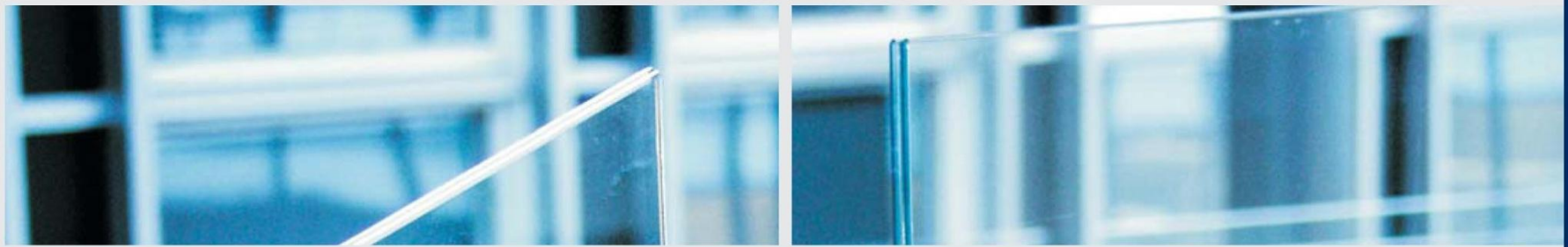


Futus 2a: The technological dimension of sustainability



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Technology – some definitions

- the practical application of knowledge especially in a particular area
- the branch of knowledge that deals with the creation and use of technical means and their interrelation with life, society, and the environment, drawing upon such subjects as industrial arts, engineering, applied science, and pure science.
- a manner of accomplishing a task especially using technical processes, methods, or knowledge
- the system by which a society provides its members with those things needed or desired

Technology – a little history

Paleolithic (2.5 million – 10,000 BC)

- Stone tools
- Fire
- Clothing and shelter

Neolithic through Classical Antiquity (10,000BC – 300AD)

- Metal tools
- Energy and transport

Modern history (0CE —)

- Simple machines (such as lever, screw, pulley)
- More complex machines (clock, engine, computer, space station...)
- Knowledge necessary to produce machines increases together with their complexity

Technology for sustainable development – some examples

- Scientific measurement and analysis identified the social, economic and environmental dangers associated with global changes in the climate and ozone layer
- Implementation of RE projects in developing countries (off-grid solar panels, micro-hydro...)
- Enhancement of communication and information flow between countries and continents (computers, mobiles, internet...)
- Other examples: your ideas!

The role of technology in SD – another point of view

- the classic definition of SD implies that the future generation should be able to satisfy their own needs
- Study material: *Huesemann M. and Huesemann J., Will progress in science and technology avert or accelerate global collapse? A critical analysis and policy recommendations.*
- Definition of environmental impact as: $I = P(T) * A(T) * T$

where: I = environmental impact

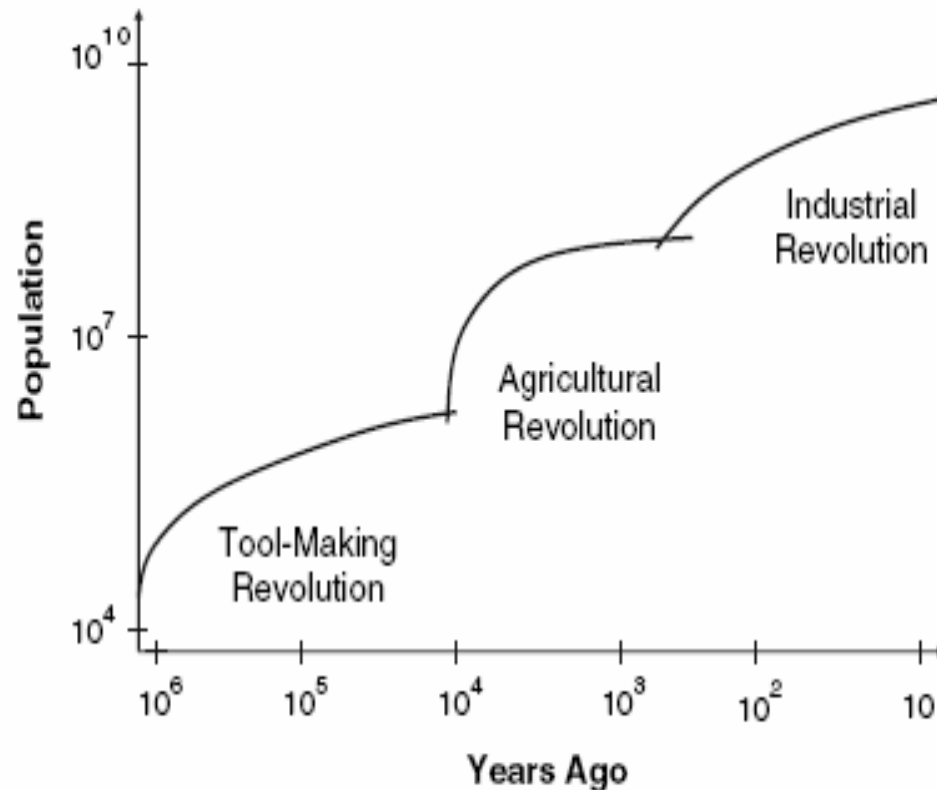
P = population size

T = impact of technology

A = affluence (or GDP/capita)

Technology and population size (P)

Fig. 1 Human population surges in response to three different technological revolutions. Please note logarithmic scale. Adapted from Deevey (1960)



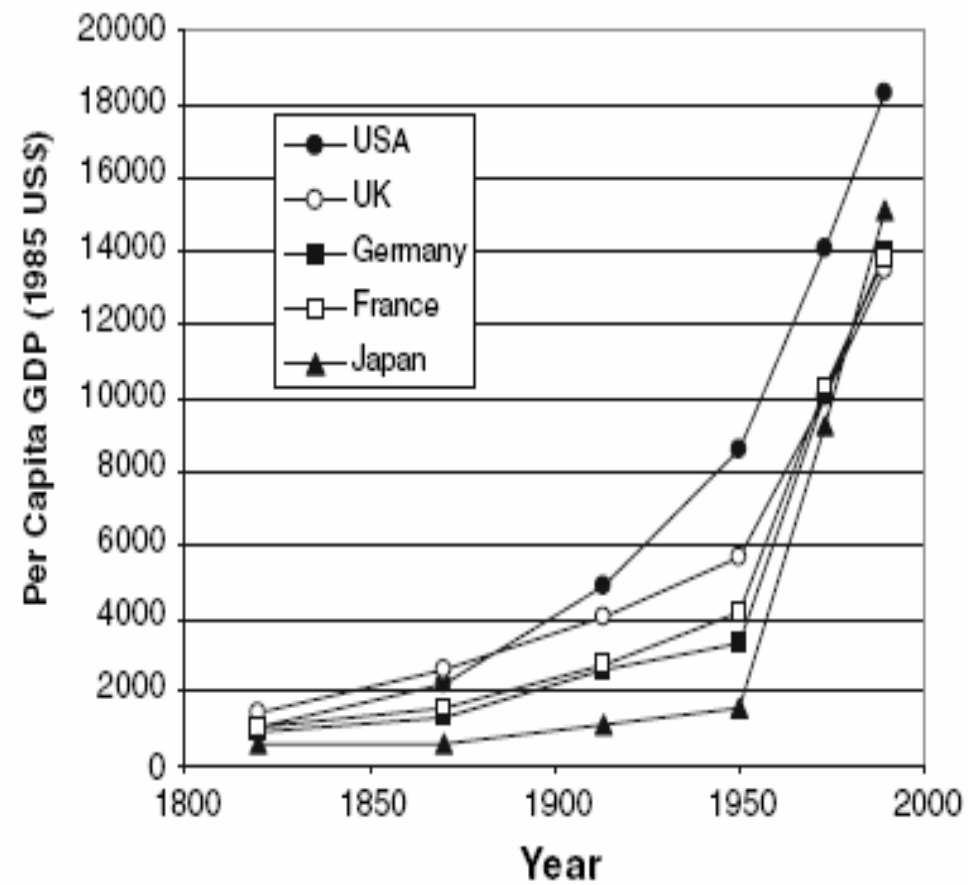
All of the three major increases in world population were based on improved access to energy.

Current access to fossil energy \rightarrow increased crop productivities both in terms of land and labor \rightarrow most recent and largest growth in human population.

Fossil energy stocks are non-renewable and likely to be depleted in the near future \rightarrow the current world population of more than 6 billion, much of which depends on fossil fuel inputs for food production, cannot be sustained indefinitely.

Technology and GDP/capita (A)

Fig. 2 Increase in per capita GDP from 1820 to 1989 in five industrialized nations
(Maddison, 1991, Table 1.1)

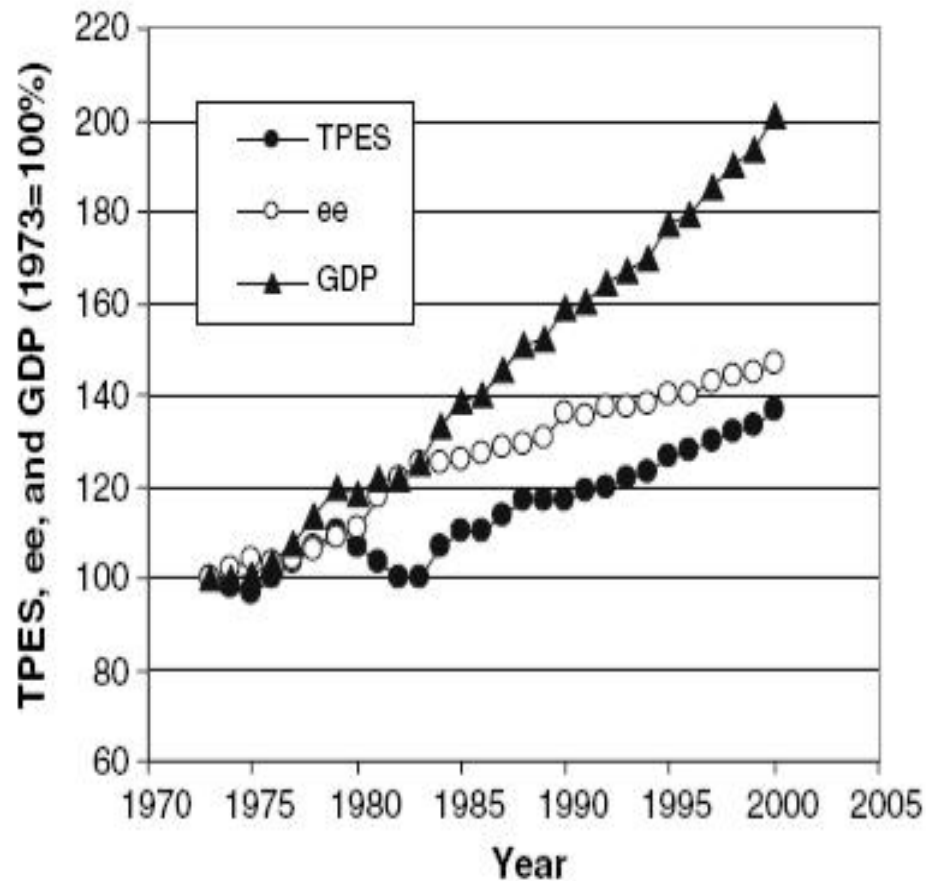


Rebound effect

- technological progress results in efficiency gains: business reduce production costs and therefore the price of goods is lowered. Consumer demand increases.
- This is not related to an actual reduction in resources consumption (example: car efficiency and fuel consumption)
- Four categories:
 - a) **direct rebound effects** (increased use of goods and services affected directly by their efficiency-induced price reduction), usually small 10-30%
 - b) **secondary rebound effects** (increased consumption of other goods and services as a result of real income increases), larger than direct effects, re-spending effect
 - c) **economy-wide effects** (price and quantity readjustments)
 - d) **transformational effects** (changes in consumer preferences, social institutions, and the organization of production)

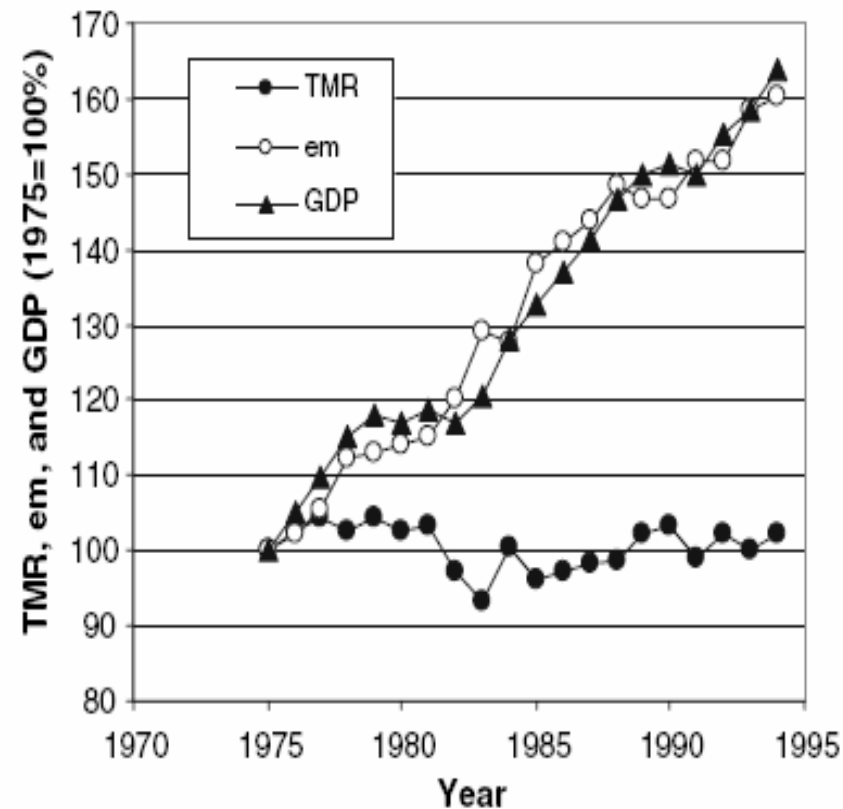
Efficiency and TPES

Fig. 4 Total primary energy supply (TPES, EJ), energy efficiency of the total economy (e_e), and gross domestic product (GDP, \$US) in IEA (International Energy Agency) countries from 1973 to 2000 (OECD/IEA, 2004)



Efficiency and Total Material Requirements

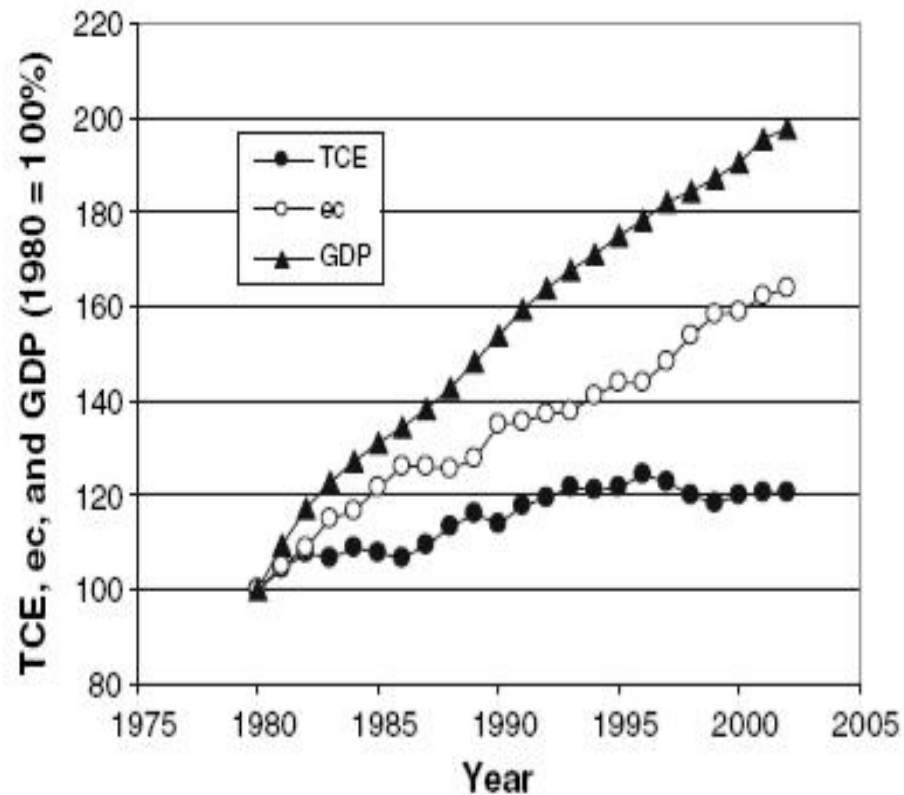
Fig. 7 Total material requirements (TMR, tons), efficiency of materials use for the total economy (e_m), and gross domestic product (GDP, \$US) in the United States from 1975 to 1994 (Adriaanse et al., 1997)



Technology and the carbon intensity of the economy

$$e_c = \frac{GDP}{Carbon} = \frac{1}{CI}$$

Fig. 9 Total amount of carbon emitted (TCE, Gt), efficiency of carbon use (e_c) for the total economy, and gross domestic product (GDP, \$US) in the United States from 1980 to 2002 (U.S. DOE, 2003; U.S. OMB, 2004)



Is substitution the solution?

- replacement of non-renewables with renewables would certainly promote long-term sustainability, but even RE technologies would have significant negative environmental impacts if deployed on the extremely large scales required to supply all products and services for the fast growing world economies
- No technological advance can create substitutes for the basic necessities, such as clean air, clean water and a functioning ecosystem
- technological breakthroughs and resource substitutions will certainly reduce energy and material requirements as well as pollution, but there is only limited potential for reducing the T-factor: there cannot be unlimited growth in population (P) and affluence (A) if the goal is the reduction of total impact (I). Thus, strategies for averting global collapse will not only require far-reaching technological innovation and significant efficiency improvements but also the stabilization of and ultimately reductions in both population size and per capita affluence.

Policy options suggested to avoid collapse

- Reverse population growth
 - a) increasing education for women
 - b) incentives for small families and disincentives for large ones
 - c) social security and universal health care
 - d) changing cultural norms regarding ideal family size

Policy options suggested to avoid collapse

- Improve efficiencies to reduce matter-energy use
 - a) change our current goal of unlimited economic growth to a reduction in overall matter-energy use, and apply technological innovation to meet this new objective
 - b) most common way to implement these policies: regulation and taxation

However: too much focus on efficiency as a way to achieve a sustainable future could conflict with other societal values such as freedom, creativity and aesthetics

Gains in efficiency will only result in greater sustainability if they are used to reduce the total matter-energy throughput rather than promote economic growth

Policy options suggested to avoid collapse

- **Stabilize affluence at sustainable levels:** in this new sustainable society, **qualitative development** would take precedence over **quantitative growth** in the consumption of goods and services.

While higher relative income of individuals is associated with greater subjective well-being at any given point in time, an increase in average affluence of entire nations (i.e., per capita GDP) over extended time periods has yielded no significant gains in happiness.

-human desires are insatiable

-consumption of positional goods loses its ability to raise social status as soon as many others are able to purchase the same status symbols

-the frantic pursuit of materialism deprives people of opportunities to receive more meaningful satisfaction from the numerous social, cultural, and spiritual activities that are well known to promote happiness and feelings of wellbeing

Effective methods of reducing material consumption to sustainable levels include the dissemination of information on ways in which needs and desires may be satisfied including the aspiration for higher social status, in non-materialistic ways.

Policy options suggested to avoid collapse

- two basic strategies for reducing total material consumption.
 - a) eliminating any type of consumption that is presently used to satisfy non-material needs (reduction of per-capita consumer expenditures by more than 50%).
 - b) remaining material needs for food, housing, health, and transportation could be met with less environmental impact if there were specific policies to promote “green” consumption alternatives. (example: switching from the current meat-based diet to a more vegetarian one)

Conclusions

- Society will move towards sustainability if total impact (I), expressed either in terms of energy and materials use or pollution, declines with time, i.e., $dI/dt < 0$. Conversely, society will approach collapse if $dI/dt > 0$.
- Your ideas about the policies described in the article
- Other suggestions?
- What is your point of view?