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Global and Sectoral Mitigation Potentials to 2030 and the Carbon Price:

towards decarbonising the global economy

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Keynote address to the Global Conference on Global Warming 2008, July 6-10, Dedeman Hotel, Istanbul

Outline of keynote lecture

1. Establishing the concept of mitigation potentials
2. The carbon price and other economic incentives
3. Enhanced market potential (through policies to reduce barriers)
4. AR4 estimates of economic potential to 2030
5. Key messages from IPCC AR4 on costs, technology and carbon prices

Acknowledgements
This presentation has been developed from that given to the Press Conference, Bangkok, May 4, 2007, by the Co-Chairs of IPCC AR4, WG III. The text and figures in the presentation come from the WG III Summary for Policy Makers, unless otherwise stated. The comments are my own.

Establishing the concept of mitigation potential

- There was a need to have a set of definitions
  - acceptable to engineers and economists across WG III chapters (“bottom-up” and “top-down” approaches)
  - encompassing different economic modelling approaches (neo-classical, institutional)
  - applicable to mitigation in all countries & sectors and from one IPCC report to the next
- IPCC Third Assessment Report definitions were unclear and confusing
- Agreed: market, economic, technical and physical mitigation potentials and associated “carbon prices”

Costs assessment:

costs can and are measured at different “levels”

Project: assessed by cost–benefit analysis, cost-effectiveness analysis, and lifecycle analysis.

Technological: specific GHG mitigation technologies covering technical and cost characteristics, especially evidence on learning curves

Sectoral: a partial context, in which other sectors and the macroeconomic variables are assumed to be given e.g. technical simulation models for the energy, agriculture, forestry, and the transportation sector.

Macroeconomic: impacts of policies across all sectors and markets with policies including taxes, specific investment programmes, and technology and innovation policies, assessed by CGE, Keynesian econometric models, and Integrated Assessment Models (IAMs)

Private and social costs

- Cost estimates based on applying taxes in a macroeconomic model are not comparable with abatement costs calculated at other assessment levels
- Costs can be measured from a private as well as from a social perspective, since activities of social groups may cause “externalities”
  - private costs are based on market prices
  - a social costs include the value of the externalities
  - social costs can come from a lack of property rights, lack of full information and transaction costs related to policy implementation
  - social costs allow for effects of regulation, limited competition, environmental damages and other externality costs

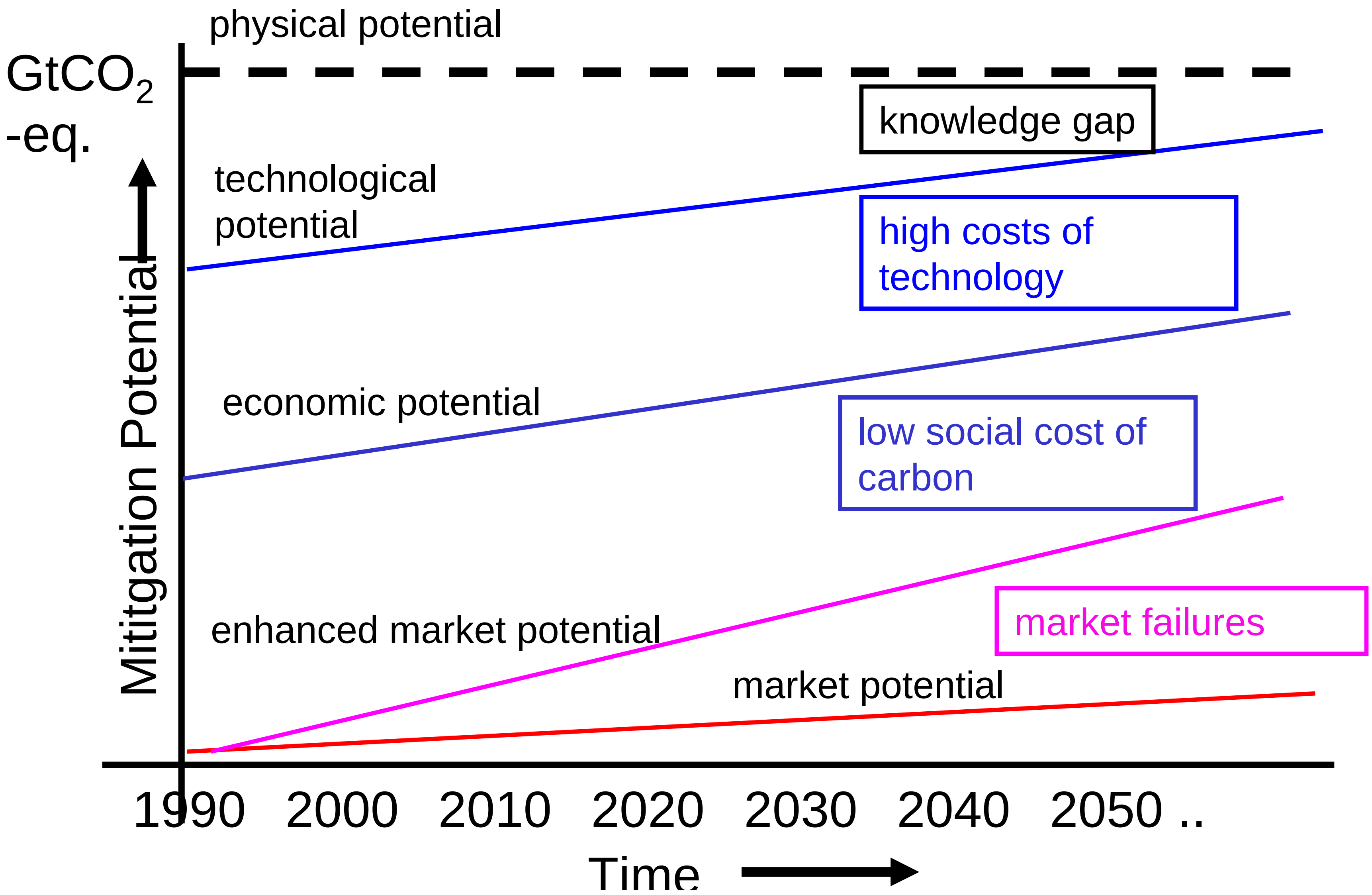
Definitions of mitigation potentials

Mitigation potential: the scale of GHG reductions that could be made, relative to emission baselines, for a given level of carbon price (expressed in cost per unit of carbon dioxide equivalent emissions avoided or reduced).

Market potential: the mitigation potential based on private costs and discount rates, which might be expected to occur under forecast market conditions, including policies and measures in place, but with barriers limiting actual uptake.

Economic potential: the mitigation potential based on social costs and social discount rates. Direct benefits of for instance energy savings are normally included, while most external costs are generally not.

Mitigation potentials and barriers



Note : Box □ indicates barrier.

Source: Adapted from Figure 7.1, IPCC Third Assessment Report, Synthesis Report, 2001.

Comments on the definitions (1)

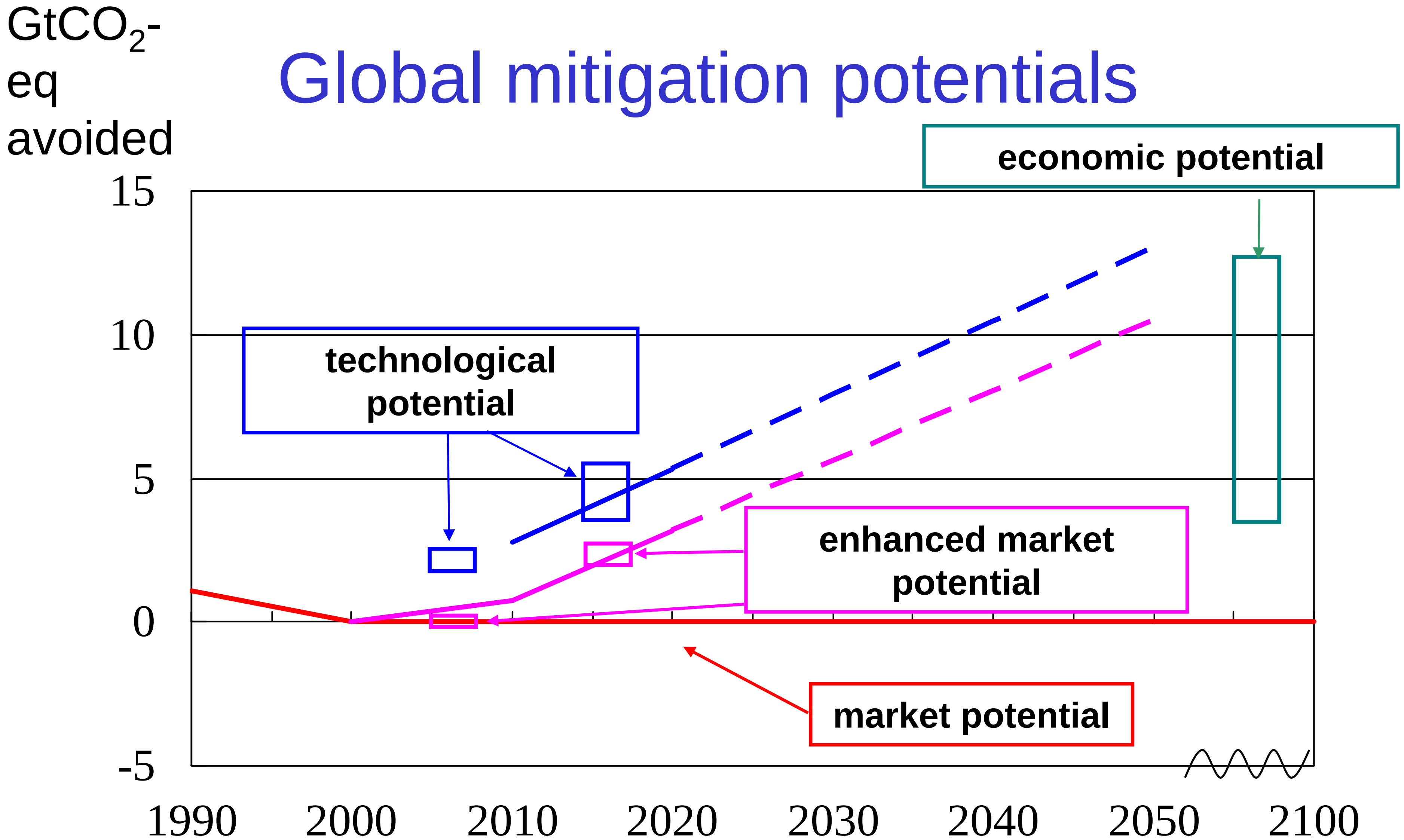
- The mitigation potentials are quantities, measured in Giga tonnes CO_2-equivalent a year ($GtCO_2$-eq/yr)
- They are world-wide, or for countries or sectors, and usually in the future
- They are defined for given carbon prices expressed as $(2000 prices) per tonne CO_2-equivalent (US$/$tCO_2$-eq)
- Four key prices have been chosen to measure economic potentials: 0, 20, 50 and 100 US$/$tCO_2$-eq
- The market potential at a zero carbon price is basically “business as usual” in the projections
- If a country introduces a carbon tax, the effects become embodied into the market mitigation potential

Comments on the definitions (2)

- Most of the potentials in the literature are economic potentials
- “Enhanced” market potential is realised by lowering barriers by special policies, e.g. carbon labelling
- Any positive carbon price is a “social cost”, i.e a price created by policies and measures e.g. the EU’s emissions trading scheme
- Climate stabilization studies provide estimates of required reductions in GHG emissions, globally by year, i.e. the required economic potentials
- The economic models provide estimates of the carbon prices yielding such economic potentials: hence the carbon price ranges in the tables

Memo: “social costs of carbon” include monetary valuation of climate damages in a cost-benefit analysis, but governments have chosen climate targets and a cost-effectiveness approach

Global mitigation potentials



Notes: (1) - - - means 'implied'.

□ means the range of estimated potentials, which are estimated from the IPCC TAR, 2001.

(2) The potentials depend on the carbon price and are normalised against different SRES baseline market potentials.

The importance of a “price of carbon”

- Economic mitigation potentials are defined only for specific carbon prices
- Policies that provide a real or implicit price of carbon can create incentives for producers and consumers to significantly invest in low-GHG products, technologies and processes
- Such policies could include economic instruments, government funding and regulation
- Examples
  - **economic instruments**: cap-and-trade schemes for GHGs, carbon taxes, incentives for low-GHG technologies
  - **government funding**: competitions for CCS subsidies
  - **regulations**: CO_2-emission standards for road vehicles or coal-fired power stations

Two approaches to estimating economic mitigation potential

Techno-economic analysis ("bottom-up")

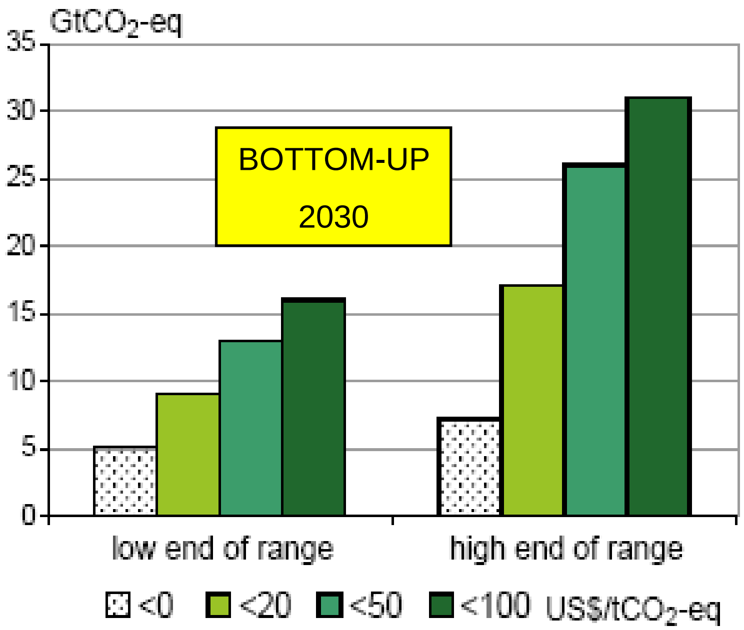
- emphasizes specific technologies and regulations
- has a stronger relation with business practices
- Relates to sectoral policies

Integrated Assessment analysis ("top-down")

- integrates the energy system and the economy
- includes economic and natural system feedbacks
- allows modelling of economy-wide polices and measures, e.g. carbon tax

Economic potential is substantial for the mitigation of global GHG emissions over the coming decades

- Estimates are from both bottom-up and top-down studies



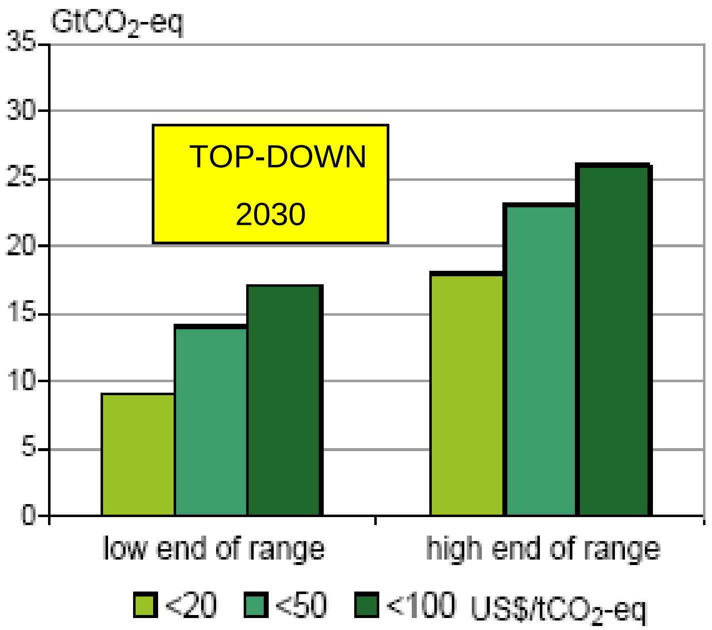


Figure SPM 5A:*Global economic potential in 2030 estimated. Cost categories in US$/tCO2eq.*	***Figure SPM 5B:*** *Global economic potential in 2030 Cost categories in US$/tCO2eq..*

Note: estimates do not include non-technical options such as lifestyle changes

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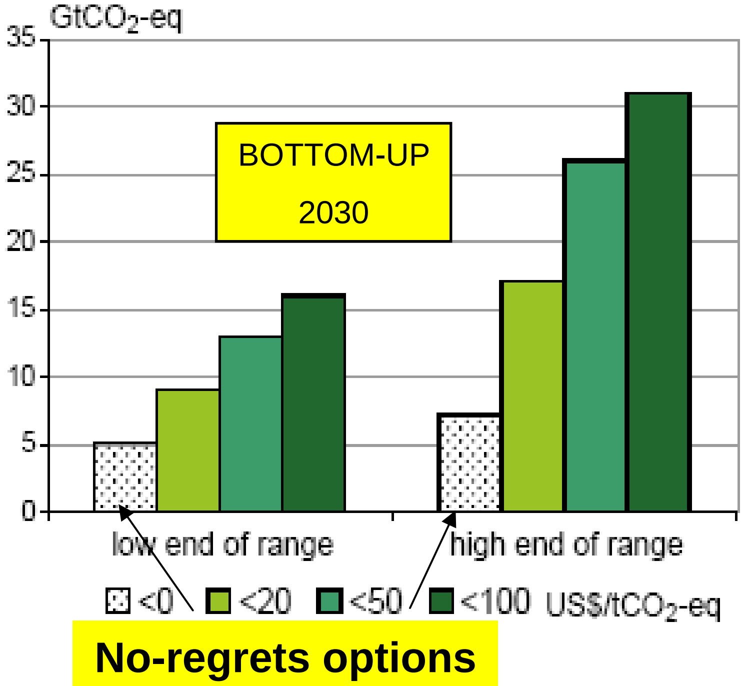

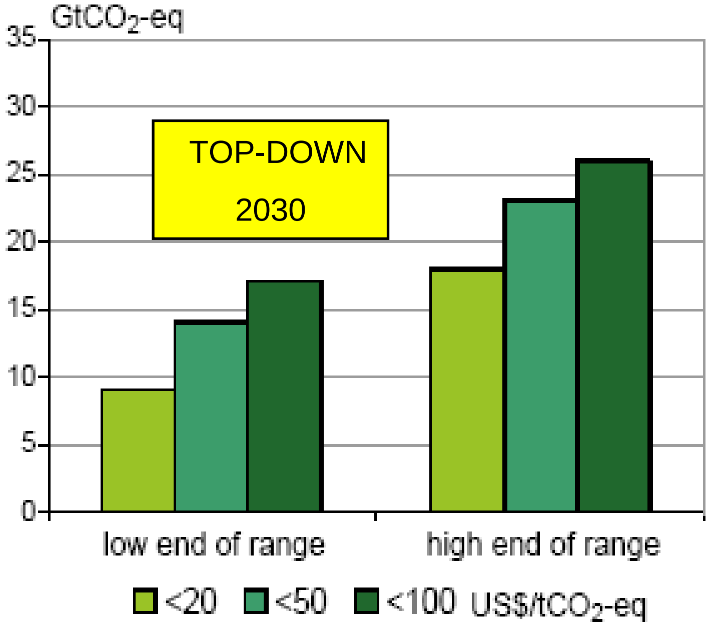

Figure SPM 5A: *Global economic potential in 2030 estimated. Cost categories in US$/tCO2eq.*	***Figure SPM 5B:*** *Global economic potential in 2030 Cost categories in US$/tCO2eq..*

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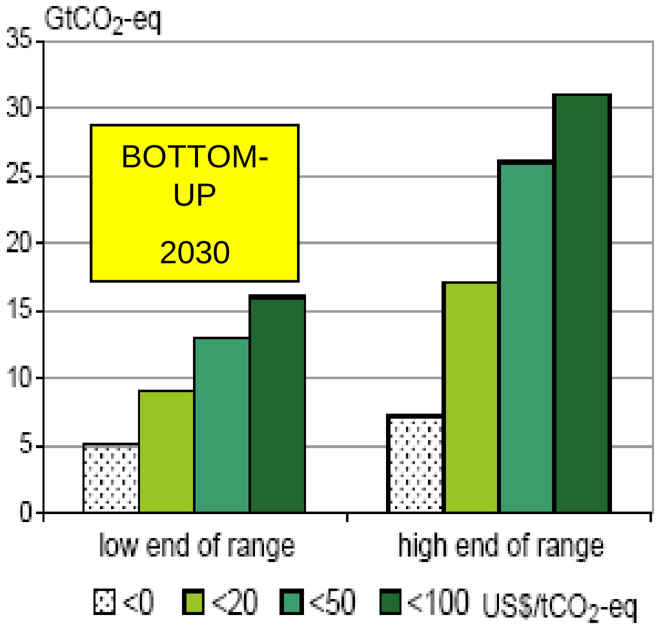

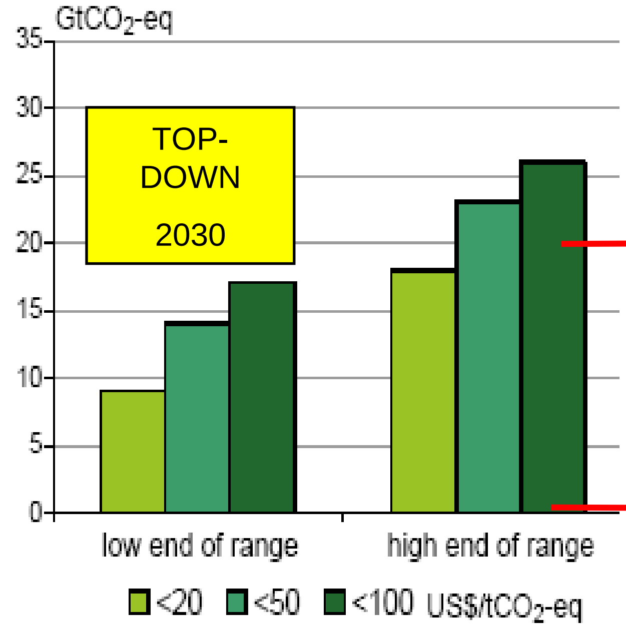

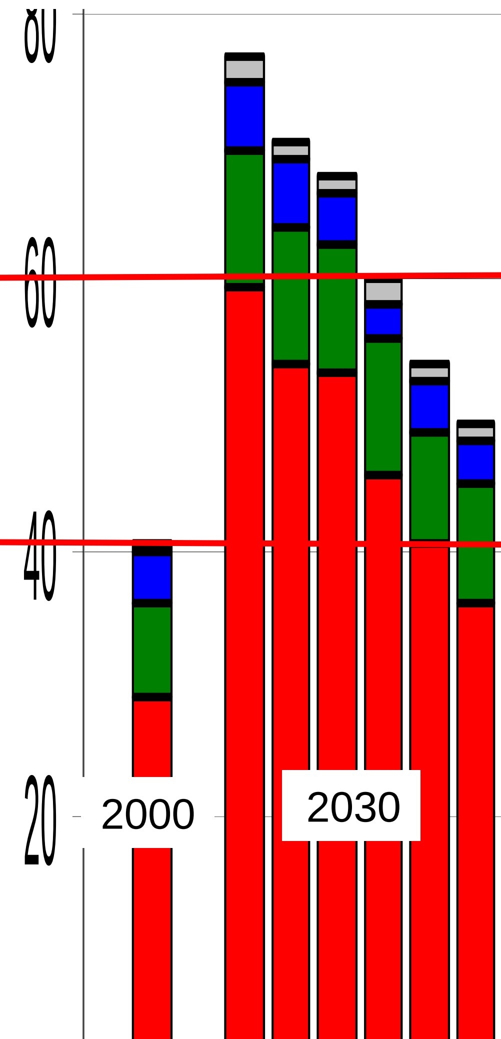

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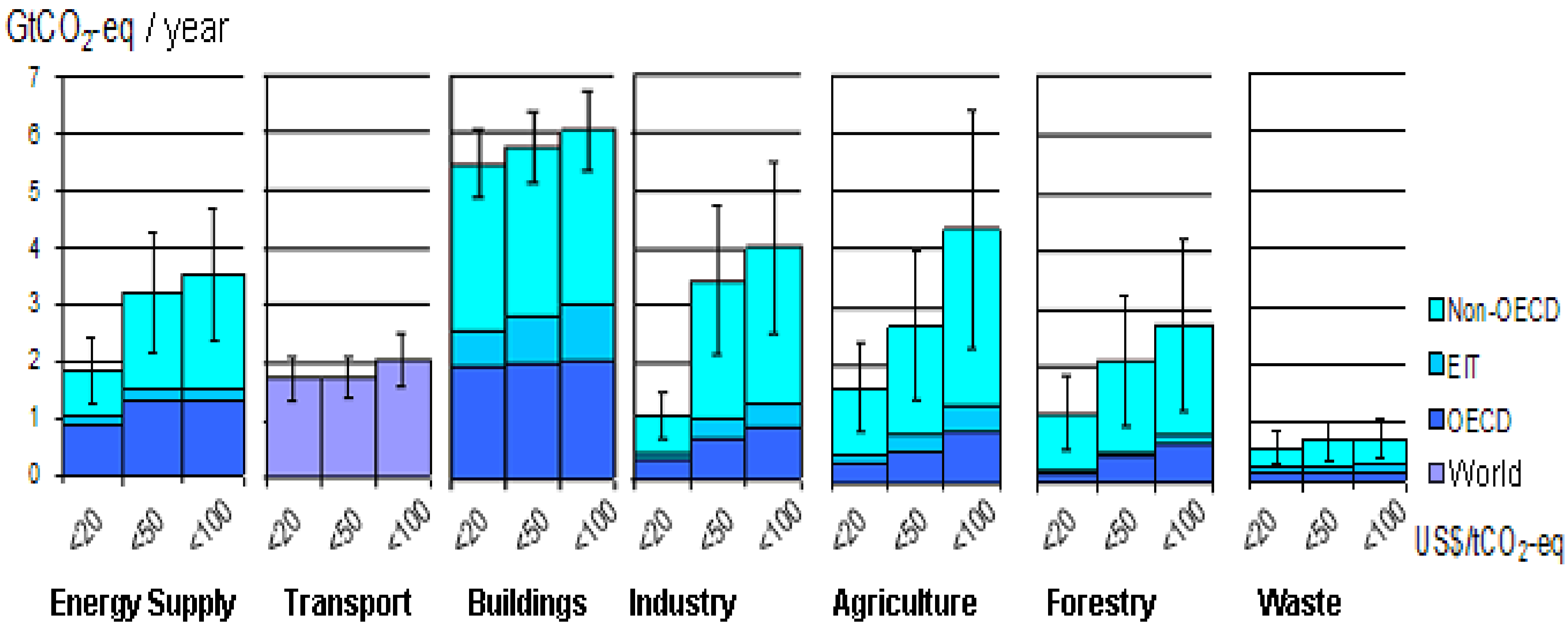
All sectors and regions have the potential to contribute



Note: estimates do not include non-technical options, such as lifestyle changes.

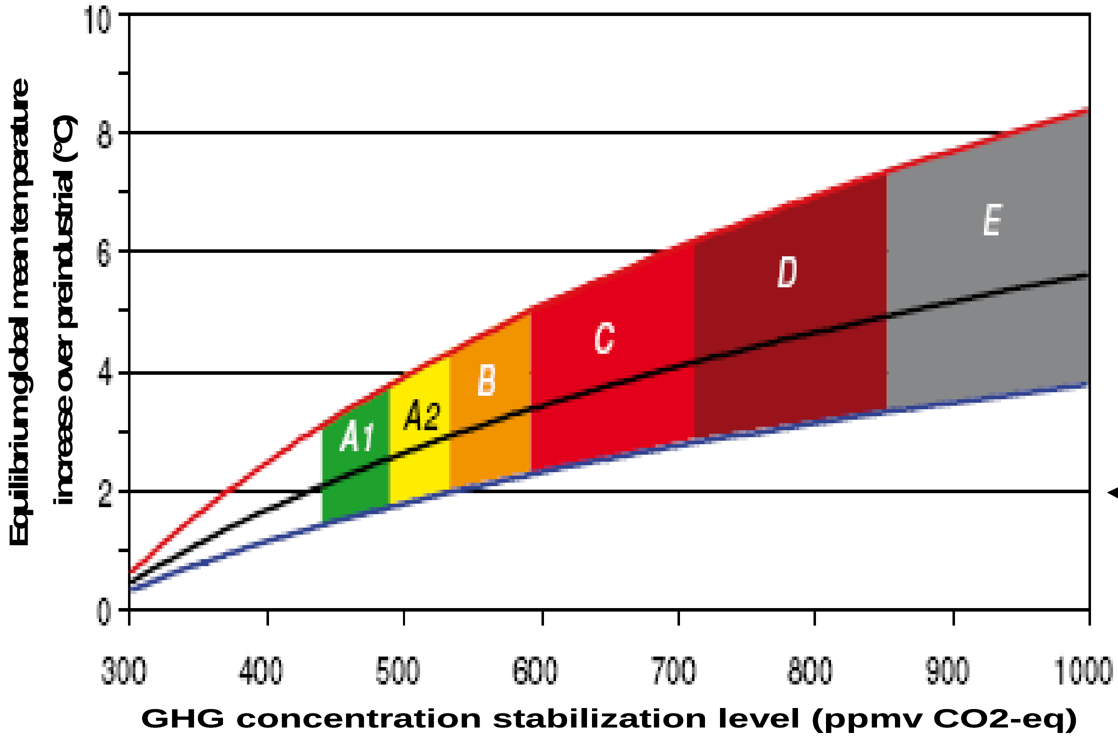
Informing the 2030 mitigation target: long-term climate stabilisation

- The lower the stabilization level, the more quickly emissions would need to peak and to decline thereafter
- Mitigation efforts over the next two to three decades will have a large impact on opportunities to achieve lower stabilization levels

Stabilization level (ppm CO_2-eq)	Global Mean temp. increase at equilibrium (ºC)	Year CO_2 needs to peak	% reduction in 2050 compared to 2000
445 – 490	2.0 – 2.4	2000 - 2015	-85 to -50
490 – 535	2.4 – 2.8	2000 - 2020	-60 to -30
535 – 590	2.8 – 3.2	2010 - 2030	-30 to +5
590 – 710	3.2 – 4.0	2020 - 2060	+10 to +60
710 – 855	4.0 – 4.9	2050 - 2080	+25 to +85
855 – 1130	4.9 – 6.1	2060 - 2090	+90 to +140

Stabilisation levels and equilibrium global mean temperatures

Mean temperatures

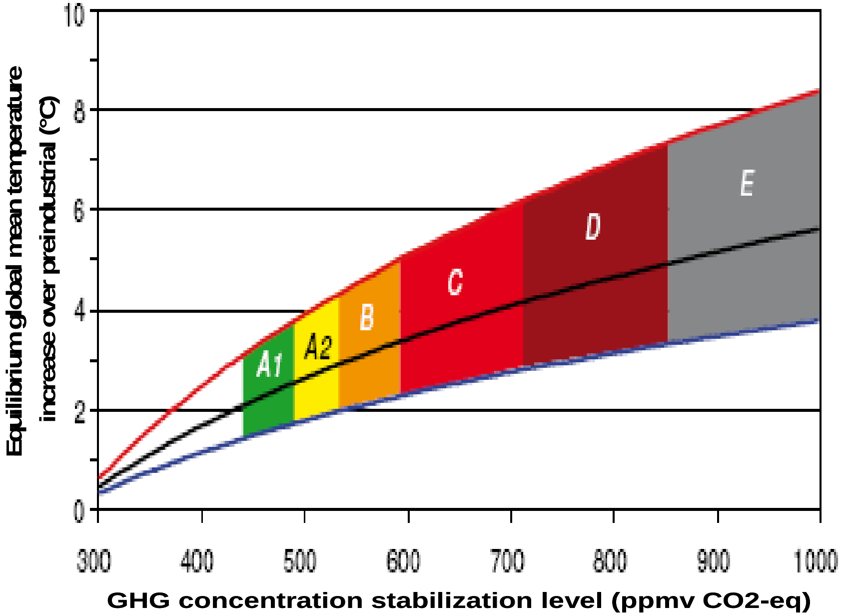


2ºC EU target

***Figure SPM 8**: Stabilization scenario categories as reported in Figure SPM.7 (coloured bands) and their relationship to equilibrium global mean temperature change above pre-industrial, using (i) "best estimate" climate sensitivity of 3℃ (black line in middle of shaded area), (ii) upper bound of likely range of climate sensitivity of 4.5℃ (red line at top of shaded area) (iii) lower bound of likely range of climate sensitivity of 2℃ (blue line at bottom of shaded area). Coloured shading shows the concentration bands for stabilization of greenhouse gases in the atmosphere corresponding to the stabilization scenario categories. The data are drawn from AR4 WGI, Chapter 10.8.*

The key question: can “dangerous anthropogenic climate change” be avoided?

EU interpretation:
global mean temperature increase at less than 2ºC above pre-industrial level

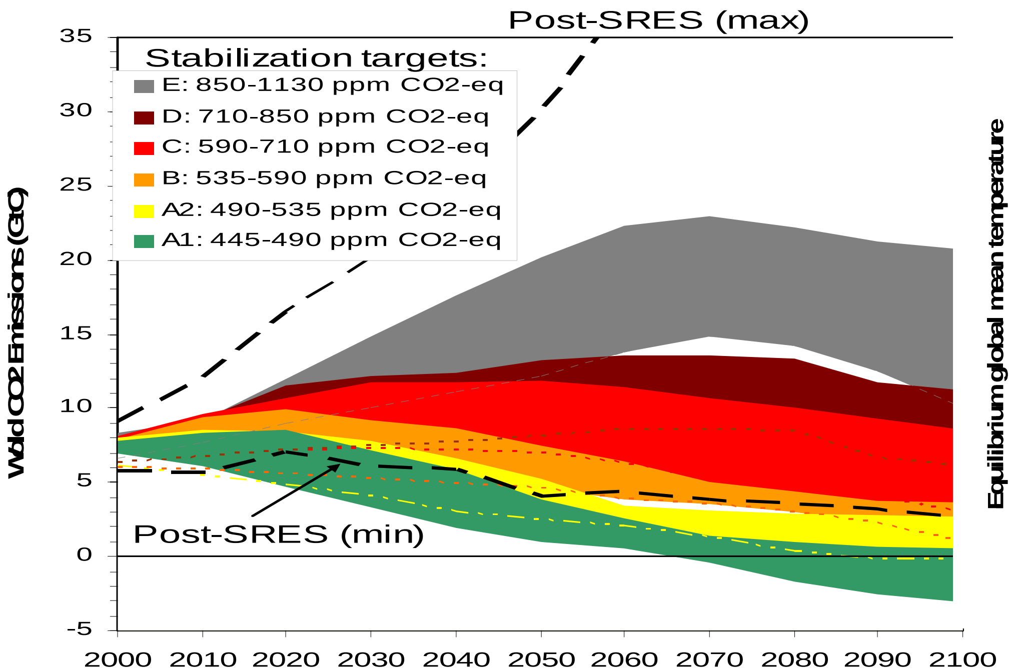


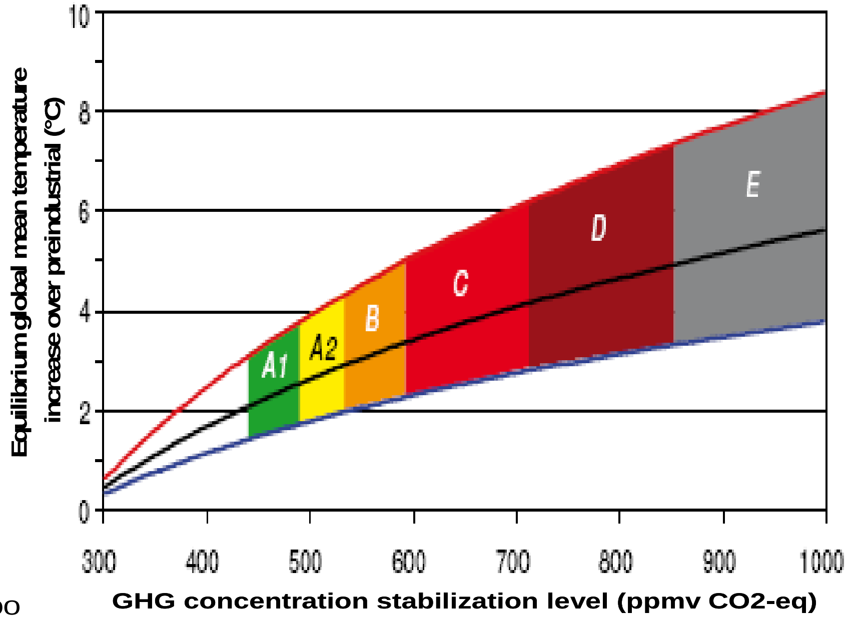
Source: IPCC WG3 SPM 2007

The lower the stabilisation level, the earlier global emissions have to go down

Range comes from diferent models

Range comes from alternative estimates of climate sensitivity





Multigas and CO_2 only studies combined

Note lack of studies below 450ppmv-CO_2-eq

Source: IPCC WG3 SPM 2007

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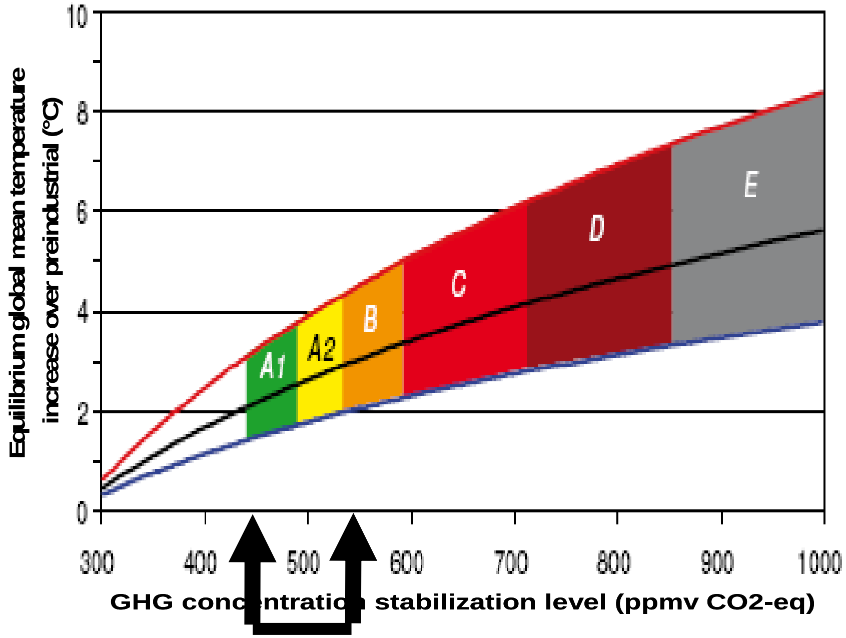


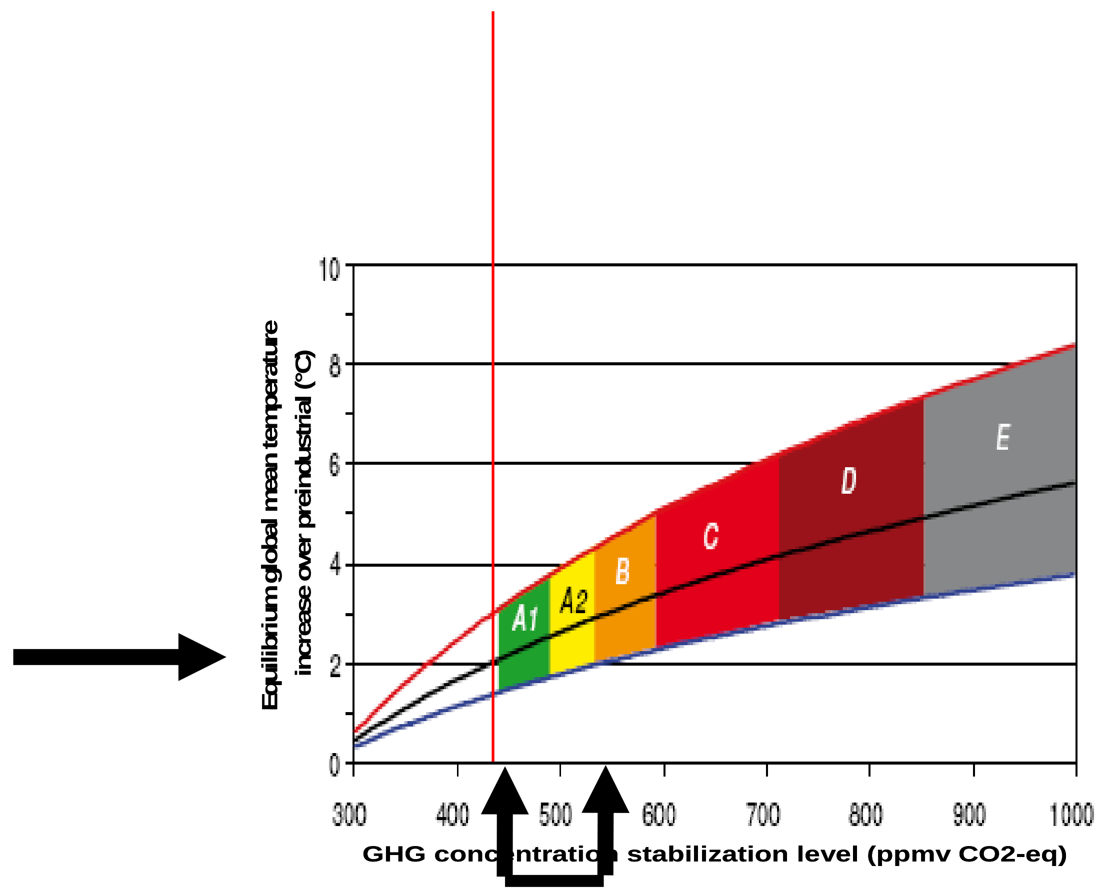
Stern 450-550

Source: IPCC WG3 SPM 2007

The key question: can "dangerous anthropogenic climate change" be avoided?

where we are now

EU interpretation: global mean temperature increase at less than 2ºC above pre-industrial level

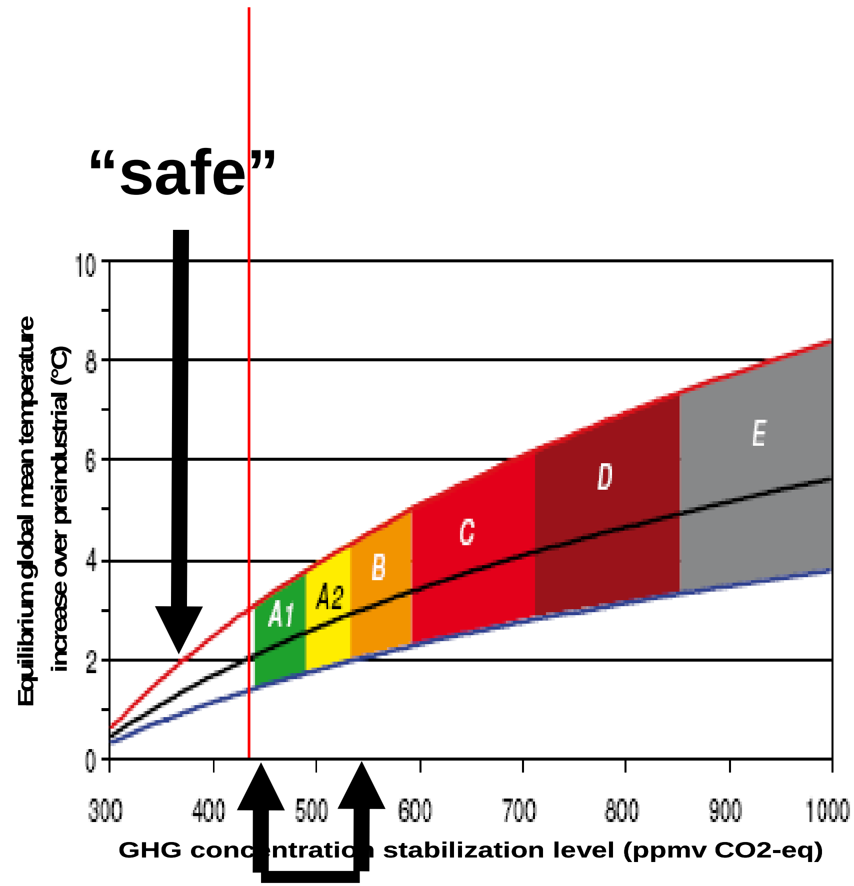


Stern 450-550

Source: IPCC WG3 SPM 2007

The key question: can “dangerous anthropogenic climate change” be avoided?

where we are now!



Stern 450-550

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Source: IPCC WG3 SPM 2007

The key question: can “dangerous anthropogenic climate change” be avoided?

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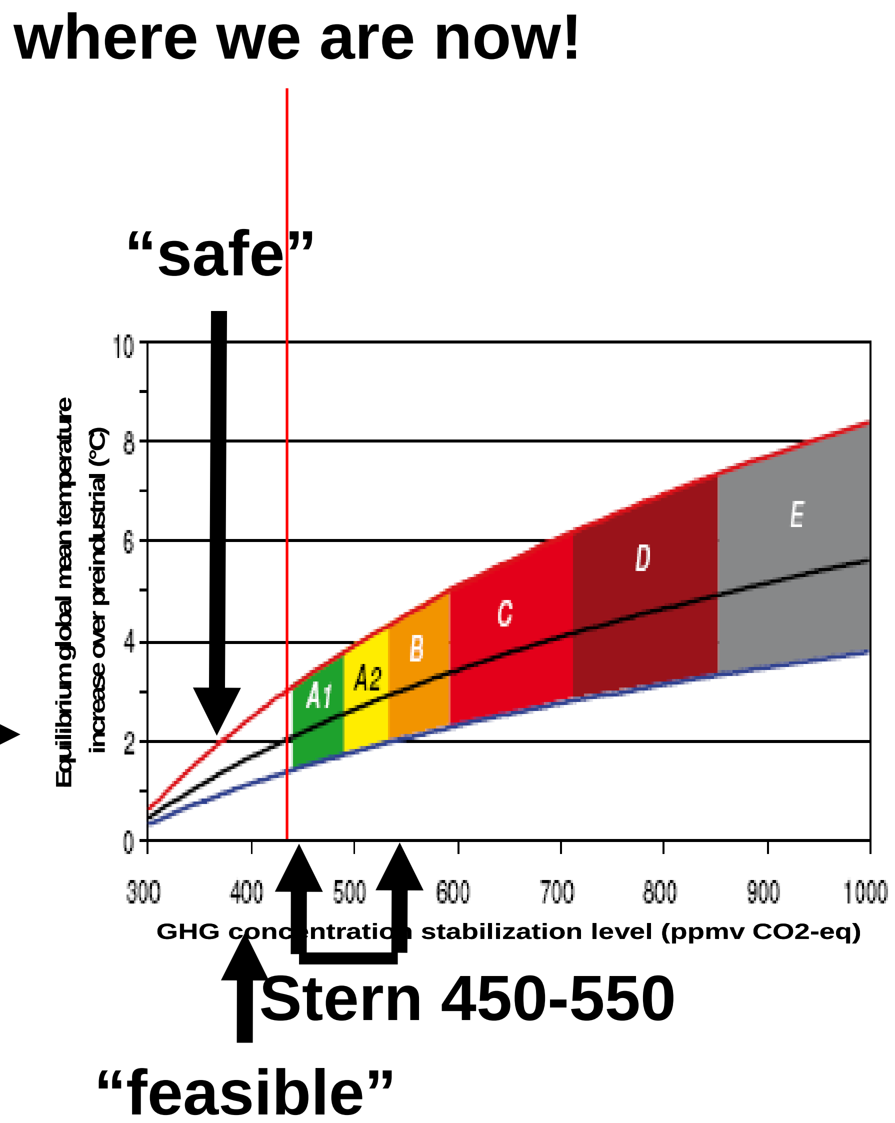


Source: IPCC WG3 SPM 2007

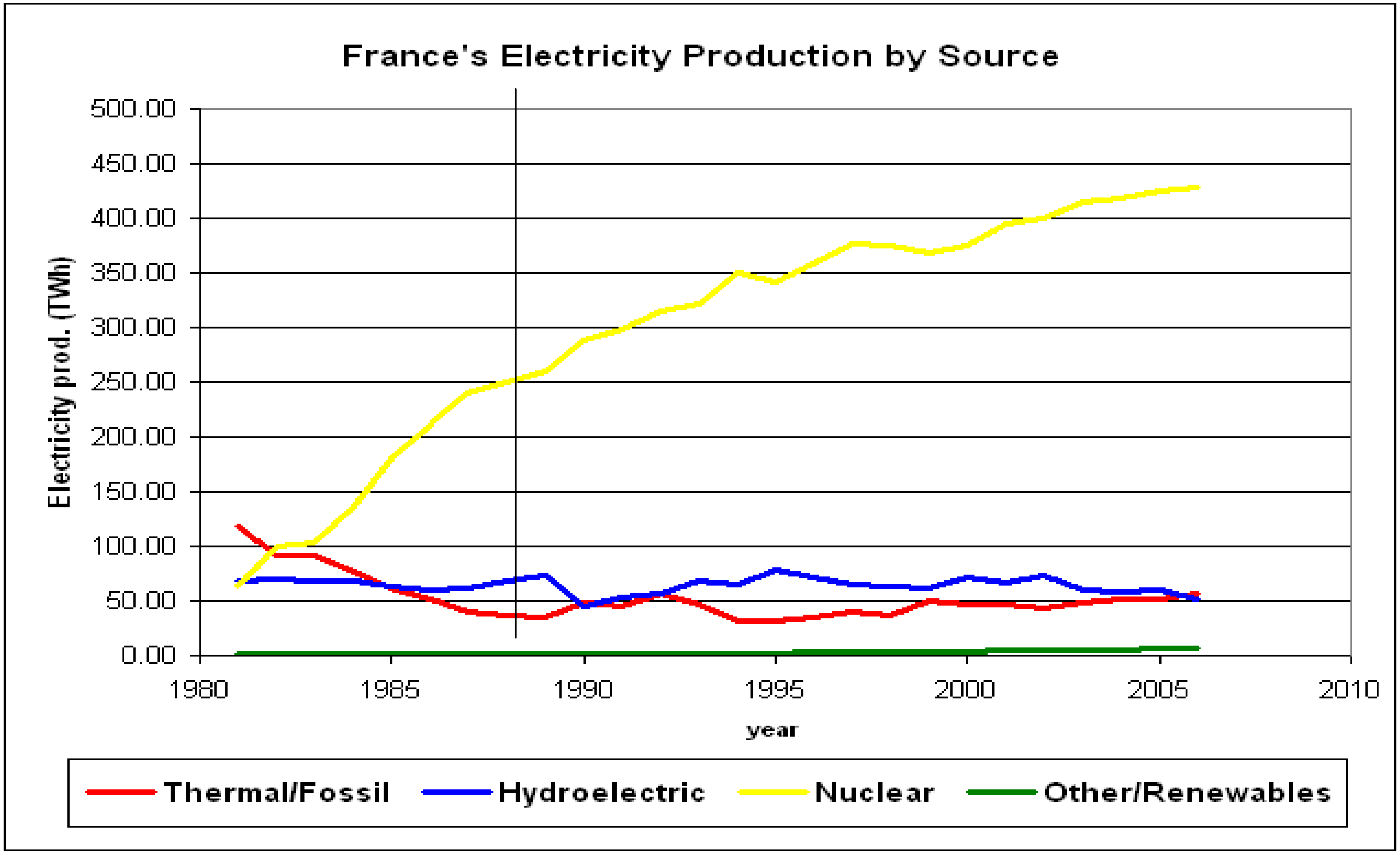
Implications for avoiding dangerous climate change

- To have a good probability of achieving <2ºC rise
  - CO_2-eq concentrations have to be <450ppm CO_2 eq (c/f c430 now)
  - global GHG emissions have to fall by >70% below baseline by 2050
  - technologies have to be developed to capture CO_2
- Fossil-fuel GHG stocks cause damages and industrialized countries are responsible for most of current stocks
  - hence reduction in OECD of c90% below BAU/1990 by 2050
- Risks are asymmetric
  - so precaution suggests a zero-carbon economy as soon as possible (without excessive costs)
- Eventually all countries & sectors have to decarbonize
  - not “How much?” but “When?” for each business and government
  - With a policy portfolio that is effective, efficient, equitable and flexible

Examples of accelerated decarbonisation

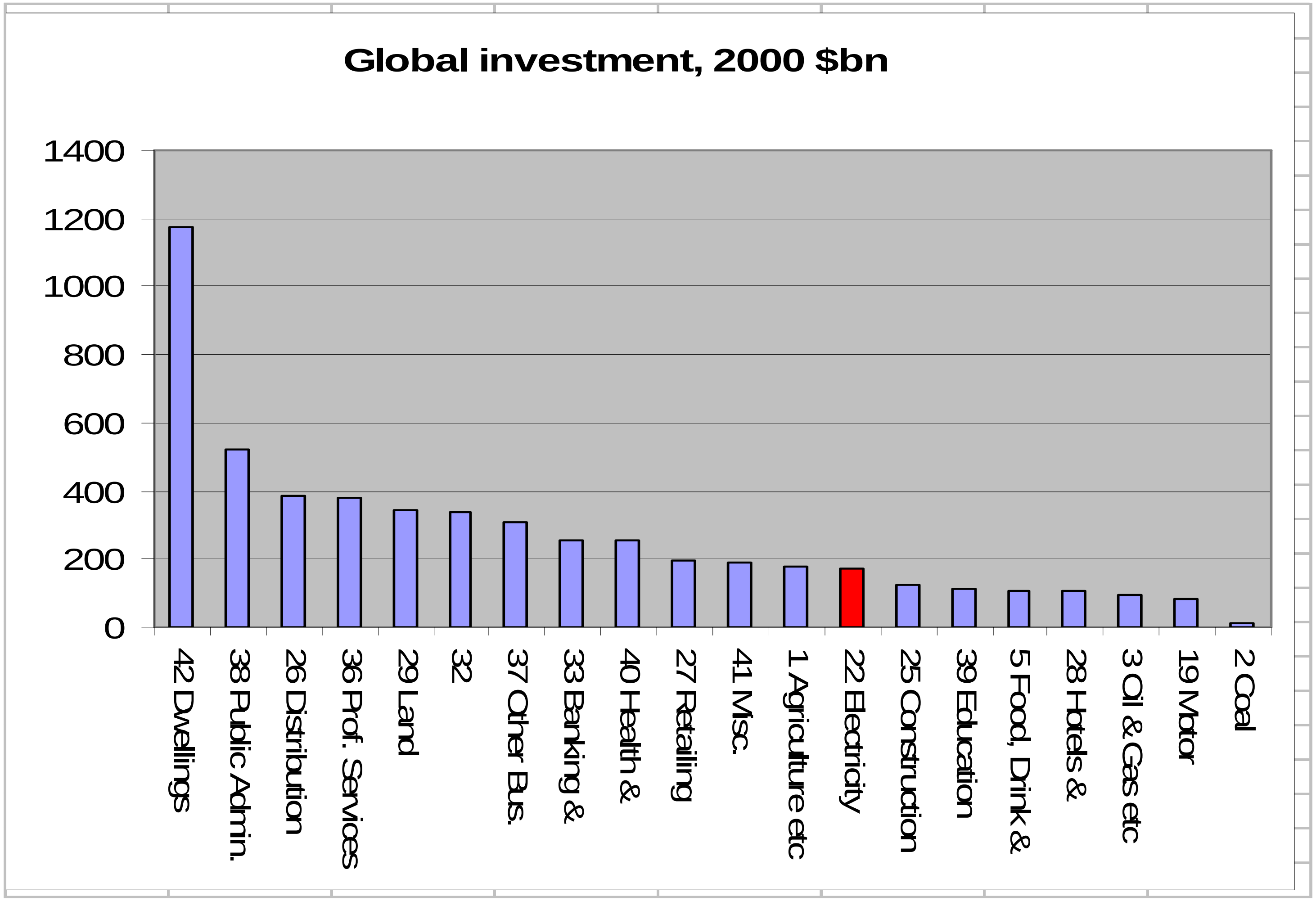
- France's move to nuclear power in the 1980s
- Copenhagen's 25% reduction in CO_2 emissions below 1990 levels
- Studies of 30% reduction in US CO_2 emissions required for Kyoto ratification

France: decarbonising electricity production from 50% thermal in 1980 to 10%in 1987



Source: http://www.eia.doe.gov/emeu/international/electricitygeneration.html

Electricity investment in context: global investment, 2000 $bn



Copenhagen's 25% cut in per capita CO_2 emissions by 2005 below 1990 levels

- *"Every citizen has reduced his input to global warming from 7 tons to 4.9 tons, by 2.1 tons in fact compared to the 1990 figures." … despite remarkable growth in the city … due to connecting the district heating system and generating stations to cleaner fuels, especially …natural gas."*
- "*So, we dare to set an ambitious new goal of reducing CO_2 emissions by a further 20% by 2015 compared to today (2005 figures). This means that by 2015 we will have reduced emissions by 40% compared to 1990."*

US study of accelerated reductions in CO_2 emissions

US Administration EIA study (1998) for Congress on effects of ratifying the Kyoto Protocol on the US economy, assuming action from 2006

	2010		2020	
number of years to adjust:	3 to 4		13	
trade in emission permits:	none	Annex I	none	Annex I
CO_2 change (%)	-30.6	-18.4	-35.1	-23.9
GDP cost (incl co-benefits) (%)	-1.2	-0.7	0.1	0.0

Note: GDP cost allows for co-benefits not included in original study.

Sources: US Energy Information Administration (EIA) (1998). *Impacts of the Kyoto Protocol on U.S. Energy Markets and Economic Activity.* Washington DC.

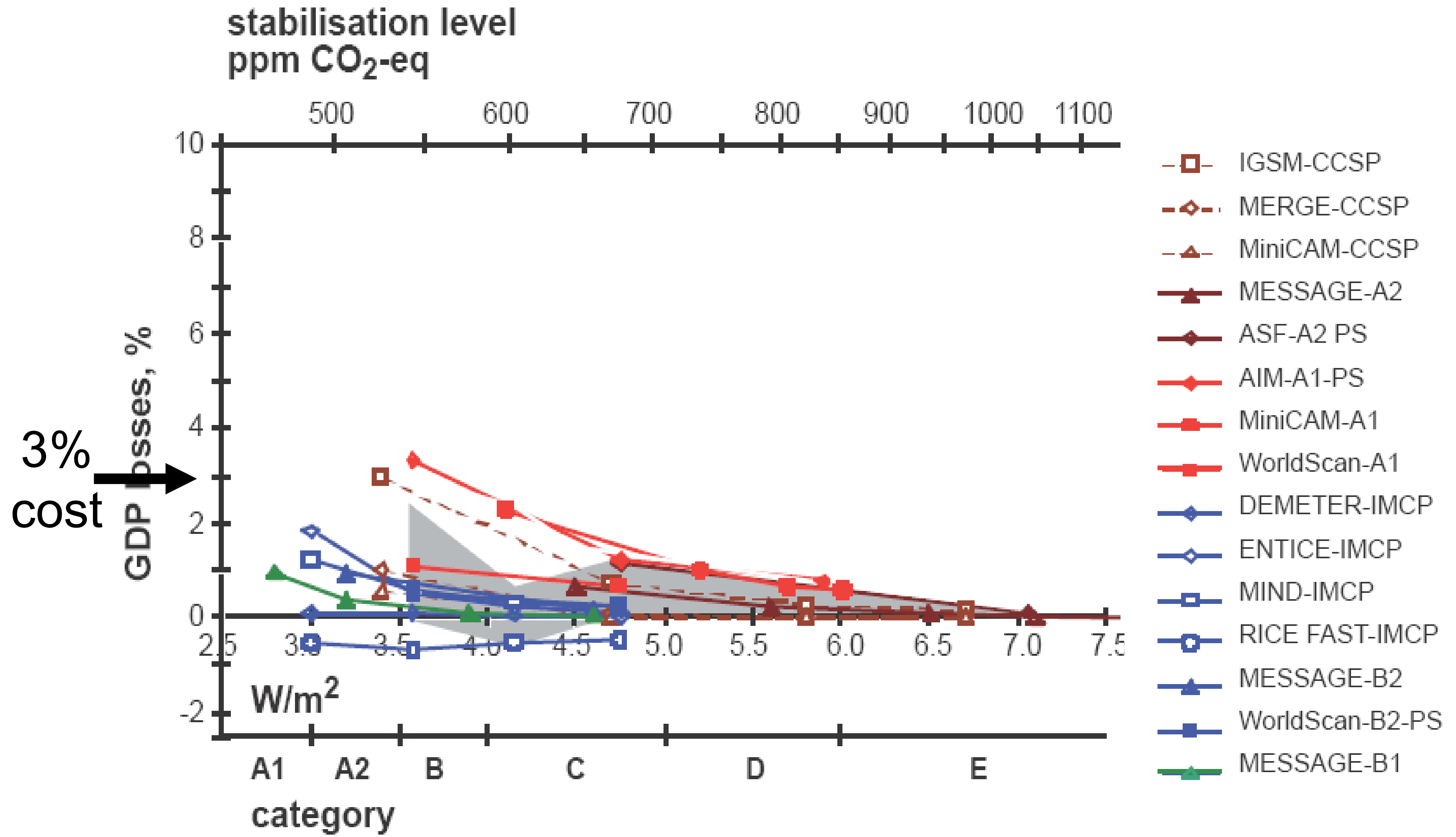
Barker, T., Ekins, P. (2004) 'The costs of Kyoto for the US economy', *The Energy Journal*, Vol. 25 No. 3, 2004, pp 53-71

What are the macro-economic costs by 2030 for different stabilization levels?

Stabilization levels (ppm CO_2-eq)	Median GDP reduction[1] (%)	Range of GDP reduction [2] (%)	Reduction of average annual GDP growth rates [3] (percentage points)
590-710	0.2	-0.6 – 1.2	< 0.06
535-590	0.6	0.2 – 2.5	<0.1
445-535[4]	**Not available**	**< 3**	**< 0.12**

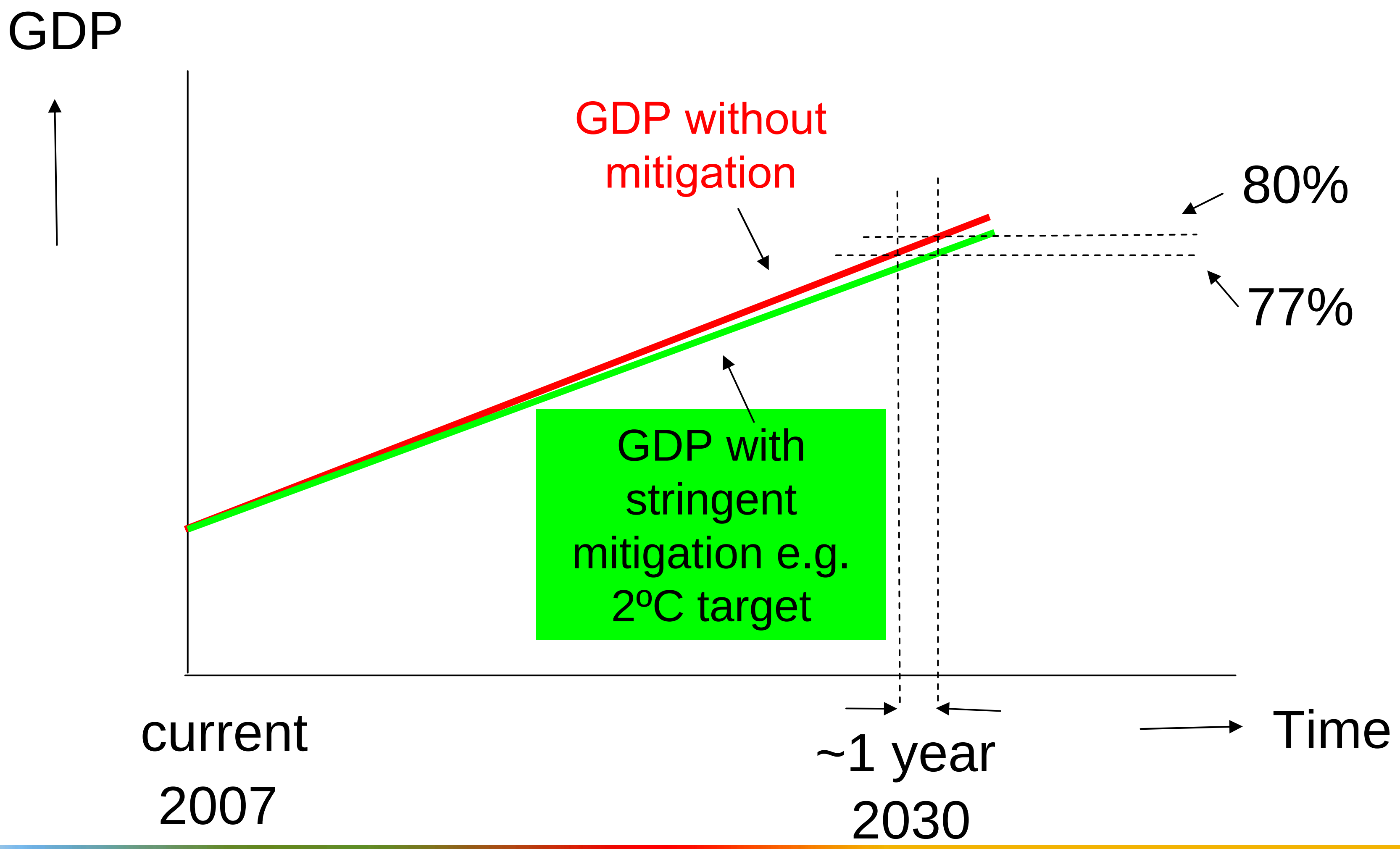
[1] This is global GDP based market exchange rates.
[2] The median and the 10th and 90th percentile range of the analyzed data are given.
[3] The calculation of the reduction of the annual growth rate is based on the average reduction during the period till that would result in the indicated GDP decrease in 2030.
[4] **The number of studies that report GDP results is relatively small and they generally use low baselines.**

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



IPCC

There are co-benefits of mitigation

- Near–term health benefits from reduced air pollution may offset a substantial fraction of mitigation costs
- Mitigation can also be positive for: energy security, balance of trade improvement, provision of modern energy services to rural areas and employment

BUT

- Mitigation in one country or group of countries could lead to higher emissions elsewhere (“carbon leakage”) or effects on the economy (“spill-over effects”).

The role of technology policies (1)

- Deployment of low-GHG emission technologies and RD&D would be required for achieving stabilization targets and cost reduction.
- The lower the stabilization levels, especially those of 550 ppm CO_2-eq or lower, the greater the need for more efficient RD&D efforts and investment in new technologies during the next few decades.
- Government support through financial contributions, tax credits, standard setting and market creation is important for effective technology development, innovation and deployment.
- Memo:
  - OECD Government funding for most energy research programmes has been flat or declining for nearly two decades (even after the UNFCCC came into force); now about half of 1980 level.

The role of technology policies (2)

- Third to Fourth Assessment report
  - “remarkable progress has been achieved in applying approaches based on induced technological change to stabilisation studies; however, conceptual issues remain” (SPM, p. 28) (EMF19, IMCP)
  - technology is now responsive to carbon prices in many models
- In the models that adopt these approaches, projected costs for a given stabilization level are reduced
  - the reductions are greater at lower stabilisation levels.
- Although most models show GDP losses, some show GDP gains
  - because they assume that baselines are non-optimal and mitigation policies improve market efficiencies
  - or they assume that more technological change may be induced by mitigation policies.

Summary: the costs of achieving the 2º C target

Key conclusion from IPCC AR4: not enough studies on stringent mitigation have been done!

Extrapolating from current studies:

The macro-economic costs of the 2ºC target appear to be negligible (even beneficial) for global GDP and welfare, provided policies are "well-designed"

- Equilibrium models (providing nearly all the cost estimates) *assume* that mitigation will be costly, despite evidence from econometric models and business
- Low-cost, low-GHG technologies are likely to be developed both directly and through rising carbon prices
- But this requires international co-operation on allocation of burdens and benefits

Conclusions for policy

- 450ppmv CO2-eq is not stringent enough to avoid dangerous climate change
- A rising real carbon price is required of about \$100/tCO_2 by 2020 (rising thereafter) to be on the safe side, e.g. by a trading scheme
  - the price should be guaranteed by government so as to reduce the risks of investing in low-GHG technologies
  - a portfolio of supporting policies (regulation, ecotax reform, information) reduces costs and accelerate change
- A zero-carbon economy appears feasible at negligible (but uncertain) macroeconomic costs, with high carbon prices and strong regulation
  - costs critically depend on international co-ordination

Conclusions: an interpretation of the outcome

- We, collectively, may be able to reduce the risks of rapid warming, but action is urgent
- There are huge gaps in knowledge, particularly of the costs and means of effective action, but the way forward is clear
- The 3% overall economic cost is the top end of a wide range that includes substantial benefits
- The Fourth IPCC assessment report marks a turning point in understanding about technology-economy interaction by both the scientific community and governments

The full SPM can be downloaded from www.ipcc.ch

for the Cambridge research see www.4cmr.org

Further information:

IPCC Working group III

Technical Support Unit:

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Memo: Relationship between \$50/tCO_2 and US fuel prices

		2005 base	Added cost of \$50/tCO_2	
		$	$	%
Crude Oil	**(\$/bbl)**	**60**	**22.4**	**37%**
Regular Gasoline	**(\$/gal)**	**2.39**	**0.48**	**20%**
Heating Oil	**(\$/gal)**	**2.34**	**0.53**	**23%**
Wellhead Natural gas	**(\$/tcf)**	**10.17**	**2.73**	**27%**
Residential Natural gas	**(\$/tcf)**	**15.3**	**2.75**	**18%**
Utility Coal	**(\$/short ton)**	**32.6**	**101.4**	**311%**
Electricity	**(c/kWh)**	**9.6**	**3.23**	**34%**

Source: Derived from Table ES.5, US CCSP, 2006, sourced in turn from Bradley et al. 1991, updated with U.S. average prices for the 4th quarter of 2005 as reported in DOE, 2006.
Note: This table does not include any adjustments in producer prices due to changes in energy demands under stabilization.