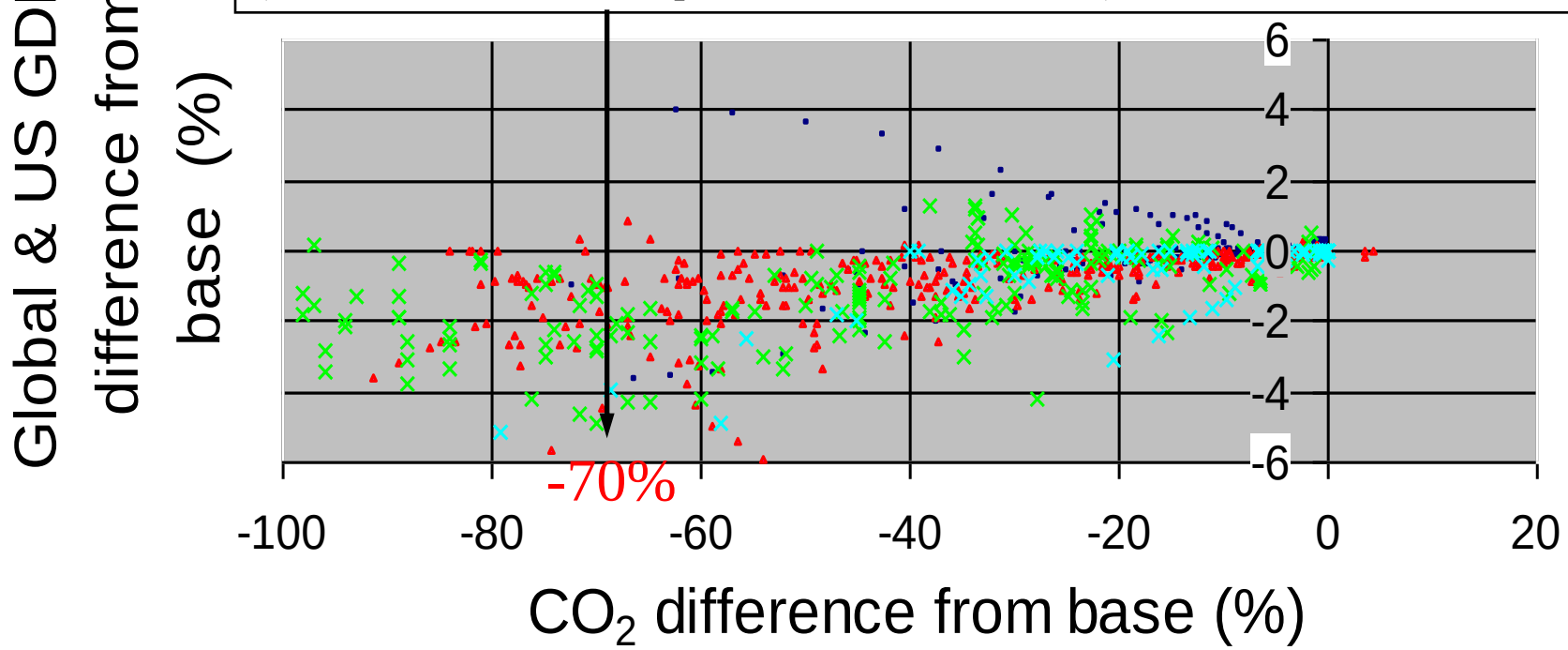
Cost evolution and learning rates for selected technologies



Source: IEA, 2000, Stern Review, Chapter 9

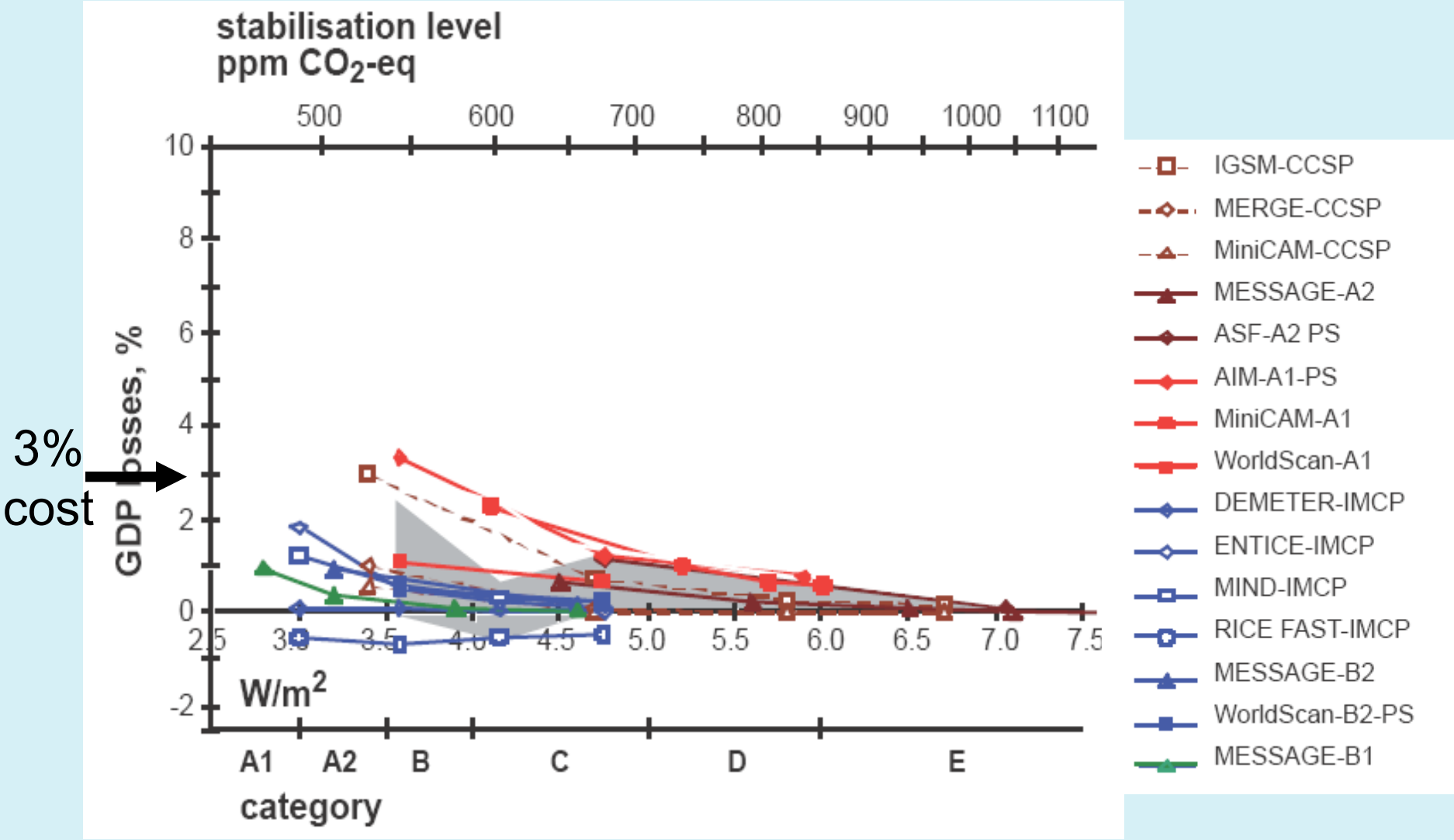
Scatter plot of model cost projections, 2000-2050

Each point refers to one year's observation from a particular model for changes from reference case for CO2 and the associated change in GDP (from four sources, for periods over 2000-2050)



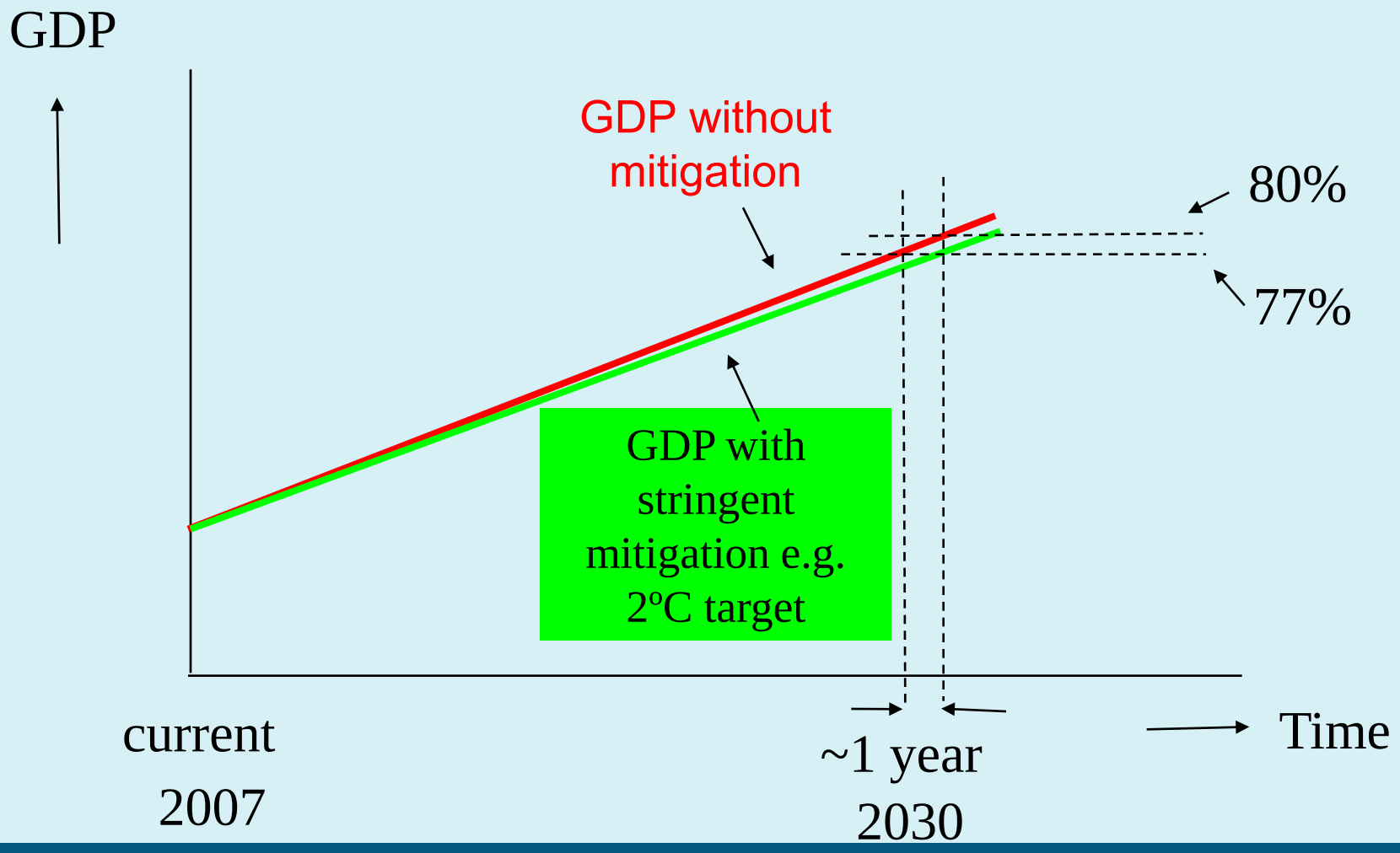
- IMCP with ITC dataset
- post-SRES dataset
- WRI dataset (USA only)
- EMF-21 with multigas

3% maximum global cost by 2030



Source: IPCC AR4, WG III Report 2007, Chapter 3, Figure 3.25 (a)

Illustration of the maximum 3% cost number



Conclusions on costs and growth

- Low impacts on growth assume no special productivity improvements from cheap/plentiful/ concentrated energy (fossil fuels) or technological developments (e.g. fusion) that achieve this in other ways
- Higher impacts on growth might not matter for rich countries (growth/well-being relationship) if we could learn to manage a low/no growth capitalist economy (maintain investment, need to redistribute productivity gains)
- Most unlikely that this could be achieved in one country alone

Further economic implications

- Attaining the 2°C target or anything near it will require huge investments in low-carbon technologies right along the innovation chain (research, development, demonstration, diffusion).
- IEA ETP estimates of *additional* investment needs in energy sector: USD 45 trillion (1.1% global GDP from now until 2050)
  - Buildings and appliances: USD 7.4 trillion; Power sector: USD 3.6 trillion
  - Transport sector: USD 33 trillion; Industry: USD 2.5 trillion
- Government funding of R,D&D must increase dramatically, but demonstration and diffusion can only be driven at scale by markets
- This will require high (now) and rising carbon prices over the next half century, to choke off investment in high-carbon technologies (e.g. runways) and incentivise low-carbon investments
- These high carbon prices will also greatly change lifestyles and consumption patterns
- Provided that the world goes cooperatively in this direction, there are enormous profits to be made from these high carbon prices and changing consumption patterns
- Technological and policy uncertainty mean that the risks are also high