Sustainability Transitions:
Economic Aspects and Policies

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Motivation: Two energy-related problems

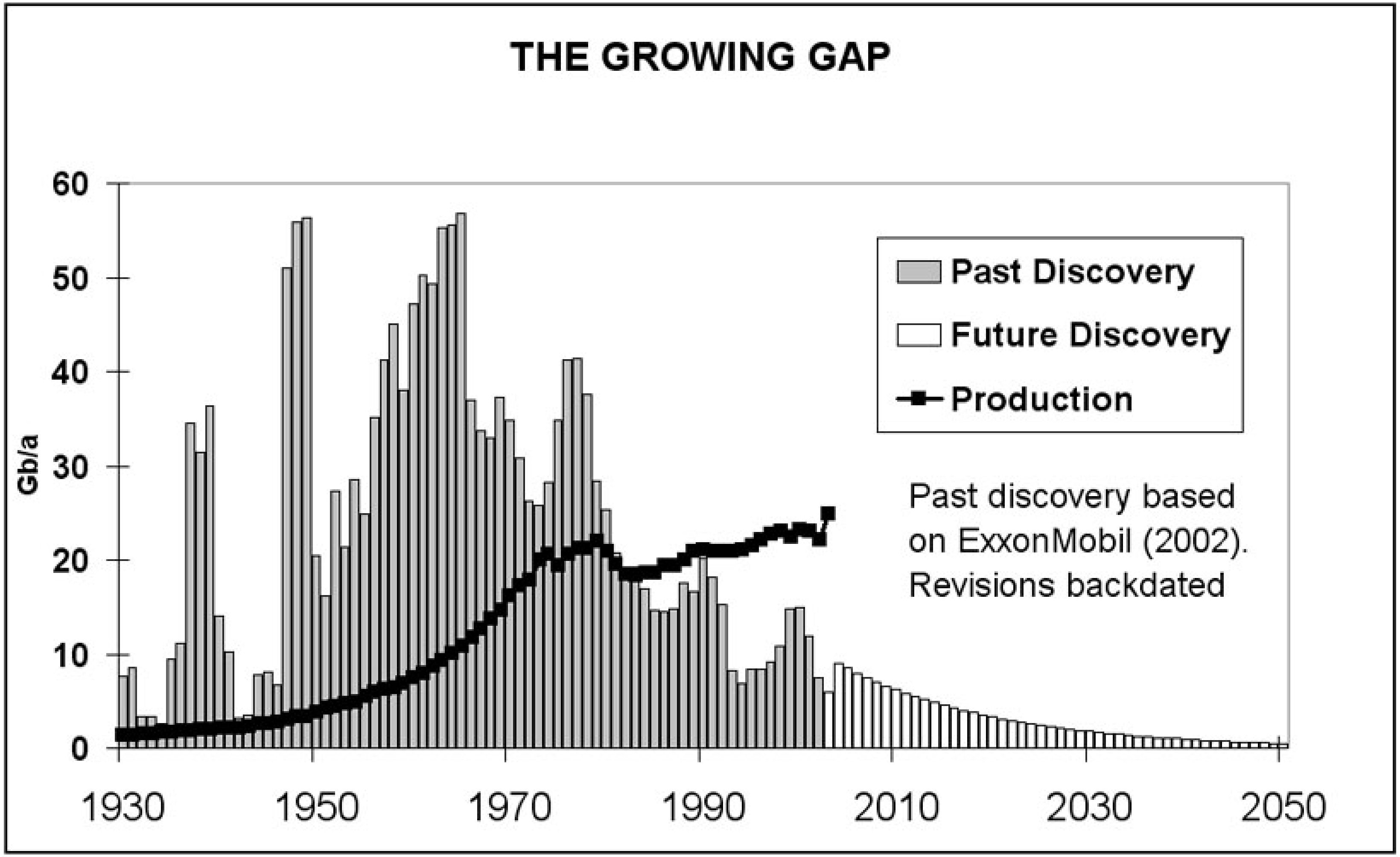
- ➔ Peak oil (& global energy demand rise): oil scarcity trend translating in steadily rising oil prices

- ➔ Global warming: long term social, economic, security and health risk - *fact, no hypothesis*
  - *Important (future) cause of biodiversity loss*

- ➔ Peak oil as a solution to global warming?
  - Coal and unconventional sources of oil (heavy crude oil, oil sands, and oil shale) generate many times more CO_2

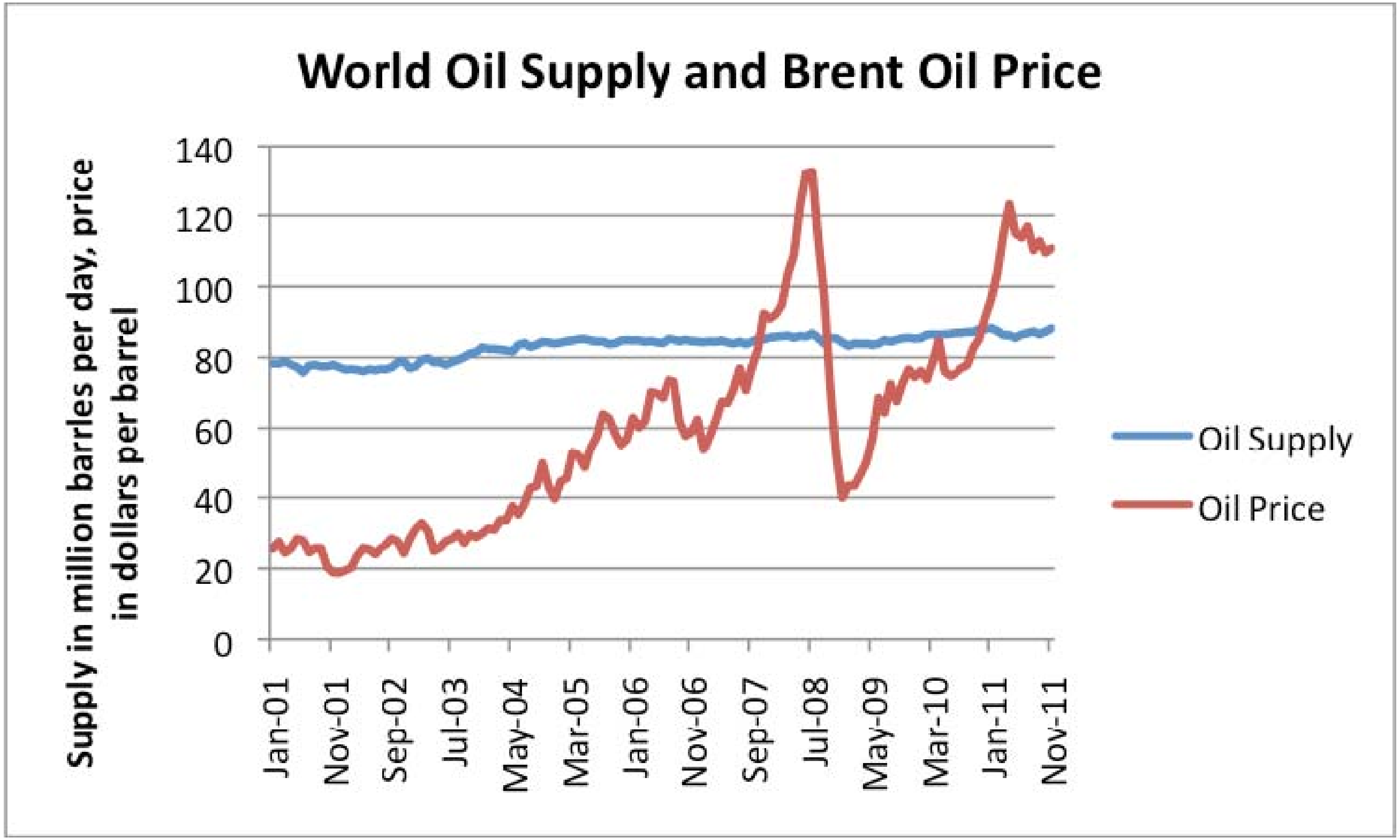
- ➔ Three strategies to reduce CO_2: Forestation, carbon capture & storage, less use of fossil fuels

Peak in supply of conventional oil



Source: Wikipedia.

Supply and oil price

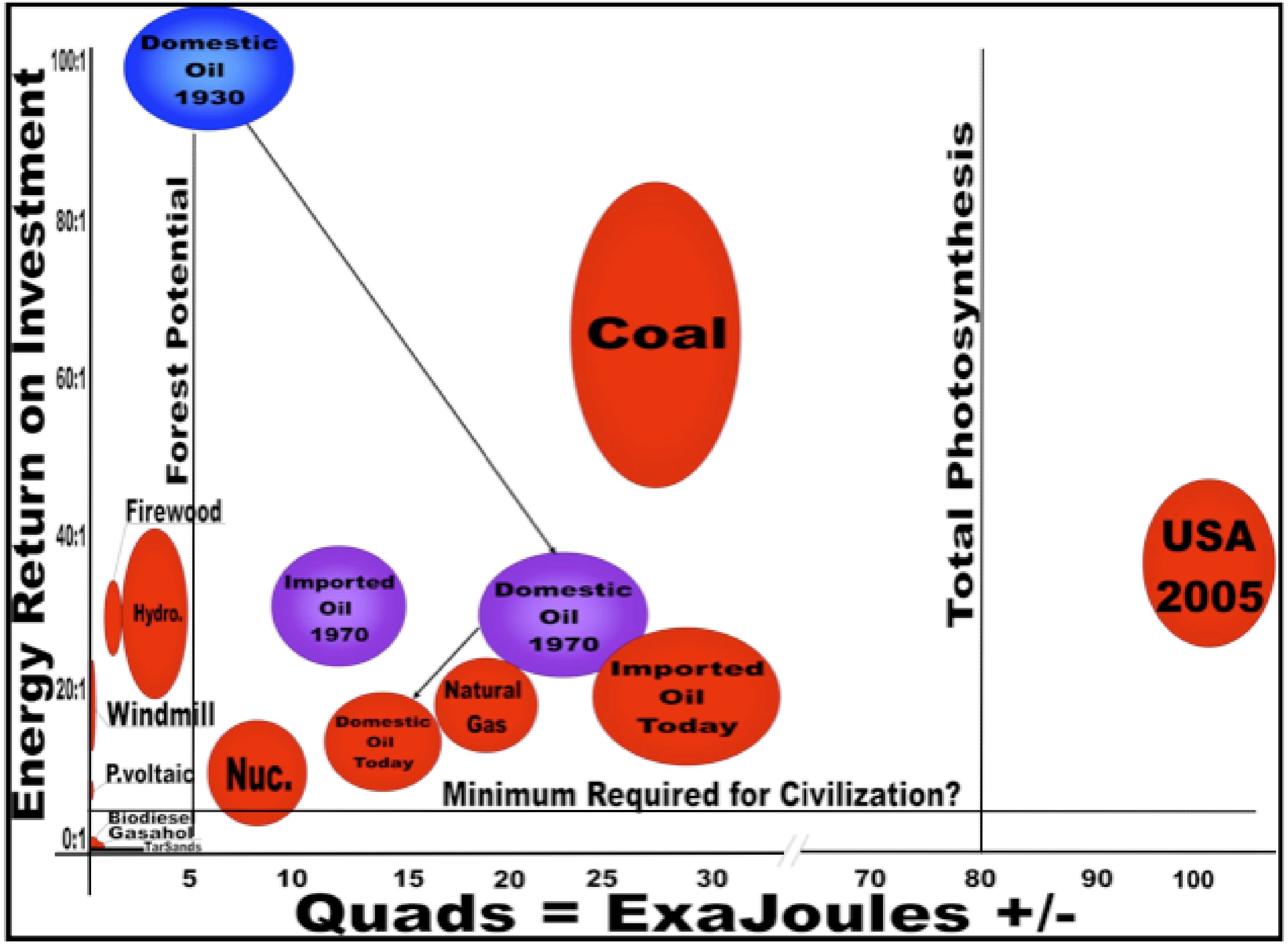


Source: http://www.euribor.com.

A few energy facts to "warm you up"

- UK 2000 cost of lighting was 1/3000 of 1800 value, while spending power increased 15 fold. *But we spend about half.*
- Energy intensity (energy input per monetary output) has dropped by > 30 % since 1970s – but total use has gone up.
- The ratio of all energy expenditures to GDP since the 1970s has been on average roughly 10 % or less.
- The economic crisis may have been triggered by unprecedentedly high oil prices in 2008 (or causality reverse?).
- If the price of fossil fuel energy goes up due to climate policy renewable energy will become more expensive as well since its production depends very much on fossil fuel energy inputs.
- If we tax CO_2 oil prices will not go up to the same extent as we will indirectly tax oil producers (OPEC).

Energy return on energy investment



Source: Hall et al. (2009)

Energy in production: innovation vs. substitution

- $Y_t = A_t L_t^{\beta_{1t}} K_t^{\beta_{2t}} E_t^{\beta_{3t}}$

- E_t is environmental or energy input (or waste output)
- Change in A_t is neutral technical change
- Change in β_{3t} represents environmental innovation
- Changes in *Lt*, *Kt*, *Et* for given parameter values mean factor substitution

Contribution of technical innovation

- ➔ High hopes/expectations: main solution, cheap, a substitute for environmental regulation

- ➔ Cost savings modest:
  - Jorgenson et al. (2008) CGE study of USA: Over 2025–2040, induced technical change (ITC) reduces cost of econ. adjustment by 7–8%
  - Azar et al. (2006) dynamic optimiz. world model: Innovation reduces NPV of abatement costs with 7-17 %
  - These magnitudes are consistent with other studies (Goulder, Nordhaus, Wing)

- ➔ Using energy-related patents as proxy for energy innovation, Popps (2001): 1/3 of overall response of energy use to prices is due to induced innovation, and 2/3 to factor substitution.

- ➔ But:
  - Past studies based on weak environmental regulation – future different?
  - After 2040/50 a transition needed? Only feasible with innovation
  - Initially CO_2 emission reduction by changing behavior firms/consumers

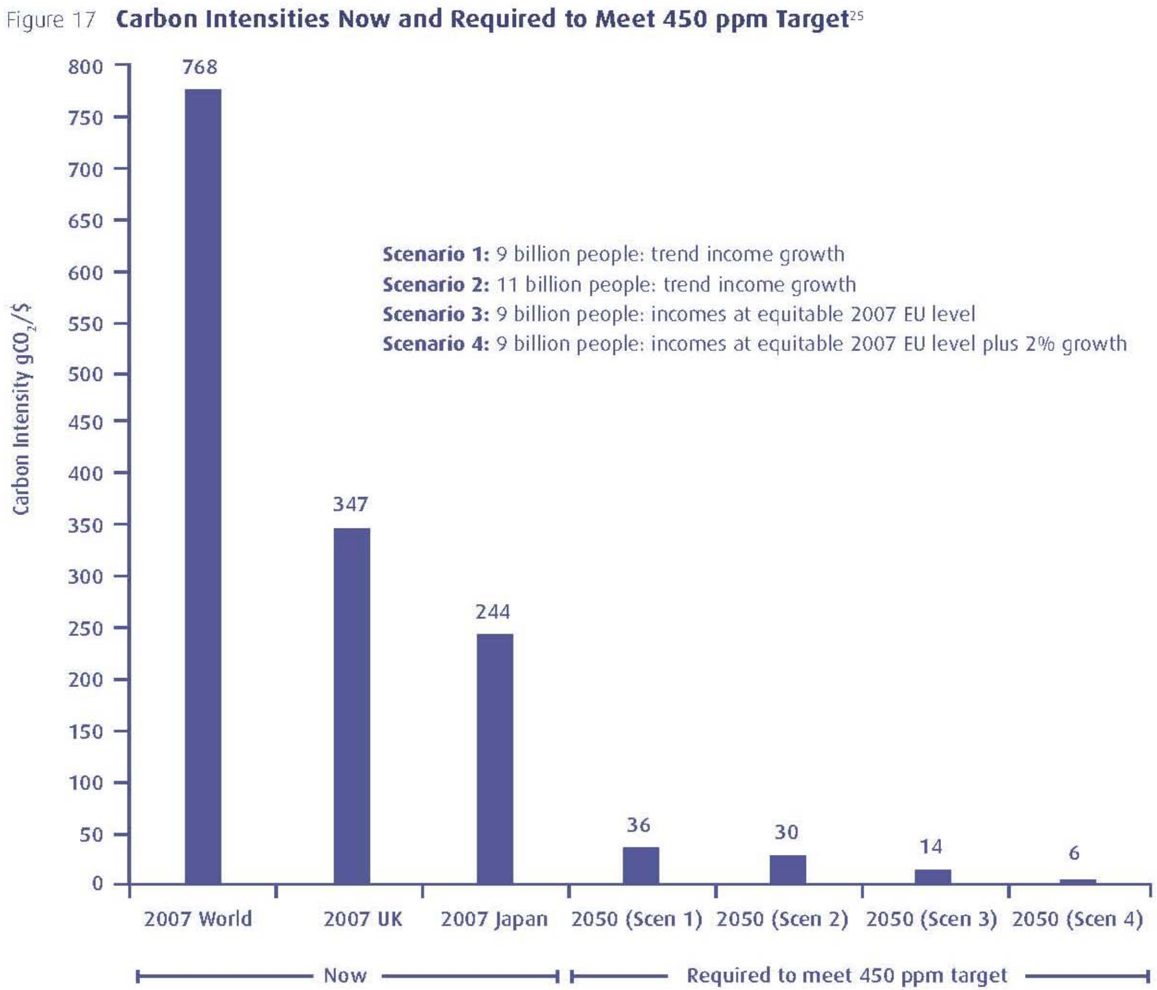
Sustainability transition and economic growth?

- ➔ Traditional view: Knowledge crucial production factor
- ➔ *World Bank* composition of capital illustrative:
  - – low-income countries 58% intangible (human capital and informal institutions), 16% produced, 26% natural capital
  - – OECD 80%, 17%, 2%, respectively
- ➔ *Economics:* 1950s “Solow residual”, 1980s endogenous growth theory

- ➔ But Ayres/Warr (2009), IMF (2012) & others: energy much more important factor of historical economic growth
  - – Among others because of wrong measurement – money vs. exergy, different weighting of qualities of energy use, “factor cost share fallacy”
- ➔ Towards a service economy? computer chip very pollutive (per kg)
- ➔ Energy use and CO_2 emissions relatively high in sectors that contribute much to growth – potential conflict between environmental and growth objectives

Decoupling requirement is astonishing:

Factor 20-100 reduction in emission/energy intensity



Source: Jackson (2009).

My main concern: 3 *escape routes*

- Indirect and avoidable effects of well-intended strategies and policies: *undercut their effectiveness*

- *Carbon leakage of unilateral policies:* shift in location of dirty industries and adaptation of dirty trade flows (happened with ETS – aluminium and cement industries)

  => International climate treaty needed

- *Rebound of energy conservation* - incomplete set of technical standards or voluntary action

- *Green paradox*: market subsidies to renewables interact with oil market - may increase CO_2 emissions

Rebound: examples, reasons and policy

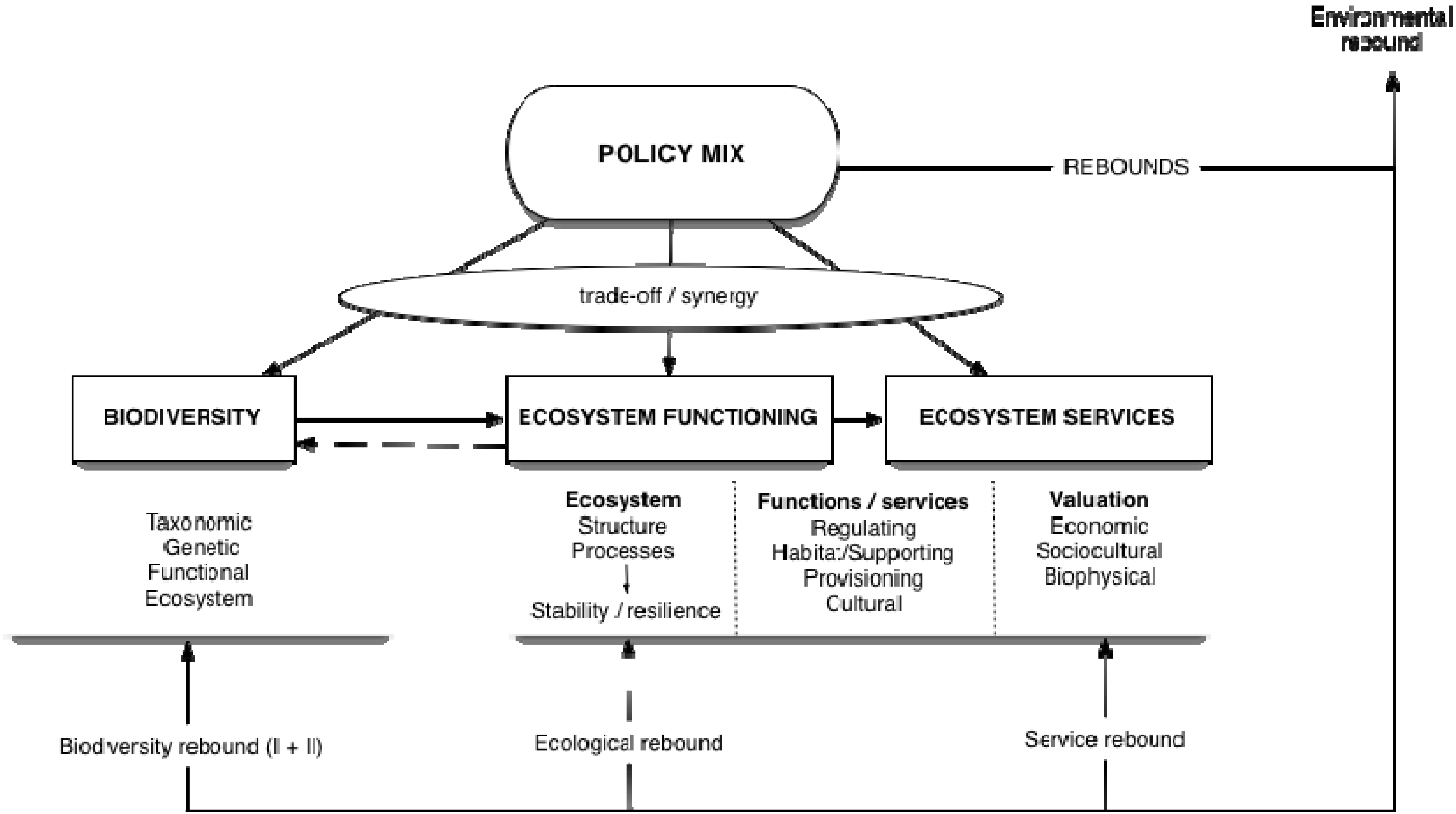
- ➔ More intensive use of efficient energy-consuming equipment
- ➔ Purchase of larger units or units with more functions
- ➔ Re-spending financial savings due to conservation
- ➔ Purchase of new device that embodies energy

- ➔ In addition changes in: energy price, factor input mix, transport, trade/re-location, preference change due to innovation – *all affect energy use*

- ➔ Fundamental reasons for rebound:
  - Improved efficiency in effect relieves *limits on available energy*
  - Diffusion of more efficient *general purpose technologies*
  - *Bounded rationality* of individuals and firms – *despite good intentions*
  - Solutions usually create more *complexity* and energy use *(Tainter)*
  - *Cost of dirty energy* too low

- ➔ Energy conservation best induced by higher energy prices and associated higher product/service prices => *complete system control*

Biodiversity policy – also rebound



Which transition policy?

- ➔ Only carbon pricing – but problem of *lock-in*:
  - – reinforces early lock-in of currently cost-effective technologies
  - – learning potential of alternatives is neglected
  - – incremental innovation more attractive than radical innovation

  => Technology-specific policies help escape from lock-in & guide alternative technologies

- ➔ Only technology support – but *green Paradox*:
  - – in the absence of a carbon tax, effective subsidizing of renewables stimulates increase in extraction of fossil fuels
  - – moreover, net energy cost down and thus energy demand up

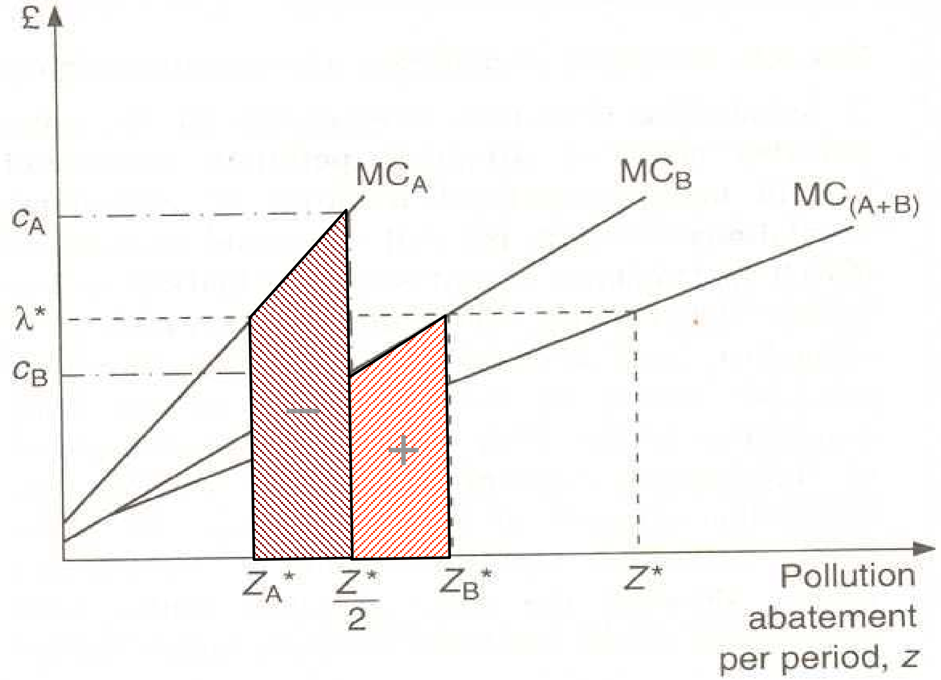
  => “supply policy” needed – cap/price fossil fuel extraction (Sinn, 2008, ITPF)

- ➔ Innovation (policy) no substitute for environmental regulation: *both needed* (conclusion not original but additional arguments)

The power of *pollution prices*

- *(Alternative instruments:* emission or technical standard, subsidy, 'moral suasion'*)*
- Price instruments cost-effective – equalize marginal abatement costs among polluters: *cost-effectiveness contributes to social/political acceptability*
- Subtle and complete control: all goods & services will have prices in proportion to pollution generated over their life-cycle - *no rebound, no green paradox (oil prices will go up)*
- Price represents a continuous incentive for both technology adoption and innovation: Environmental innovation trajectories are misguided if prices wrong
- (Choice between *taxes and tradable permits* - much debate)

Standard versus charge: fairness or efficiency



MC_A = Marginal cost of abatement of firm A
MC_B = Marginal cost of abatement of firm B
MC_{A+B} = Combined marginal cost of abatement for industry, A + B

$$Z_A^* + Z_B^* = Z^*$$

$$2\left(\frac{Z^*}{2}\right) = Z^*$$

Empirical considerations

- ➔ Empirical evidence for the role of prices is strong (econometric studies):
  - – Price critical factor in purchase choices by firms and consumers.
  - – Energy prices have the largest inducement effect on innovation (patents)
  - – When energy prices stable less, and after oil price hike more, innovation to make equipment more energy-efficient

- ➔ Additional instrument: *information provision* – to help polluters respond "rationally" to price incentives: technology adoption decisions more sensitive to up-front than to long-run operating costs (energy use) – *high implicit discount rate*

- ➔ Subsidies - *but where? R&D* often contributes more than *market learning* to cost reduction of env. technologies (Popp et al. 2009).
  - – *Germany* 50 billion subsidies for PV market in past 10 years

… more policy: Escape from *dominant, locked-in* technologies & fossil fuels

- ➔ *CO_2 price essential but insufficient*
- ➔ *Many suggestions in the literature: Set clear future goal, Semi-protected niches, Public procurement*

- ➔ More radical policies may be considered as well:
  - *Discourage innovation & learning in dominant technology:* combustion engine and car industry
  - *Employ status seeking:* hybrid car, solar panels on houses
  - *Restrict current advertising aimed at status sensitivity of consumers:* cars with oversized engines, exotic holidays and plane flights

- ➔ … not because of ideology - findings of “happiness studies”
  - Easterlin paradox: status zero sum-game and adaptation

Conclusions

- Role of CO_2/GHG pricing crucial crucial for a sust. transition
  - Necessary for complete system control, avoiding escape routes
  - Will stimulate behavioral change of producers/consumers, & innovation
  - Post-Kyoto treaty essential – unilateral and voluntary policies ineffective
- Additional instruments: technology policy, information provision, regulating advertising, and channeling status seeking
- Decades of R&D and technological diversity - transition in 2050
  - *Patience difficult* – but avoid large renewable energy market with outdated technology
- Integration macroeconomics and transition thinking:
  - How to realize a sustainability transition in times of crisis?
  - Less focus on growth (“a-growth”): Sustainable economy will grow less
  - Transition to renewable energy: environmental but no economic logic

Environmental Innovation and Societal Transitions

(EIST)

www.elsevier.com/locate/eist