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Energy and material flows

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Sustainable Global Technologies: Part 2. Technology for development

- Content
  - Theoretical basis; ecological economics
  - Throughput economy and Factor targets
  - Material flow accounting and analysis
  - Eco-efficiency thinking
  - Material and energy minimisation, recycling, reuse

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Economics view on environmental problems

From the point of view of economics environmental hazards are products of the economy just like the products that enterprises produce. These negative products or by-products of economy that should be taken into consideration in economic analysis and decision-making.

Market mechanism can not take into account environmental by-products that has no market price. This leads to inefficient allocation of resources and functioning of an economy. There losses create welfare losses. Also an environmental policy can hardly be efficient if there is no linkage to functioning of economy.

In order to have efficient functioning of an economy, must these negative products have price tag so that they can be taken into account in decision-making and the total welfare of an society can be maximised.

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Branches of environmental economics

Neoclassical economics, welfare economics

Institutional economics

Ecological economics, including thermodynamic economics

Some theoretical foundations

- Theoretical foundations of Environmental Accounts can be found directly in the economics theory, especially from welfare economics.
- Market mechanism can not direct the environmental hazards if they lack prices. Also environmental policy is meaningless if is not connect to economic activities.
- Environmental hazards are products of economy as the ordinary products that companies manufacture. In order to increase the efficiency of production system we must take into account also these negative by-products of production in national planning and decision making.
- Only thus we can effectively increase the level of welfare that we are desire.

Social thermodynamics

Is mainly based on two basic laws of physics.

(a) conservation of energy and mass, which states that the amount of energy and materials stays constant in the universe, and

(b) the second rule of thermodynamics, that states that heat never flows from the cold to the hot. Generalisation of this is the entropy law.

=> in the universe the total amount of energy and materials remains constant, but the quality of energy and materials can deteriorate (exergy concept).

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Thermodynamic economics

Earth is open system regard to energy, but a closed system what comes to materials.

Functioning of biosphere is based on the utilisation of solar energy. Dissipative structures create through their processes high quality and useful environmental and natural resources. Functioning of economy is a reverse process to this.

= > Today global economy utilises these resources faster than they are generated in natural processes.

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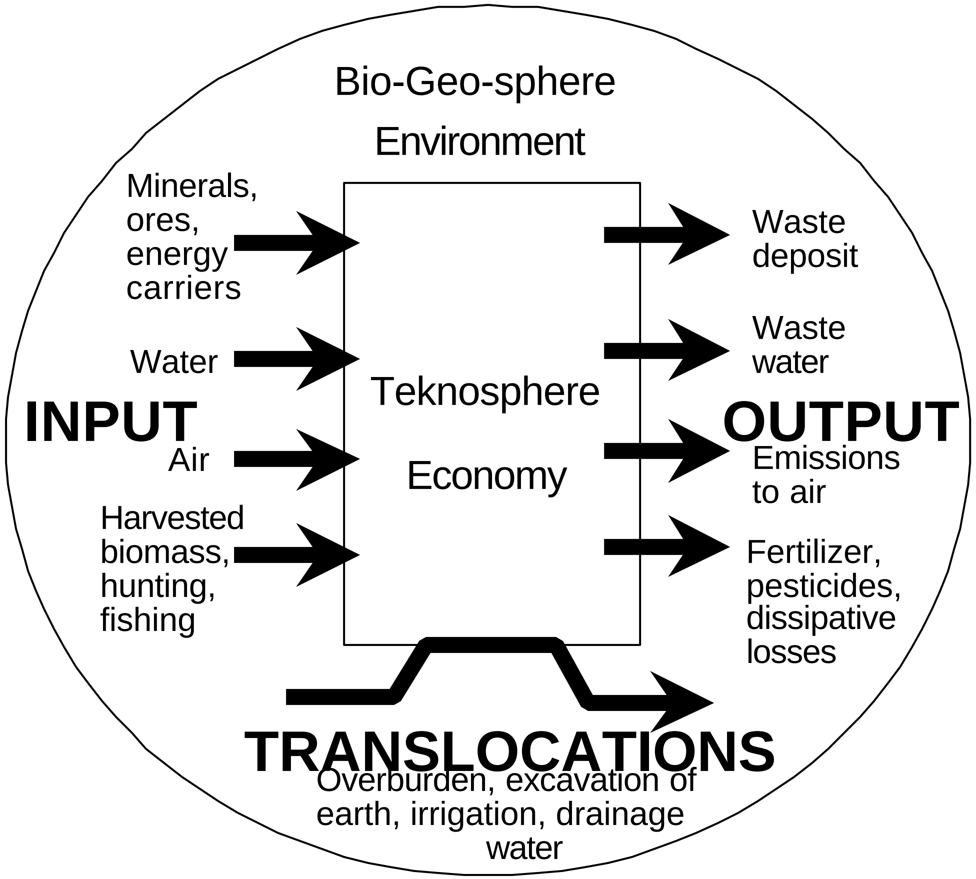
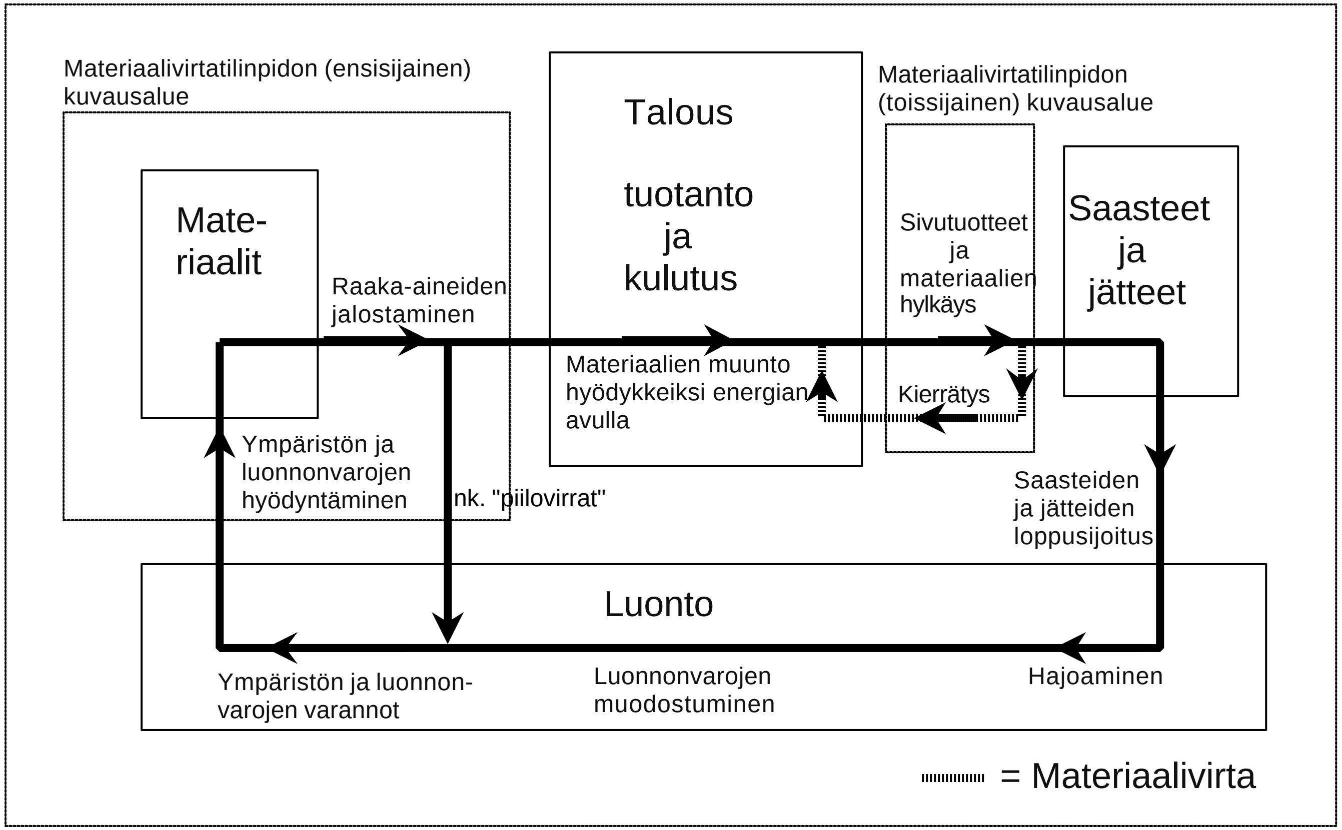
The throughput economy idea - basis of systematic material flow accounts



Closed cycle of materials and material flow accounting (MFA)



Exceeding the global limits

- WWF: World ecological footprint is 2.23 hectares per capita and the biocapacity only 1.8 hectares per capita. Thus world exceeds the sustainable level by 24 per cent.
- In Finland the ecological footprint is third highest in the world: 7.6 hectares per capita, but the biocapacity 12 hectares per capita.
- The northern location and natural resource intensive industries contribute greatly to Finnish ecological footprint.

Factor -targets

- **Factor 4** - an objective whereby the input of natural resources, raw materials and energy in each unit of production is to be reduced to one quarter of its current level in the medium term, i.e. over the next 20 to 30 years.
- **Factor 10** - This is an objective whereby the input of natural resources, raw materials and energy in each unit of production is to be reduced to one tenth of its current level in the long term, i.e. over the next 30 to 50 years.

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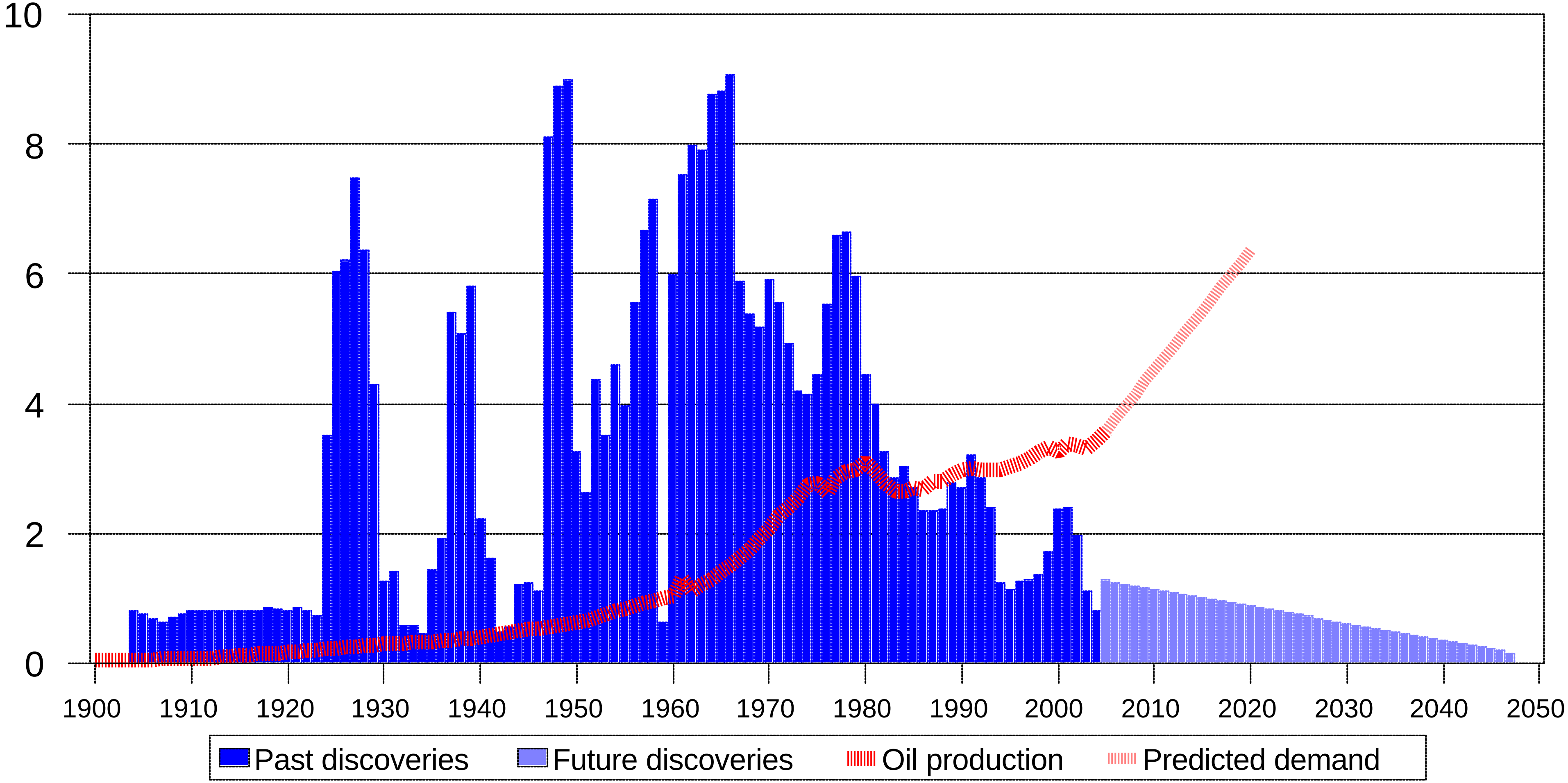
World oil discovery and production (billion metric tonnes)



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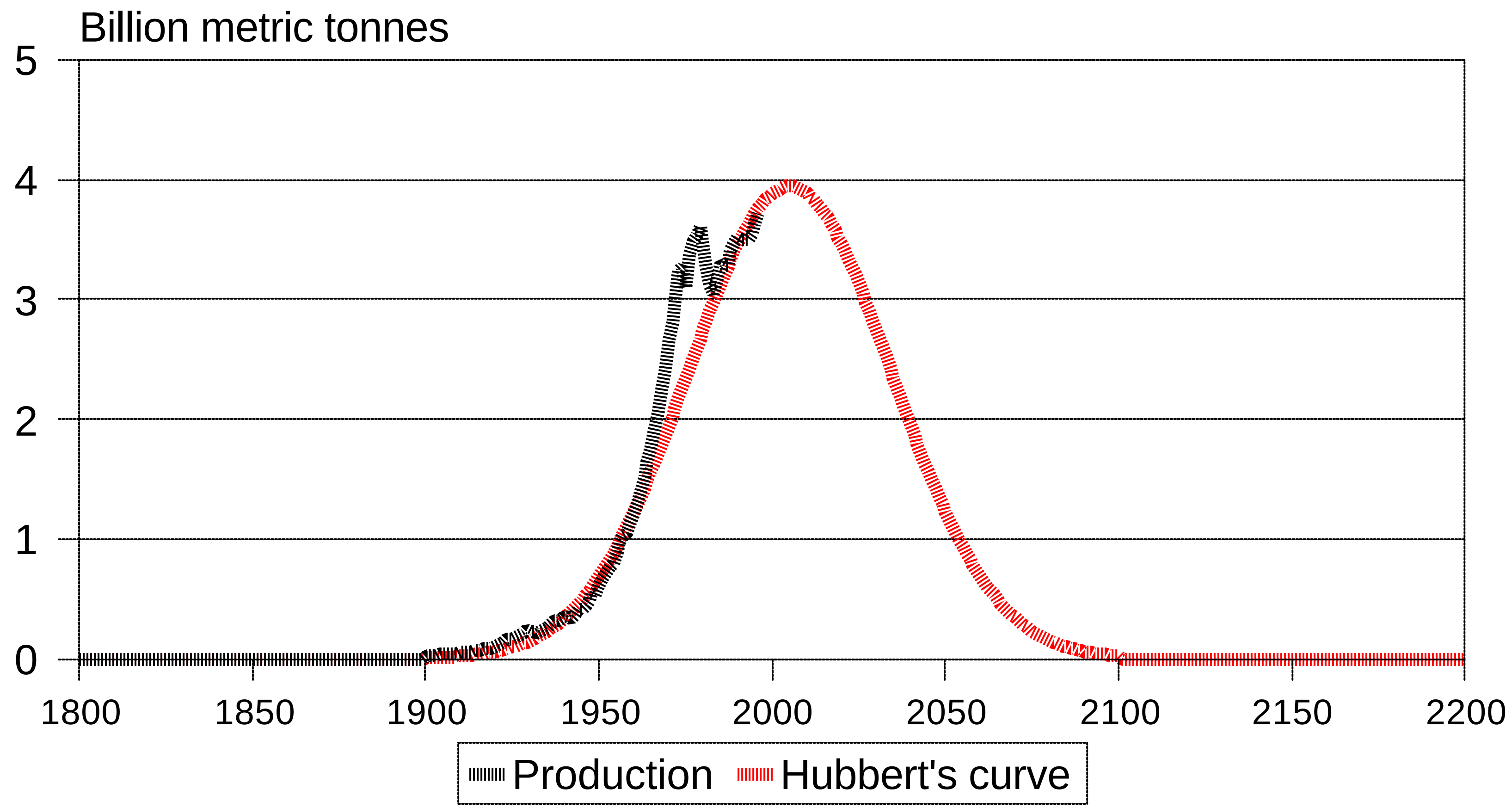
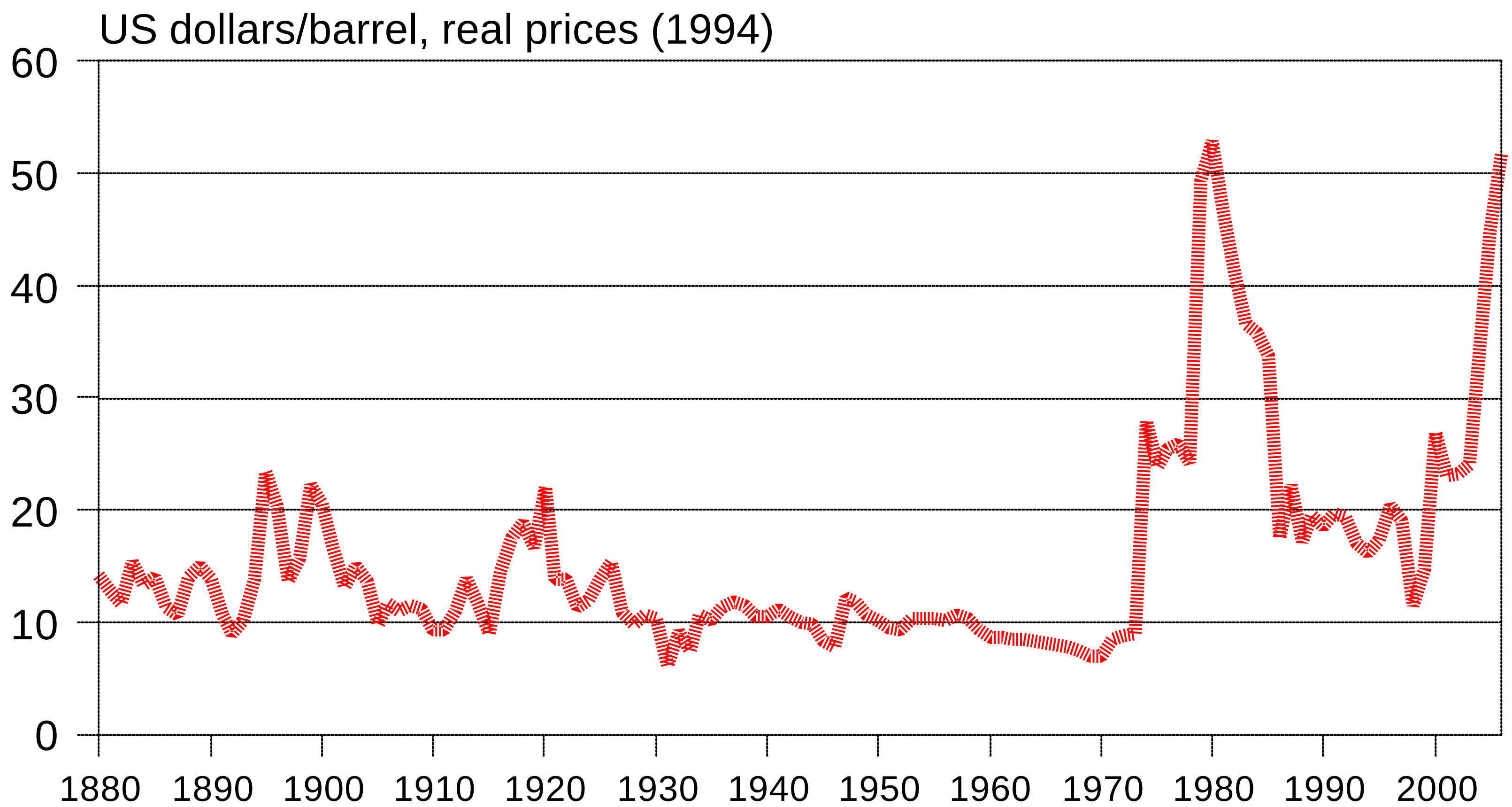
World oil production and peak oil



Real world market price of oil 1890-2005



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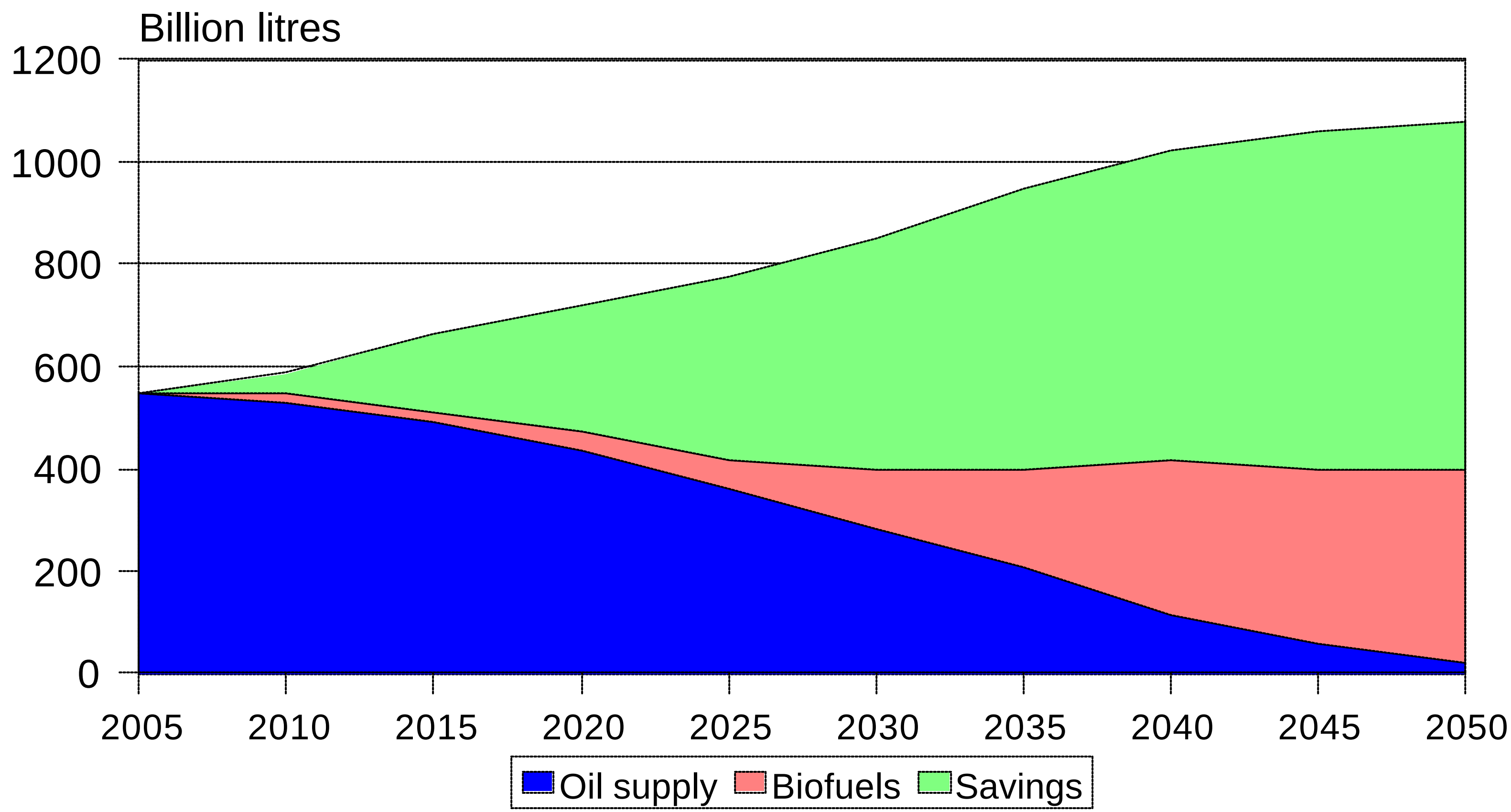
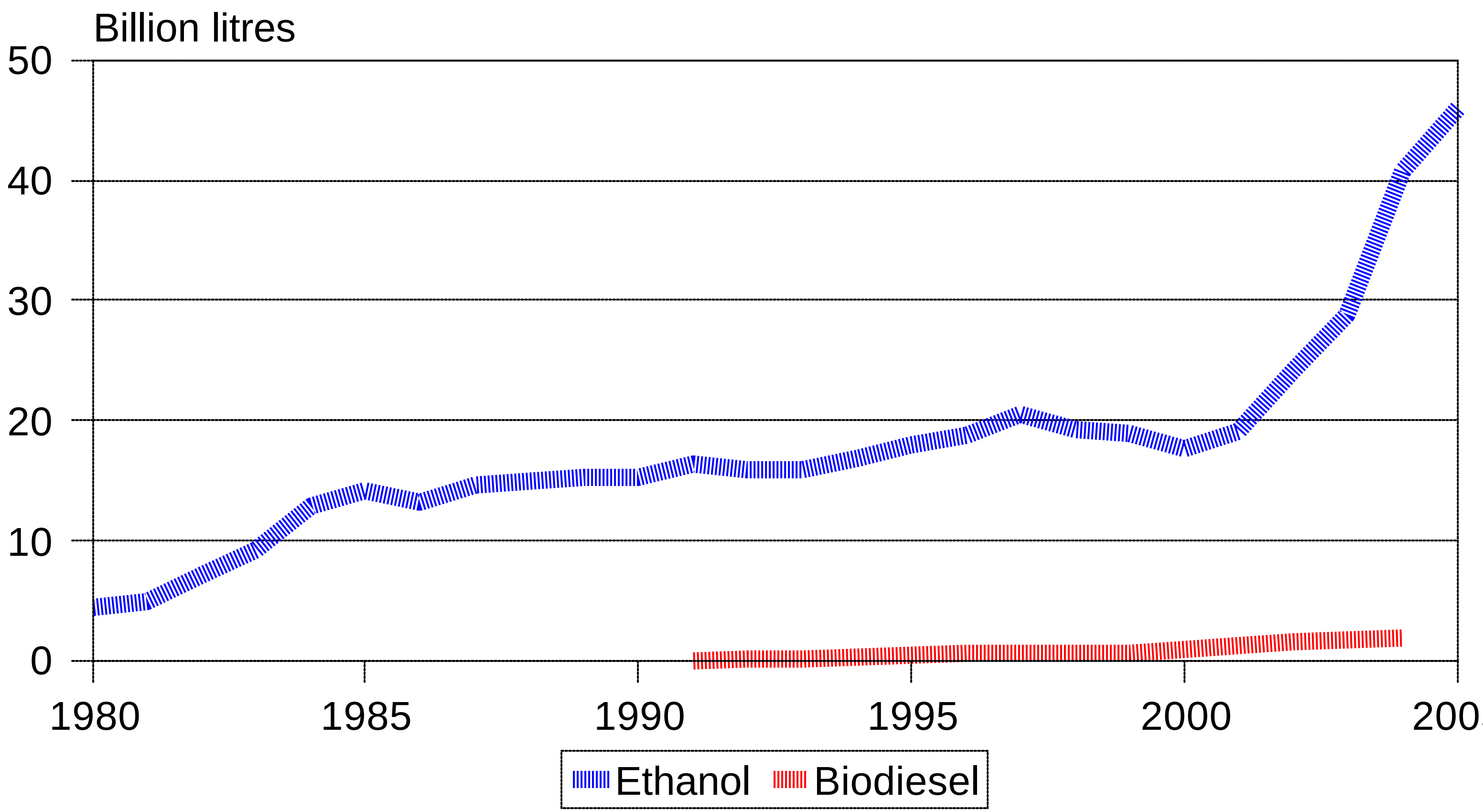
Forecasted trends in U.S. fuel use 2005-2050



World ethanol and biodiesel production 1980-2005



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Challenges for Finland

- Climate change
- Predicted increase in energy and resources consumption, also peak oil
- Old waste and deposit loads in nature
- Energy and natural resource intensive structures of industries

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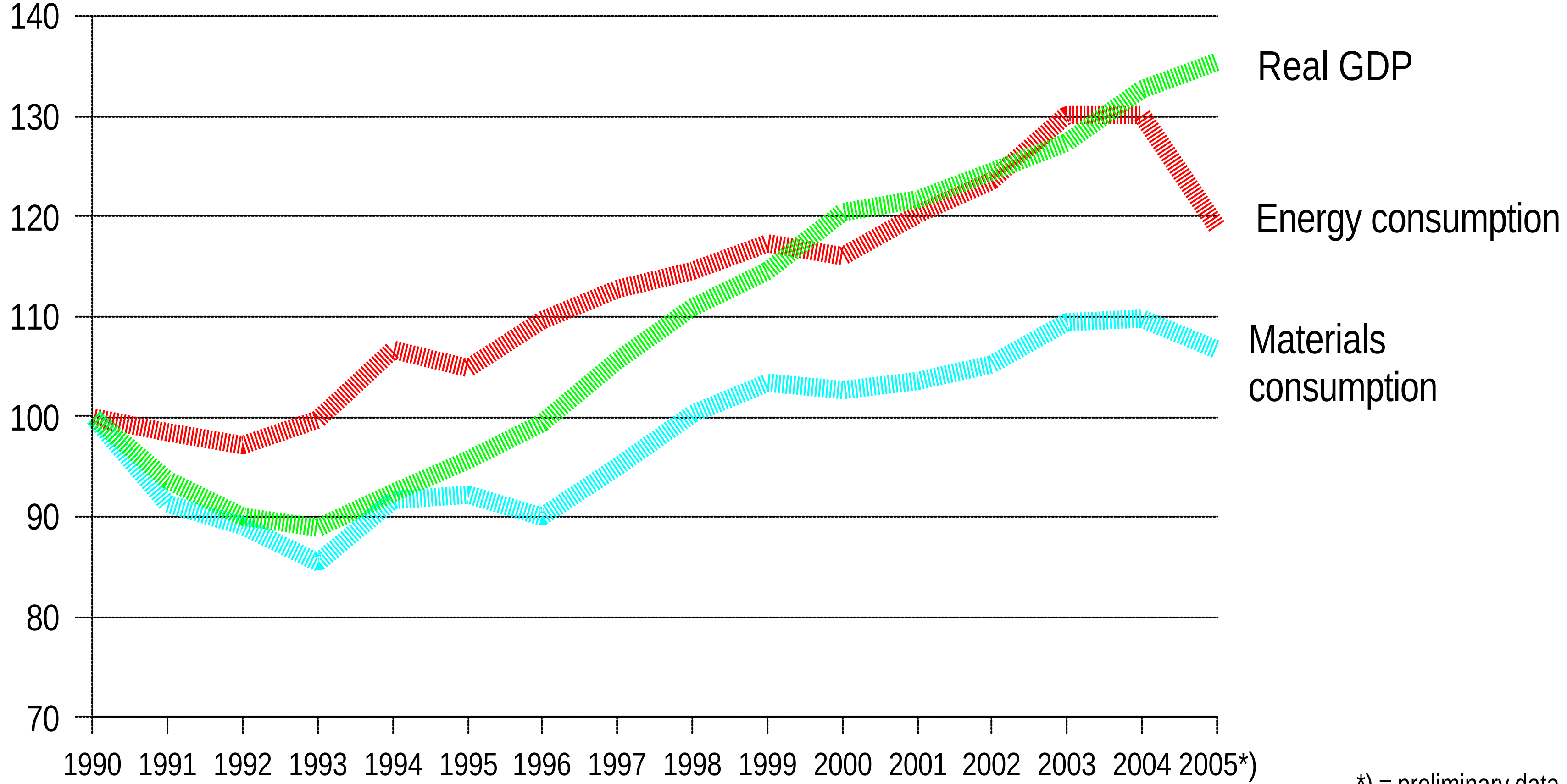
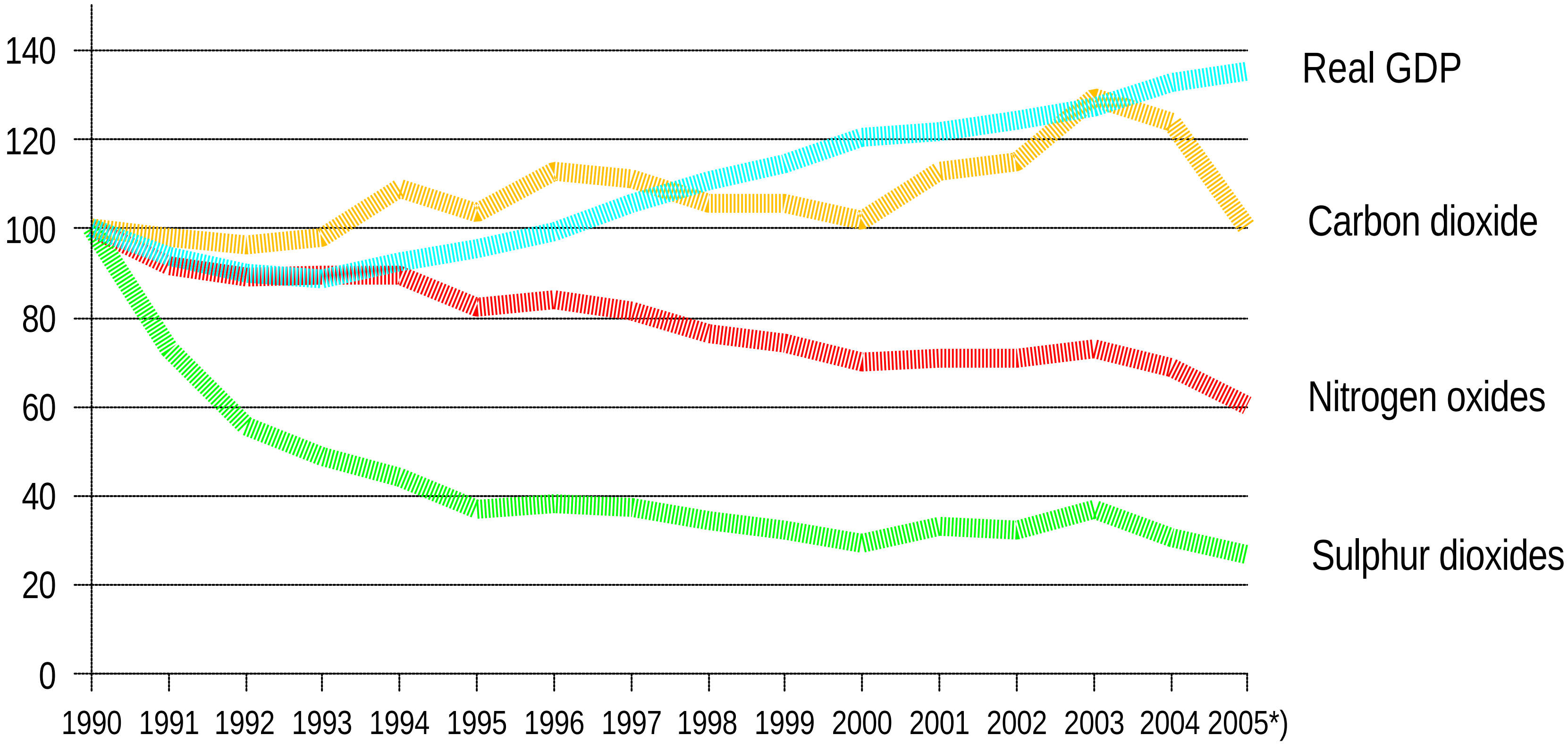
Trends in Finland's real GDP and consumption of energy and materials (1990=100)



*) = preliminary data.

Trends in Finland's real GDP and atmospheric emissions (1990=100)



*) = preliminary data.

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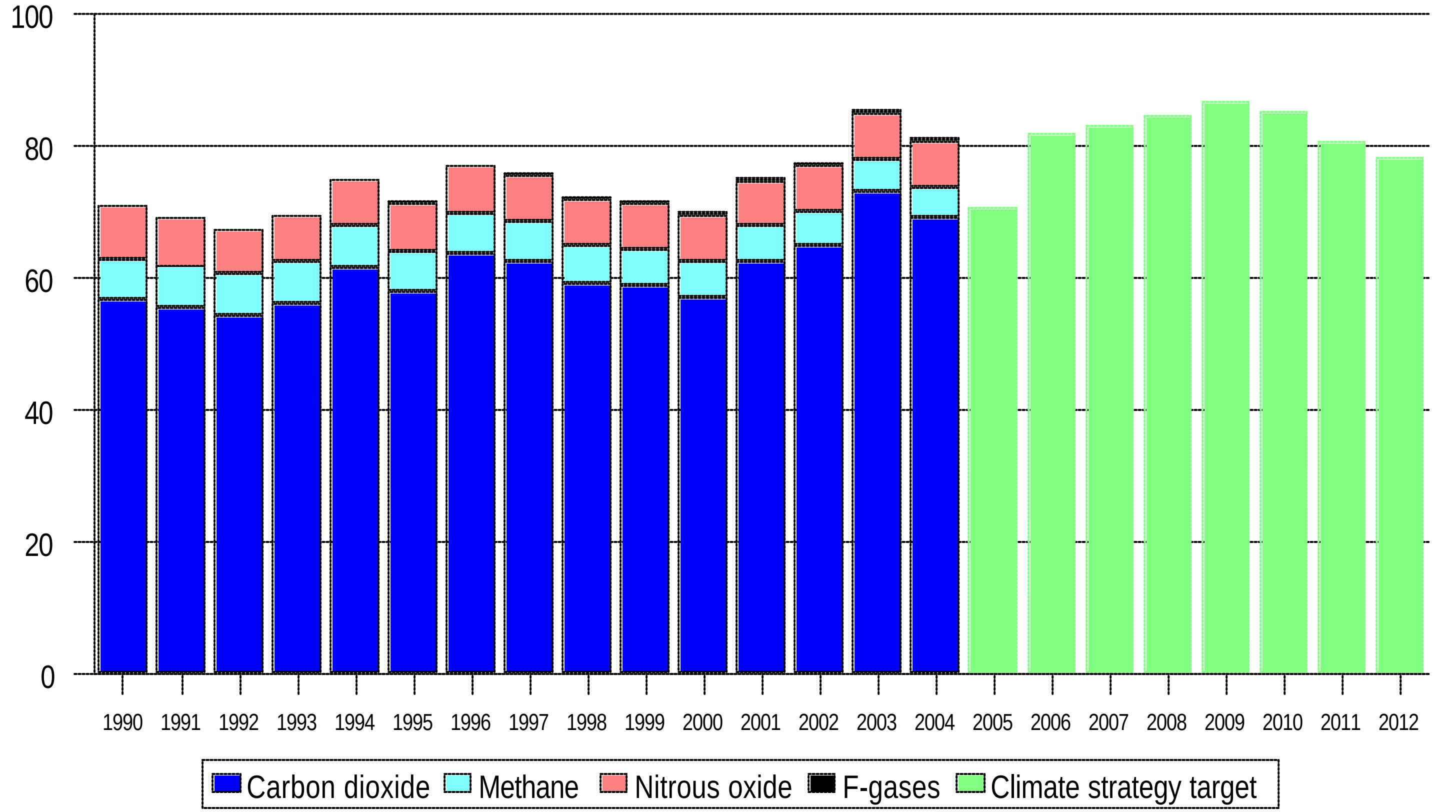
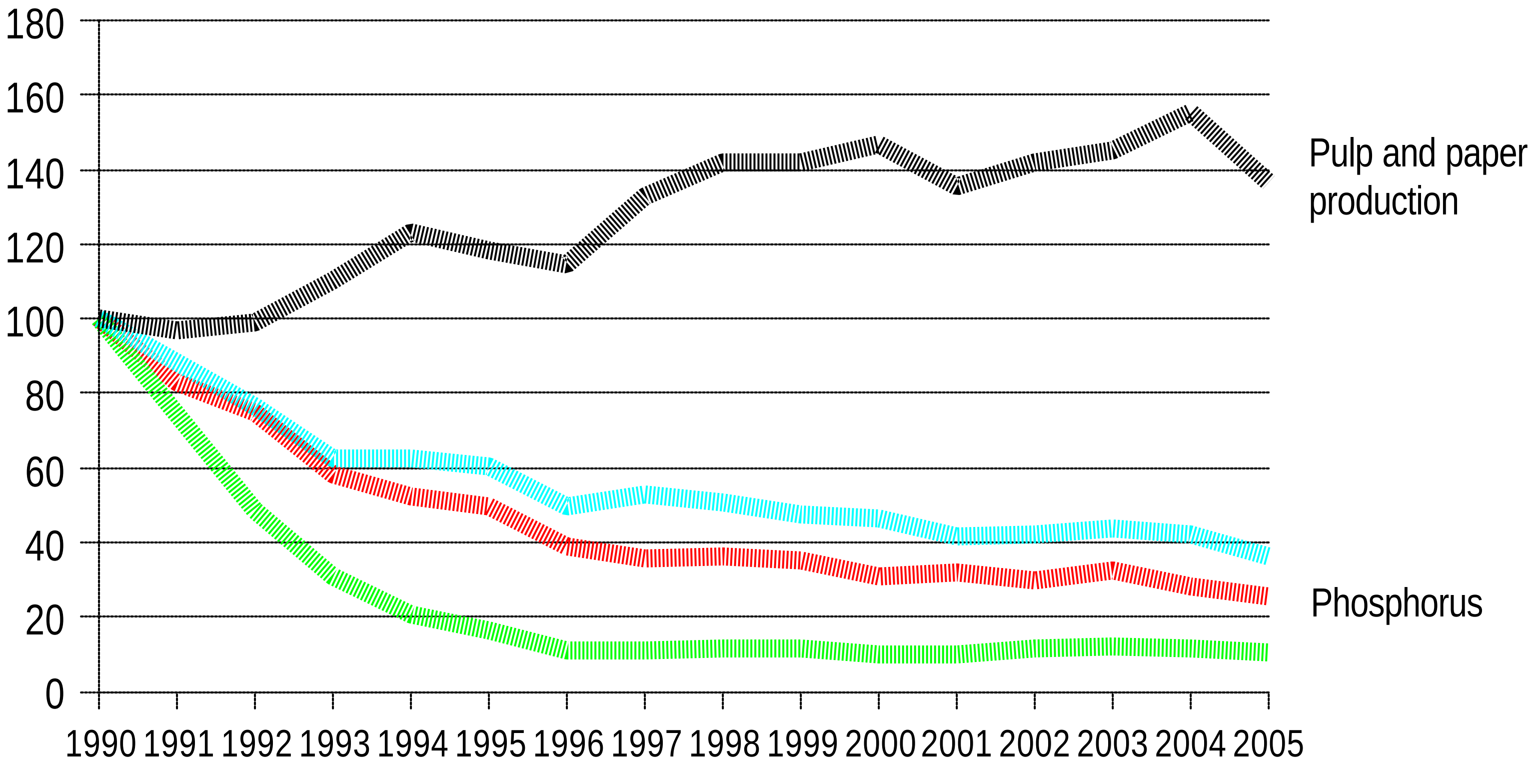
Finland's greenhouse gas emissions for 1990-2004 and climate strategy target to 2012 (million carbon dioxide-equivalent tonnes)



Pulp and paper industry production and effluent load in rivers and lakes (1990=100)



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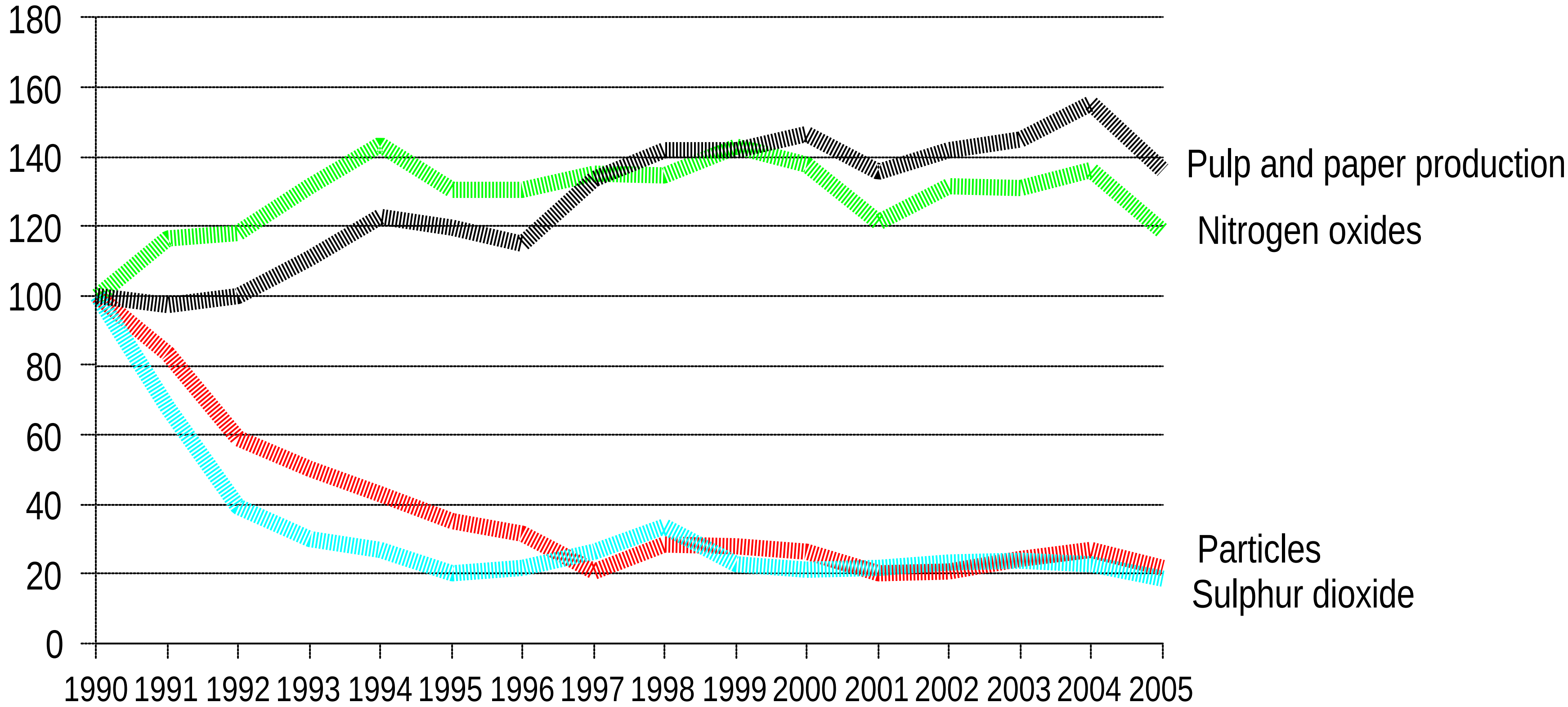
Pulp and paper industry production and emissions into the atmosphere (1990=100)



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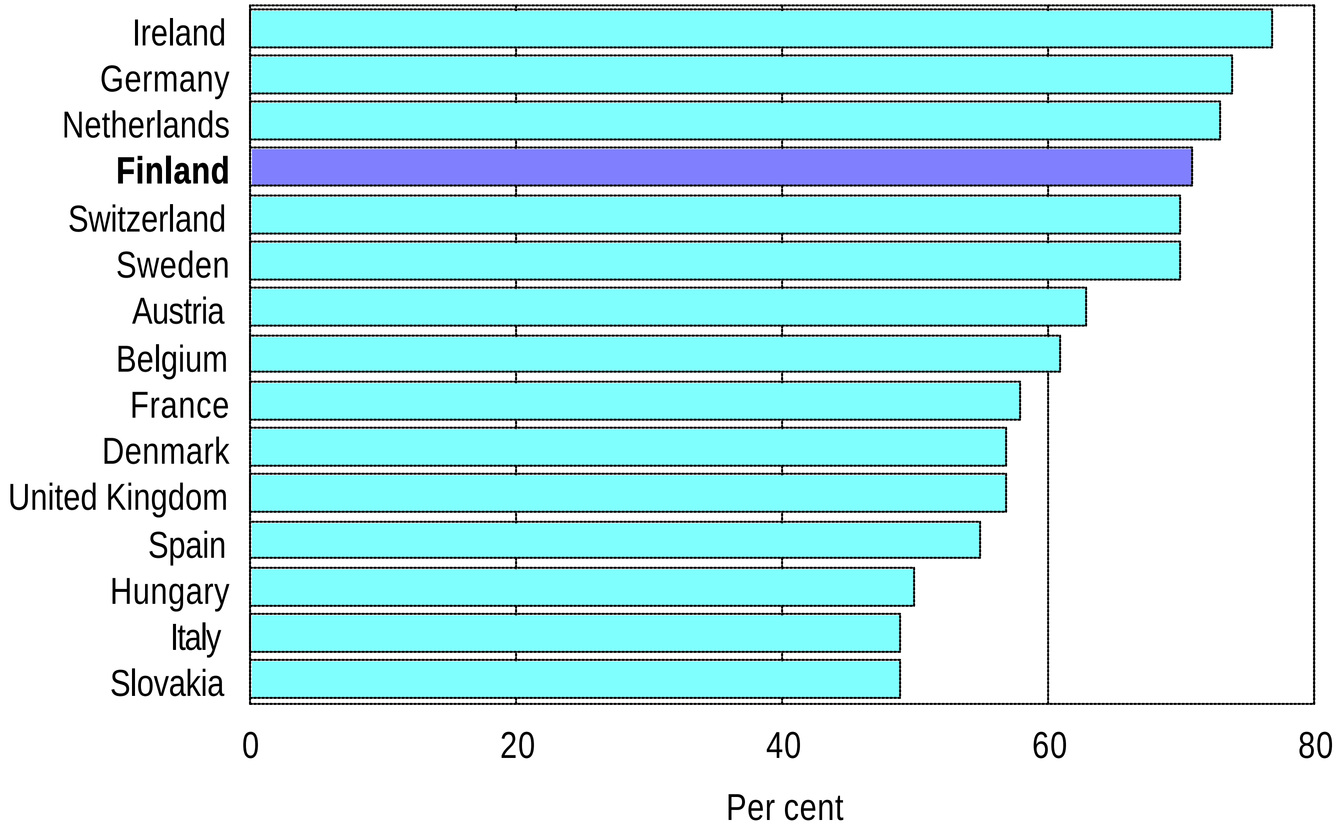
Recovery of waste paper in different countries in 2004



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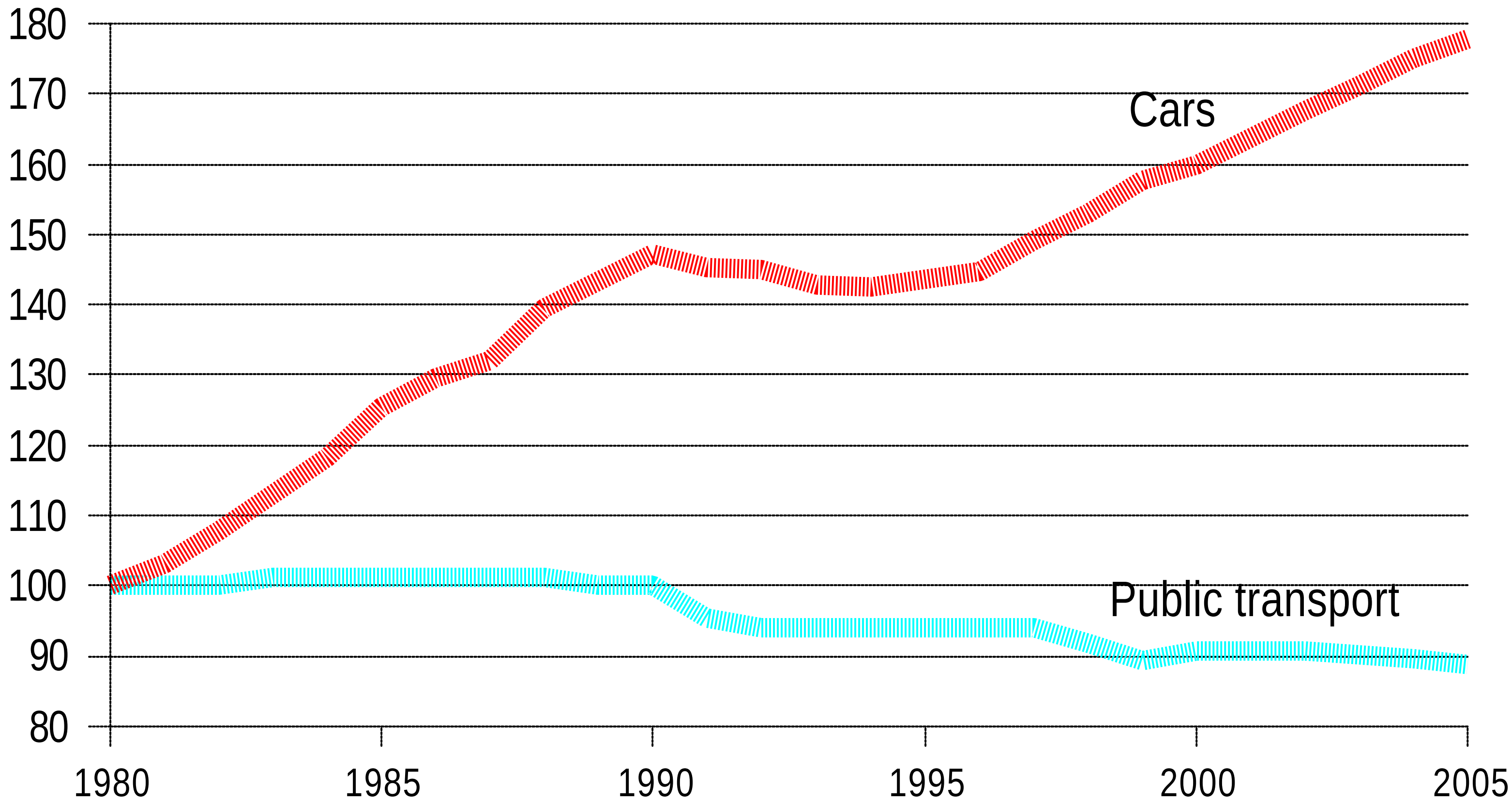
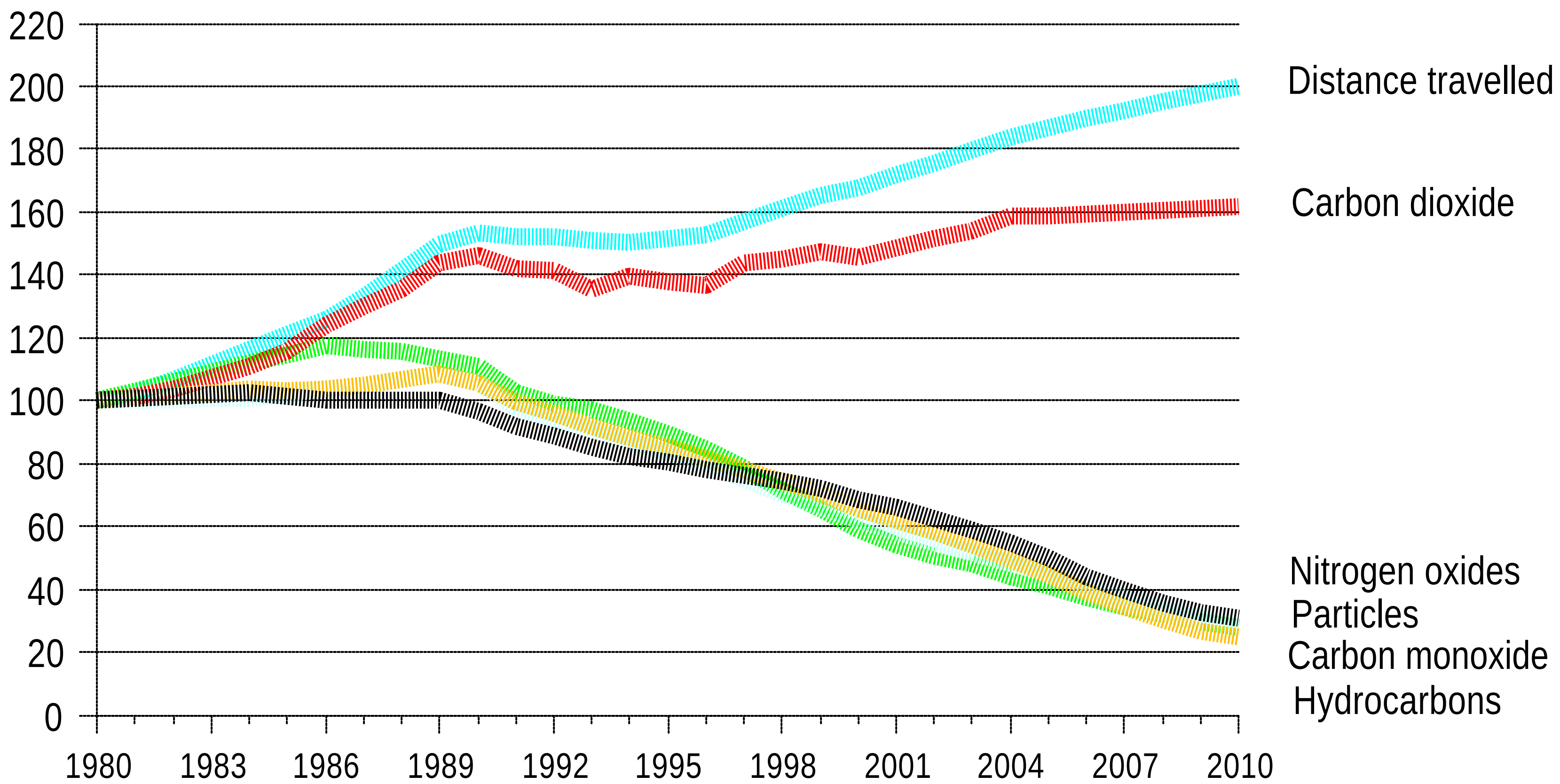
Trends in the use of public transport and cars (1980=100)



Trends in emissions from road traffic and projection to 2010 (1980=100)



Challenges of environmental metrics

- **Challenges**
- Monetarisation of environmental effects - the use of controversial methods of setting prices on environmental hazards. Market mechanism can not direct the environmental hazards if they lack prices. Also environmental policy is meaningless if is not connect to economic activities.
- "How much is much" problems (understanding the scale).
- Better planning and decision-making: "No target can be set nor can a target be reached without measuring the current state of affairs", i.e “you can't manage what you can't measure”
- **Benefits**
- Increases in welfare and production efficiency.
- Cost savings as resource use decreases
- Image benefits

Background to Eco-efficiency concept

- Material flow Accounts (MFA) 1970 -
- Sustainable development (WCED): 1987:
  ”Satisfy current needs and conserve for future generations the opportunity to satisfy their own needs”
- Rio environment and development conference 1992:
  ”How to define the carrying capacity of earth?”
- SEEA handbook 1993; green GDP accounting practises

- Schaltegger and Sturm 1990:
  Eco-efficiency is ”desired output output per environmental impact added”.

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Eco-efficiency concept

- The idea of Eco-efficiency derives from the fact that several studies show that consumption of materials in the industrialised countries in particular exceeds the replenishment and carrying capacity of the environment.
- The objective of Eco-efficiency is to reduce the use of raw materials so as to reduce the environmental impacts such as pollution and waste volumes which are caused by exceeding the carrying capacity of the limited global ecosystem in accordance. The goal is to achieve a sustainable level of satisfaction of human needs (= welfare).
- Eco-efficiency seeks to combine economic efficiency and the material efficiency of production with the objectives of sustainable development and the notion of social justice under a single heading.

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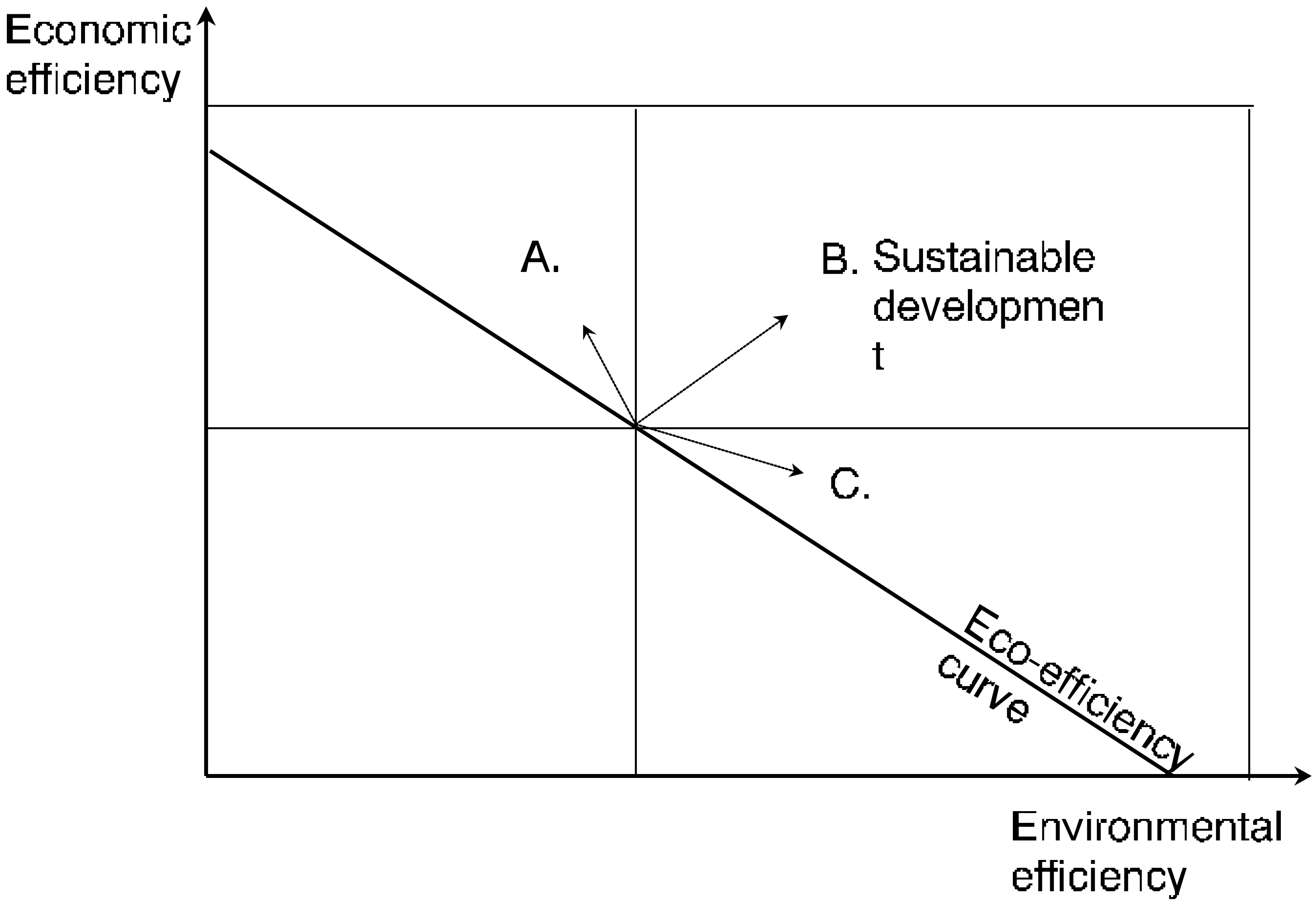
Eco-efficiency concept 2

- The goal of Eco-efficiency is to achieve a sustainable level of satisfaction of human needs (or welfare) and avoiding environmental problems before they arise.

- "An economy is progressing along Eco-efficient lines when it produces the improvement in quality of life it consumes using ever-lower quantities of natural resources and energy."

Eco-efficiency as an operating strategy of sustainable development



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Theoretical basis of Eco-efficiency

There is no single theory, but Eco-efficiency concept combines existing theories from technical sciences, economics, natural sciences, behavioural sciences etc.

Laws of thermodynamics - constraints of technology
Industrial ecology - materials and energy cycles
Economics - welfare economics
Systems theories - system boundaries
Biology - limits of carrying capacity
Leadership theories - Eco-efficiency goals and management

Today practical implementation of Eco-efficiency dominates at the expense of theoretical development.

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Sustainable cycle of materials

Herman Daly (1991); materials cycle between natural environment should satisfy three conditions in order to be ecologically sustainable:

1. The rate of use of renewable natural resources must not exceed the pace at which such resources are generated in the natural environment,

(2) The rate of use of non-renewable natural resources must not exceed the rate at which renewable substitutes for them are developed, and

(3) The rate of increase of polluting discharges must not exceed the capacity of the environment to absorb pollution.

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Measuring Eco-efficiency

Generally efficiency is equal to benefit per costs, which is smaller than 1.

OECD (1997):

$$\text{Eco-efficiency} = \frac{\text{Improvement in the quality of life}}{\text{Costs + Resources + Damages}}$$

Schaltegger&Burritt (2000):

$$\text{Eco-efficiency} = \frac{\text{Value added}}{\text{Environmental impact added}}$$

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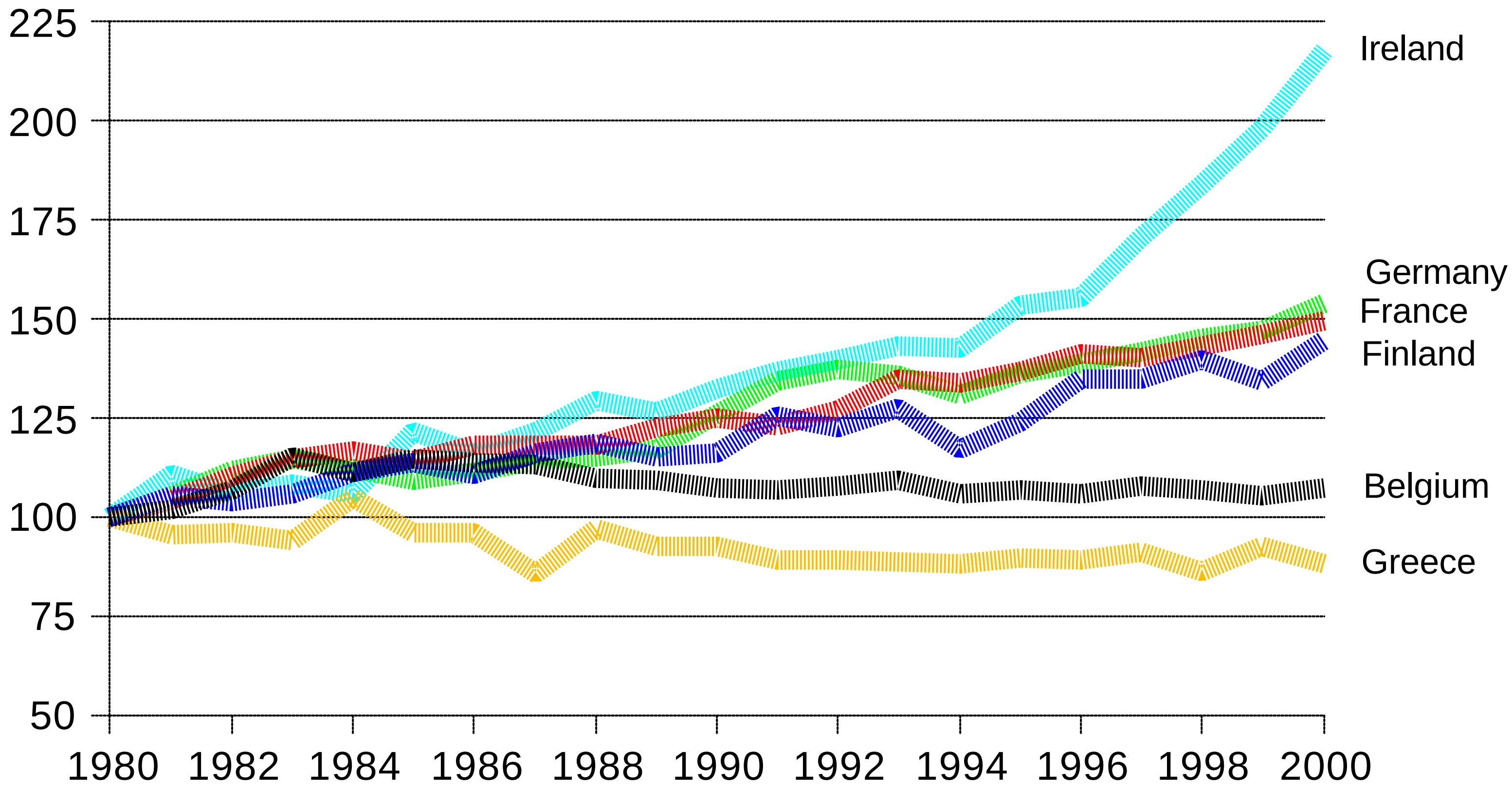
Trends in Eco-efficiency in some EU countries (Eco-efficiency = GDP/Materials consumption) (1980=100)



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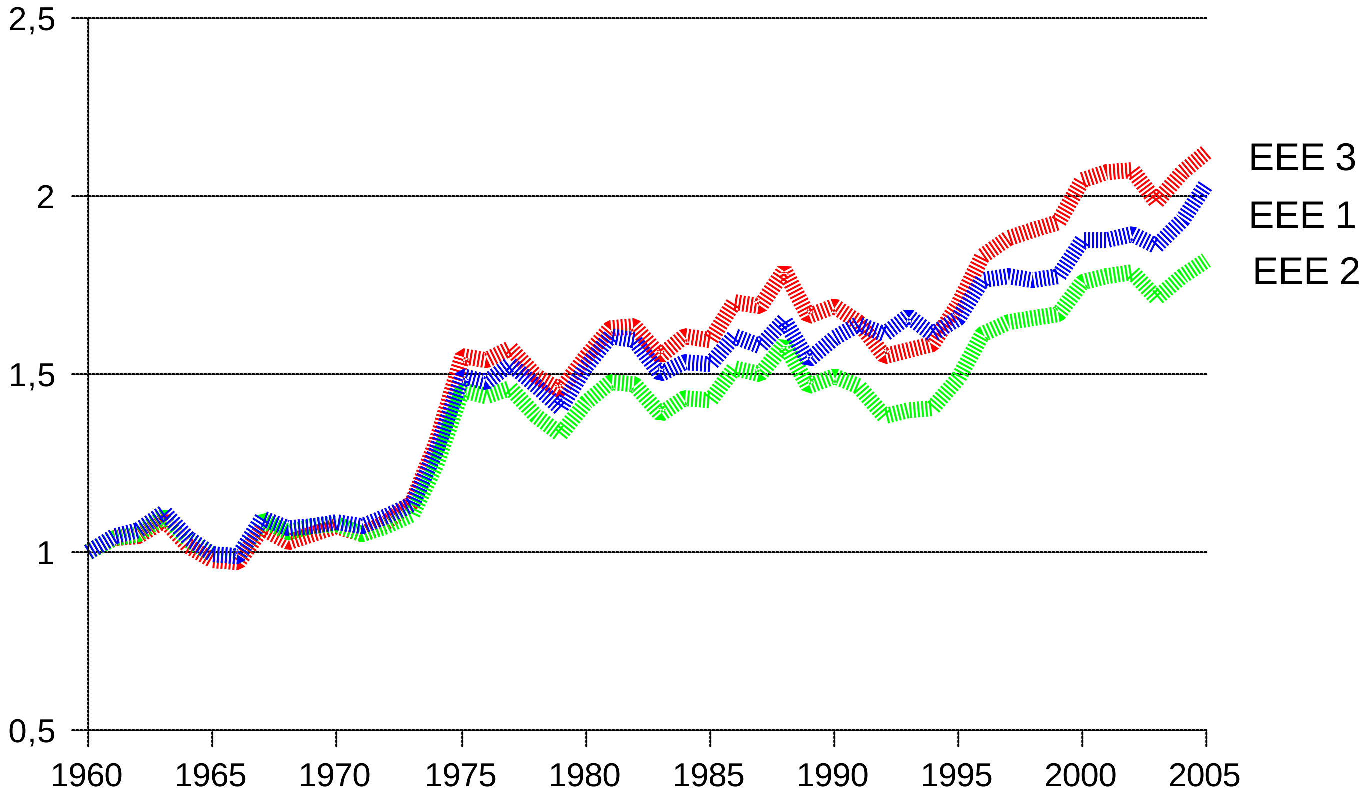
Development of different Eco-efficiencies of Finnish economy 1960-2005 (EEE = GDP, EDP or SBM per materials consumption) (1960 =1)



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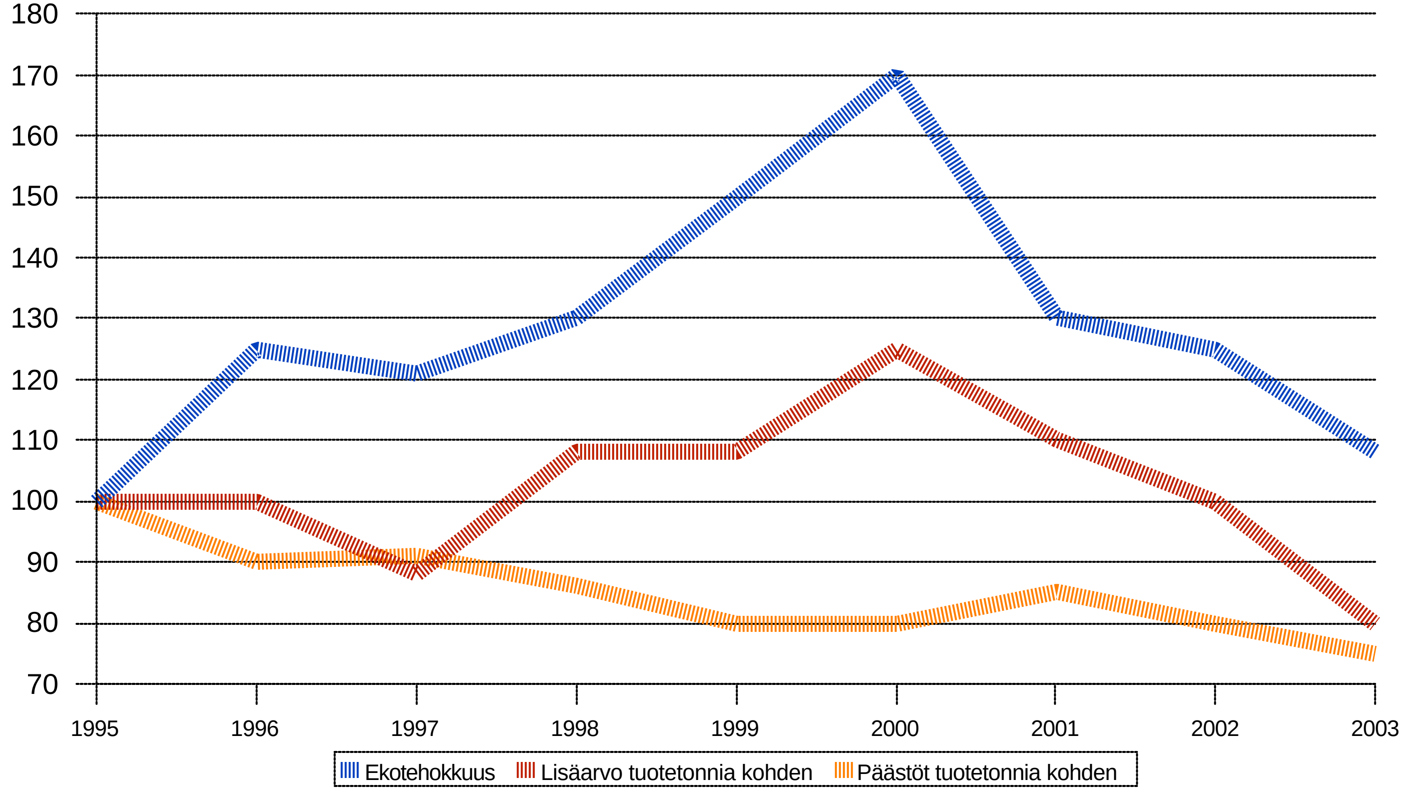
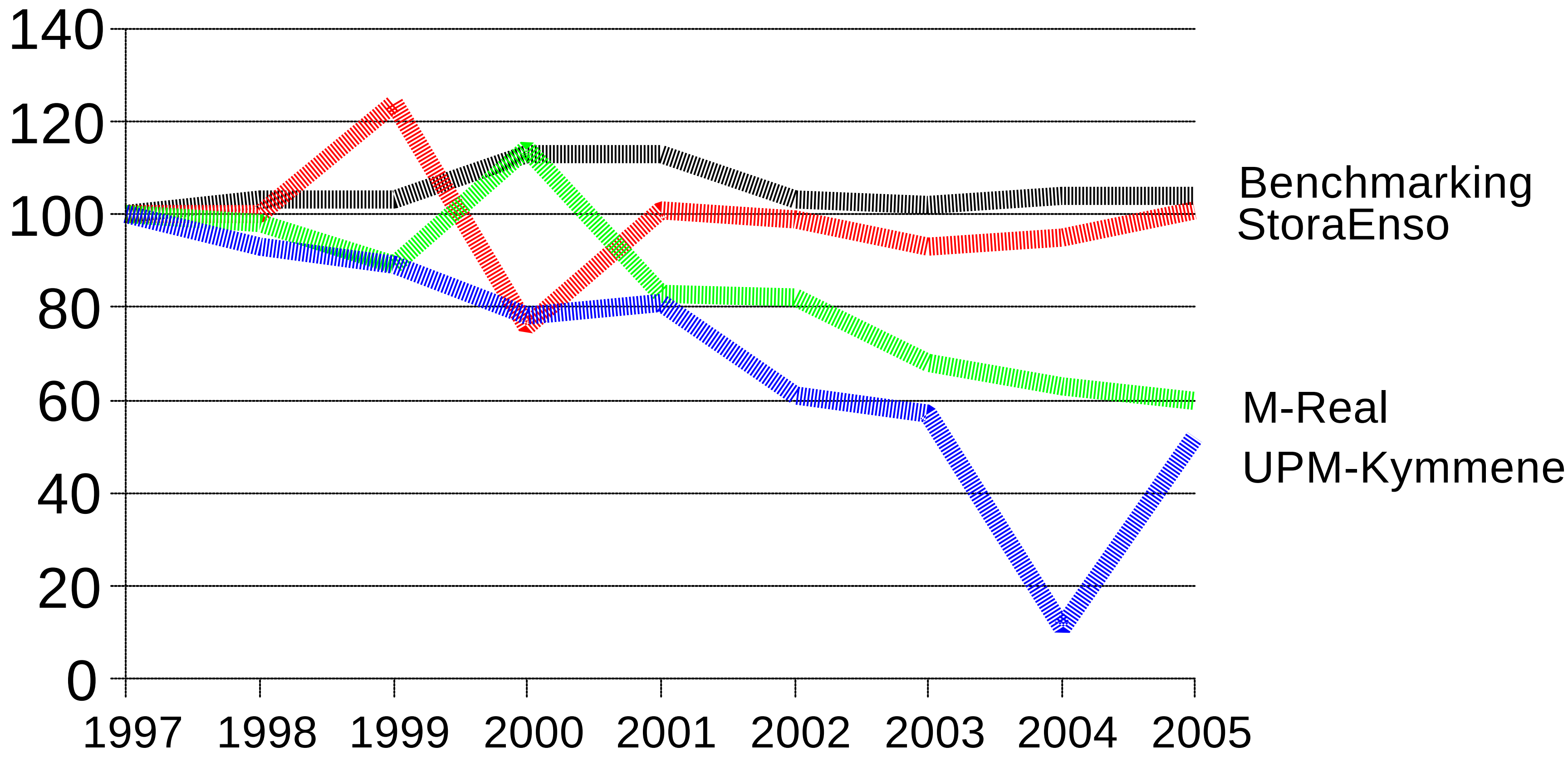
M-Real´s Eco-efficiency measure 1997-2003

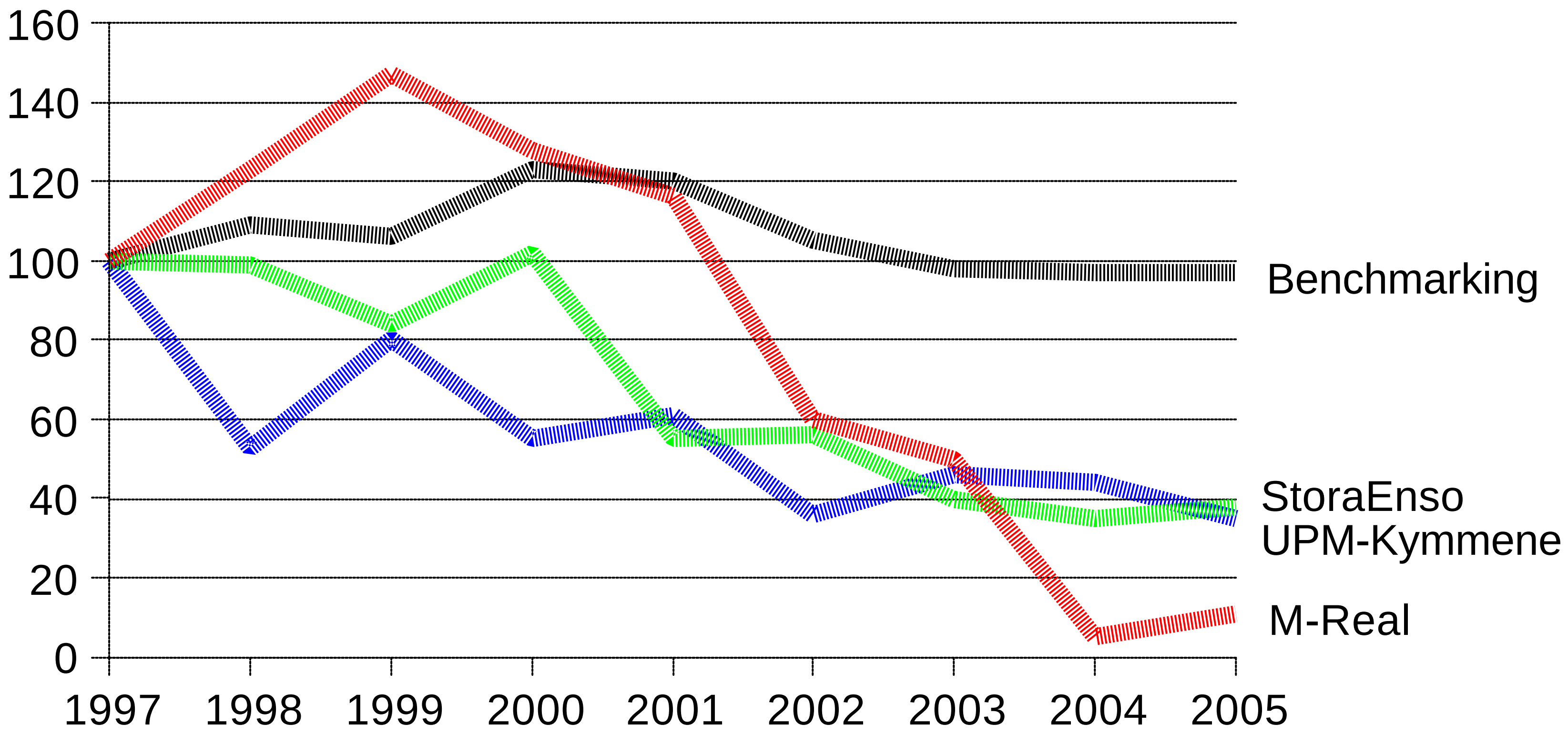
$$\text{Eco-efficiency} = \frac{\text{value added}}{\text{environmental impact}} = \frac{\text{personnel costs + profit}}{\text{total hazards (weighted emissions)}}$$



Trend of Eco-efficiency in Finnish forest industry (EE= turnover/materials use)



Trend of Eco-efficiency in Finnish forest industry (EE = profit+personnel costs/materials use)



Weaknesses of Eco-efficiency approaches

Popularisation of Eco-efficiency is somewhat challenging; technical way of thinking, use of relative measures, other measures are needed to support … is easily left to the tool of experts.

Other indicators, like ecological footprint and ecological rucksack are more understandable and visual. It is difficult to adopt carrying capacity of earth to processes approach is difficult to be adopted processes.

Summing up of different materials to approximate environmental impacts is problematic.

Benefits of activities are hard to estimate since the market prices are fluctuating.

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Strenghts of Eco-efficiency thinking

Provides clear operational action strategy and relevant indicators.

Eco-efficiency analysis support the sustainability picture of the activity assessed.

Environmental impacts are not priced by controversial pricing methods in Eco-efficiency analysis.

Eco-efficiency analysis is best suited to assess the internal effectiveness of single prosesses.

Towards sustainable industrial ecology

Carrying capacity of earth can not sustain the current expansion of global economic activities and their growth. Expanding economic activities overcome the improvements in Eco-efficiency. Thus the implementation of sustainability should be fostered.

Industrial ecology reaches towards production and consumption patterns that are based on sustainable material and energy flows. The Eco-efficiency of production must be improved in order to minimise materials and energy uses. Transition from quantitative expansion of economy to qualitative growth i.e. “to get more out of less”.

Only practical rapidly change attitudes in companies and in society is properly price environmental and natural resources as well as environmental impacts so that they will be taken into consideration in all decision-making. Also environmental taxation can be utilised.