Reconciling Economic Growth and Environmental Sustainability

A presentation to the seminar ‘Are Economic Growth and Environmental Sustainability Compatible?’

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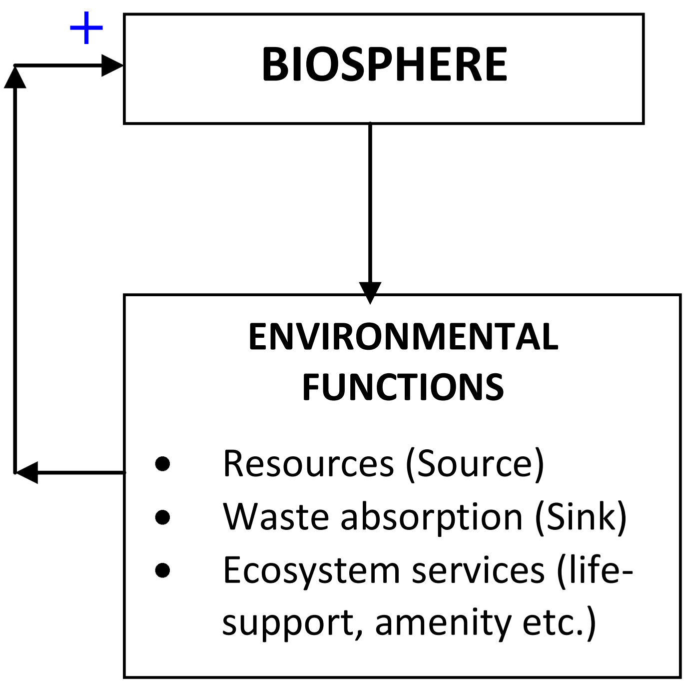
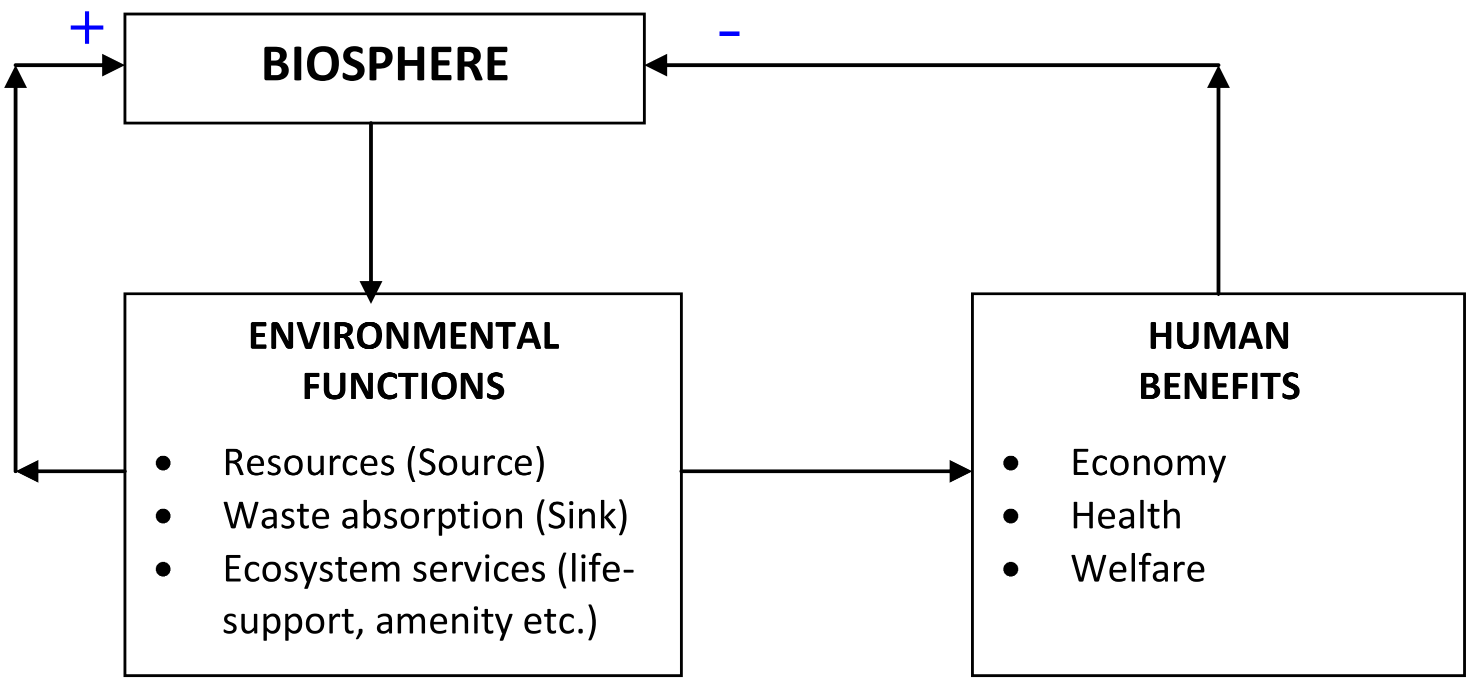
Principles of sustainable growth

- Borrow systematically only to invest, not to consume
- Keep money sound: control inflation, public borrowing, trade deficits, indebtedness
- Establish transparent accounting systems that give realistic asset values
- Maintain or increase stocks of capital (manufactured, human, social, natural)
- As has become apparent every one of these principles has been spectacularly broken over the last few years, even in the financial sector and mainstream money economy
- What prospect then for the big one, maintaining and rebuilding ecosystems/natural capital for environmental sustainability?
- We must start by getting right the basic conception of how the human economy relates to the natural environment

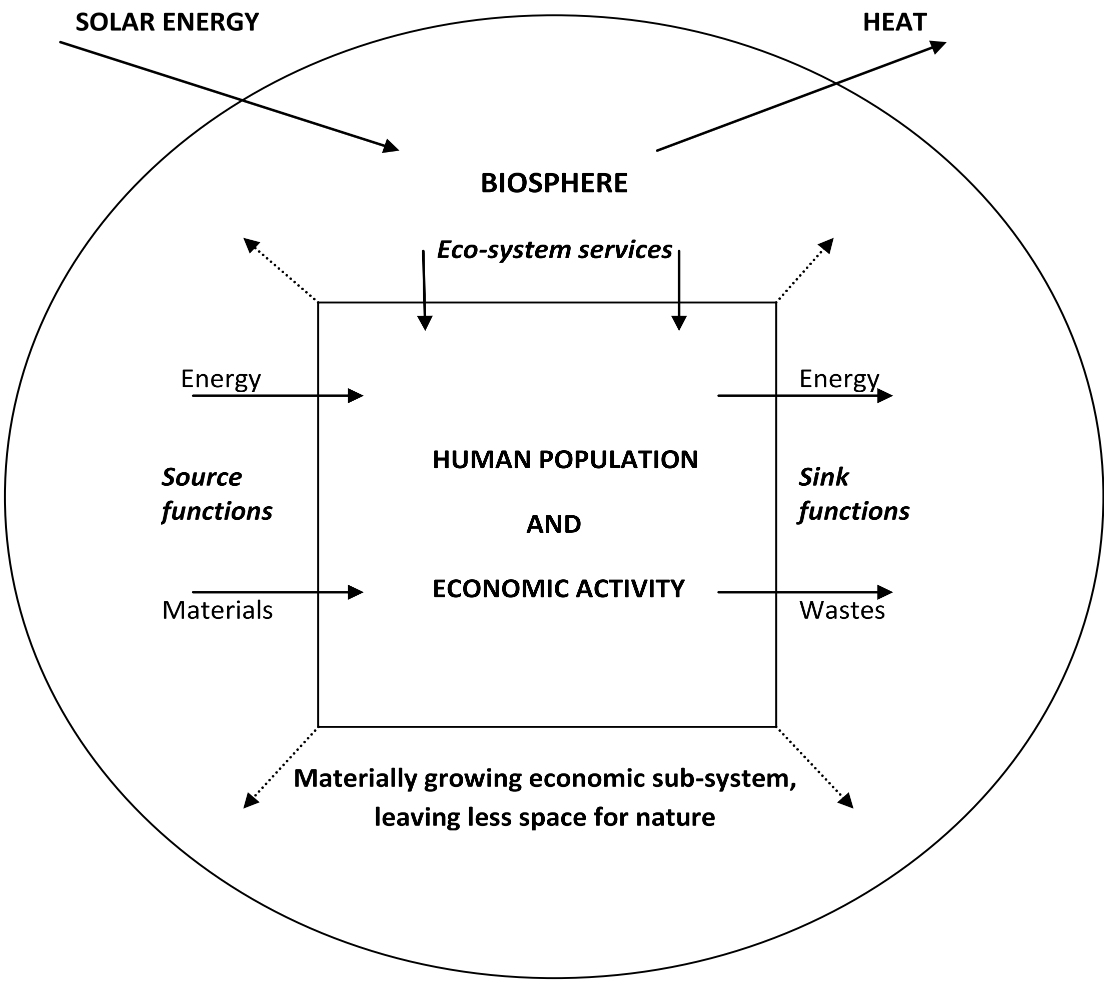
The ecological cycle



The ecological cycle and human well-being



The economy as a sub-system of the biosphere



What kind of growth?

- Physical growth (growth in the amount of matter/energy mobilised by the economy: indefinite growth of this kind is impossible in a finite physical system subject to the laws of thermodynamics
- Economic (GDP) growth: growth in money flows/incomes/value added/expenditure: there is no theoretical limit on this kind of growth
- Growth in human welfare:
  - Dependent on sustaining environmental functions
  - Complex relationship to economic growth (although hard to argue that, *ceteris paribus*, more money is not better than less)
  - Dependent on many other factors (employment, working conditions, leisure (in)equality/income distribution, relationships [family/community], security/safety of the future)

Environmental sustainability

- Sustainability: capacity for continuance
- Environmental sustainability: maintenance of important environmental functions and the natural capital which generates them. Importance:
    - Not substitutable, irreversible loss, ‘immoderate’ losses
    - Maintenance of health, evidence of threat, economic sustainability
- Any aspiration for sustainable economic growth must start from the recognition of the need for the sustainable use of resources and ecosystems, and be rooted in basic laws of physical science:
    - Indefinite physical expansion of the human economy on a finite planet is impossible;
    - All use of non-solar forms of energy creates disorder, and potential disruption, in the natural world
- Thermodynamics: at a certain physical scale, further physical growth becomes counter-productive.

– There is little doubt that except from a very short-term perspective this scale has now been exceeded

– What is the optimal physical scale of the human economy?

Sustainability Gap

	Environ-mental stress (ES)		Sustain-ability standard (SS)	Sustain-ability Gap (SGAP) (ES-SS)		Normalised SGAP (100*SGAP/SS), EPeq		Years to sustain-ability
	1980	1991		1980	1991	1980	1991	
Climate change, Ceq	286	239	10	276	229	2760 100	2290 83	54
Ozone depletion, Oeq	20000	8721	0	20000	8721	na	na	8.5
Acidification, Aeq	6700	4100	400	6300	3700	1575 100	925 59	16
Eutrophication, Eeq	302	273	86	216	187	251 100	217 86	71
Dispersion, Deq	251	222	12	239	210	1992 100	1750 88	80
Waste disposal, Weq	15.3	14.1	3	12.3	11.1	410 100	370 90	102
Disturbance, Neq	46	57	9	37	48	411 100	533 130	never
TOTAL	na	na	na	na	na	7399 100	6085 82	**51**

Table 3.2: Various Sustainability Measures for the Netherlands

Source: Ekins, P. & Simon, S. 2001 'Estimating Sustainability Gaps: Methods and Preliminary Applications for the UK and the Netherlands', *Ecological Economics*, Vol.37 No.1, pp.5-22

The imperative of decoupling physical from financial growth

- **Decoupling:** a decline in the ratio of the amount used of a certain resource, or of the environmental impact, to the value generated or otherwise involved in the resource use or environmental impact. The unit of decoupling is therefore a weight per unit of value.
- **Relative decoupling:** in a growing economy, the ratio of resource use (e.g. energy consumption) or environmental impact (e.g. carbon emissions) to GDP decreases
- **Absolute decoupling:** in a growing economy, the resource use or environmental impact falls in absolute terms
- If GDP growth continues, climate stabilisation at levels of CO2 concentration that limit global average temperature increases to 2^{o}C will require a degree of absolute decoupling of GDP from carbon emissions that is outside all previous experience

The necessary improvements in energy/resource 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

Headline conclusion on sustainable (green) growth

- Conclusion from book

Economic Growth and Environmental Sustainability: the Prospects for Green Growth (Routledge 2000)

- Technologically feasible, economically feasible

BUT

requires sustained, wide-ranging, radical policy interventions to bring about technological revolution and change lifestyles. These interventions are resisted by affected economic sectors (e.g. energy) and households who want to keep current lifestyles (e.g. transport), or attain Western lifestyles

An unprecedented policy challenge

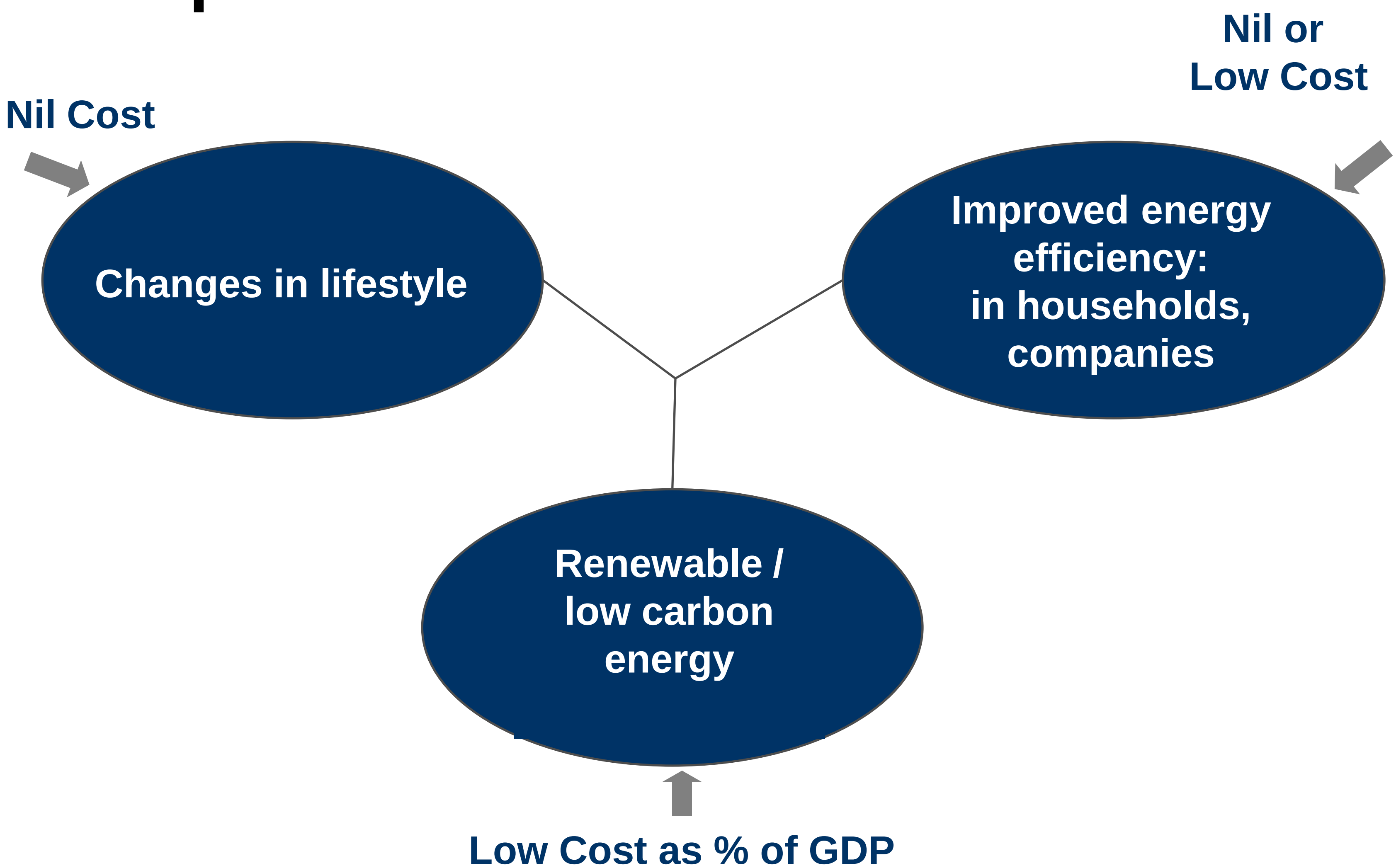
The Stern Review Policy Prescription for climate change

- 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)
- The basic insights from the Stern Review need to be applied to the use of other environmental resources (water, materials, biodiversity [space])
- In a market economy, pricing is the key to resource efficiency, investment and behaviour change. If it was politically feasible to increase resources prices to the necessary extent, what would this do to economic growth?

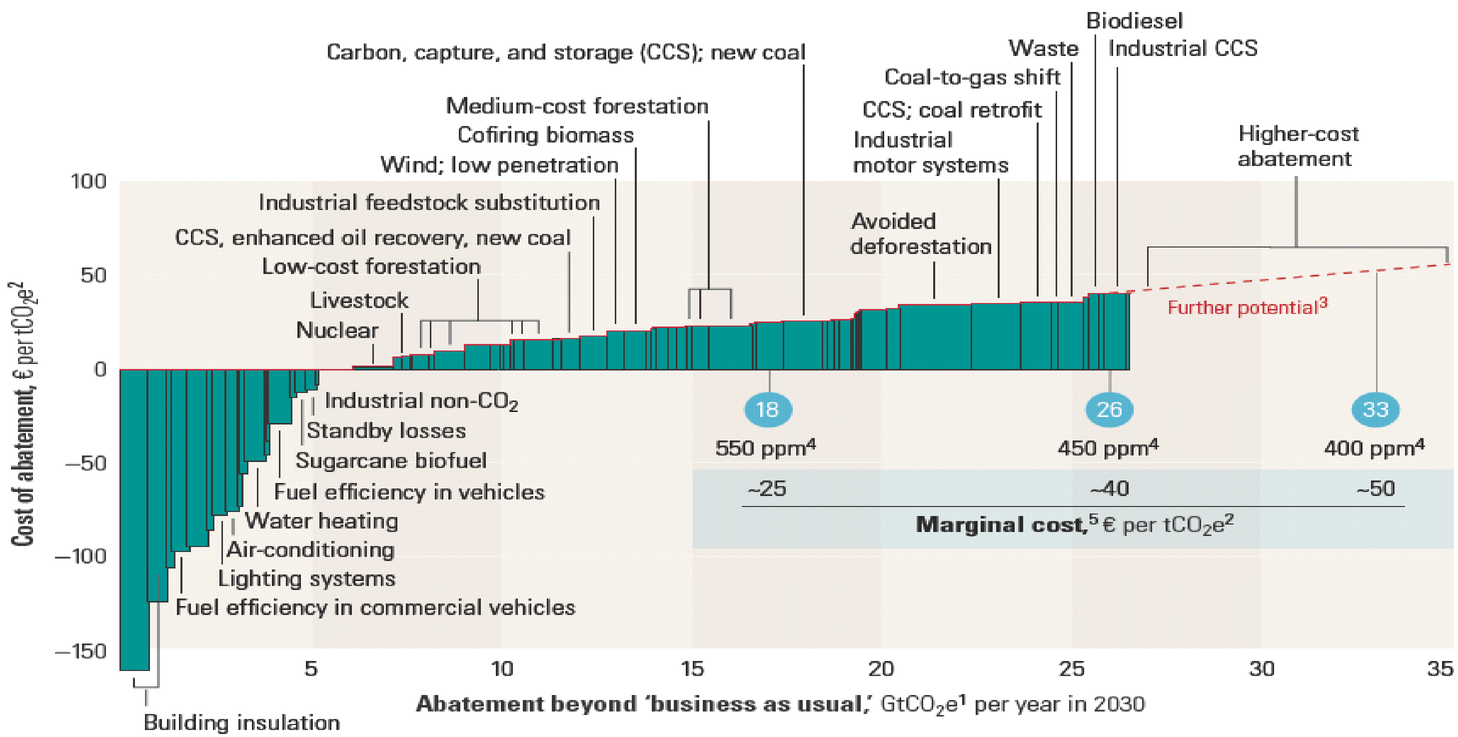
The costs of increasing resource productivity

- Optimists:
  - ‘Costs’ are really investments, can contribute to GDP growth
  - Considerable opportunity for zero-cost mitigation
  - A number of resource-efficient technologies are (nearly) available at low incremental cost over the huge investments in the economic system that need to be made anyway
  - ‘Learning curve’ experience suggests that the costs of new technologies will fall dramatically
  - Resource efficiency policies can spur innovation, new industries, exports and growth
- Pessimists:
  - Constraining resource use is bound to constrain growth
  - Cheap, abundant energy and other resources are fundamental to industrial development

The hope for affordable economic cost



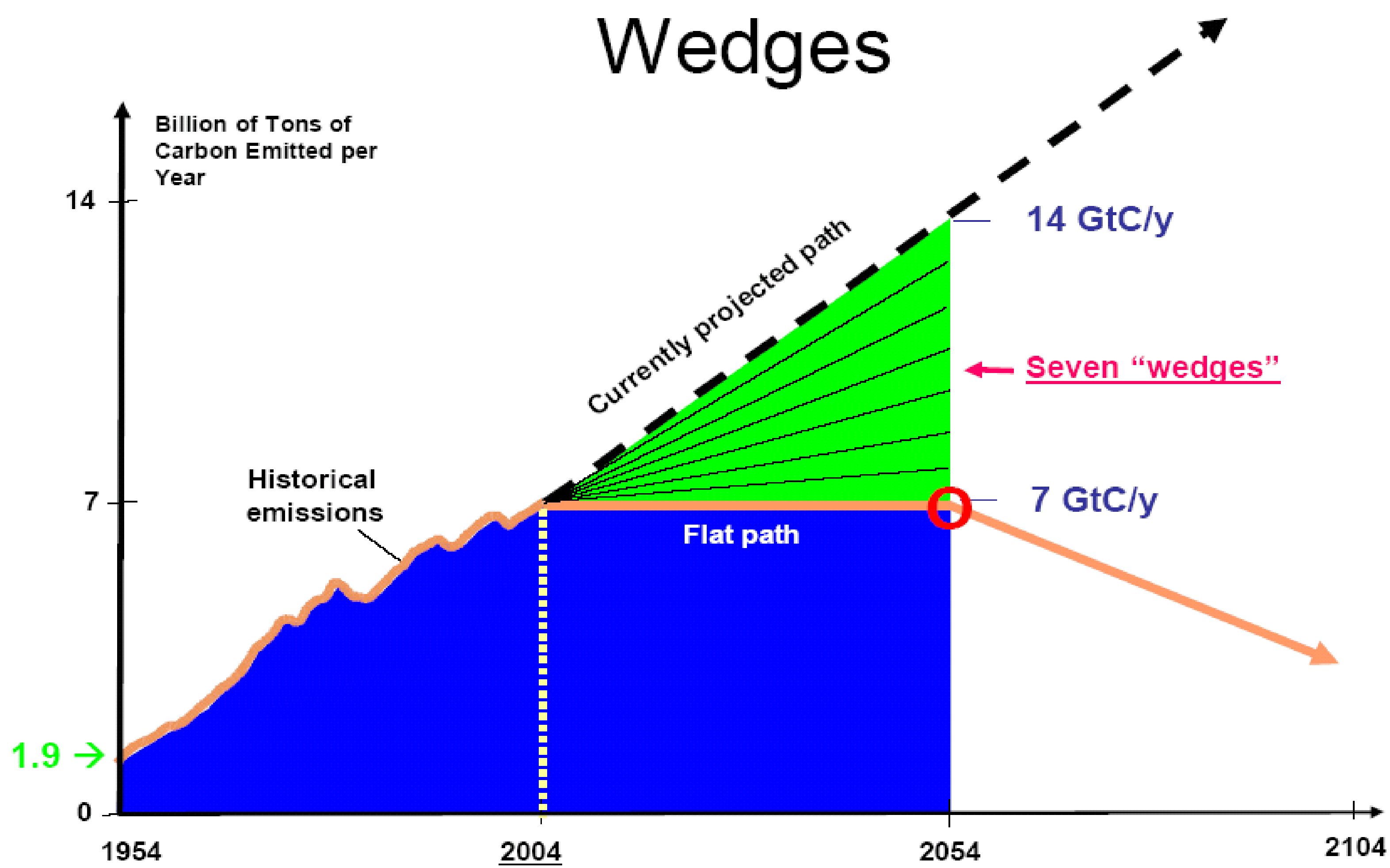
The (micro)economic cost: global cost curve for greenhouse gas abatement



[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.

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

Technological potential: the Socolow Wedges



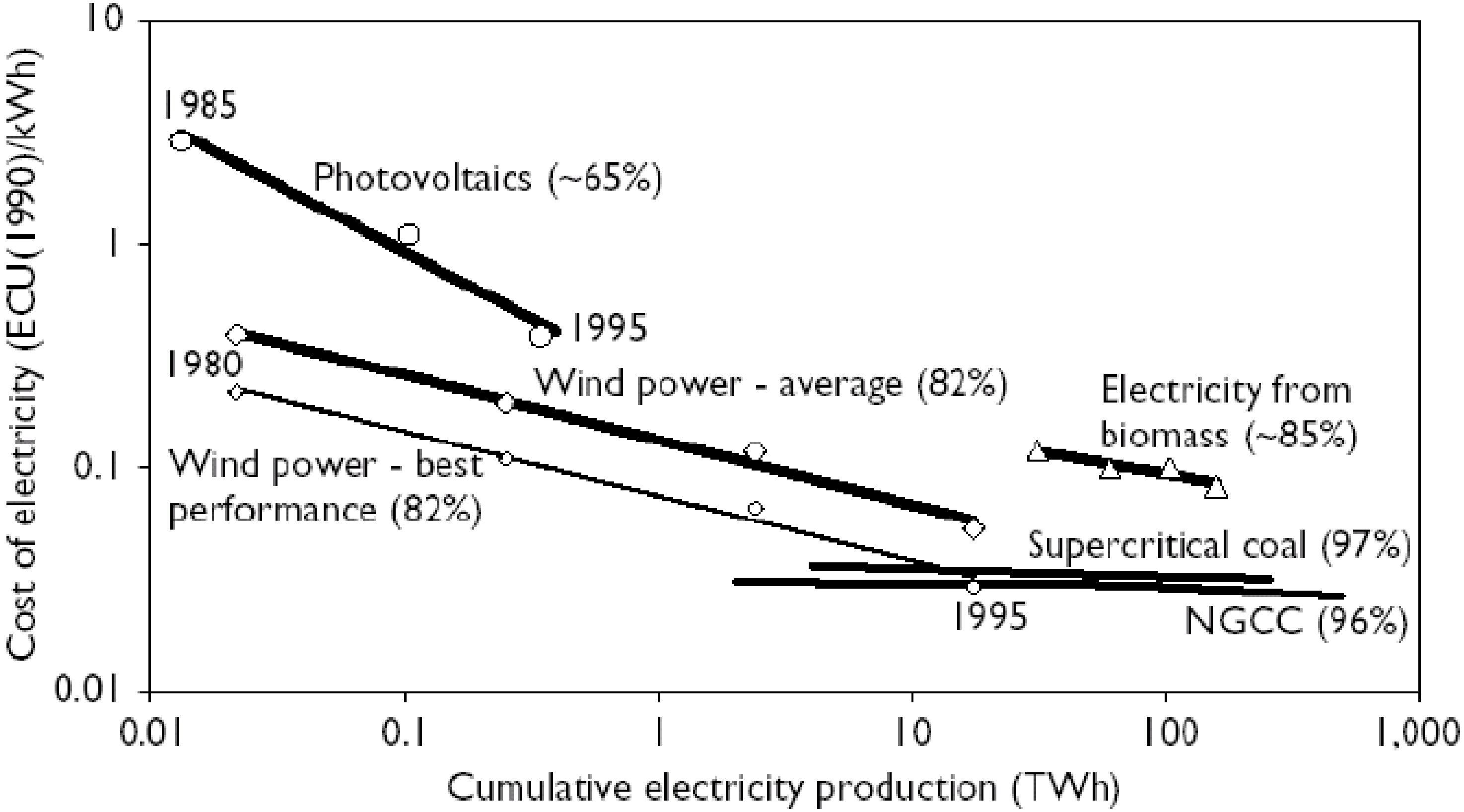
Source: Professor Robert Socolow "Stabilisation Wedges", Met Office Symposium, 3rd February 2005

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”

Cost evolution and learning rates for selected technologies



Source: IEA, 2000, Stern Review, Chapter 9

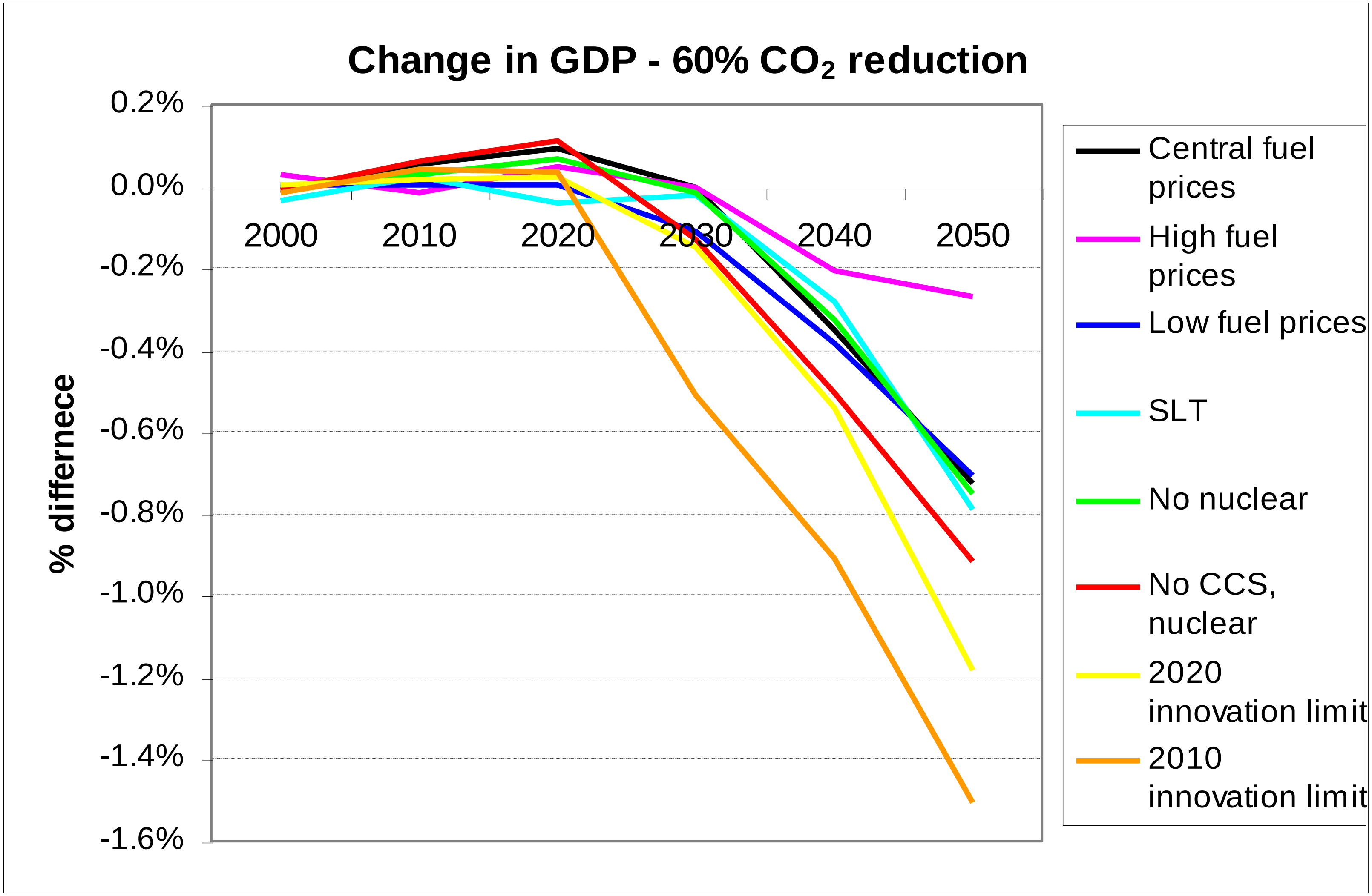
Estimating the macro-economic cost of carbon reduction

- Models are essential to integrate cost data in a representation of
  - The energy system (MARKAL): energy system cost, welfare cost, GDP cost
  - The economy : macro-econometric/general equilibrium models
  - Good models are 'garbage in – garbage out'; getting the inputs right
- Stern's conclusion (p.267)
  - "Overall, the expected annual cost of achieving emissions reductions, consistent with an emissions trajectory leading to stabilisation at around 500-550 ppm CO_2e, is likely to be around 1% GDP by 2050, with a range of +/-3%, reflecting uncertainties over the scale of mitigation required, the pace of technological innovation and the degree of policy flexibility."

UK MARKAL

- **MARK**et **AL**location dynamic optimization model
- 100+ users in 30+ countries under IEA ETSAP network
- A **least cost optimization** model based on life-cycle costs of competing technologies (to meet **energy service demands)**
- **Technology** rich bottom-up model (e.g. end-use technologies, energy conversion technologies, refineries, resource supplies, infrastructure, etc)
- An **integrated energy systems** model
  - Energy carriers, resources, processes, electricity/CHP, industry, services, residential, transport, agriculture
- Range of physical, economic and policy **constraints** to represent UK energy system
- **Extension** to MARKAL-Macro (M-M), MARKAL Elastic Demand (MED)

GDP % changes – UK MARKAL MACRO

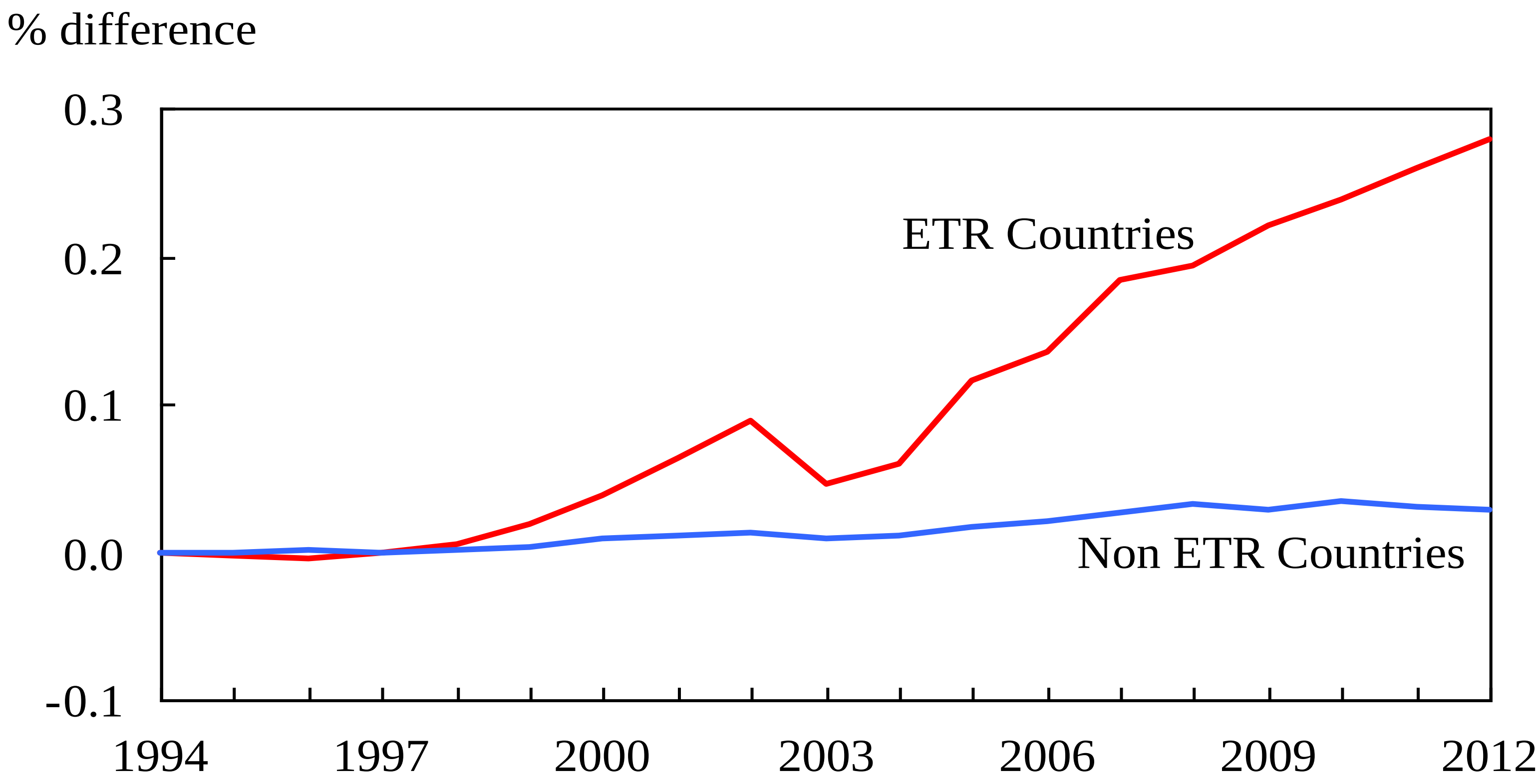


Relevant projects on environmental tax reform (ETR) or green fiscal reform (GFR)

Definition: ETR is the shifting of taxation from ‘goods’ (like income, profits) to ‘bads’ (like resource use and pollution)

- COMETR: Competitiveness effects of environmental tax reforms, 2007. http://www2.dmu.dk/cometr/ (What is the experience to date of ETR in Europe?
  See Andersen, M.S. & Ekins, P. (Eds.) *Carbon Taxation: Lessons from Europe*, Oxford University Press, Oxford/New York, 2009
- petrE: ‘Resource productivity, environmental tax reform (ETR) and sustainable growth in Europe’. One of four final projects of the Anglo-German Foundation under the collective title ‘Creating Sustainable Growth in Europe’. Final report published October 29, Berlin, November 25, London. www.petre.org.uk
- UK Green Fiscal Commission. Final report published October 26, London. www.greenfiscalcommission.org.uk

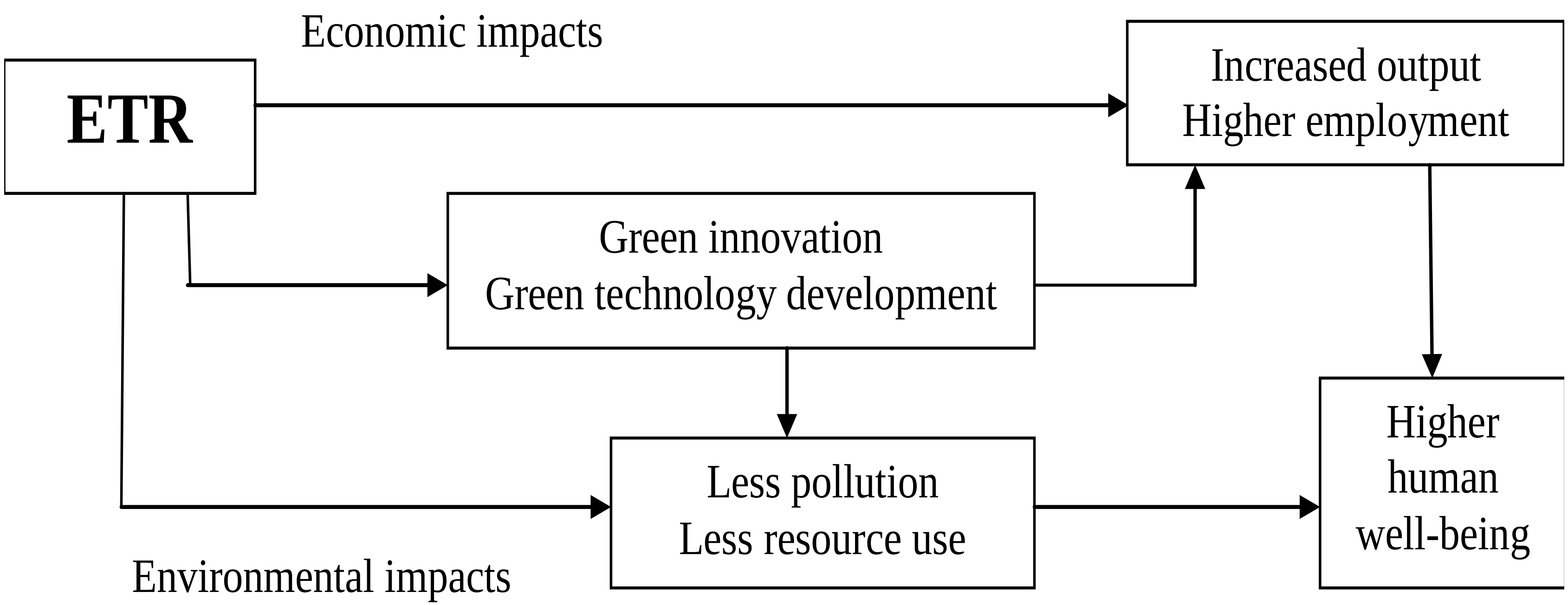
CHART 7.28: THE EFFECTS OF ETR: GDP IN ETR AND NON ETR COUNTRIES



Note(s) : % difference is the difference between the base case and the counterfactual reference case.

Source(s) : CE.

PETRE: What opportunities are presented by ETR in Europe?



What might a large-scale ETR in Europe look like.....? (1)

- Two European macro-econometric models: E3ME, GINFORS.
- Models deliver insights, not forecasts or 'truth'
- Six scenarios:
  - Baseline with low energy price (LEP)
  - Baseline sensitivity with high energy price (HEP, reference case)
  - Scenario 1: ETR with revenue recycling designed to meet 20% EU 2020 GHG target (S1 – scenario compared with LEP Baseline)
  - Scenario 2: ETR with revenue recycling designed to meet 20% EU 2020 GHG target (S2 – scenario compared with HEP Baseline)
  - Scenario 3: ETR with revenue recycling designed to meet 20% EU 2020 GHG target (S3 – scenario compared with HEP Baseline)
    - proportion of revenues spent on eco-innovation measures
  - Scenario 4: ETR with revenue recycling designed to meet 30% 'international cooperation' EU 2020 GHG target (S4 – scenario compared with Baseline with HEP)

What might a large-scale ETR in Europe look like.....? (2)

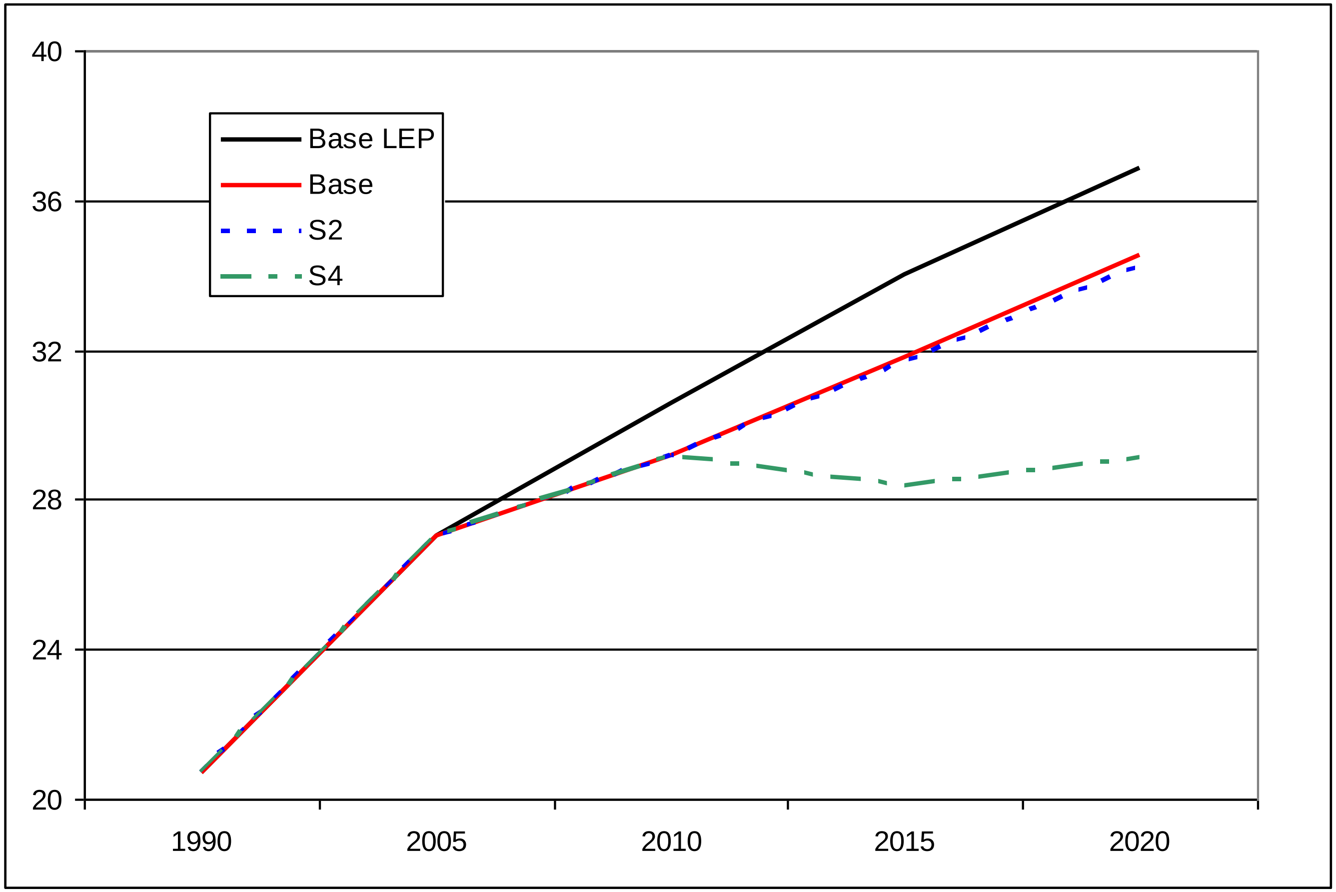
- The taxes …
  - A carbon tax rate is introduced to all non EU ETS sectors equal to the carbon price in the EU ETS that delivers an overall 20% reduction in greenhouse gas emissions (GHG) by 2020 (in the international cooperation scenario (S4) this is extended to a 30% GHG reduction)
  - Aviation is included in the EU ETS at the end of Phase 2 in 2012
  - Power generation sector EU ETS permits are 100% auctioned in Phase 3 of the EU ETS (from 2013) [NB auctioning does not change carbon prices or emissions]
  - All other EU ETS permits are 50% auctioned in 2013 increasing to 100% in 2020
  - Taxes on materials are introduced at 5% of total price in 2010 increasing to 15% by 2020
  - S4 carbon tax in non-EU countries is 25% of carbon tax in EU
- … and tax reductions
  - Reductions in income tax rates (for households) and social security contributions (for businesses) in each of the member states, such that there is no direct change in tax revenues
  - In S3 10% of the environmental tax revenues are recycled through spending on eco-innovation measures

What might a large-scale ETR in Europe look like.....? (3)

Scenario	CO_2 price Euro2005/t	GDP pc against baseline	Employment pc against baseline	Labour productivity pc against baseline
S2				
E3ME	89	0.6	1.5	-0.9
GINFORS	74	-0.6	0.4	-1.0
S3				
E3ME	80	1.0	1.6	-0.6
GINFORS	66	-0.3	0.4	-0.7

... and what would be its implications for the rest of the world?

CO_2 emissions- GINFORS

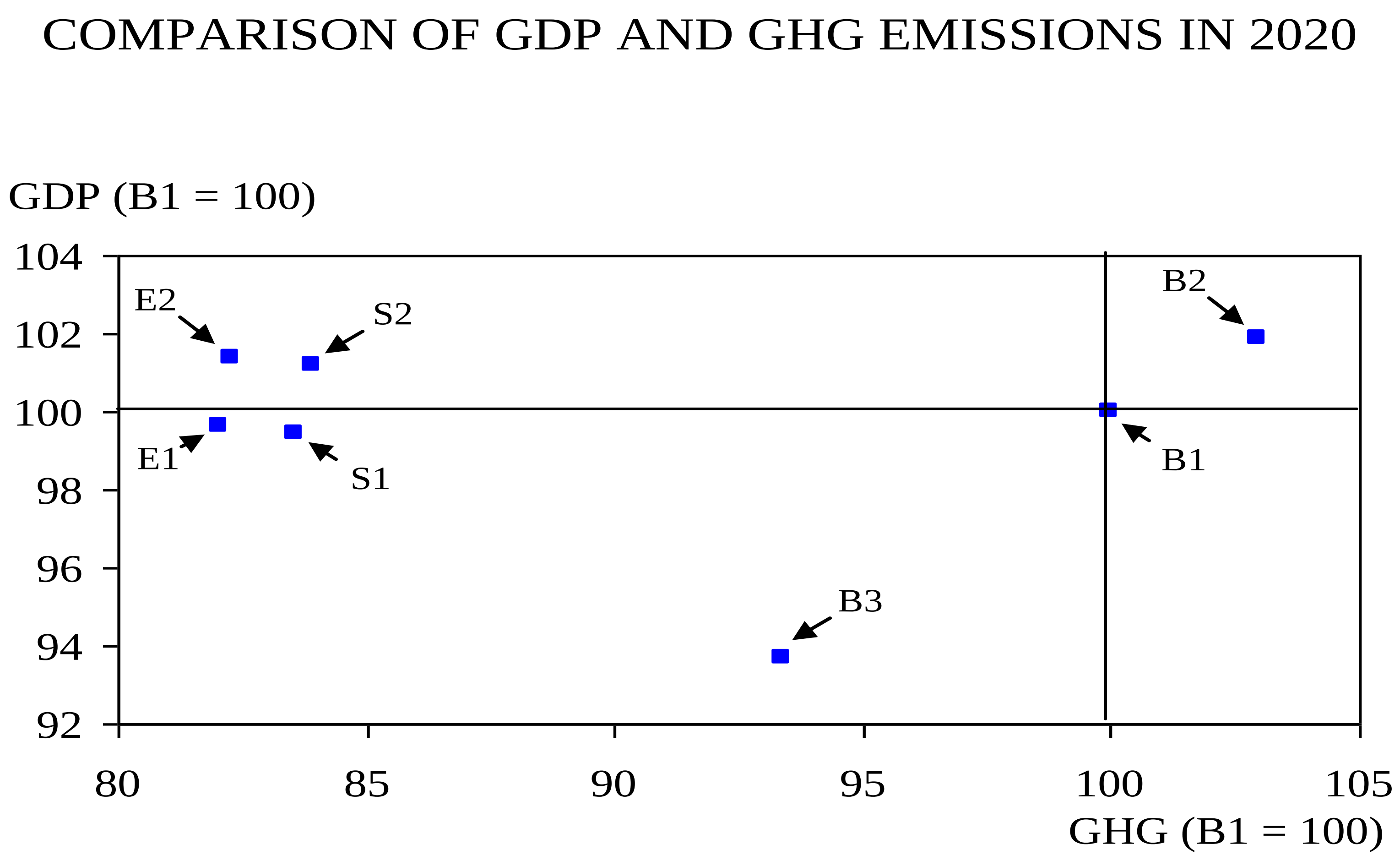


UK Green Fiscal Commission

- Investigation of
  - Enonomic, social and environmental implications of major green fiscal reform (GFR) (share of environmental taxes in total revenues from 5% to 15-20% by 2020)
  - Public attitudes to GFR

- Modelling of scenarios
  - Three baselines (B1, B2, B3) – low, medium, high world market fossil fuel prices
  - Two GFR scenarios (S1, S2) – increase in transport, household and industrial energy taxes, and taxes on water and materials, reductions in income taxes (households) and social security contributions (business)
  - Two ’eco-innovation’ scenarios (E1, E2) – spending 10% of green tax revnues on energy-efficient buildings, renewable energy and hybrid vehicles

Results: GDP and carbon emissions



Note(s) : GHG figures have been calculated on a net carbon account basis in MtCO2e.

Source(s) : ONS, NAEI, Cambridge Econometrics.

Will ETR lead to ‘sustainable growth’ in Europe? (1)

- ETR would rule out a resource-intensive growth path
- This would constrain growth unless it led to innovation in low-resource technologies
- ETR would stimulate such innovation, but this may need to be supported with complementary policies

Will ETR lead to ‘sustainable growth’ in Europe? (2)

- ‘Sustainable’ growth will be resource-efficient and may in time turn out to be slower growth, with higher employment (lower productivity and incomes)
- Relatively high-growth countries in a sustainable future will be those that have developed, and can export, resource-efficient technologies and industries
- ETR is a key policy for fostering sustainable growth
- There is no evidence that ETR or other policies for environmental sustainability would choke off economic growth altogether
- ‘Unsustainable’ growth will not last beyond this century, and could lead to environmental collapse well before 2100
- The choice is clear and from a cost-benefit angle is a no-brainer at any but the highest discount rates.
- That will not make implementing the choice politically easy

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)

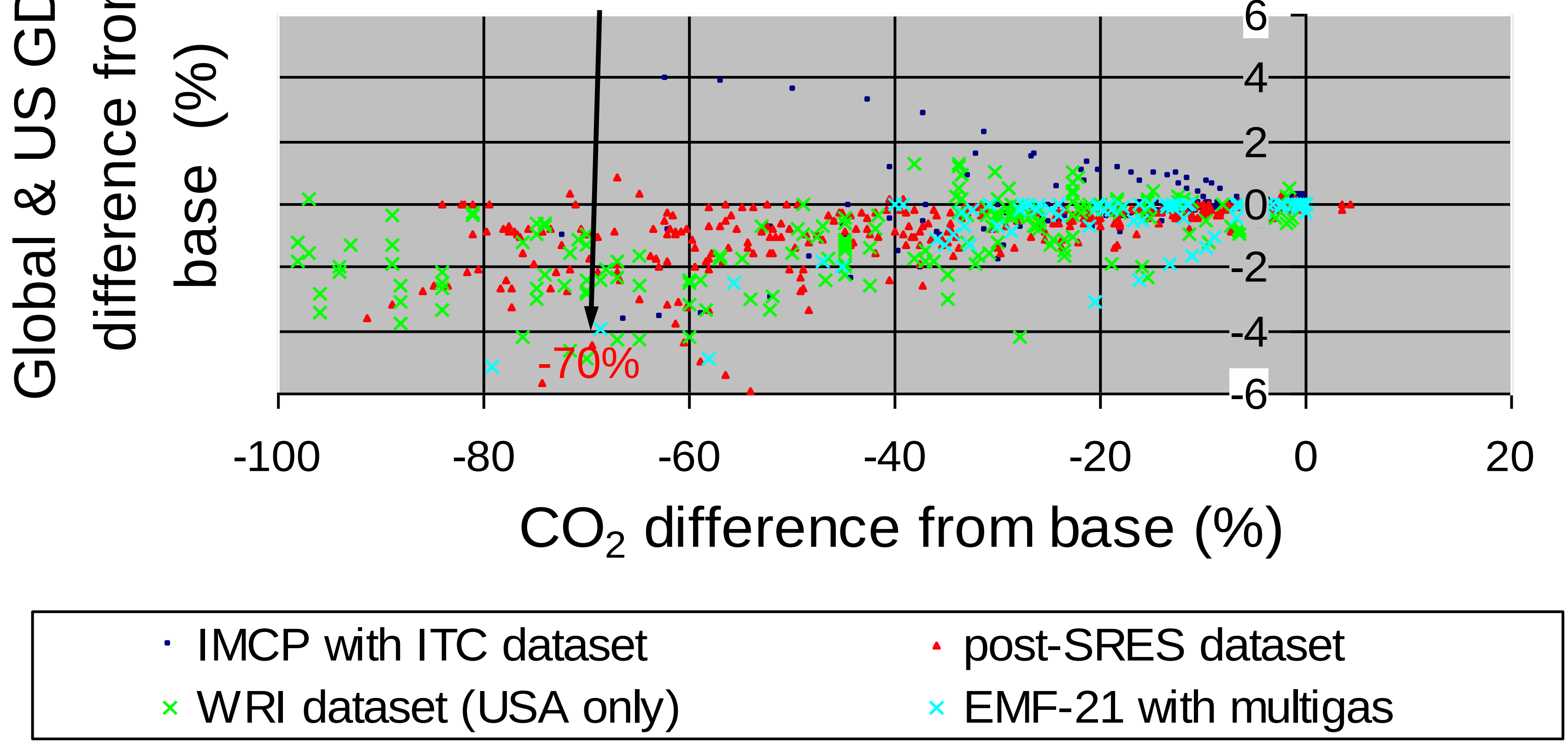
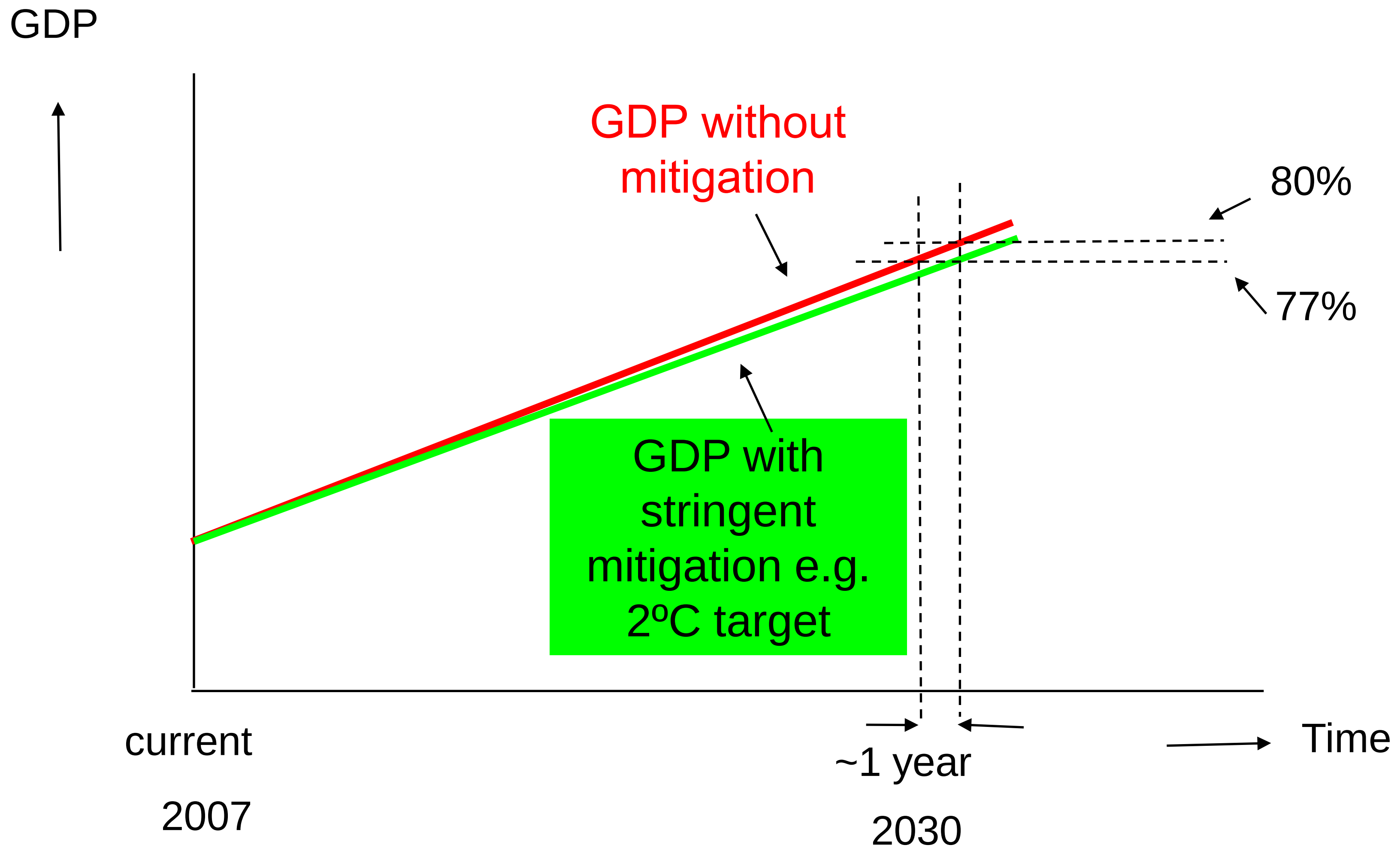


Illustration of a 3% GDP cost number with 3% GDP growth per annum



Conclusions on costs and growth

- The Stern Review central estimate (1% GDP) was on the low side, but its upper range (1-4% GDP) is certainly consistent with the evidence
- There is no evidence that strong action to mitigate climate change will have much higher costs or halt economic growth completely, BUT
- Low impacts on growth assume low-carbon technological development consistent with past experience **and** no special productivity improvements from cheap/plentiful/concentrated energy (fossil fuels); **or** technological developments (e.g. fusion) that achieve this in other ways
- If the economic costs are low, why is carbon reduction so difficult?

The cost/political feasibility paradox (1)

- The technologies for large-scale climate change mitigation are, or soon will be, available at affordable cost.
- Government funding of R,D&D will need to increase dramatically, but deployment and diffusion can only be driven at scale by markets.
- Developing and deploying the technologies will require huge investments in low-carbon technologies right along the innovation chain (research, development, demonstration, diffusion).
- Financing this investment will require a substantial shift from the UK’s consumption-oriented economy of today to an investment economy that builds up low-carbon infrastructure and industries.
- This shift need not impact negatively on GDP (incomes) and employment but will require higher savings and lower consumption rates. This may not be politically popular in a consumer society (UK savings rates fell below zero in early 2008).

The cost/political feasibility paradox (2)

- Stimulating the required investment will require high (now) and rising carbon prices over the next half century, to choke off investment in high-carbon technologies and incentivise low-carbon investments.
- These high carbon prices will also greatly change lifestyles and consumption patterns. This too may not be politically popular.

Conclusion

- It is not technology or cost, that are the constraining factors to climate change mitigation, but politics – related to people's attachment to consumption rather than savings/investment, and aspects of high-carbon lifestyles.
- Changing this political reality is the necessary condition for the adequate mitigation of climate change, which will alone avoid the potentially enormous, but still very uncertain, costs of adapting to climate events and conditions outside all known human experience.

UCL

Thank You

www.ucl.ac.uk/energy