Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Interactions between Energy, Information and Growth

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Introduction

In the 1970‘s I postulated:

Energy, time and information
can be regarded as main inputs to a task and
can, partially, be substituted for each other.

In my talk I will narrow the conference theme
ICT for sustainability,
and focus on
making info available for energy conservation,
and – this is the main point of my talk – show that we are well advised to do so by considering also the factor **time**.

Introduction (cont.)

Conclusion will be an obvious one:

Not all ICT applications further energy conservation (and sustainability).
Automated mass production of chunk is possible.

The talk will demonstrate that

- ICT by itself **does not** further energy conservation (and sustainability) and
- **time** is a useful criteria to judge whether it does or not.

Part 2: Substitutability of energy, time and information

In order to save energy one can either do a job smarter or slower:

•more time reduces friction, losses in heat-transfer, etc.

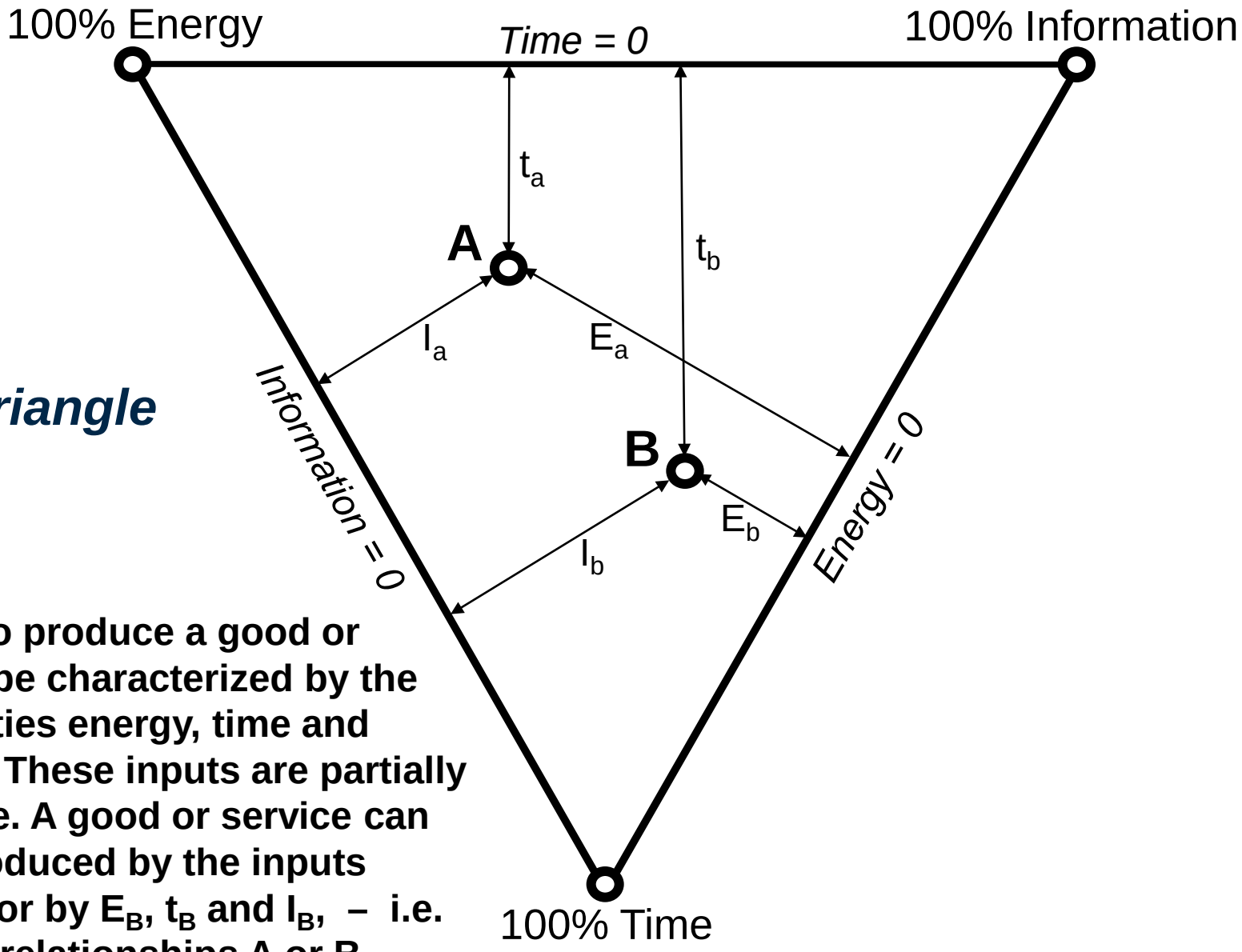
•more information reduces unnecessary safety margins, trial-and-error operation, useless and unused energy services

A trip from A to B can be made more energy efficient

•by choosing a slow mode of travel, by not speeding

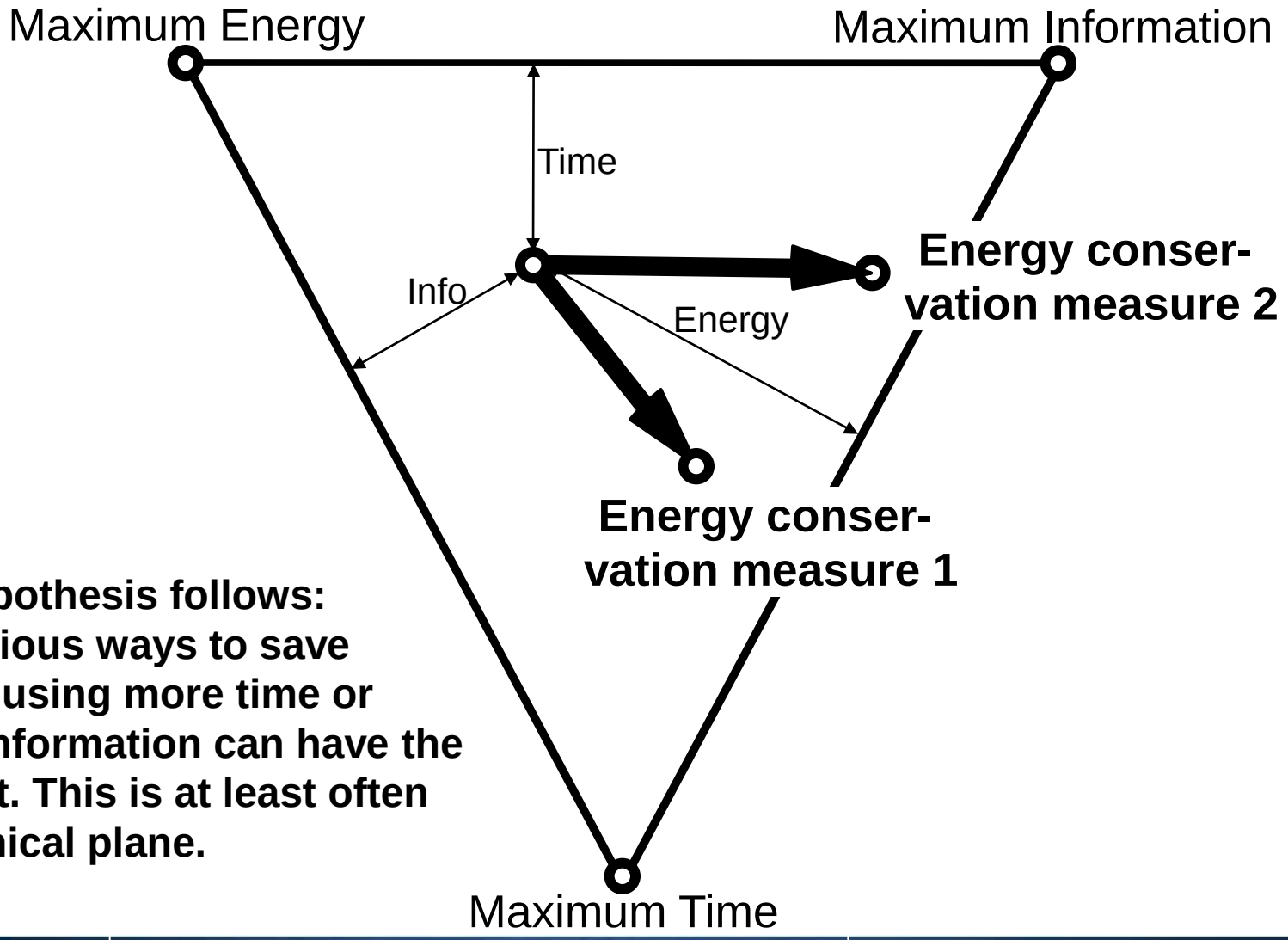
•by taking the best route, and best (high-tech) vehicle

Spreng Triangle



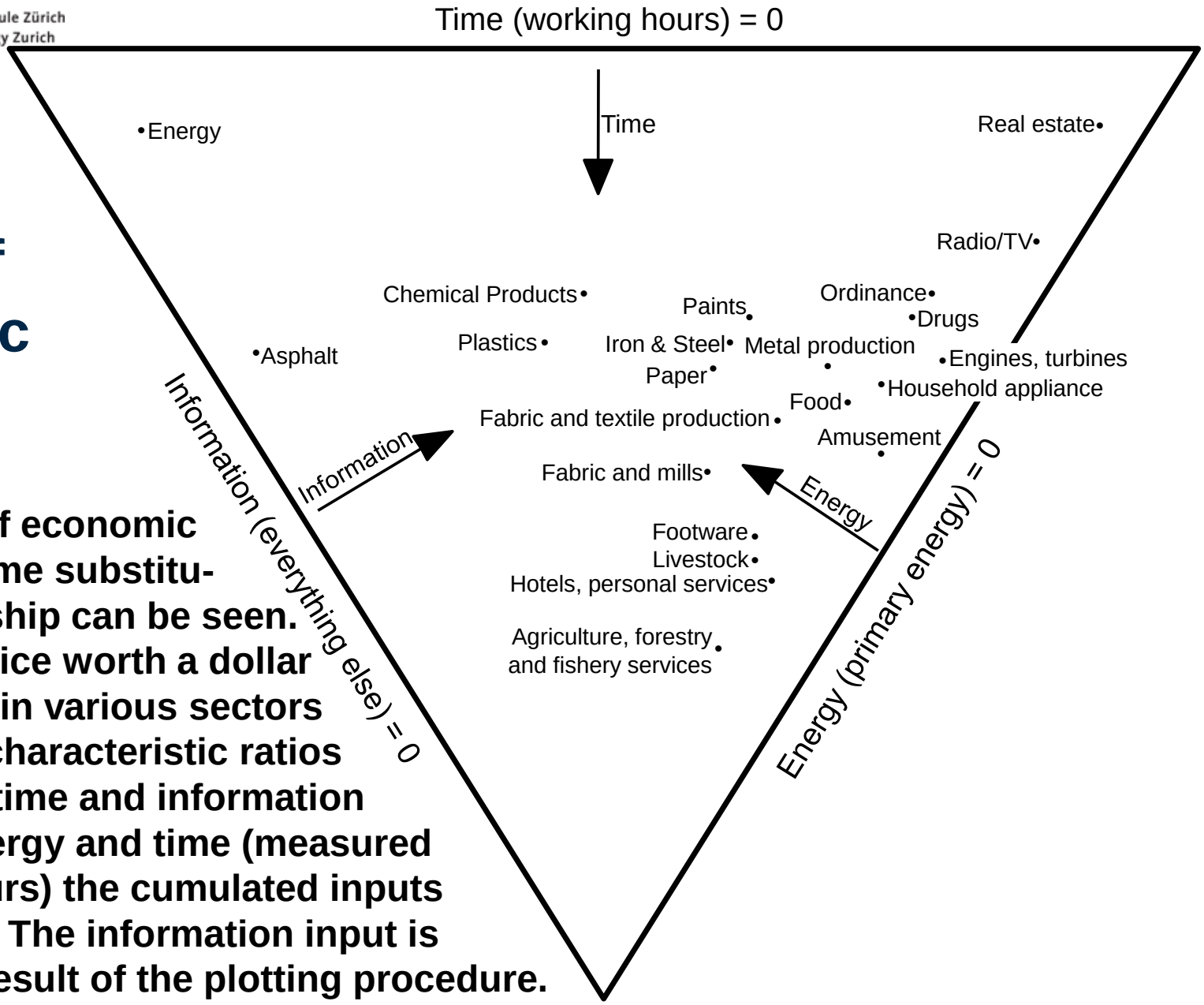
Hypothesis:
The inputs to produce a good or service can be characterized by the three quantities energy, time and information. These inputs are partially substitutable. A good or service can either be produced by the inputs E_A, t_A and I_A or by E_B, t_B and I_B, – i.e. by the input relationships A or B.

Triangle applied to energy conservation



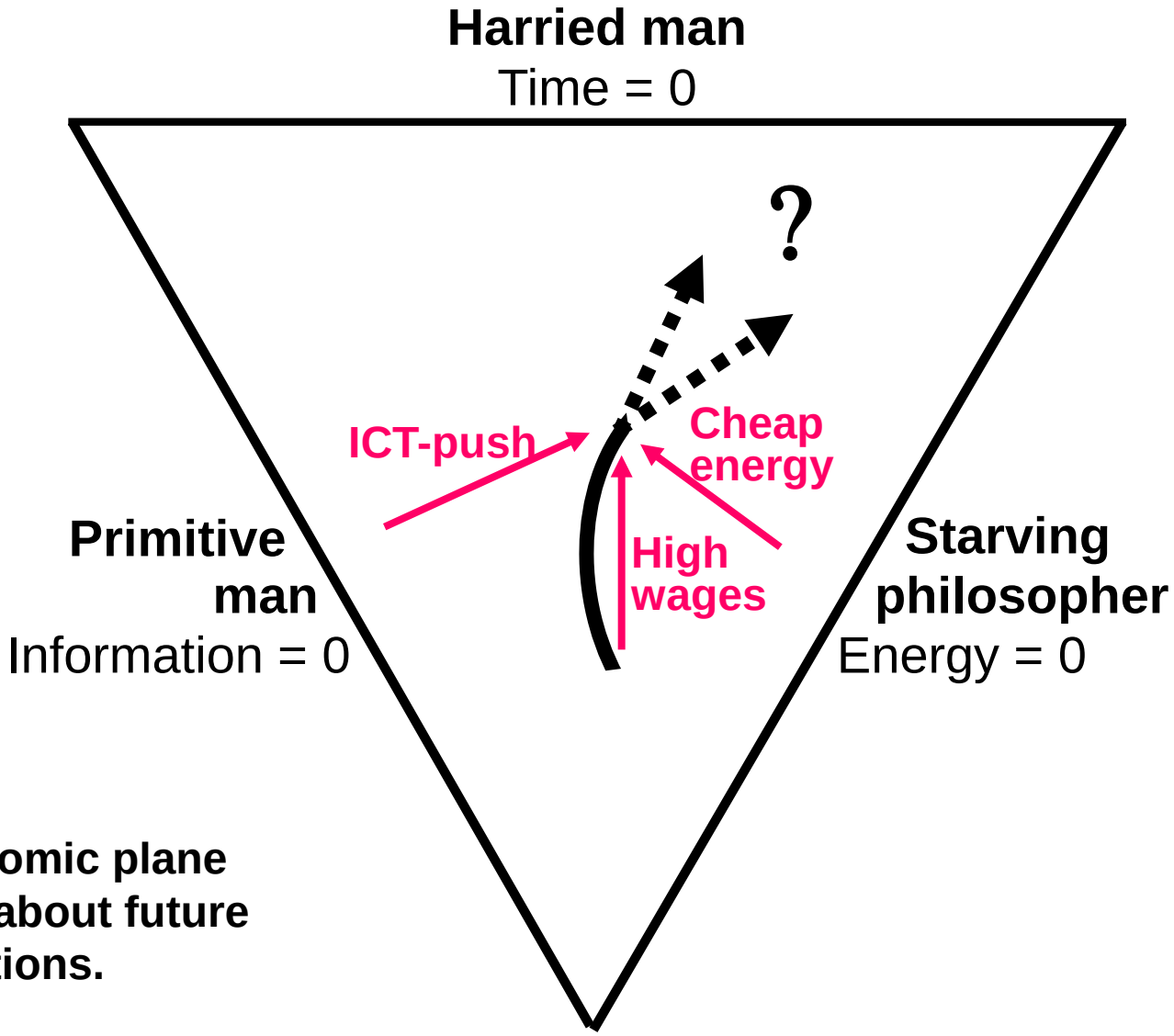
From this hypothesis follows: There are various ways to save energy. Both using more time or using more information can have the desired effect. This is at least often so on a technical plane.

Inputs of economic sectors



On the plane of economic sectors the same substitutional relationship can be seen. A good or service worth a dollar can be earned in various sectors with different characteristic ratios of the energy, time and information inputs. For energy and time (measured in working hours) the cumulated inputs are calculated. The information input is the plausible result of the plotting procedure.

Marco economic plane



On the macro economic plane one can speculate about future development of nations.

Energy

Even though there are

•four thermodynamic potentials (as well as exergy),

•many commercial and non-commercial forms,

•although time and location matters a lot in terms of usefulness,

definition is rather straight forward.

Energy is an extensive quantity (depends in quantity).

The quantitative relationship between energy on the three levels (technical, micro and macro) is the topic of many models.

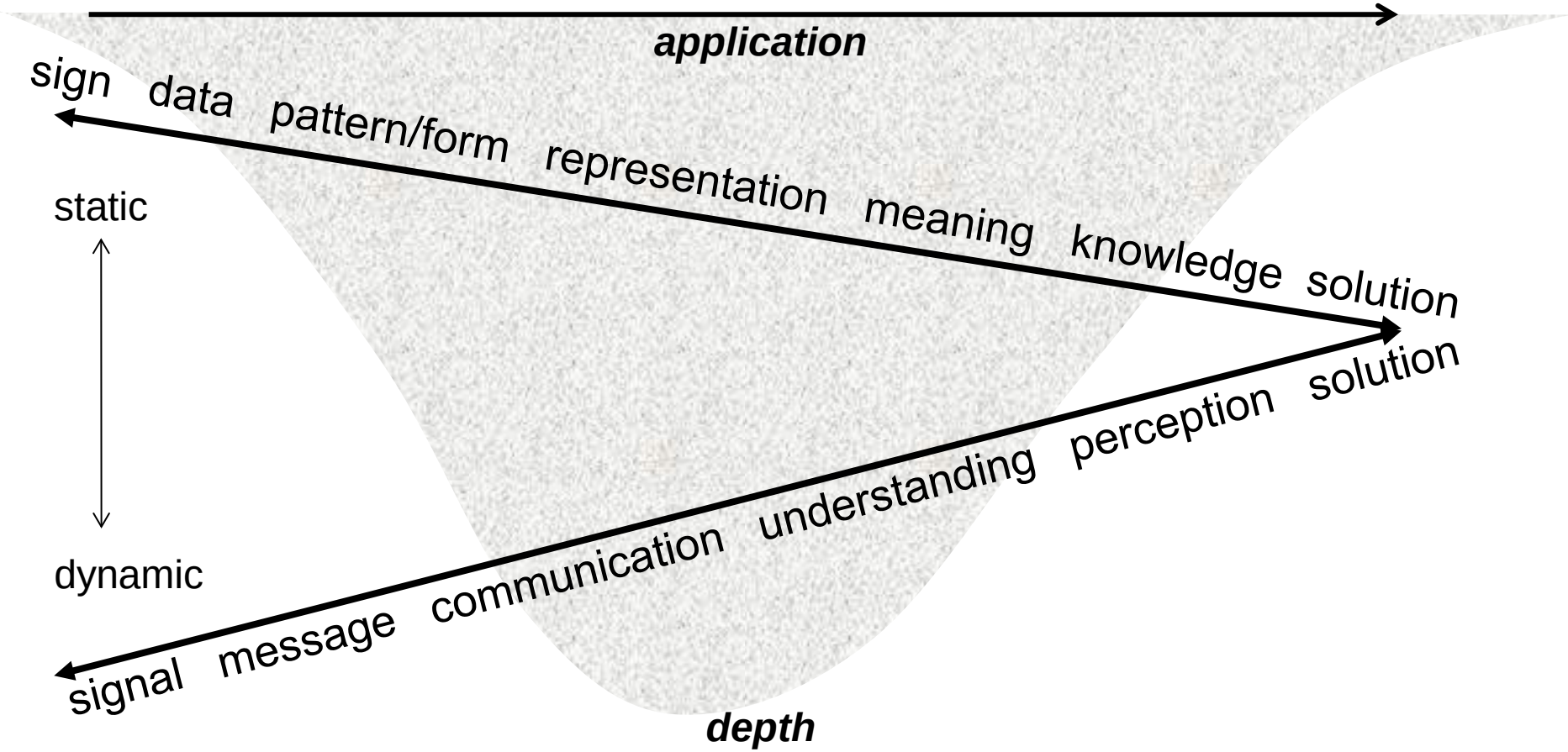
Time is a mysterious quantity

Time is

- both extensive (time period) and quasi intensive (time availability: 24 h a day, life time),
- an irreversible flow,
- both linear (in the technosphere) and cyclical (in nature),
- chronos and kairos.

However, time is easily measureable on the technical level and labor (one aspect of time) or free-time, can be measured on the micro and macro level.

Information (as applied to a task)



Information and innovation **on various levels of aggregation**

To some degree elusive meaning, differently specified (and measured) on various levels

Technical level: Possible specification on previous slide

Micro: Choice of technology (in particular ICT), choice of personnel (skill), choice of product and service

Macro: Penetration of ICT in national economy, education of labor force, concentration and clustering of high-tech firms, demand for quality rather than quantity of products and services

Substitutability of energy, time and information

…. is not a law of physics, but is

- **often a fact on the technical level** (old saying: haste makes waste, but there are many exceptions)
- **often plausible on the micro level** (see triangle with economic sectors)
- and it is **an intuitive truth, also on the macro level** (nations with much stability and high innovative capacity seem to be more sustainable)

Part 3: Two studies

Results referring to

The early introduction of IT in the textile industry

A research program launching power electronics:
Introduction of improved technology (improved largely via IT) in a range of applications

In both studies the three levels (tech., micro, macro) were examined in detail, using results of the lower levels in studying the upper levels, but looking at practices, penetrations, demands and out-comes separately on each level.

Early introduction of IT in the textile industry

together with R. Bergrath, W. Hediger - NFP 44

- Large energy conservation potentials in spinning, weaving and finishing (big factor: reduction of safety margins)
- Massive productivity gains in production through possible speed-ups (partially with higher energy requirements), some times reducing energy conservation effects
- “Unexpected” speed-up of fashion cycles leading over-all to indeterminable energy consumption effects

>> IT opens up both
- possible large energy consumption increases and
- decreases

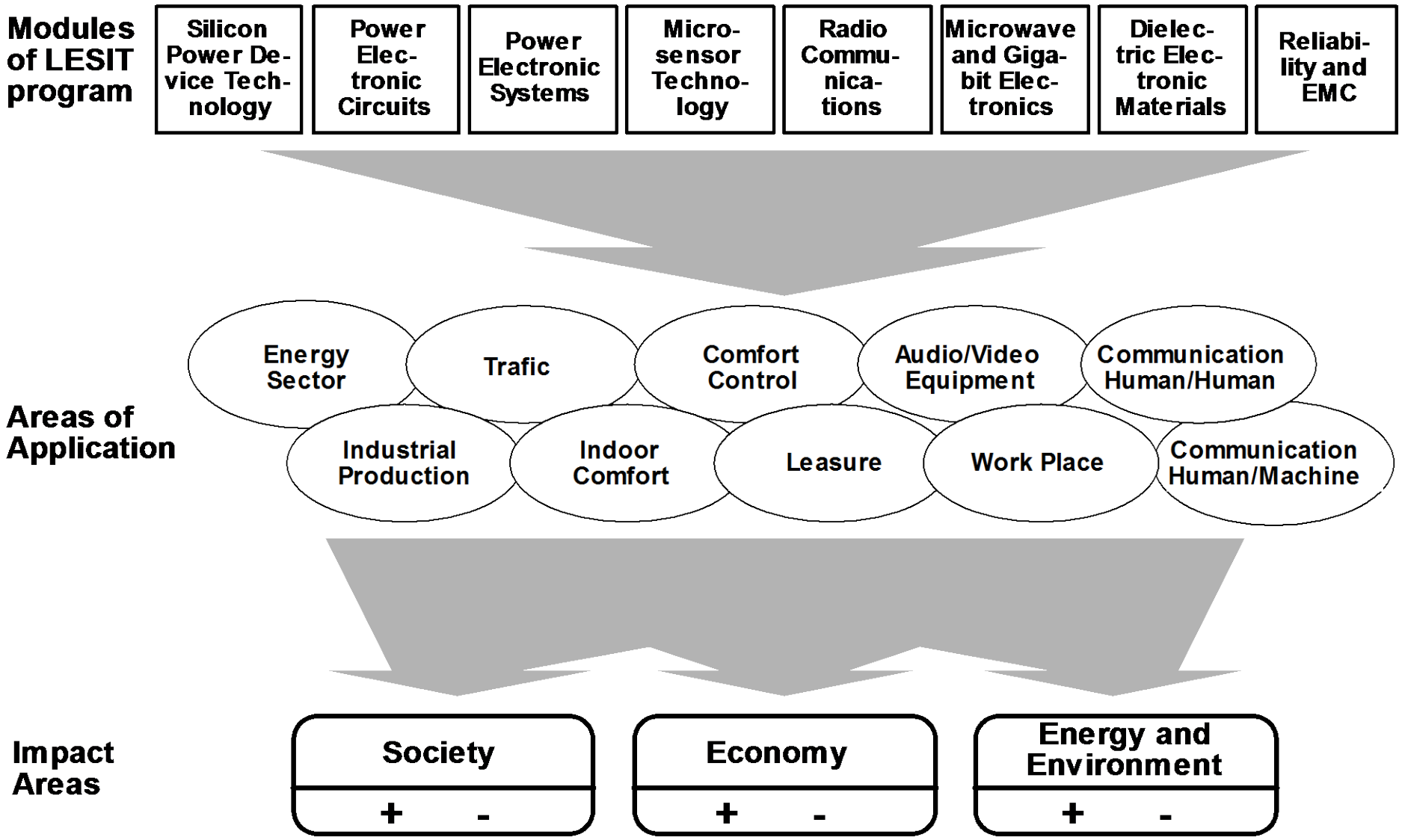
Energy effects of big research program in power electronics

TA-study

with F. Varone, B. Aebischer, W. Eichhammer, E. Gruber, St. Kuhlmann, D. von Wichert-Nick

IT is an integral part of ***advances in power electronics***

- Energy conservation potentials on the technical level are very large
- Studying the effects on the macro scale is a complex interdisciplinary undertaking
- Shortcuts by assuming some kind of rebound effect can be entirely misleading

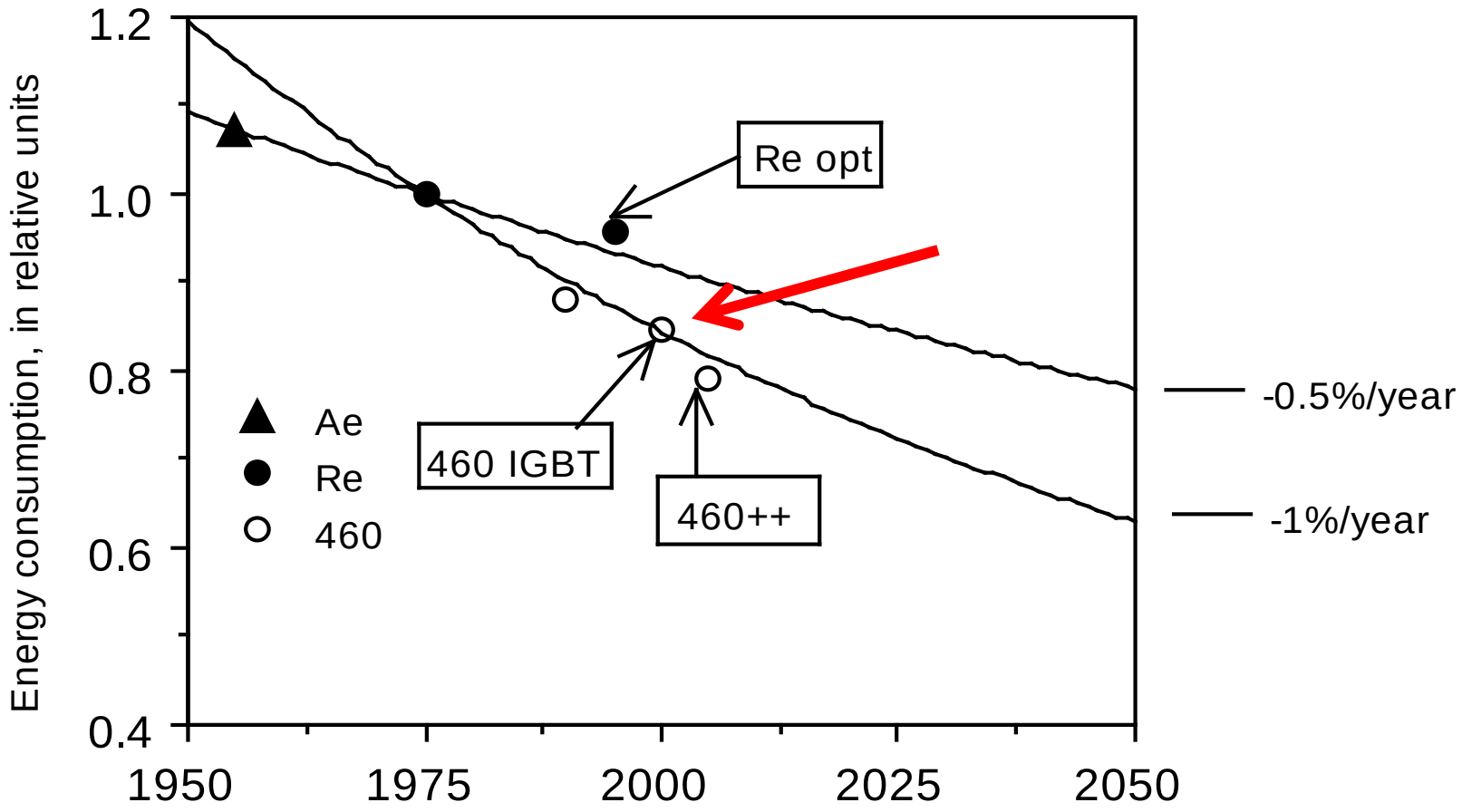


A complete TA for the Priority Research Program would have entailed the analysis of many areas of application with several areas of impact in each of them.

TA-project's focus on three case studies

Stages of the innovation process	Focus	Topic	Object of the analysis
Applied research and technology development	1	Perceptions of researchers on impacts on energy consumption	Selected products and research methods
Technology transfer and production	2	Research co-operation industry and academia / Technology transfer	Energy considera-tions when choosing industry partners
Sale and use of new products	3	Impact of "intelligent buildings" on users	Marketing situation for new energy optimal products

Study included many details



Energy consumption of three types of train engines, Ae 6/6, Re 6/6 and 460, plotted in function of their first year of service, also improved versions, Re opt, 460 IBGT and 460++ are shown. 460 IGBT is +/- result of LESIT and shows reduced energy consumption exactly in line with the business-as-usual trend.

Energy conservation and energy efficiency
(as a result of ICT application)

Energy conservation is a cultural achievement, but is not natural to us (Westerners), it requires valuing leisure,

where as

energy efficiency often increases without special effort and does not necessarily lead to energy conservation.

Part 4: Macroeconomic effects of accelera-ted innovation & higher penetration of ITC

If time (labor) and cumulated time (capital) cost more than energy (and other natural resources) and if consumer preferences remain unchanged then more ICT leads over all to

- no energy conservation, but instead to
- time savings, faster production and economic growth,
- i.e. higher labor and capital productivity (likely more unemployment and cheaper products).

Macroeconomic effects (cont.)

ICT could easily lead to more sustainability, if

- leisure,
- quality of products and services and
- energy as well as other natural resources

would be more highly valued.

Policy design should take into account both the

- massive transformative power of ICT and
- the necessity to steer its application in the right direction.

Energy is not a bad multi-dimensional proxy for the very multi-dimensional issue sustainability

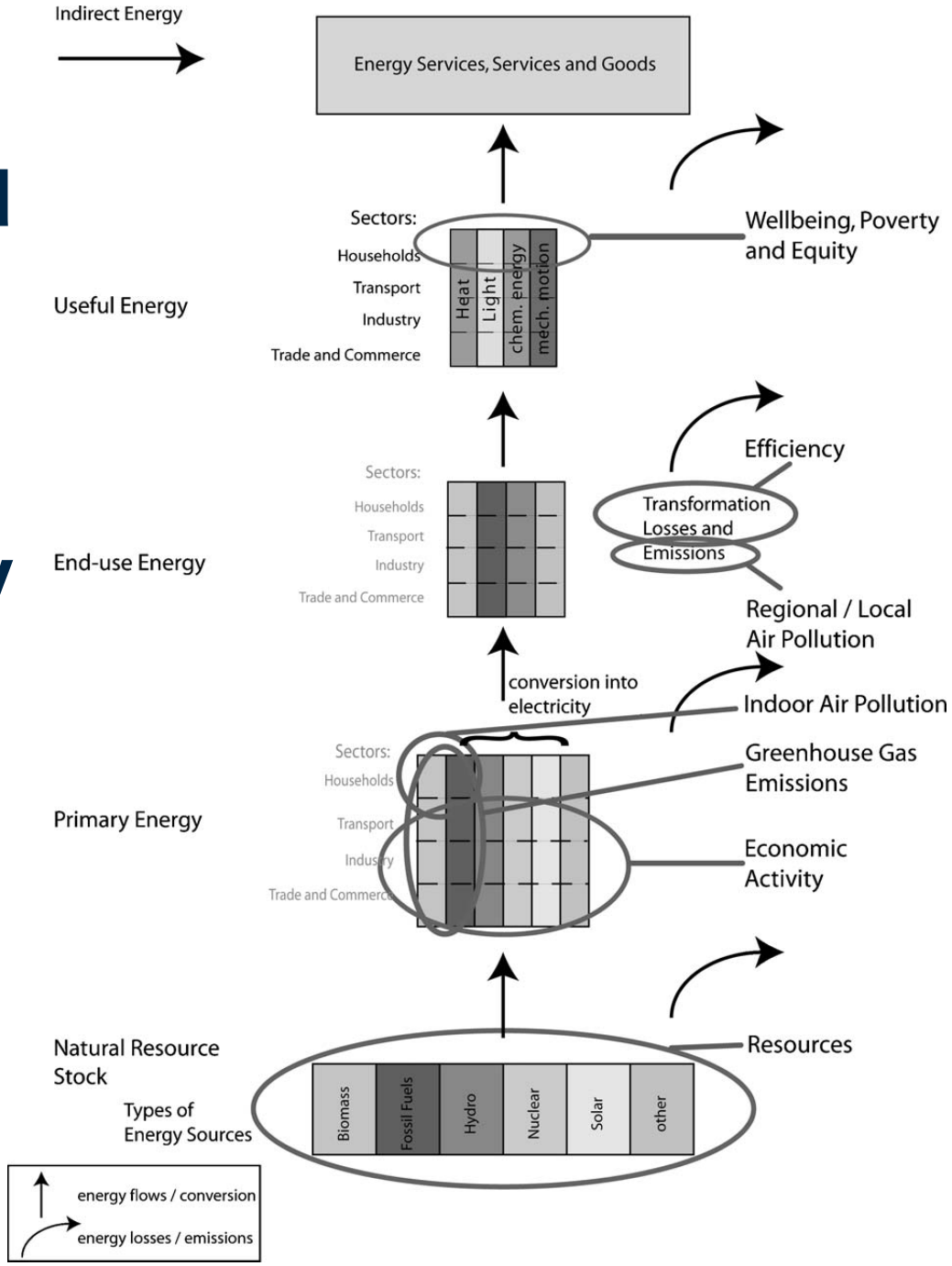
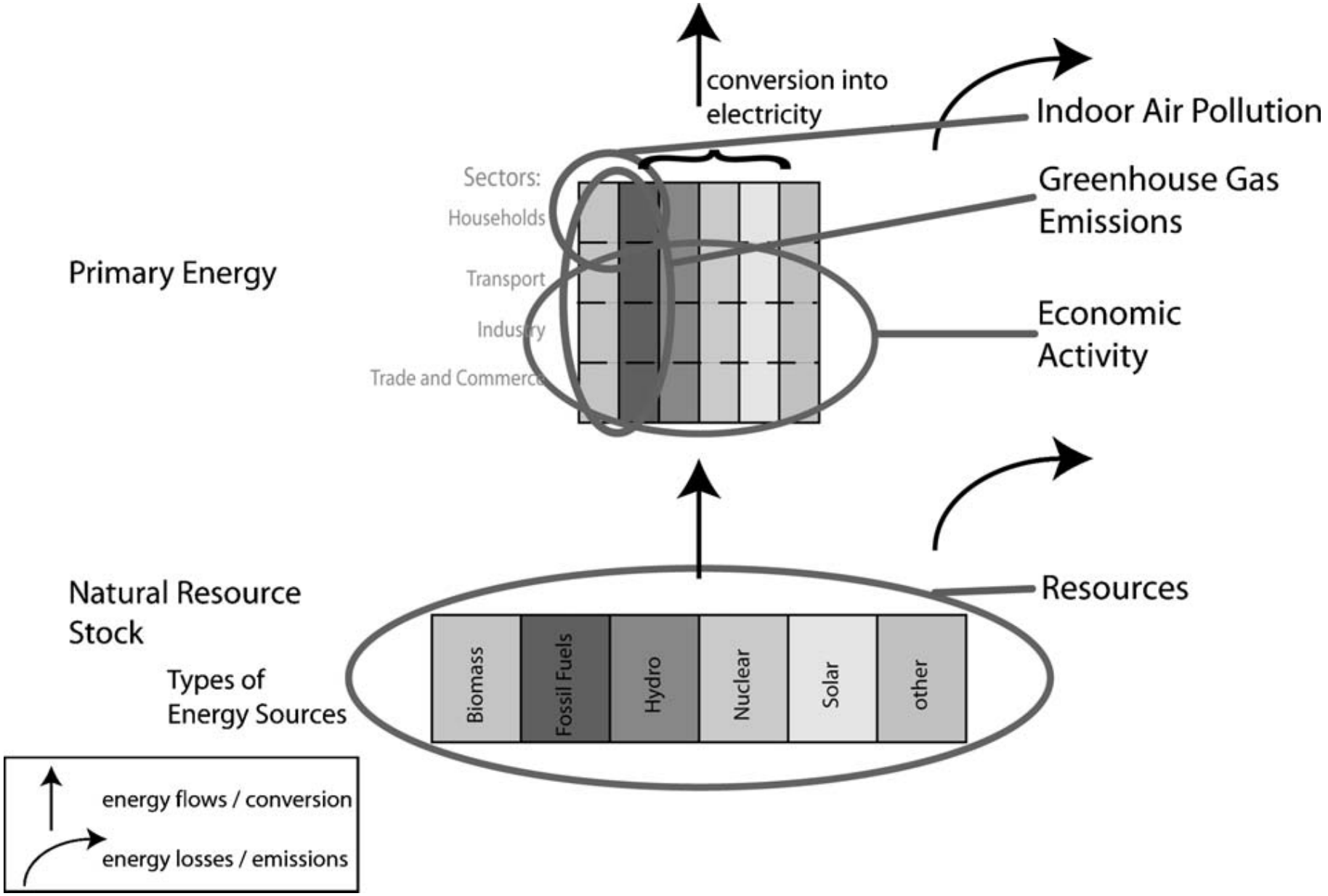
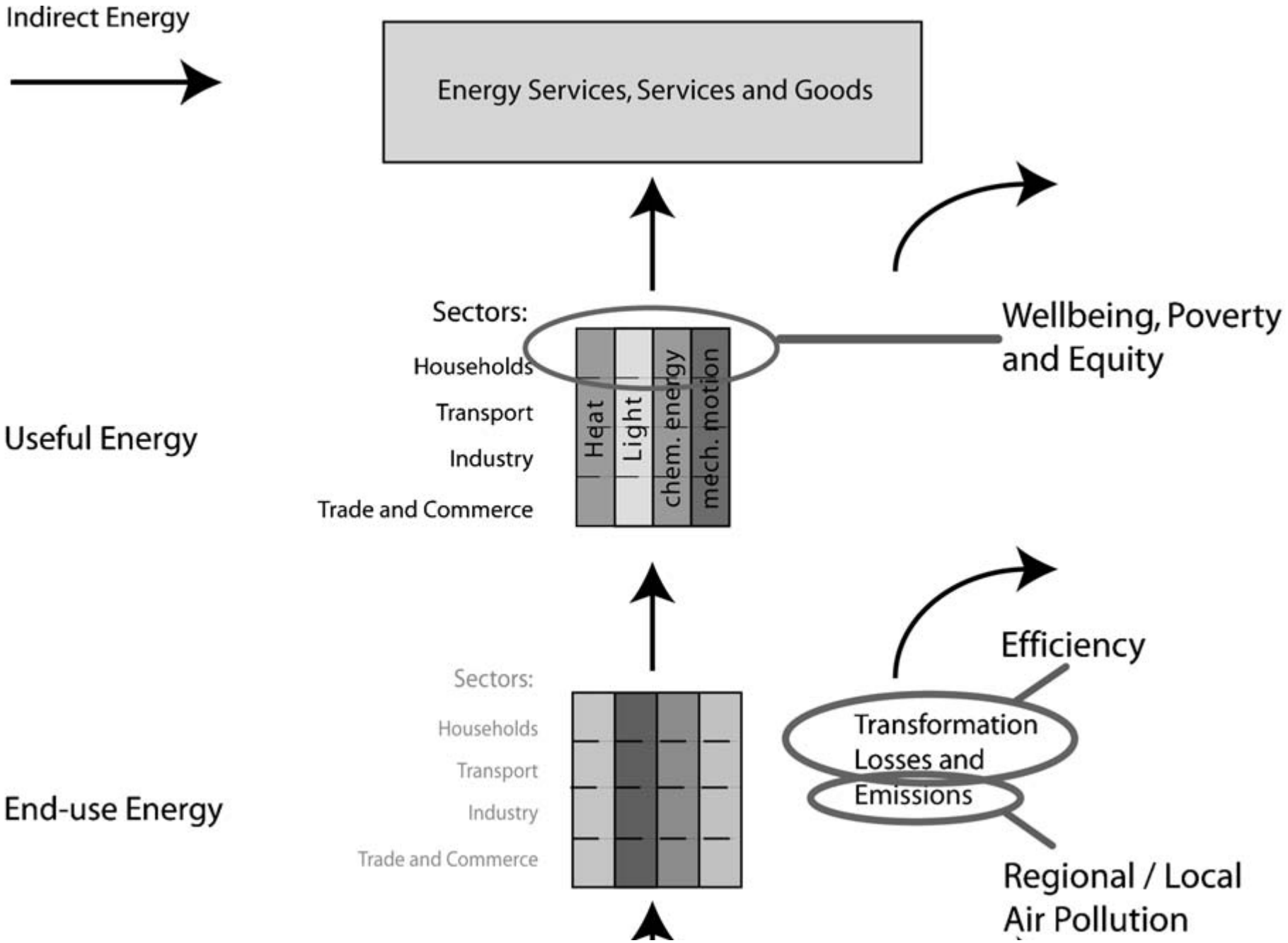


Figure from:
Kemmler A., Spreng D. (2007).
Energy indicators for tracking sustainability in developing countries.
Energy Policy 35 2466–2480


conversion into electricity
Indoor Air Pollution
Sectors:
Households
Transport
Industry
Trade and Commerce
Greenhouse Gas Emissions
Primary Energy
Economic Activity
Natural Resource Stock
Resources
Types of Energy Sources
Biomass
Fossil Fuels
Hydro
Nuclear
Solar
other
energy flows / conversion
energy losses / emissions


Indirect Energy
Energy Services, Services and Goods
Sectors:
Households
Transport
Industry
Trade and Commerce
Heat
Light
chem. energy
mech. motion
Wellbeing, Poverty and Equity
Useful Energy
Efficiency
Sectors:
Households
Transport
Industry
Trade and Commerce
Transformation Losses and Emissions
End-use Energy
Regional / Local Air Pollution

Energy as an indicator of sustainability

1. Not bad as multi-dimensional indicator (all dimensions being connected to each other by the energy flow diagram)
2. More energy does not in all cases mean less sustainability - think of energy poverty
3. Deviation from 2000 watt per capita is an o.k. indicator, approximating many concerns, even if it does leave out a lot.