Safe climate policy is affordable

14 reasons

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Motivation and aim

- ➔ Safe climate policy seen as extremely expensive
  - in terms of monetary cost, welfare loss or reduced GDP growth
- ➔ Supported by cost-benefit analyses of climate policy
  - but climate CBA overly ambitious – has been severely criticised

- ➔ Combination of risk aversion, pervasive uncertainty, irreversibility and extreme climate events suggests precautionary principle:

  a focus on safe rather than optimal climate policy

- ➔ Climate policy cost estimates
  - much variety
  - less ambitious than CBA but also debatable assumptions
- ➔ Broader picture needed: *range of perspectives*

The failure of cost-benefit analysis of climate policy

- CBA of climate policy has received much criticism
  (Ayres & Walters, 1991; Daily et al., 1991; Broome, 1992; Barker, 1996; Azar, 1998; Neumayer, 1999; Spash, 2002; DeCanio, 2003; van den Bergh, 2004; Padilla, 2004; Ackerman & Finlayson, 2007; Maréchal, 2007; Gowdy, 2008; Tol, 2008)
- Combination of small probabilities & large impacts poses problems for an expected value CBA approach
  - & not how humans tend to evaluate these (Kahneman & Tversky, 1979)
- Precautionary principle
  - Tol (2008b, p.10) supports the precautionary approach implicitly by stating that in view of the strongly right-skewed distribution of climate change damage costs (median \$14/tC, mean \$93/Tc, 95 percentile \$350/tC) "The policy implication is that emission reduction should err on the ambitious side"

Precaution

- Dietz et al. (2007, p. 250) make it even more clear: “Those who deny the importance of strong and early action should explicitly propose at least one of three arguments: (i) there are no serious risks; (ii) we can adapt successfully to whatever comes our way, however big the changes; (iii) the future is of little importance. The first is absurd, the second reckless, and the third unethical.”

- Environmental economists have since long thought about uncertainty and irreversibility: (quasi-)option value theory (Arrow and Fisher, 1974)
  - but they have refrained from systematically applying this to the most relevant case, namely climate change (exceptions are Schimmelpfennig, 1995; Ha-Duong, 1998)
  - *option value* of climate policy represents value of flexibility to either or not accept climate change at a later date; flexibility due to avoiding irreversible build-up of GHGs in the atmosphere
  - *quasi-option value* of climate policy reflects that precaution allows for learning about climate change, in terms of risks, costs and adaptation opportunities
  - main weakness of applying (quasi-)option value theory to climate change policy is expected utility theory basis

Other fundamental issues related to the social welfare function in climate CBA

- ➔ Population endogenous to climate change, causing welfare optimization to involve ethically debatable implications for population size

- ➔ Alternatives to discounted utilitarianism as normative criterion for intergenerational public decision making
  - an intergenerational maximin criterion (Rawls-Solow-Arrow)
  - maximization of some Quality of Life (human development) indicator,
  - a happiness approach (perspective 4 later)
  - a minmax regret goal – precaution (Loulou & Kanudia, 1999; van den Bergh, 2004)

Discounting & discount rate

- (1) CBA over long time horizons as in climate change analysis extremely sensitive to discounting and choice of discount rate (2) Much disagreement about the latter: combination (1)&(2) important reason to be critical of climate CBA studies
- The debate on intergenerational discount rates was revived by The Stern Review (2006): market rate of interest versus ethical choice
- My view:
  - discounting means erroneous analogy: society ≠ individual
  - as opposed to an individual, a society does not have a finite life (overlapping generations), *notably when society aims for sustainability*
- Low long term discount rates are consistent with certain stated preference (Weitzman, 2001), experimental and theoretical findings (hyperbolic discounting)

Extreme climate events and trends

- ➔ Perhaps most important shortcoming of past climate CBA studies is incomplete account of extreme and irreversible climate scenarios
  - extreme low or high temperatures
  - extreme weather events (hurricanes)
  - an extreme sea level rise (majority world population in coastal zones)
  - a reversal of the thermohaline circulation, of which the Gulf Stream is a part
  - a tidal wave due to large ice floes on Greenland & Antarctica breaking off into the ocean
  - substantial discharges of methane (with a 20 times higher warming potential than CO_2) from permafrost regions
  - ‘runaway carbon dynamics’ caused by positive feedback mechanisms in the biosphere
  - changes in climate subsystems such as the ‘El Niño Southern Oscillation’
  - climate-biodiversity interaction (scenarios with 50 % biodiversity loss)
  - acidification of the oceans and effects on marine life

- ➔ If such changes are moreover rapid/abrupt, then insufficient time for adaption, which contributes to high damage costs

… climate extremes

- The omission or incomplete treatment of potentially extreme and abrupt climate change and social-economic impacts is incomprehensible given that the *ultimate reason for worrying about and studying climate change* is – or should be – a concern for climate extremes that will fundamentally alter environmental conditions for humans and the rest of the biosphere
  - Our aim surely is not optimizing the climate or temperature for humans and their economy

- In fact, studies that have incompletely taken account of the extreme events should not be taken all too seriously, and the respective authors should be modest about the policy implications of their analyses

- Tol (2008) is an relevant example
  - lists many shortcomings of CBA and says that “dominance in this field is for want of challengers”, but then defends conservative CBA estimates and fiercely attacks the ‘challenging’ Stern Review

Other shortcomings of CBA of climate policy

- Neglect in existing studies of impact of climate change on:
  - human conflict
  - large scale biodiversity loss
  - economic development and human population/demography
- Supposed immediate adaptation due to assuming rational behavior by economic agents
- Neglect of any impacts beyond 2100 (in most studies)
- Most damage cost estimates for developing countries are of lower quality than those for developed countries
  - problematic since developing countries not only will suffer severely from climate change but also will be less able to undertake protection or adaptation
- Costs of illness, accidents and mortality of humans based on debatable monetary valuation assumptions (heavily skewed international income distribution)

Intermediate conclusion

- Too many reasons for not having much confidence in CBA of climate policy

  (even though CBA can be a very useful evaluation tool to support rational environmental policy or project decisions when uncertainty and time horizons are limited)

- Note: CBA has not been applied to the problem of acid rain (or at least this did not gain any significant attention in the literature and policy making)
  - acid rain has been subject to cost-effectiveness analysis (RAINS , IIASA)

Cost of safe climate policy

- The notion of policy cost is not very clear as the policy scenario and the benchmark are a matter of choice and surrounded by uncertainty

- Safeness is neither clear
  - Pre-Industrial Revolution concentration 280 ppm CO2e, currently 385 ppm. We quickly approach safe concentration of 450 ppm: (cheap) opportunities to stabilize at safe level disappear. Beyond 450 ppm risky. Stabilisation at 550 ppm considered feasible
  - Some observers: 2000 ppm in several centuries if available fossil fuels are burned, most likely scenario peaking at 1200 ppm in the next century, other estimate peaking at 1400 in three centuries (Gowdy, 2008; Kump, 2002; Kasting, 1998)
  - IPCC possibly overly cautious – aerosols cooling, ¼ of temperature rise (PNAS Sept 2008)

- An important uncertainty is the residence time of CO_2 in the atmosphere
  - No clear estimate in IPCC reports: very uncertain, considerable increase in recent studies
  - Montenegro et al. (2007) "about 75% of CO_2 emissions have an average perturbation time of 1800 years and the remainder has a lifetime much longer than 5000 years"
  - Matthews and Caldeira (2008): to stabilize atmospheric concentrations, anthropogenic emissions will have to be reduced to zero for decades to possibly centuries
  - Schellnhuber (2008): "... we are still left with a fair chance to hold the 2°C line, yet the race between climate dynamics and climate policy will be a close one. The odds for avoiding DAI [dangerous anthropogenic interference] may be improved by aerosol management ... (taking the warming components such as black carbon out first)."

Estimates of climate policy cost

- ➔ IPCC (2007) synthesizes (stabilisation at 535–590 CO_2e ppm): *cost estimates range from slightly negative to 4% of global income*

- ➔ Various studies offer systematic comparisons and meta-analyses of cost estimates of climate policy (Repetto and Austin, 1997; Barker et al., 2002, 2006; Fischer and Morgenstern, 2006; Hawellek et al., 2007; Söderholm, 2007)

- ➔ Studies vary
  - Indicators of policy cost (compliance costs, carbon price, loss in GDP growth, equivalent variation)
  - Systems engineering, general equil. & econ. growth models

Estimated costs of climate policy differ

- ➔ Structural model characteristics, notably substitution options (fuels, products), level of technological detail
- ➔ Technical progress comes out as a crucial factor
  - – Lower policy cost if endogenous/induced technical change
  - – Higher cost if knowledge spillovers across sectors neglected
- ➔ The design of climate policy (MBI, CAC, etc.)
- ➔ Use of carbon tax revenues
  - – revenue recycling in the most neutral way (lump-sum rebates) or reducing labor market tax distortions (double dividend)
- ➔ The inclusion of non-market costs and benefits

14 perspectives on the cost of climate policy

1. Extrapolation of learning curves for renewable energy

- Solar PV as ultimate solution to climate problem
- Learning curve solar PV looks promising
- Extrapolation of learning curve leads to middle estimate of US$60 billion with an uncertainty range of US$30-300 billion (subsidy over fossil fuel costs) (Van der Zwaan and Rabl, 2003, 2004)
- Possibly overestimation given rise in fossil fuel prices since 2007
- Concentrated solar heat power (CSHP) seems a neglected technology

- Provisions
  - No problem-free renewable source (wind turbines, water power, biofuels). Solar technologies (PV and CSHP) offer many advantages
  - Large share of labor population may end up in energy and delivering sectors (low EROI)
  - Cost decreases are no free lunch, but require investments in private and public R&D and public policies like subsidies
  - Sensitivity of extrapolated costs requires careful monitoring of cost dynamics and appropriate adjustment of incentives (e.g., subsidies)

2. Global climate policy cost normalized by OECD GDP

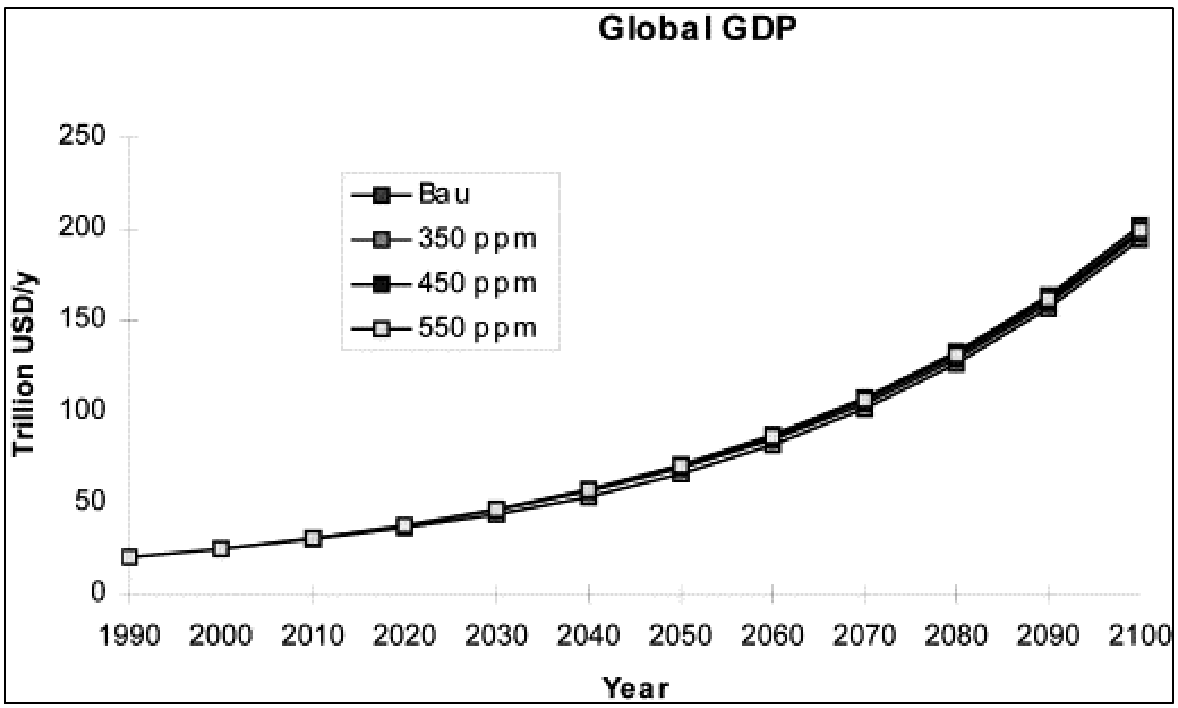
- ➔ If solar PV investment spread over 10 years, 0.017 % of OECD GDP (with uncertainty range 0.008 – 0.17 %)

- ➔ If policy cost range of IPCC used (1– 4 % of world GDP) then cost to OECD for first 10 years 1.8 – 7 % of GDP and then rapidly falling 0.017 %
  - consistent with the proposal of Sandéna and Azar (2005) to enter a decade of experimentation with low carbon technologies
  - The 4 % is quite a high estimate, and it is likely that the 1 % estimate is a more reasonable order of magnitude, giving for OECD on average 1.8 % for ten years

- ➔ An alternative is to allocate costs proportional to country GDP or country per capita GDP, which simply will mean higher costs for some and lower costs for other OECD countries

3. Delayed GDP growth

- If GDP growth is 2 % per year, and the cost of climate policy ranges from US$1 to 20 trillion (0.5-10 % of GDP at the end of period) then the delay time to reach a certain GDP within about a century from now will be about ¼ of a year to 5 years (Azar & Schneider, 2002)
- So stringent climate policy has a marginal long term effect on growth
- Will people living around 2100 worry whether they have an approximately $(1.02)^{100} = 7$ times higher income in 2100 or just a few years later?



Source: Azar & Schneider (2002)

4. Happiness instead of GDP

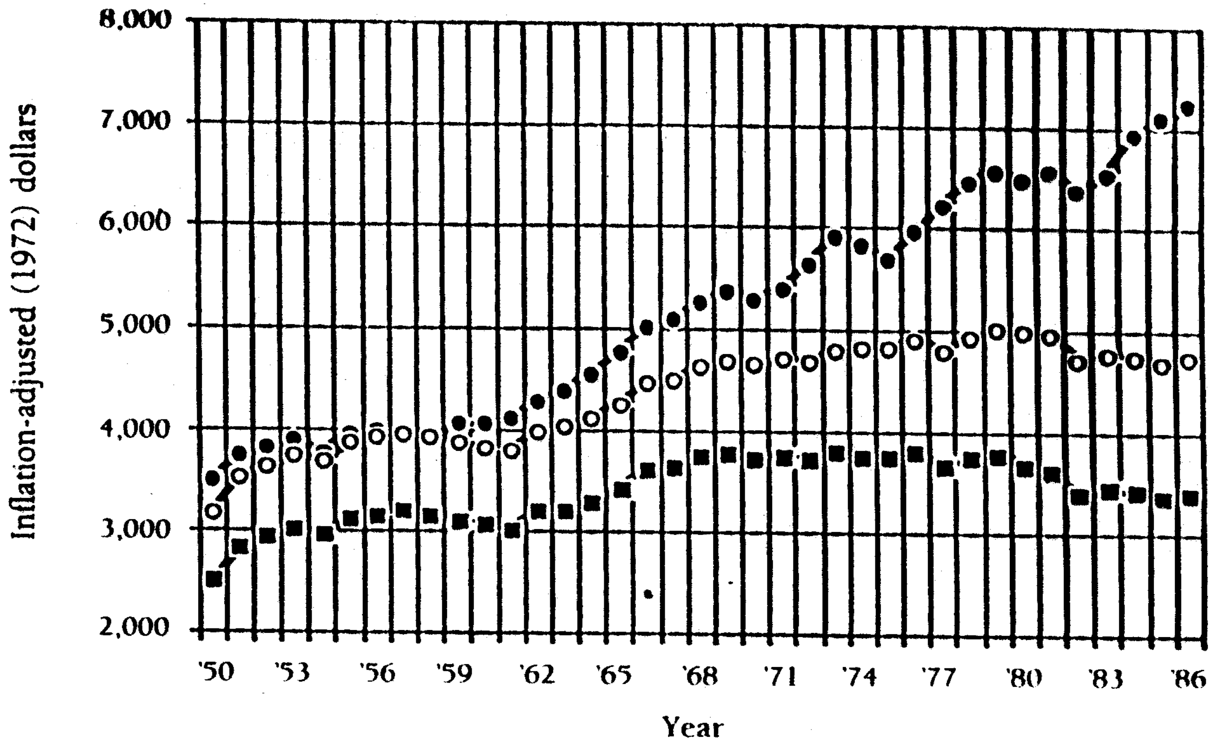
- Stylized facts
  - GDP not a good measure of happiness – cost of market activity, not benefit (*shift of informal to formal economy, damage to environment and reducing resource stock, cost of compensating damage to environment and health*)
  - Happiness/subjective well-being and corrected GDP (ISEW) delinked from GDP growth: threshold income ('Easterlin paradox')
  - Status seeking/relative welfare (zero sum rivalry game), adaptation, other happiness factors than income, large fixed component (personality)

- Less GDP growth due to stringent climate policy translates into a smaller loss in happiness terms, as GDP growth in rich countries does not or hardly raise happiness
- Impact of climate change (no climate policy) on GDP underestimates impact on happiness (non-market effects), especially in poor countries

- Provision
  - People may adapt to a changed climate in the sense of being initially affected (negatively) in their happiness, while later slowly regaining their old happiness level. Adaptation to extreme climate change is nevertheless unlikely.

GDP vs. Index of Sustainable Economic Welfare
(USA, 1950-87)

Figure A.1: Alternative Measures of Economic Welfare



-●- PC-GNP stands for per capita Gross National Product.

-■- PC-ISEW stands for per capita Index of Sustainable Welfare.

-○- PC-ISEW* is PC-ISEW excluding columns T and U in table A.1.

Source: Daly & Cobb (1989)

5. Comparison with large public investments

- ➔ Making solar PV competitive comes down a total cost with a central estimate that is 2 % and an uncertainty range of 1 – 6 % of the estimated cost of the Irak war (only) for the USA (US$3 trillion)
- ➔ Or compare with the cost of governmental responses to the financial crisis, especially since these, like climate policy, respond to a severe threat
  – cost OECD possibly order of magnitude US$2 trillion (including guarantees)
- ➔ Per year, the world invests more than twice the central estimate of the cost of making solar PV competitive (US$60 billion) on military research (US$140, of which US$85 by the USA).
  – If the solar PV investment is spread of 10 years, then it would cost only 5% of world expenditures on military research in the same period
  – In two years the world spends ± US$300 billion on military R&D, equivalent to the upper limit estimate of R&D investments to make solar PV competitive
  – *Note:* private/civilian spending is estimated to be roughly ten times the expenditures on global military R&D

6. Ancillary benefits

- Reduction of GHG emissions can go along with co-benefits, notably
  - less emissions of acidifying substances (NO_x and SO_2)
  - avoidance of human conflict due to climate change
  - omitted large scale biodiversity loss due to shifting climate zones
  - (new energy sources – renewables) moderate energy resource scarcity, enhance energy security, help avoiding fierce oil peak shocks
  - adaptation options due to mitigation activities (forestation to capture CO_2 provides wind/flood protection)
  - shifting taxes from labor to environment may create modest employment benefits due to less tax distortions in labor markets

- Certain studies of climate policy cost take some of these ancillary benefits into account, but most studies do not or partially/imperfectly

… ancillary benefits relating to energy markets and security

Table 8.6 **The Social Costs to the U.S. of Monopolization of the World Oil Market 1972–1991[a] (billions of dollars)**

Year	Wealth Transfer to OPEC	Costs of Strategic Petroleum Reserve	Total GNP Loss	Military Costs[b]	Total Costs
1972	0	0	0	14.2	14.2
1973	3	0	17	14.2	34.2
1974	35	0	189	14.2	238.2
1975	35	0	177	14.2	226.2
1976	37	0.413	157	14.2	208.6
1977	46	0.589	167	14.2	227.8
1978	39	4.182	141	14.2	198.4
1979	60	3.954	219	14.2	297.2
1980	76	(2.63)	321	14.2	408.57
1981	64	4.382	301	14.2	383.5
1982	42	5.096	204	14.2	265.3
1983	33	3.046	147	14.2	197.3
1984	34	1.064	134	14.2	183.3
1985	27	3.299	103	14.2	147.5
1986	11	0.141	53	14.2	78.3
1987	18	0.194	61	14.2	93.4
1988	12	0.793	42	14.2	69.0
1989	19	0.546	49	14.2	82.7
1990	25	0.826	53	14.2	93.0
1991	15	NA	37	14.2	66.2[c]

Green and Leiby (1993)

7. Behavior, learning and substitution

➔ Behavior and overestimation of climate policy cost

- aggregation in models for policy cost assessment hides substitution and adaptation opportunities for economic agents
- realistic bounded rationality, including psychological factors, missing in most economic models
- many ways of individual, group and system learning underrepresented in formal models

➔ Provisions

- some types of bounded rationality may lead to higher estimates for certain policy cost categories than rational agent assumption
  - but then additional policy can aim at changing such behavior – energy gap
- good translation of insights from behavioral to environmental, energy & climate economics lacking – consumers (status, imitation, habits) & producers (routines, myopia)

8. The current cost of energy is fairly low

- For the UK in 2000 the cost of lighting was 1/3000 of its 1800 value, while during the same period income (spending power) increased 15 fold. The share for only light services dropped between 1800 and 2000 with a factor 5/9 (Fouquet & Pearson, 2006)
- Energy intensity (energy input/monetary output) dropped > 30 % since 1970
- Ratio of all energy expenditures to GDP since 1970s has been on average roughly 10 % or less, which is not high given that energy is fundamental input to all human-economic activity (*i.e. 90 % is spent on other things*)
- The sharp recent increase in the oil price did not give rise to social uproar
- Cost of oil was until recently low. Currently, oil price is 3 to 5 times long term average. From 1869 to 2007, average crude oil price (adjusted for inflation in 2006 US$) $21.66 per barrel, while 50 % of the time prices were below the median $16.71 (post-1970 equivalent indicators $32.23 and $26.50)
- All in all, system can handle higher energy costs (read: climate policy)

- Provision:
  - If the price of fossil fuel energy goes up due to climate policy, renewables will become more expensive since their production depends on fossil fuel energy inputs

Other perspectives

- ➔ Avoided climate damage costs
- ➔ Upward bias in *ex ante* estimates of regulation cost
- ➔ International cooperation and agreements
- ➔ Lack of insurance against climate change
- ➔ Stimulating a social-technical transition
- ➔ Climate and economic instability

Conclusions

- ➔ CBA of climate change overly ambitious
  - Has never been done for acid rain – arguably a much simpler problem
- ➔ Economists performing climate CBA should be modest when providing policy advice
- ➔ Better to focus economic research on cost(-effectiveness) of safe climate policy
- ➔ 14 perspectives provide *many reasons to believe that safe climate policy is affordable*
  - Difficult to say what is most important angle or what is outcome of summing up all perspectives (since not all quantifiable)
  - Some aspects deserve a concentrated research effort (e.g., *Happiness and climate, Low cost of energy? Climate policy effects under bounded rationality*)