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Towards Rational Energy Use: a basis for a sustainable energy system

Frontiers of Research in Industrial Ecology
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Content

- Rational use of energy
- 2000 Watt Society
- Scenario « Towards a 2000 Watt Society »
- A basis for a sustainable energy system

Rational use of energy (1)

- « Autonomous » technological progress
  - Innovation
  - « nature » of engineers
- Examples at micro level: process, technology
  - Lighting
  - Computers
- Examples on macro level
  - Energy/GDP on country level (+ structural changes)
  - Impact technol. progress on US energy demand

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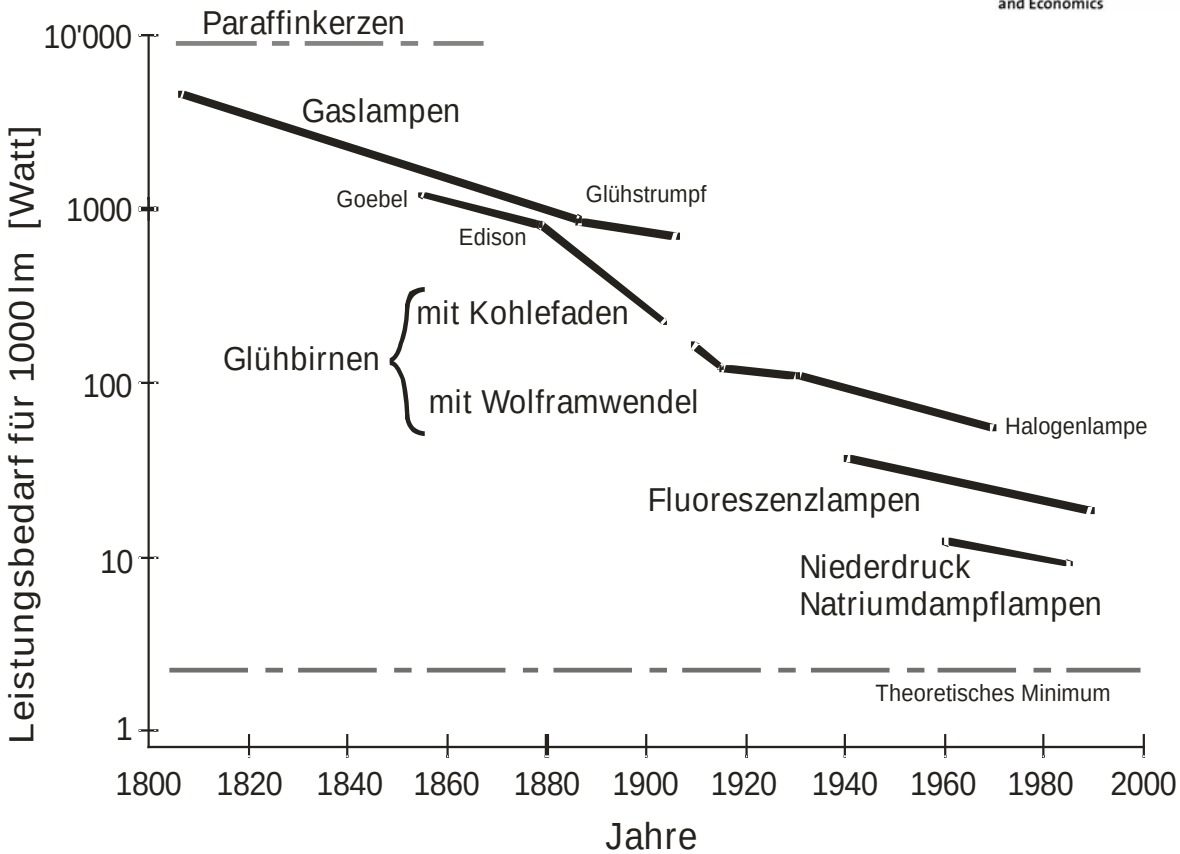
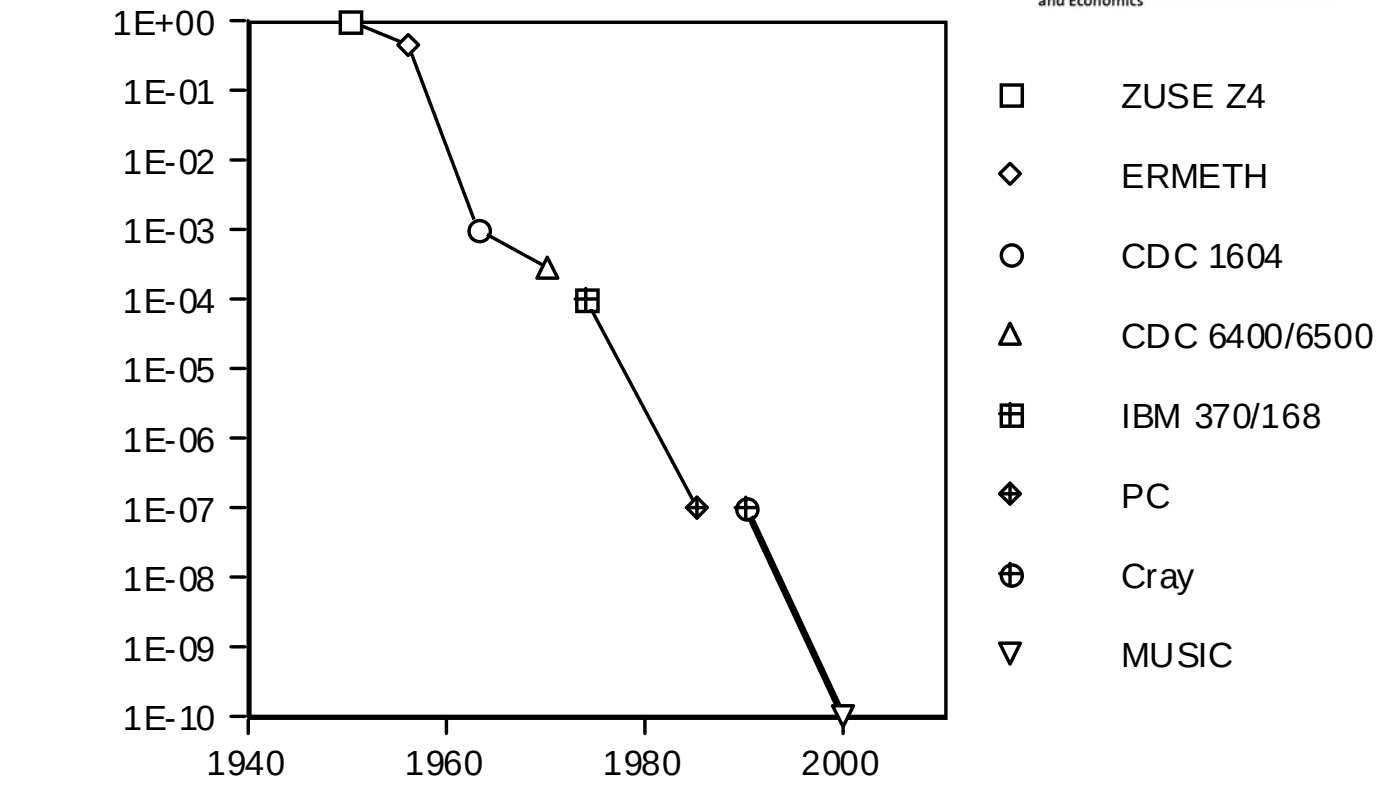


Technical progress in lighting. Source: Spreng, lecture, ETHZ, 2006



Specific electricity consumption (in relative units) of computers. Source: Aebischer et al., 1994.

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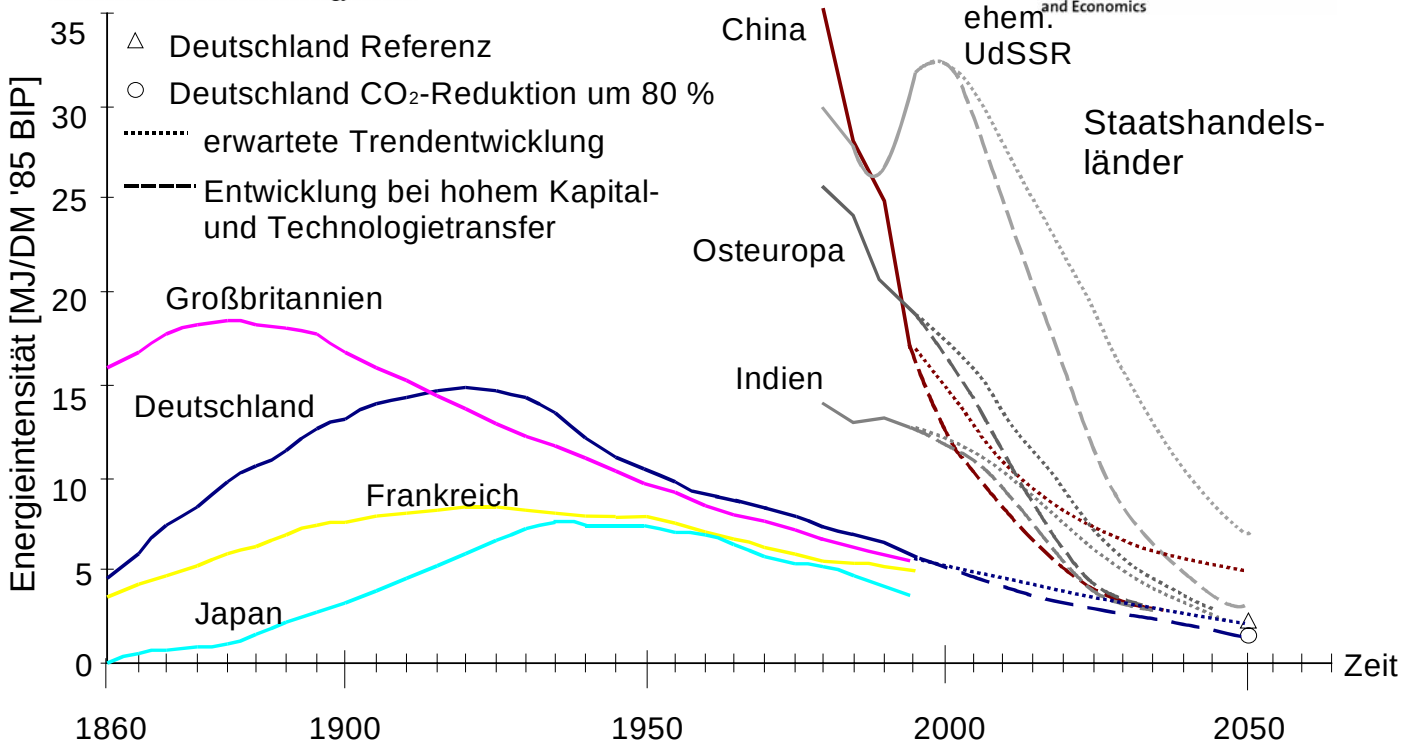
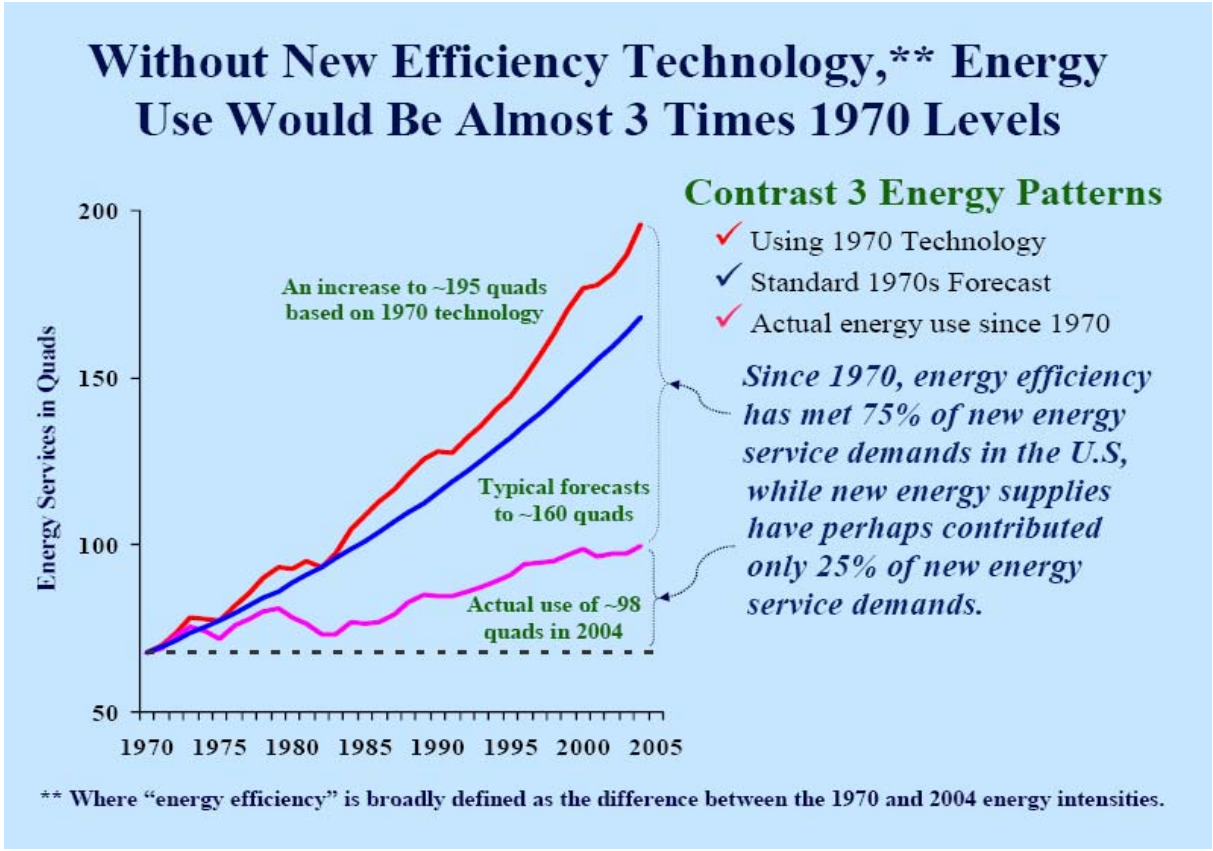


Quellen: Chandler et al., 1990; CEC, 1996; Berechnungen (mit Währungsparitäten) durch ISI, 1997

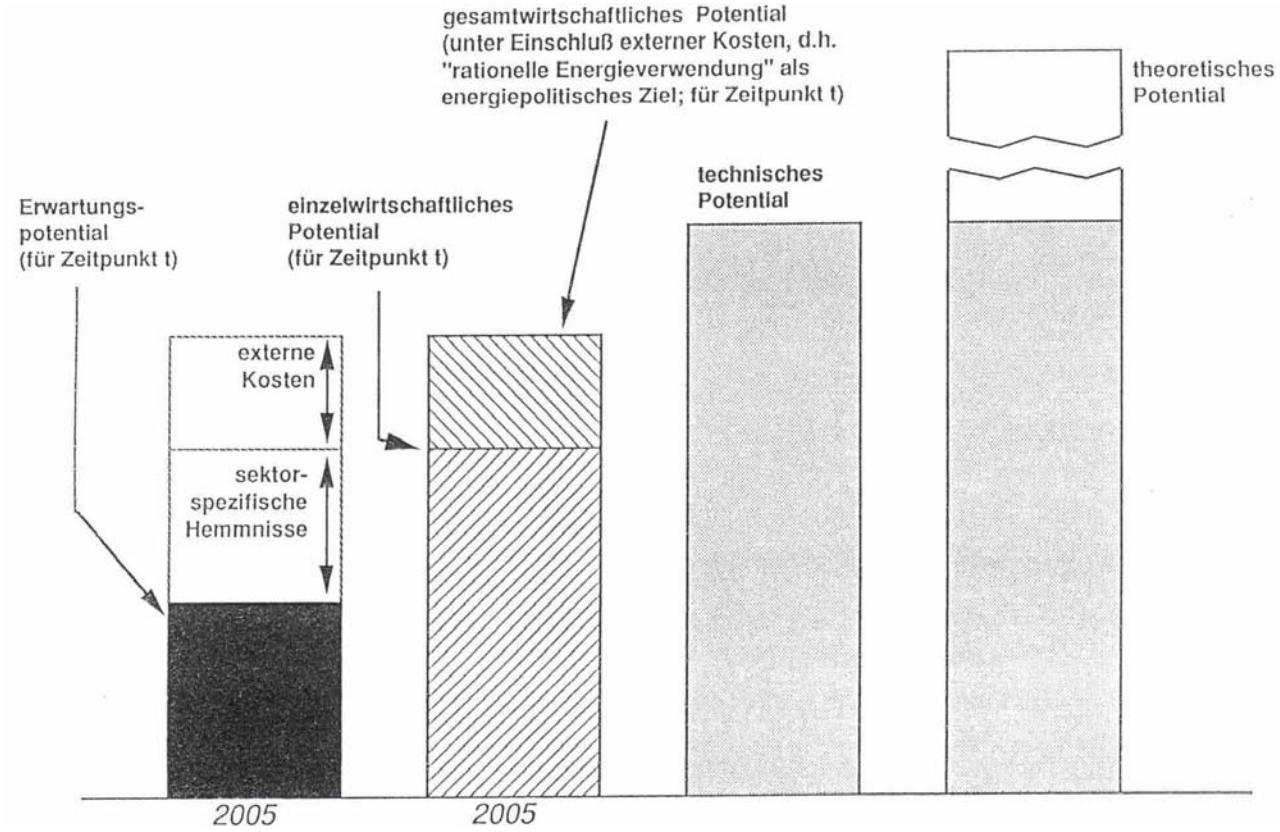
(Commercial) energy / GDP in various countries, 1860-2050. Source: Jochem, lecture, ETHZ, 2006



Source: Laitner, 2005

Rational use of energy (2)

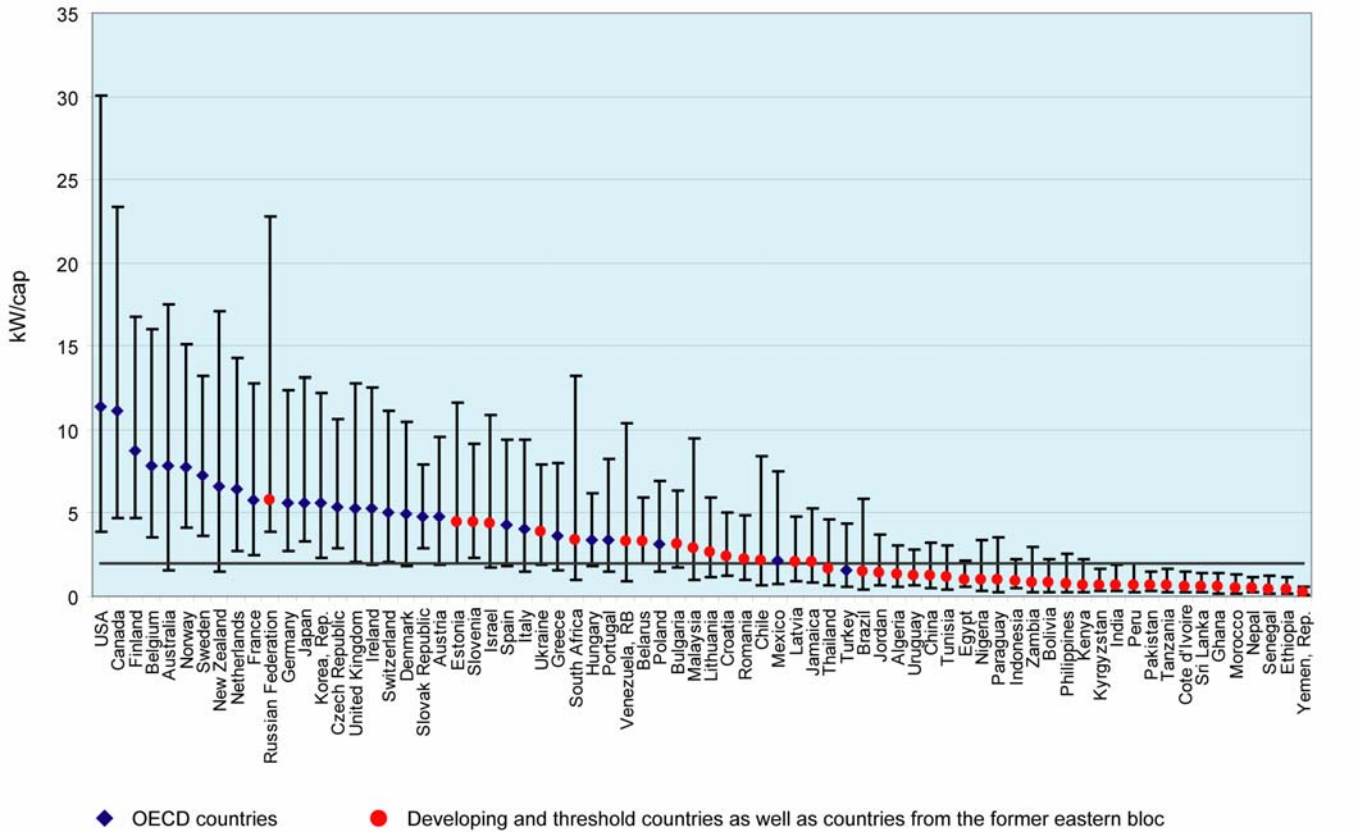
- Conclusion: despite efficiency improvements growth in demand
  - Faster increase of « drivers » (population, income, …)
  - New and more energy services (incl. rebound)
- Potentials of more rational use
  - Type of potential
  - Time scale
  - Realisation dependent on boundary conditions, energy price, investment criteria, behaviour, policies (energy and/or innovation, e.g. RAVEL)



Types of energy efficiency potentials. Source: Jochem, lecture, ETHZ, 2006

2000 Watt Society (1)

- Trial to operationalise sustainable development by using energy/capita as the leading indicator
  - Energy for satisfying basic needs (food, shelter, …)
    → 1000 Watt/cap (Goldemberg et al. 1988)
  - Economic (development) and social (equity) dimension:
    → 2000 Watt/cap (ETH-Rat, 1998)
  - Additional requirement: limitation of CO_2 concentration in atmosphere (limit global warming), e.g. Schweizerischer Bundesrat, 2002) → 1 t CO_2/cap



Energy use per time and capita (average and highest and lowest decile) in various countries and within countries, source: Spreng, 2005

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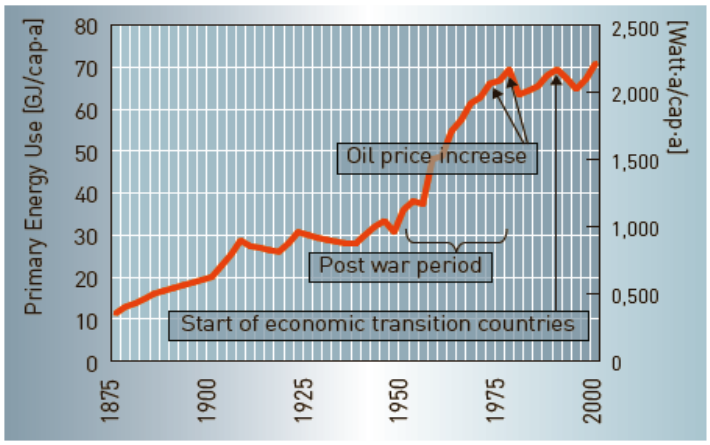
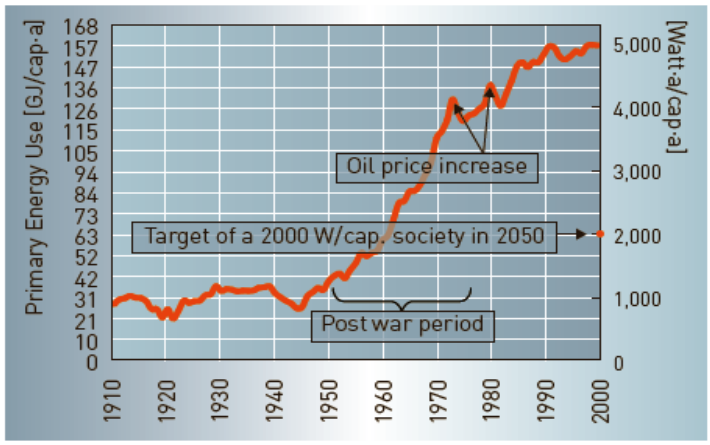
Energy demand today and 2000 Watt target





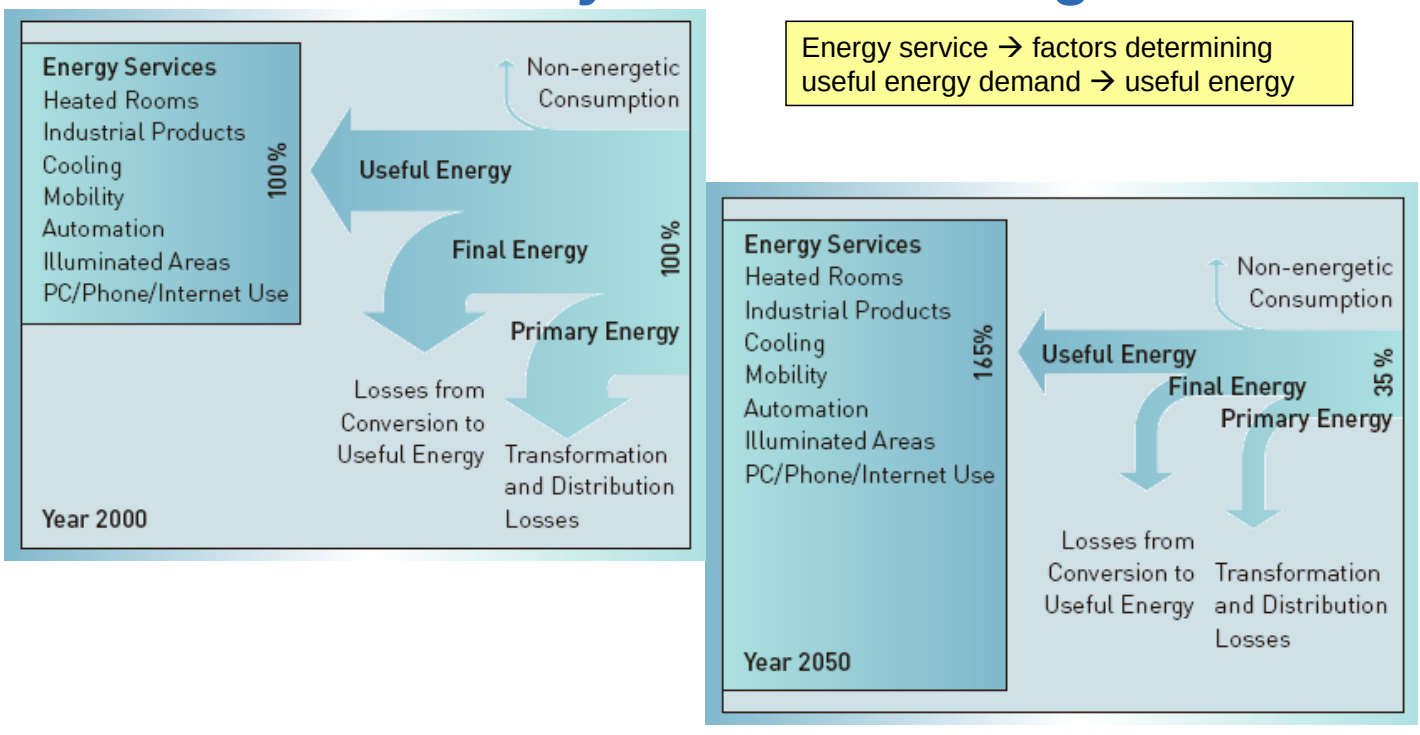
Primary energy demand worldwide 1875-2000 (left side) and in Switzerland 1910-2000 (right side) (Jochem, 2004)

2000 Watt Society (2)

- Technical feasibility investigated by a group of people from ETHZ, EPFL, PSI, EMPA, University of Zürich and published by novatlantis (Jochem, 2004)
- Questions: how to initiate the process? how to tap the full potential? how fast? how much does it cost? → scenario «Towards a 2000 Watt Society»

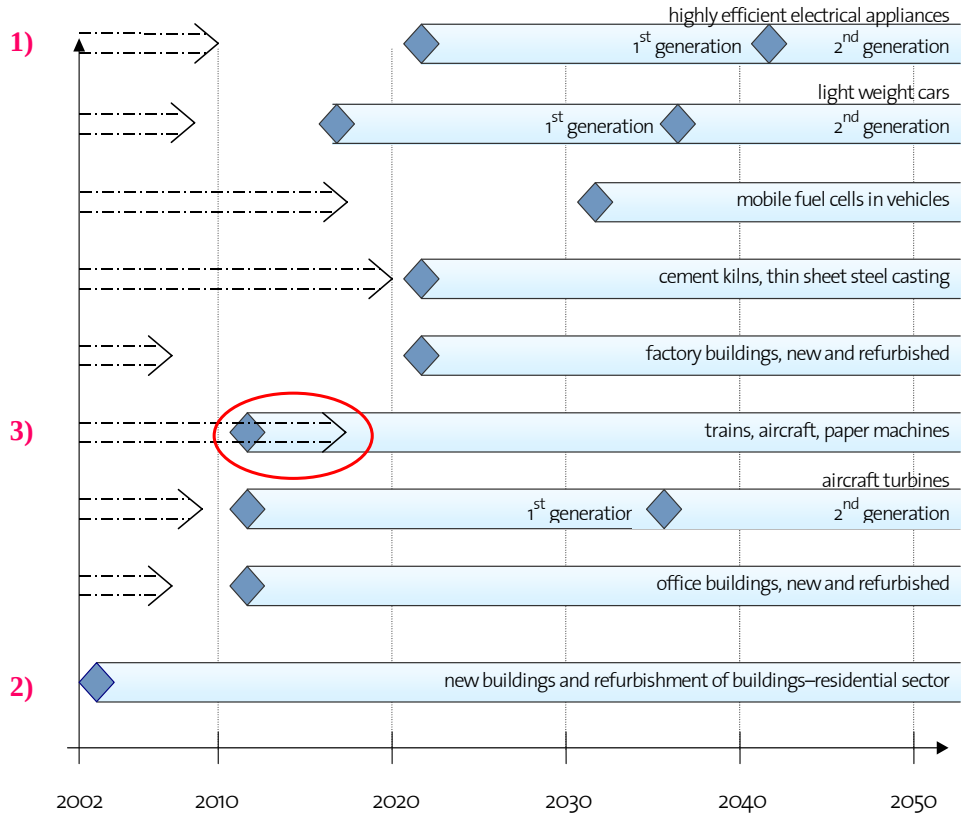
2000 Watt Society – The Challenge

Energy service → factors determining useful energy demand → useful energy



Energy flow diagram, Switzerland 2000 and 2050 (Jochem, 2004)

Back Casting for Priority Setting of R&D and Specific Policies



Timing and priorities by back-casting and re-investment cycles

point in time to have a substantial impact by mid of the 21st century

minimum time needed for R&D

Source:
Jochem, 2004

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Scenario «Towards a 2000 Watt Society» (1)

Scenario IV in framework of energy perspectives of Swiss Federal Office of Energy (final report spring 2007)

- Time horizon 2035
- Targets 2035
  - CO2 emissions: -35% relative to emissions in 2000
  - Final energy demand per capita: - 35% relative to 2000 (4 =3+1)
- Preconditions/prerequisites? Measures? Costs?

Scenario «Towards a 2000 Watt Society» (2)

Preconditions/prerequisites (all sectors, not exhaustive)

- Worldwide new priorities (governments and civil society, voluntary collaboration)
- Fast diffusion of “best practice”
- R&D with focus on energy efficiency
- Energy tax:
  - increase of energy prices for end users by 100%,
  - partially used to finance energy programs, mainly to reduce transaction costs and to a lesser extend to overcome market barriers for innovative technologies.

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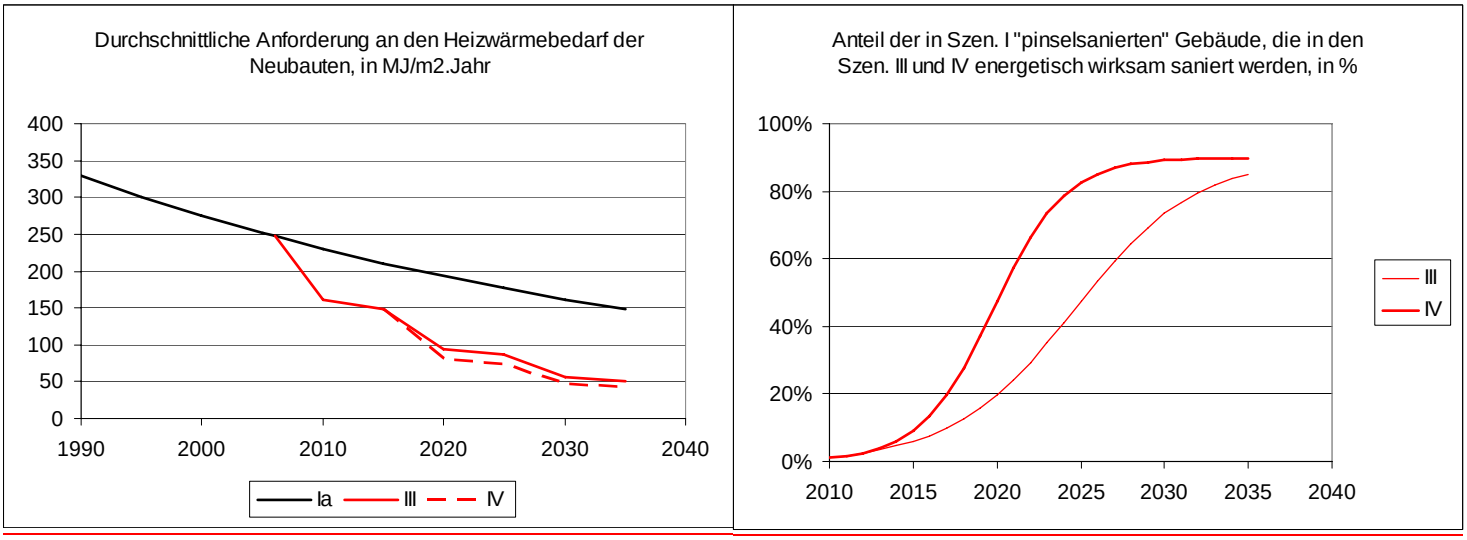
Scenario «Towards a 2000 Watt Society» (3)

Measures / model inputs (service sector, examples)

- New buildings (1/4):
  - heat demand half of “Minergie” requirements;
  - electricity demand corresponding to target values of SIA-380/4 (2006)
- Existing buildings (1/4):
  - most renewed buildings with twice as much reduction in heat demand as half of the buildings in the BAU-scenario;
  - the electricity demand of renewed buildings reaches after 2020 75% of the efficiency in new buildings
- Application of new technologies (particularly ICT) with focus on resource/energy efficiency, e.g.
  - optimal operation of equipment and buildings
  - optimal use of all kind of resources: office space, hospital facilities

Scenario «Towards a 2000 Watt Society» (5)



Heat energy demand in new buildings (left side) and fraction of the buildings without efficiency improvement in scenario BAU (Pinsel-sanierungen) but with a significant efficiency improvement in scenario IV (right side). Source: Aebischer/Catenazzi, 2006.

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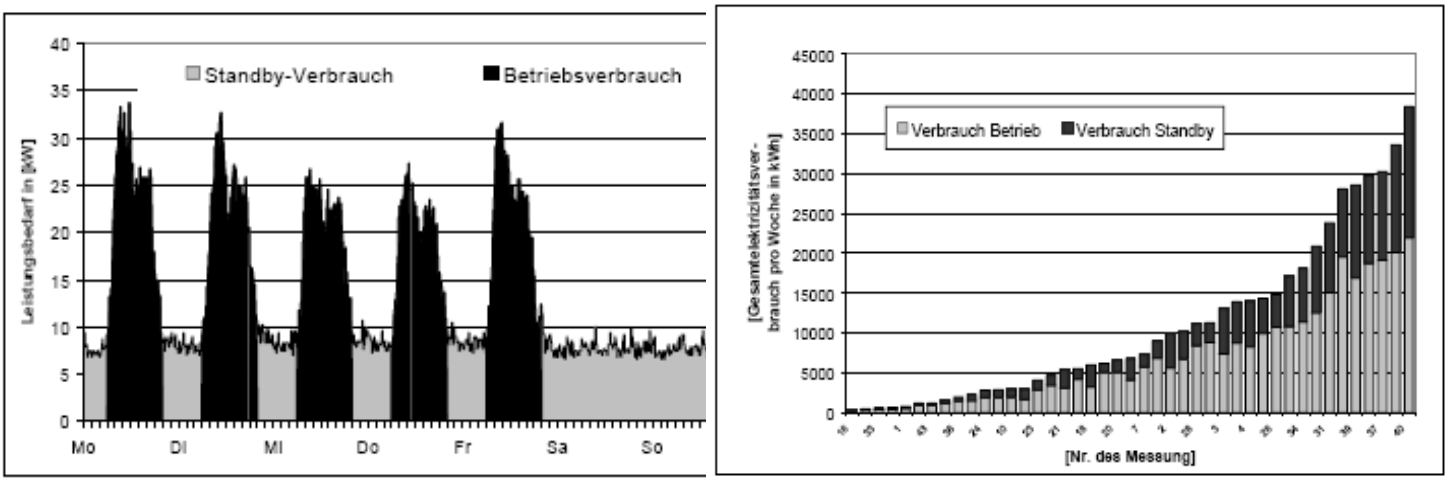
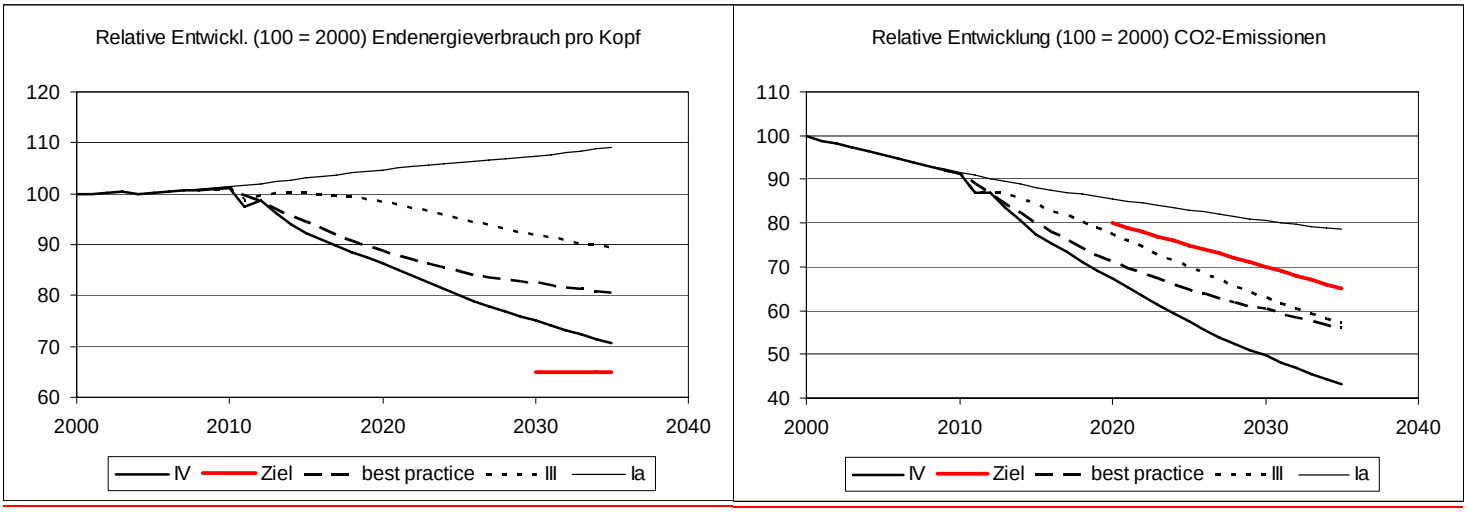
Scenario «Towards a 2000 Watt Society» (6)



Electric power (wattage) demand of an office building during one week and electricity demand (left side) and electricity demand (kWh) in 32 office buildings during one week split in electricity demand during office hours and outside office hours. Source: Menti, 1999.

Scenario «Towards a 2000 Watt Society» (7)



Final energy demand per capita and CO_2 emissions (in absolute terms) in the service/commercial sector in different scenarios - compared to the target (in red) “Towards a 2000 Watt society” (Aebischer/Catenazzi, 2006)

Rational energy use and sustainable energy system (1)

Criteria of a sustainable energy system (examples):

- Social criteria: basic needs, equity, health, …
- Economic criteria: increase of welfare (“qualitative” growth), …
- Environment criteria: CO_2 emissions, local pollution, landscape preservation, …….

Possible contributions in CH in 2035

- Fossil fuels: limited reserves, pollution and CO_2, security of supply (-> coal, methane hydrates)
- Renewables: important potentials, costs
- Nuclear: important potential, risk, waste, proliferation, acceptance, investments
- Rational use of energy (“negawatts”): important potential, costs, actors/stakeholders

Rational energy use and sustainable energy system (2)

Reduction of CO_2 emissions in the service sector (example)

- Efficiency improvements: 75% - 66%
- Substitution (decarbonising): 25% - 33%
- Assumption: CO_2 free electricity!

This order of magnitude in all scenarios and in earlier studies

- done by CEPE (and most probably others)
- in other sectors
- Assumption: heat pump = efficiency improvement, free outside heat not counted.

If gas fired power plants then rational use even more important

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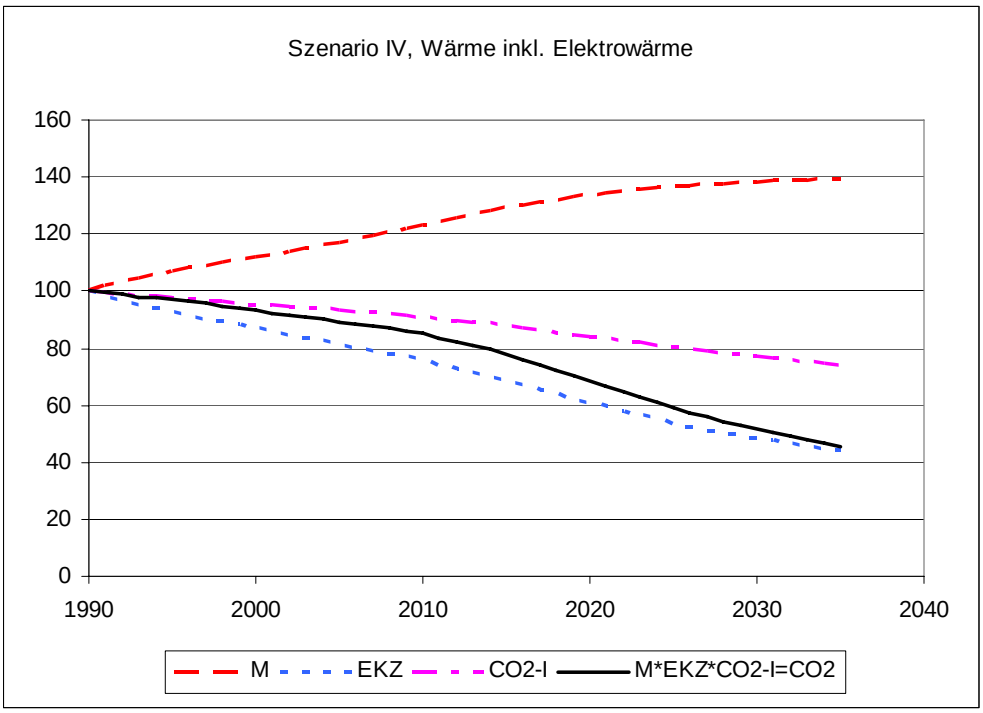
Rational energy use and sustainable energy system (3)



Contributions to reduction of CO_2 emissions in Swiss service/commercial sector, 1990-2035

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