

GIFT workshop

The Biofuel Delusion

"S' ils n'ont plus de pain, qu'ils mangent de la brioche"

Vienna May 3rd-5th, 2010

icta

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OUTLINE OF THE TALK

1. **Introducing a serious issue with a few funny stories**

2. **The First Generation of Agro-Biofuels**

3. **The mother of all troubles: the low EROI**

   3.1 The quality of energy sources (Energy Return On Investment)

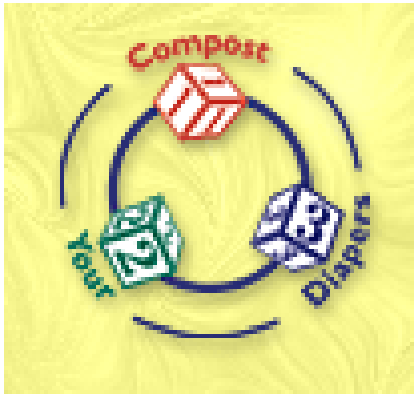
   3.2 Can biofuels replace fossil fuels? the heart transplant metaphor

4. **What about the Second Generation of Liquid Biofuels?**

5. **Conclusions about biofuels and bioenergy**

6. **The lesson to be learned!**

smallplanet™
convenience with a conscience™



fossil energy implies the same problem generated by disposable diapers !

different forms of recyclable diapers have been used since the dawn of humankind . . .

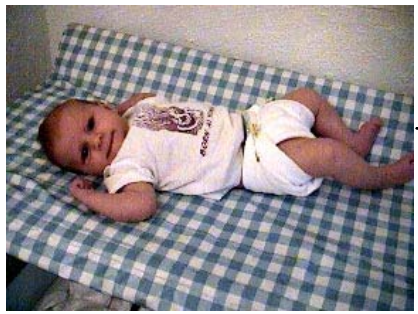
A Tikanagan used by native Americans

"When **moss** was used for diapers the baby seldom became chafed, and when it was unwrapped you could smell only sweet moss"

Statement gathered by the ethnologist Imez Hilger in the 1930s from an elder Native American

British Museum

So why did humans stop to use recyclable diapers in the first place?



So, what is wrong with recycling?

there is nothing “wrong” with recycling, but there are pros and cons associated with recycling. How to evaluate these pros and cons really depends on your priority over different objectives . . .

A similar problem, in China, has been experienced with domestic biogas plants . . .

"The vast majority of the 6 million domestic biogas plants in rural China have been abandoned as soon as fossil energy has become accessible . . ."

Vaclav Smil

So, what is wrong with domestic biogas plants?

ask the operator!

1

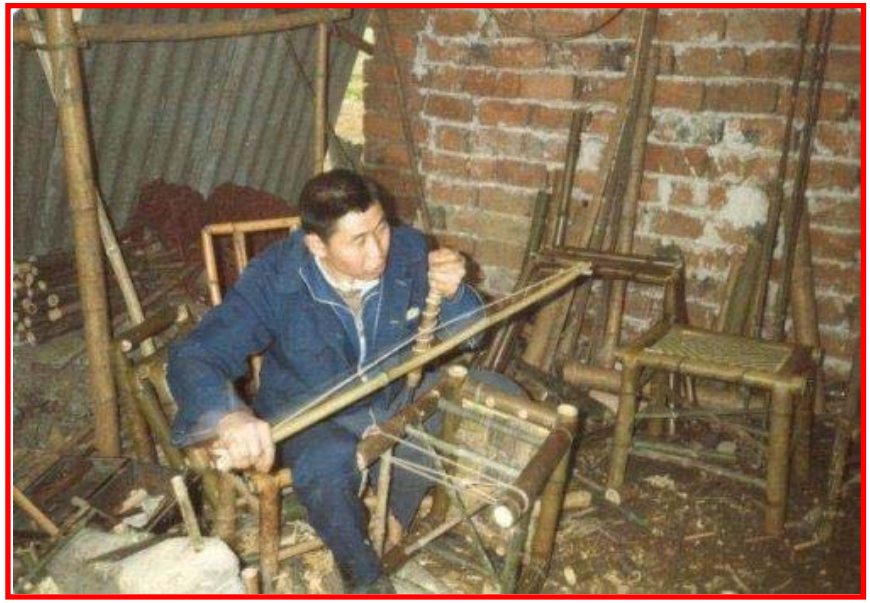
2

3

4

5

6



http://www.paulnoll.com/China/Commerce/China-factory-scenes.html

What is the relevance for the choice of alternative energy?

When looking for alternative energy, does everything goes?

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FUEL
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PM-10 emissions and power of a Diesel engine fueled with crude and refined Biodiesel from salmon oil

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when looking for alternative fuels, does everything go?

What about refined biodiesel from human fat after liposuction?

+

=

after all this is a win-win solution . . .

"There's an interesting business model: link a biodiesel plant with the cosmetic surgeons," says Mr. Bethune. "In Auckland we produce about 330 pounds of fat per week from liposuction, which would make about 40 gallons of fuel.
If it is going to be chucked out, why not?"

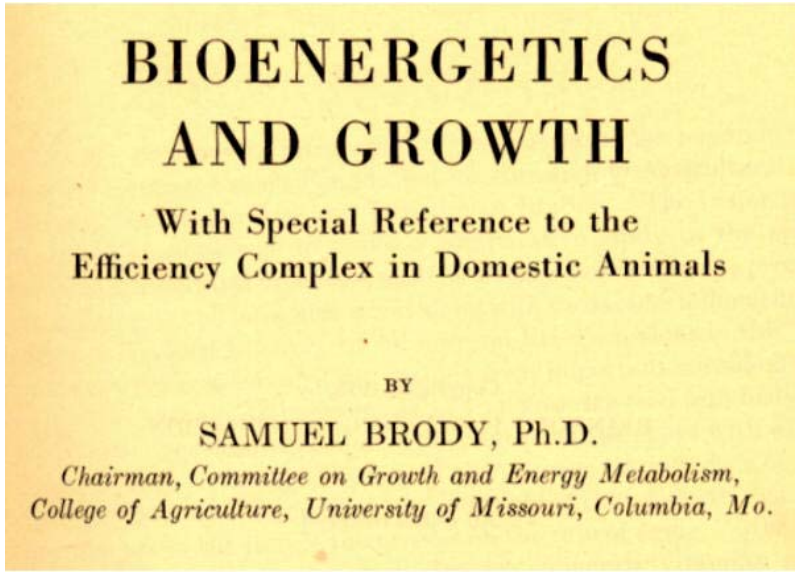
Peter Bethune

Peter Buthune is the founder of Earthrace, a project to promote the use of biofuel trying to break the round-the-world powerboat speed record in a boat powered by biodiesel fuel partly **manufactured from human fat**.

"A large liposuction operation involves removing 10 pounds of fat, which would drive a car about 50 miles once converted"

The lean Mr. Bethune had about three ounces of fat extracted from his body in a liposuction procedure, and he is seeking volunteers to donate more.

From: http://calorielab.com/news/2005/11/11/



Samuel Brody - writing in 1945! – ends his masterpiece on energy and power analysis of US agriculture with a chapter about the future of power and energy sources for agriculture. In that chapter he stigmatizes those proposing biofuels* [based on corn] *for mechanizing US agriculture using a famous quote attributed to Marie Antoinette :

“if they have no bread, let them eat the cake”

“S’ ils n'ont plus de pain, qu'ils mangent de la brioche"

2. The first Generation of Agro-Biofuels

2.1 An overview of the existing situation

The story used to sell the idea of agro-biofuels . . .

One of the options to reduce emissions is the use of biomass as an energy source. The CO2 emitted when using biomass as energy source equals the CO2 captured earlier that year in the photosynthetic process of the crops, on an annual basis no extra CO2 is emitted to the atmosphere (Nonhebel, 2010).

The first generation of biofuels

covers **less than 2%** of transportation fuels consumed in the world, which are about **20%** of total energy consumption!

86% Ethanol	from CORN produced in the USA from SUGARCANE produced in Brazil
14% Biodiesel	from energy crops mainly in Europe from palm oil non-OECD countries

Liquid fuels produced by crops:

Corn → Ethanol

Sugarcane → Ethanol

* Producing the biomass
* Sugar/Starch fermentation
* Distillation

Energy crops* → Biodiesel

* Producing the biomass
* Extracion of the oil
* Oil/Fat transesterification

* *rapeseed, soya, sunflower – in temperate areas*
  palm oil, jatropha – subtropical/tropical areas

Animal Fat → Biodiesel (restaurant oils, chicken fat, slamon oil . . .)

Ethanol Production from Corn (USA) - **1 hectare**

29 GJ

Fertilizers
Pesticides
Irrigation
Tractors
Drying

31 GJ

Transport
Plant steel
Cements
Steam
Electricity

WATER

2,500 tonnes

LAND

1 hectare

66 GJ
gross
supply

6 GJ
net
supply

SOIL EROSION

12 tonnes

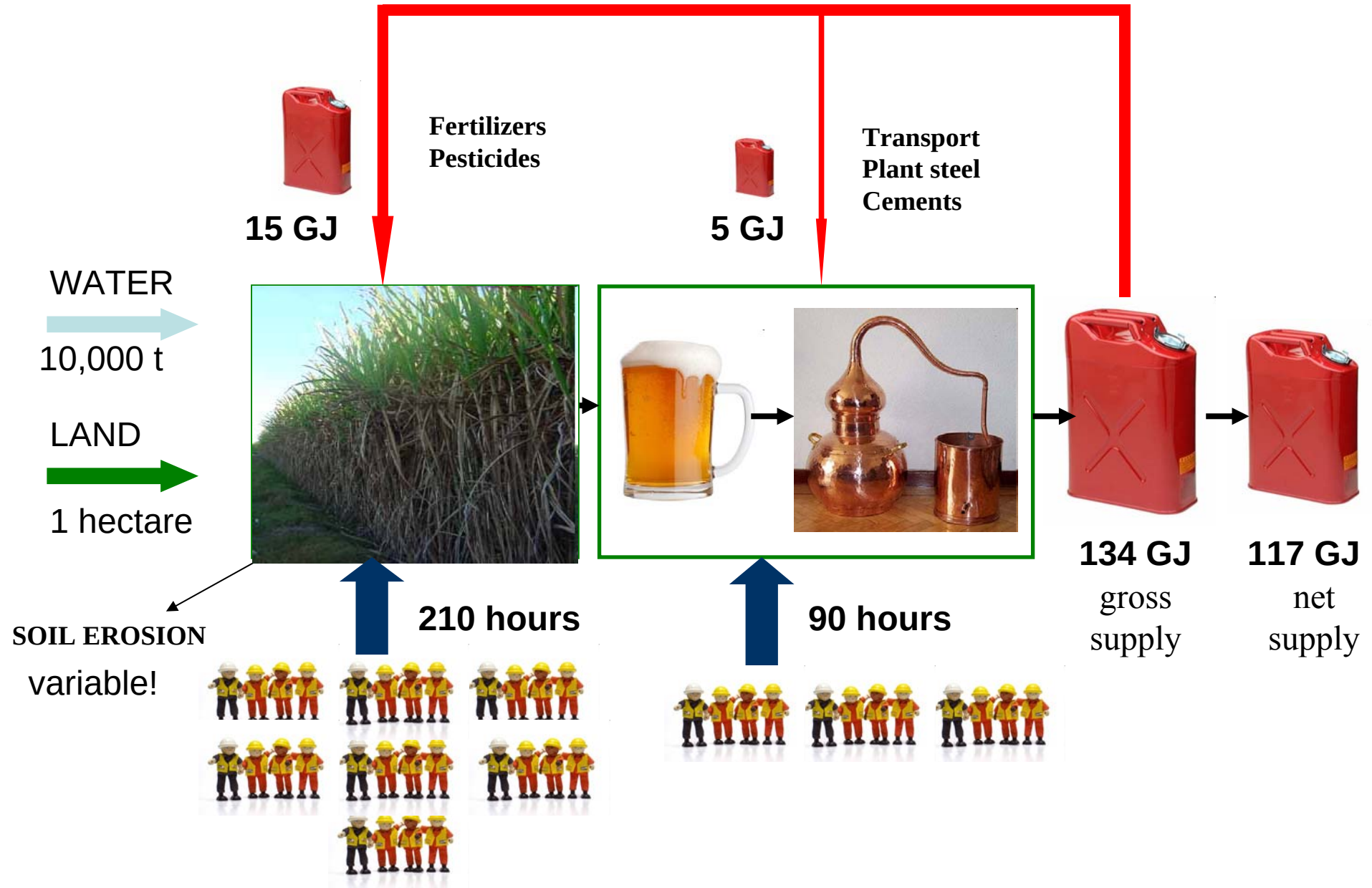
POLLUTION

* NP leakages (sea dead spots)
* pesticides residues

12 hours

14 hours

Ethanol Production from Sugarcane (Brazil) - **1 hectare**



Ethanol Production from Corn (USA)

Output/Input = **1.1/1**

power of worker = **2,300 MJ/hour**

net supply = **6 GJ/ha**
land demand for energy

net supply = **230 MJ/hour**
work demand for energy

Ethanol Production from Sugarcane (Brazil)

Output/Input = **7/1**

power of worker = **67 MJ/hour**

net supply = **117 GJ/ha**
land demand for energy

net supply = **390 MJ/hour**
work demand for energy

3. The mother of all troubles!

What is “wrong” with biofuels, which is “right” with fossil energy?

What is the “systemic” problem which makes biofuels not viable in developed societies?

Check the EROI !!!!

Let's imagine to evaluate an economic investment giving you **"a return of 10,000 €"**

Is this a good option for investing your money?

The answer depends on two questions:

#1 How much do I have to invest to get the return of 10,000 €?

#2 How long will it take to get the money back plus the interest?

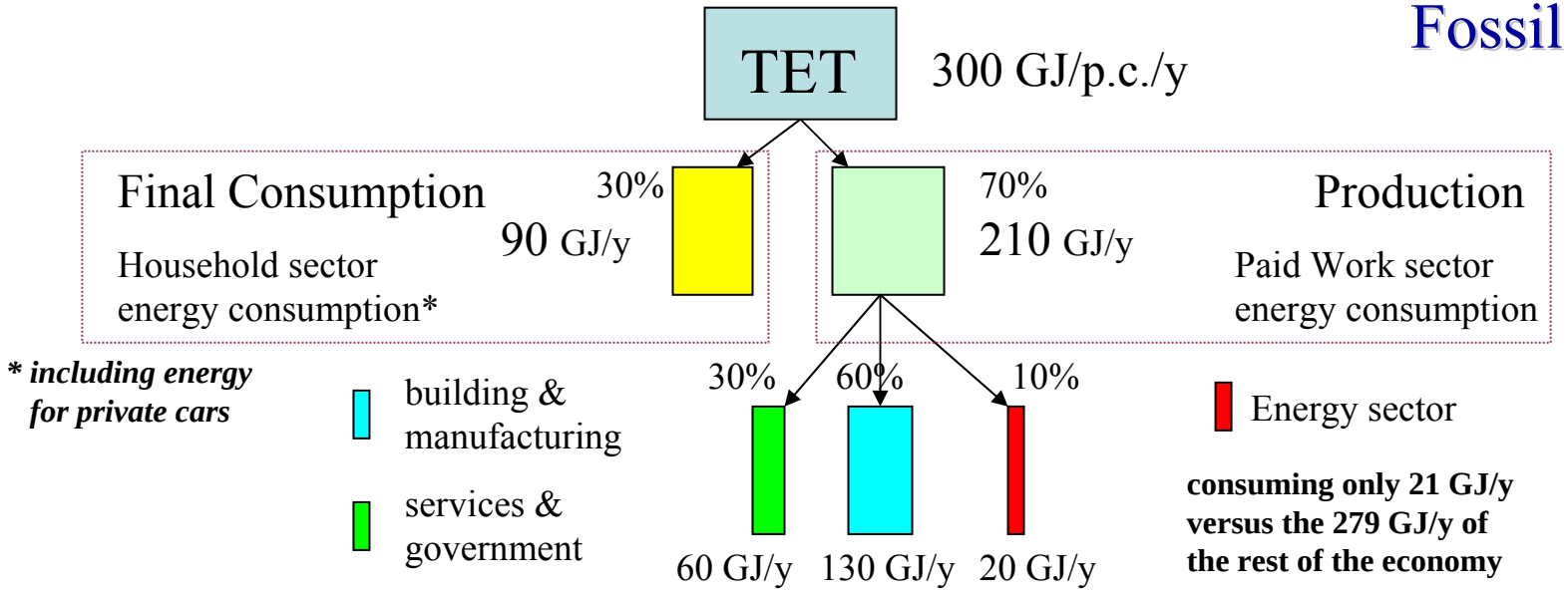
Fossil energy !

It is a VERY GOOD investment if it requires an amount of money invested of 10,000 € and if it pays back (with the interest) in only 1 year !

It is VERY BAD investment if it requires an amount of money invested of 1,000,000 € and if it pays back (with the interest) in more than 5 years!

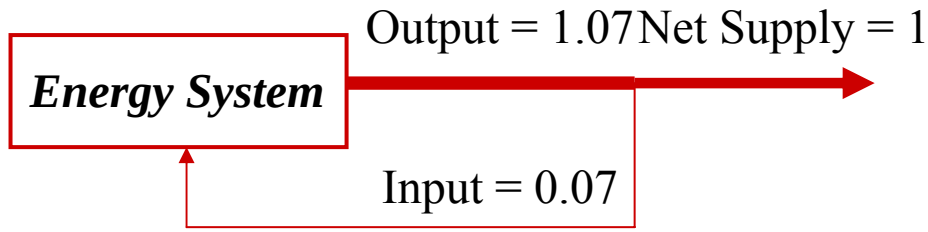
Agro-biofuels !

Fossil energy



High Quality Primary Energy Source

Output/Input = 15/1

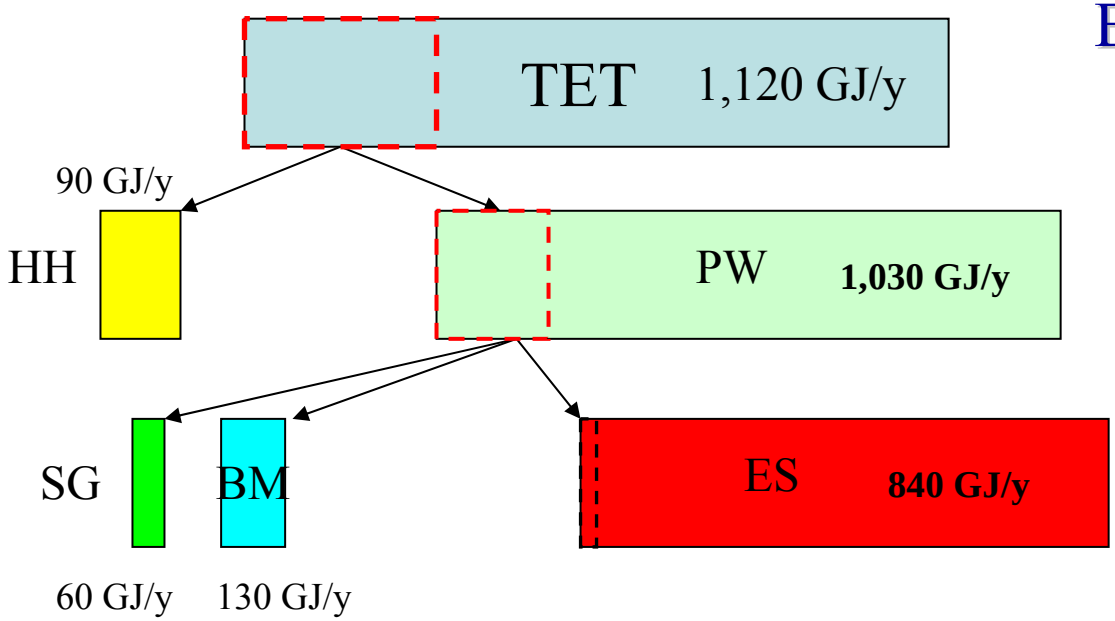


For each GJ of energy delivered to society the energy sector is consuming 0.07 GJ

energy for energy

same consumption of "the rest of society" → 280 GJ/y

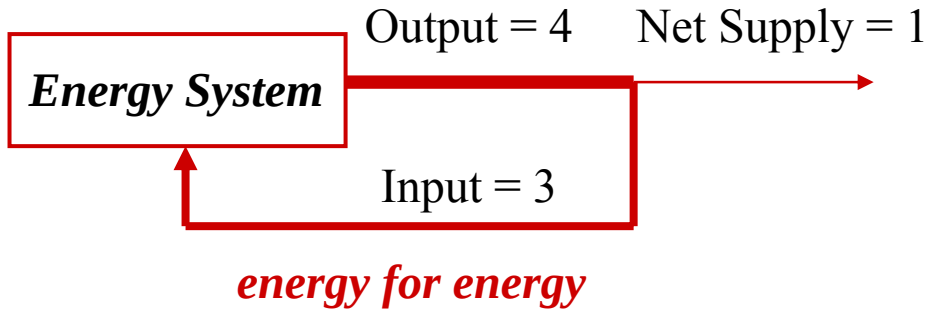
e.g. Biofuel in Europe



the "energy sector" will consume → 840 GJ/y !!!

Low Quality Primary Energy Source

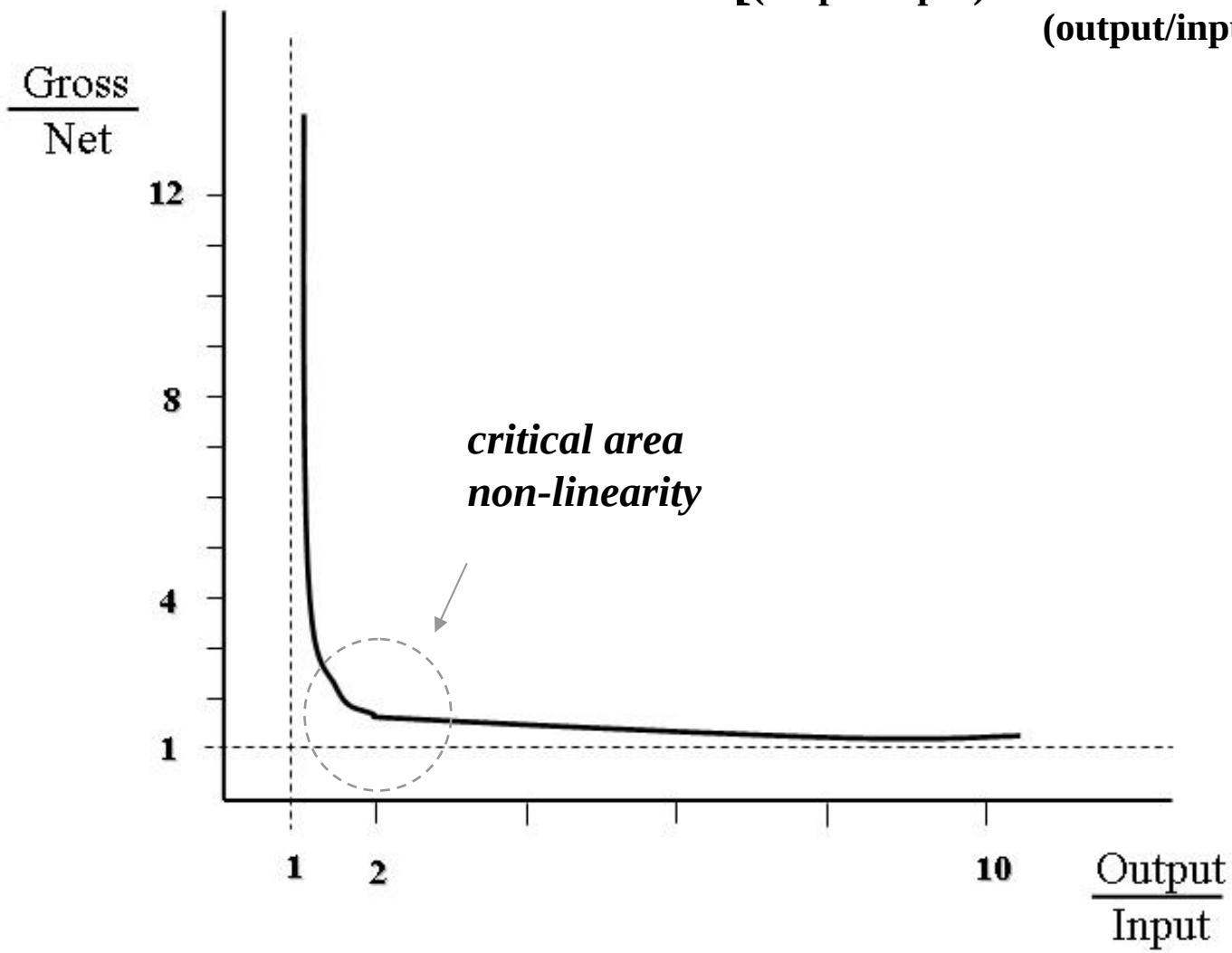
Output/Input = 1.33/1



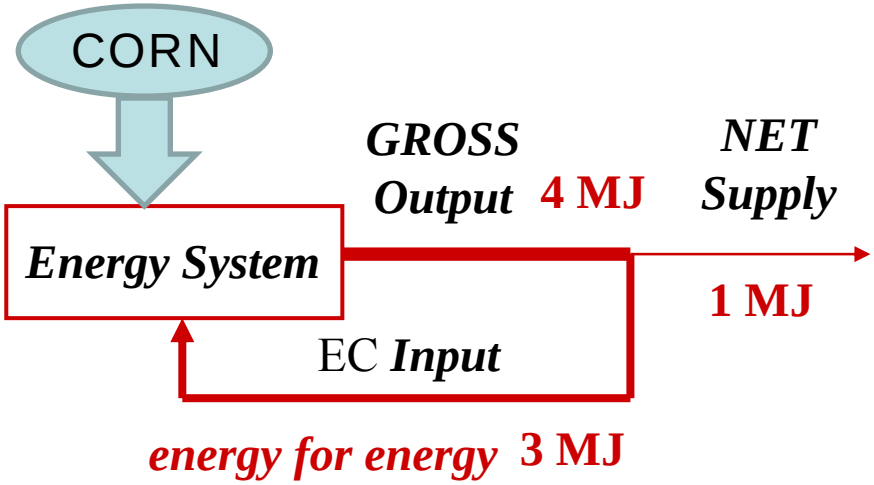
For each GJ of energy delivered to society the energy sector is consuming **3 GJ !!!**

NON-LINEARITY BETWEEN GROSS AND NET SUPPLY OF ENERGY CARRIERS

$$\text{Gross/Net} = \left[\text{(output/input)} \times \frac{1}{\text{(output/input)} - 1}\right]$$



Low Quality Primary Energy Source (ethanol from corn)



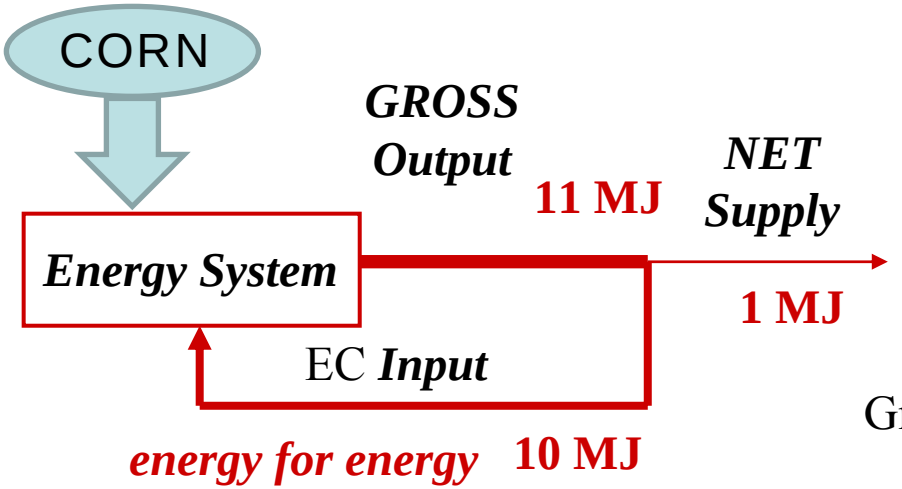
Gross Output$_{(EC)}$/Input$_{(EC)}$ = **1.3/1**

EC Gross/Net Supply$_{(EC)}$ = 4

Gross Output$_{(EC)}$/hectare = 66.1 GJ/ha

Net Output$_{(EC)}$/hectare = **16.5 GJ/ha**

only 1/4th!



Gross Output$_{(EC)}$/Input$_{(EC)}$ = **1.1/1**

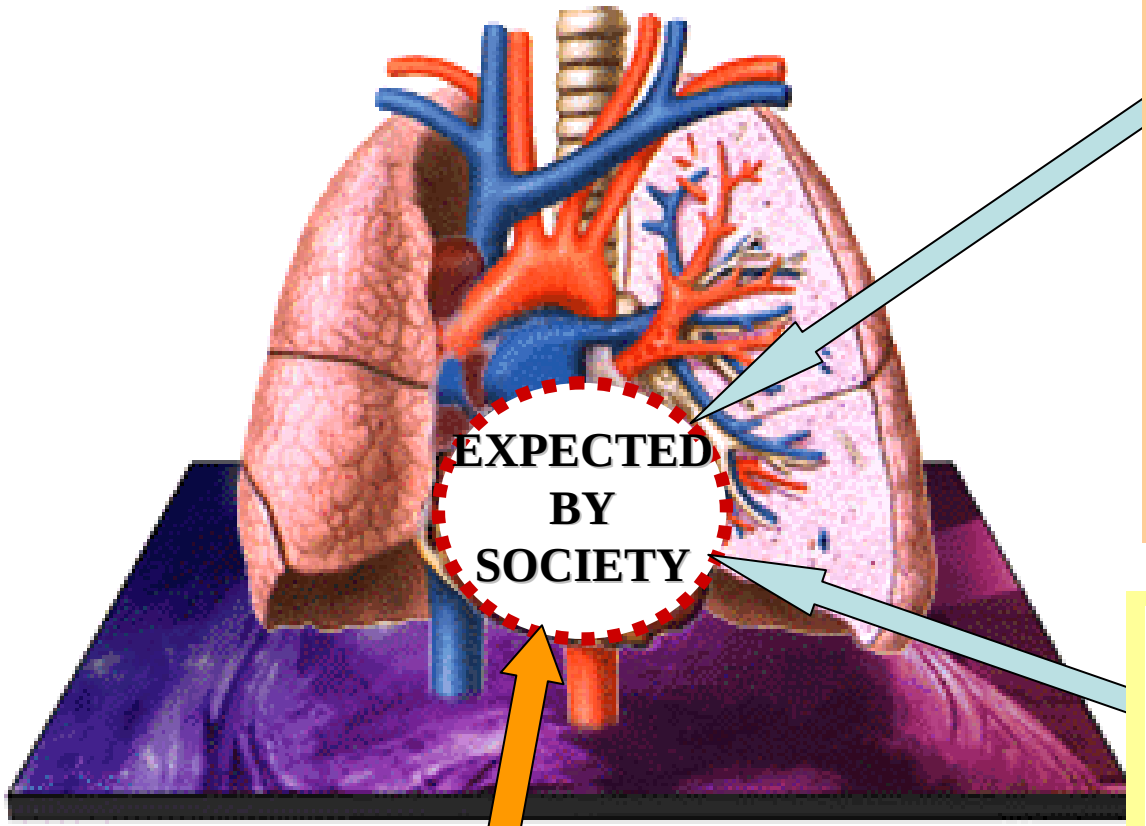
EC Gross/Net Supply$_{(EC)}$ = 11

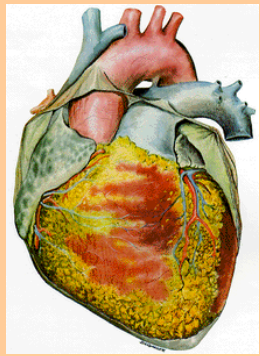
Gross Output$_{(EC)}$/hectare = 66.1 GJ/ha

Net Output$_{(EC)}$/hectare = **6 GJ/ha**

only 1/11th!

The heart metaphor





Energy Sector powered by fossil fuels

- **Technical Coefficients**
- **Biophysical Constraints**

Energy Sector powered by biofuels

- **Technical Coefficients**
- **Biophysical Constraints**

given the characteristics of its metabolism a society can only invest in its energy sector a limited amount of:

*** hours of work**

*** hectares of colonized land**

The heart metaphor for the energy sector

The heart

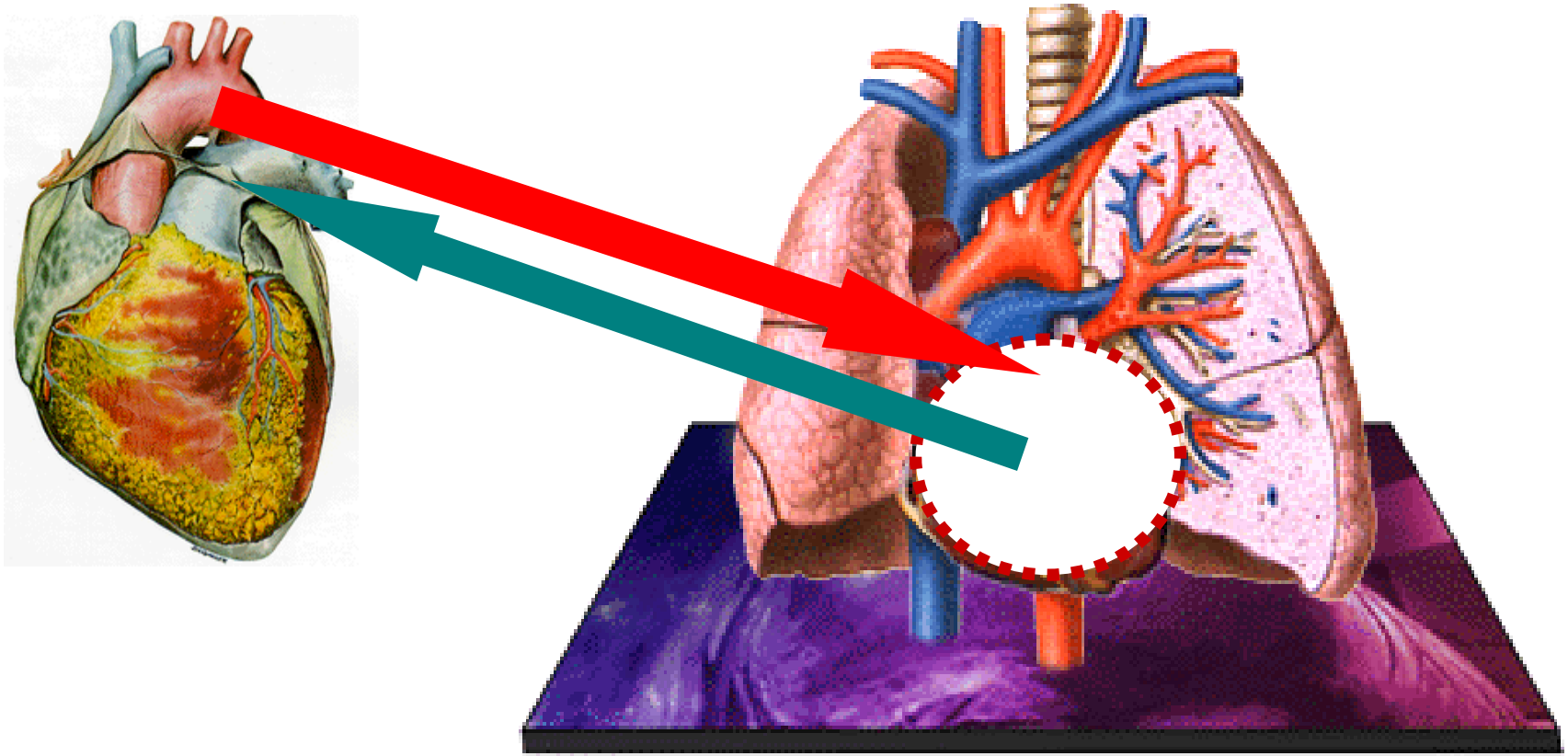
an effective supplier of the expected flow of ***blood*** to the rest of ***the body***

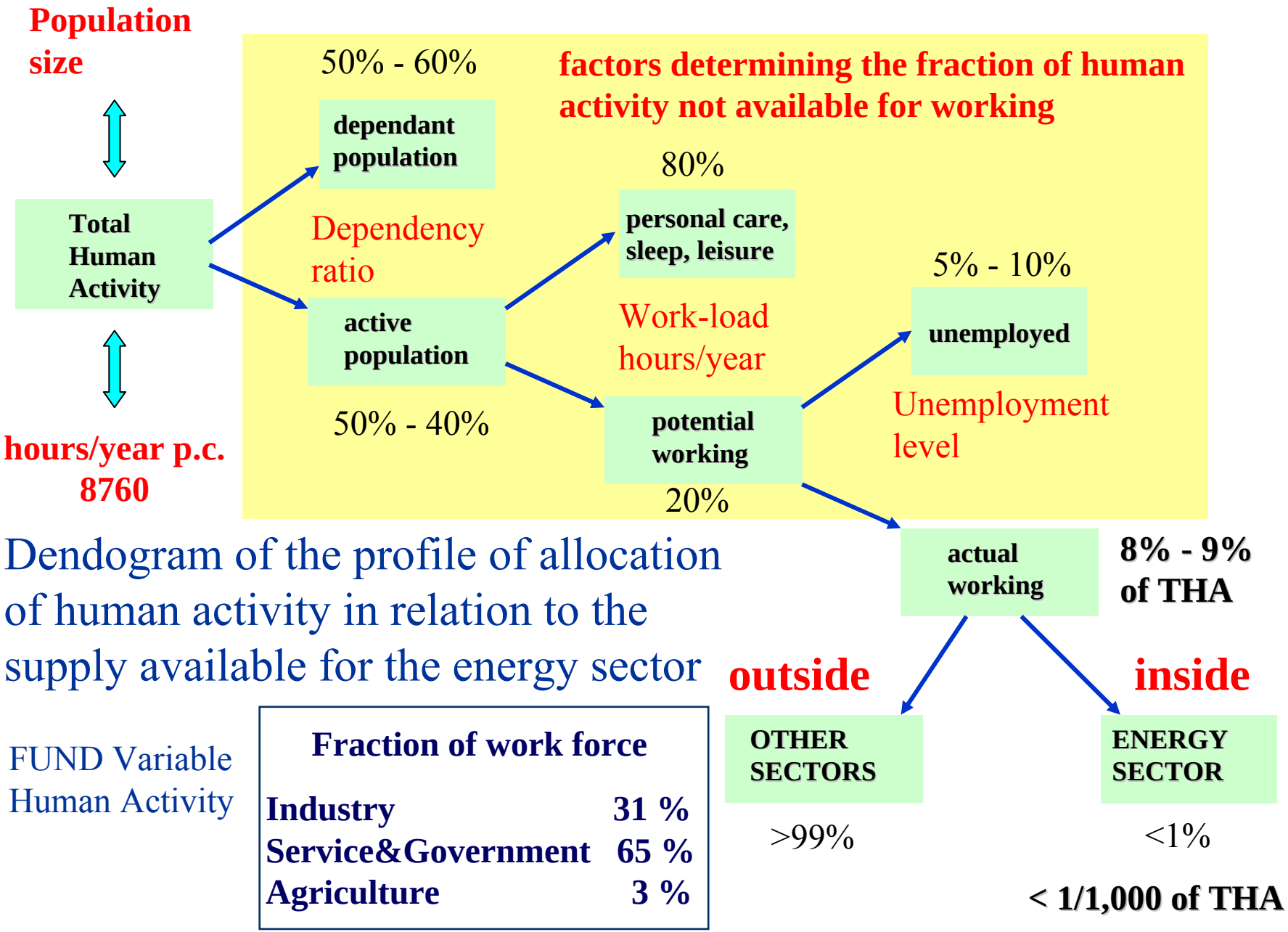
The energy sector

an effective supplier of the expected flow of ***energy carriers*** to the rest of ***society***

Checking the hearth metaphor in relation to the compatibility between:

(i) labor requirement; and (ii) **labor supply;**

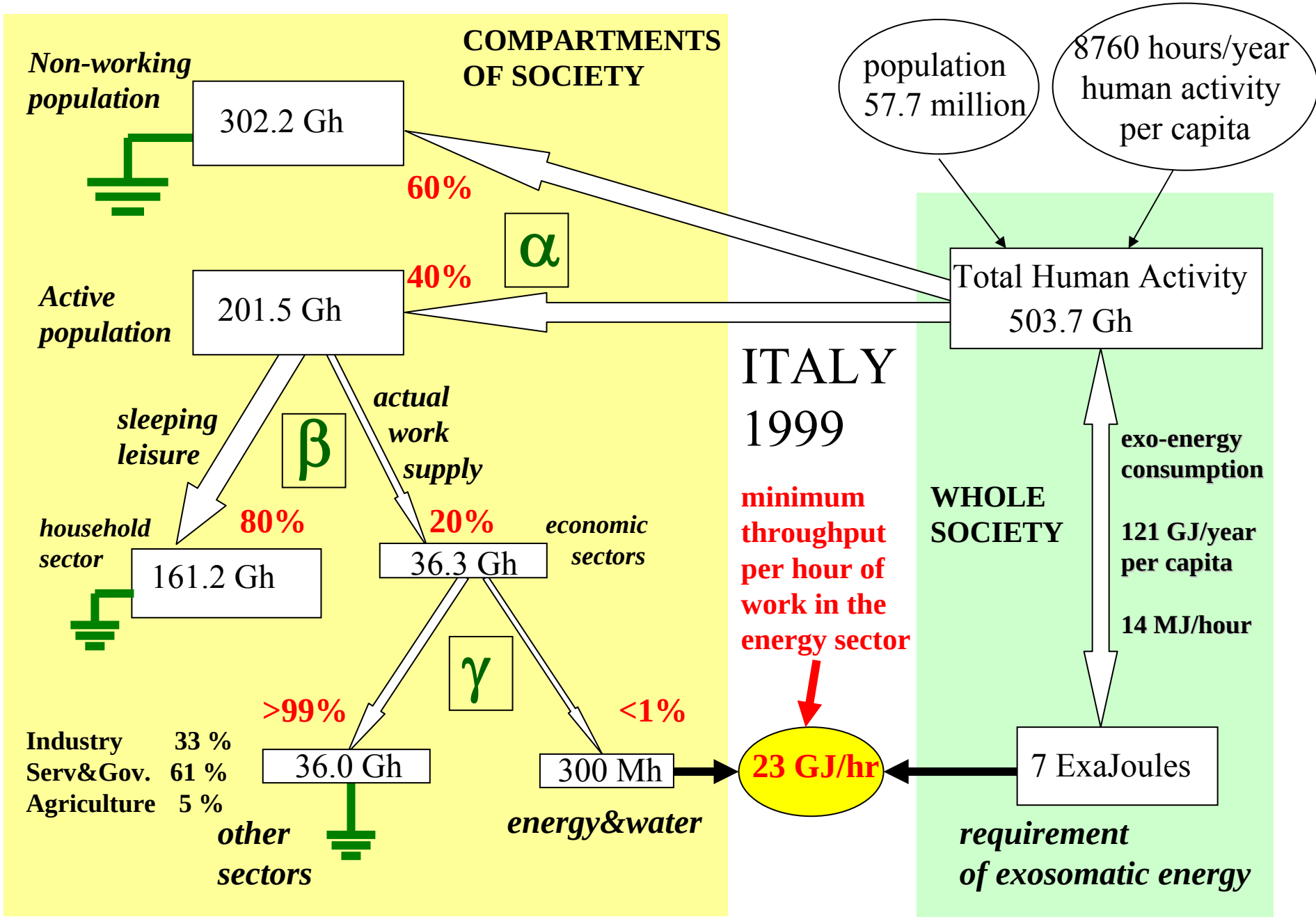


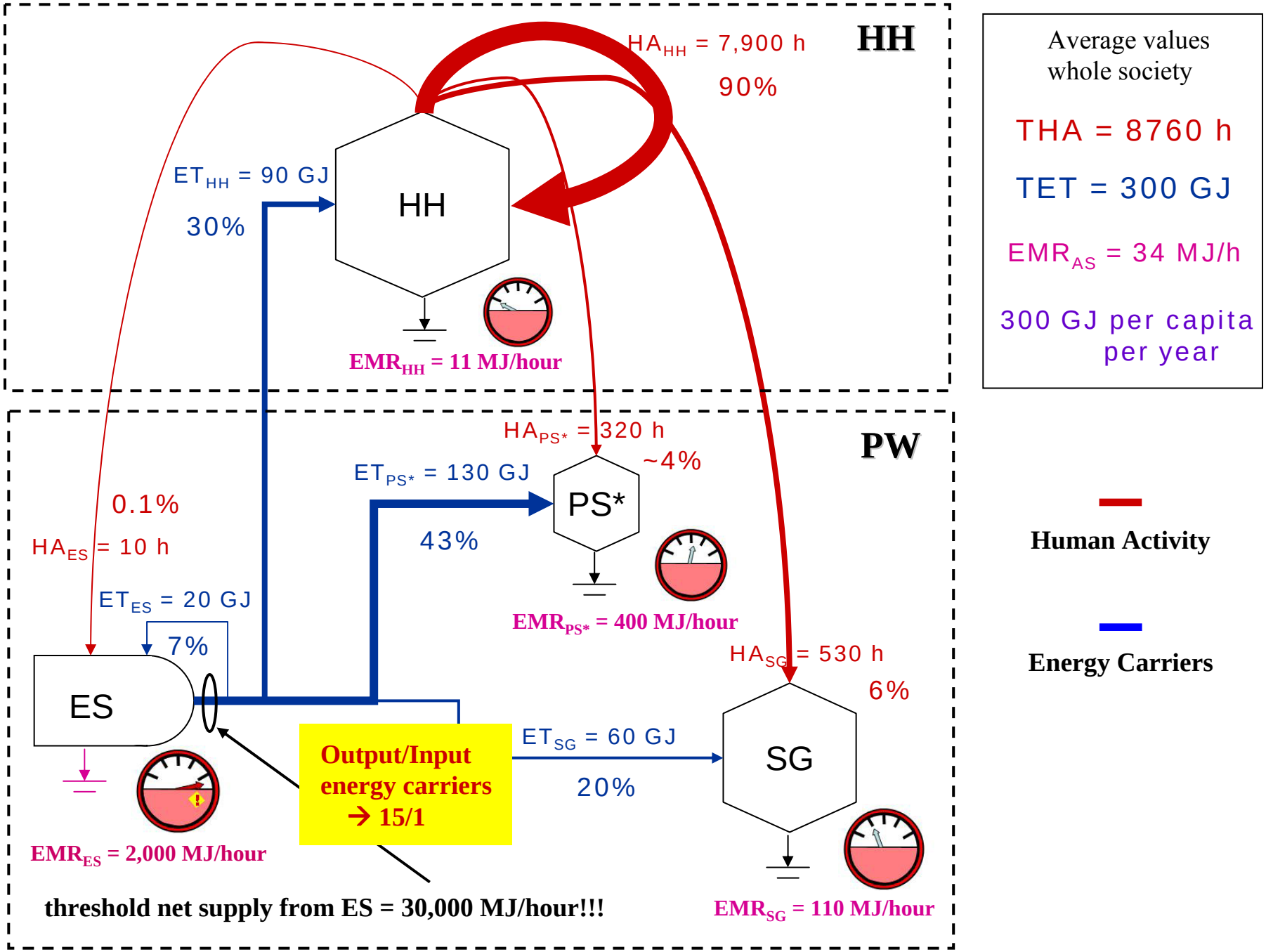


Dendogram of the profile of allocation of human activity in relation to the supply available for the energy sector

FUND Variable Human Activity

Fraction of work force	
Industry	31 %
Service&Government	65 %
Agriculture	3 %


COMPARTMENTS OF SOCIETY
Non-working population
302.2 Gh
60%
α
Active population
201.5 Gh
40%
sleeping leisure
β
actual work supply
household sector
80%
161.2 Gh
20%
economic sectors
36.3 Gh
γ
>99%
<1%
Industry 33 %
Serv&Gov. 61 %
Agriculture 5 %
36.0 Gh
other sectors
300 Mh
energy&water
population 57.7 million
8760 hours/year human activity per capita
Total Human Activity 503.7 Gh
ITALY 1999
minimum throughput per hour of work in the energy sector
23 GJ/hr
WHOLE SOCIETY
exo-energy consumption
121 GJ/year per capita
14 MJ/hour
7 ExaJoules
requirement of exosomatic energy


HH
HA$_{HH}$ = 7,900 h
90%
ET$_{HH}$ = 90 GJ
30%
HH
EMR$_{HH}$ = 11 MJ/hour
PW
HA$_{PS*}$ = 320 h
~4%
ET$_{PS*}$ = 130 GJ
PS*
43%
EMR$_{PS*}$ = 400 MJ/hour
0.1%
HA$_{ES}$ = 10 h
ET$_{ES}$ = 20 GJ
7%
ES
HA$_{SG}$ = 530 h
6%
ET$_{SG}$ = 60 GJ
SG
20%
Output/Input energy carriers → 15/1
EMR$_{ES}$ = 2,000 MJ/hour
threshold net supply from ES = 30,000 MJ/hour!!!
EMR$_{SG}$ = 110 MJ/hour
Average values whole society
THA = 8760 h
TET = 300 GJ
EMR$_{AS}$ = 34 MJ/h
300 GJ per capita per year
Human Activity
Energy Carriers

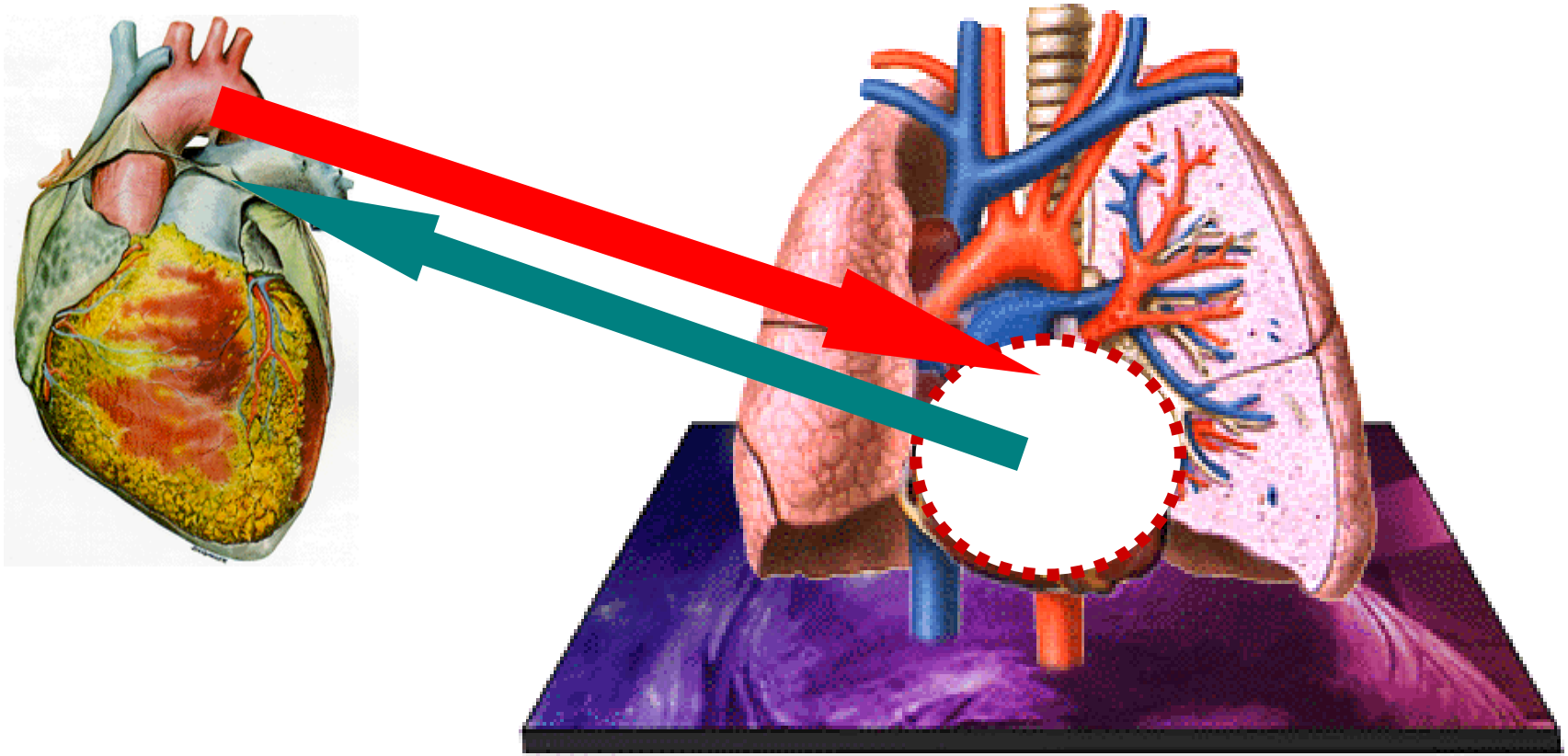

KRUPP

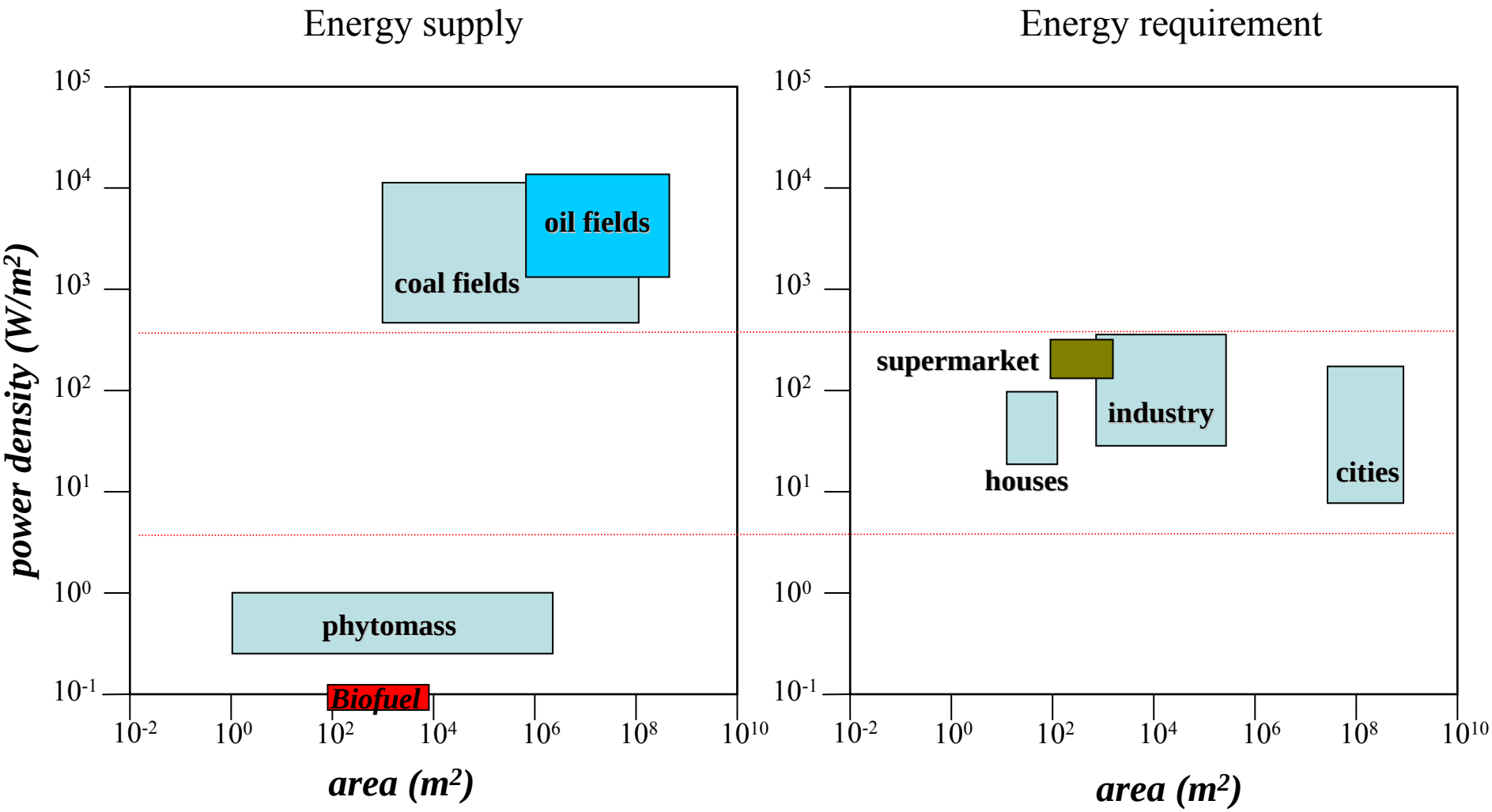

generating a supply of 10,000 trucks of coal/day
operated by 7 workers

An overview of activities in a palm-oil plantation

www.flickr.comSLASHphotosSLASHnagacocoaSLASH2464160956SLASHinSLASHphotostreamSLASH.jpg

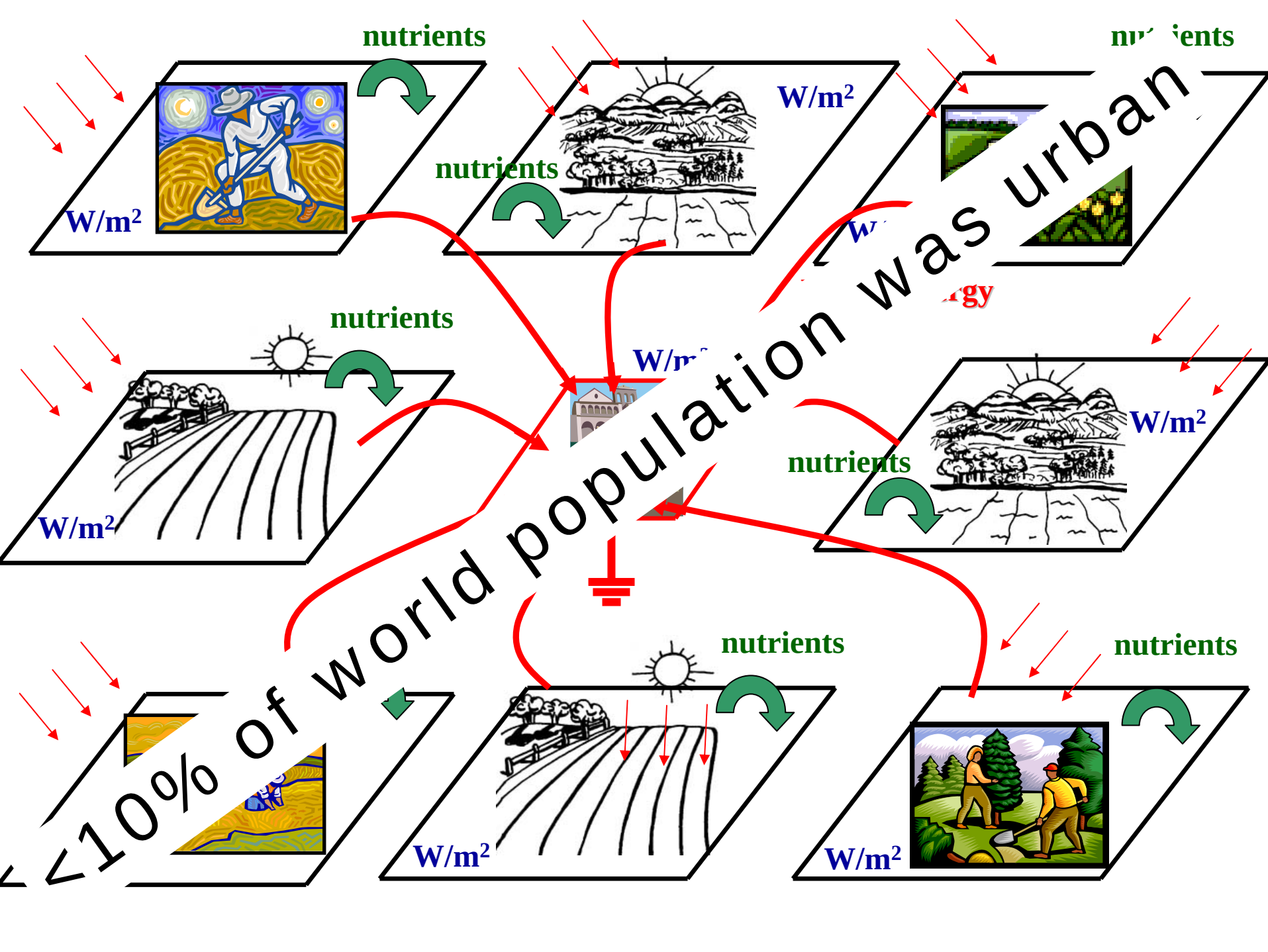
Checking the hearth metaphor in relation to the compatibility between:
(i) **land requirement;** and (ii) **land availability;**





power density gaps

after Vaclav Smil 2003 Energy at the Crossroads, The MIT press
(Fig. 5.2 and Fig. 5.3)


nutrients
W/m²
nutrients
W/m²
nutrients
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nutrients
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nutrients
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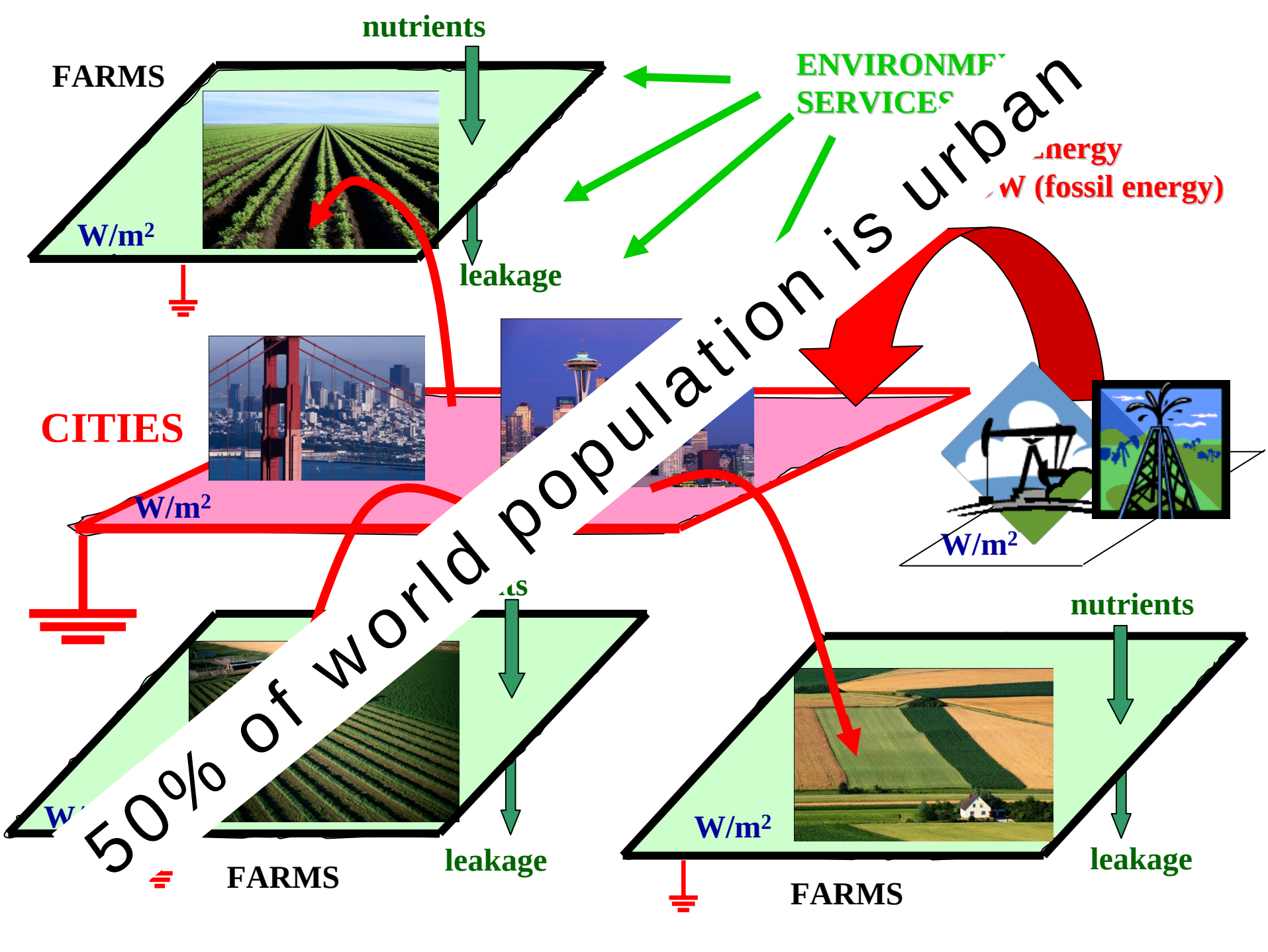
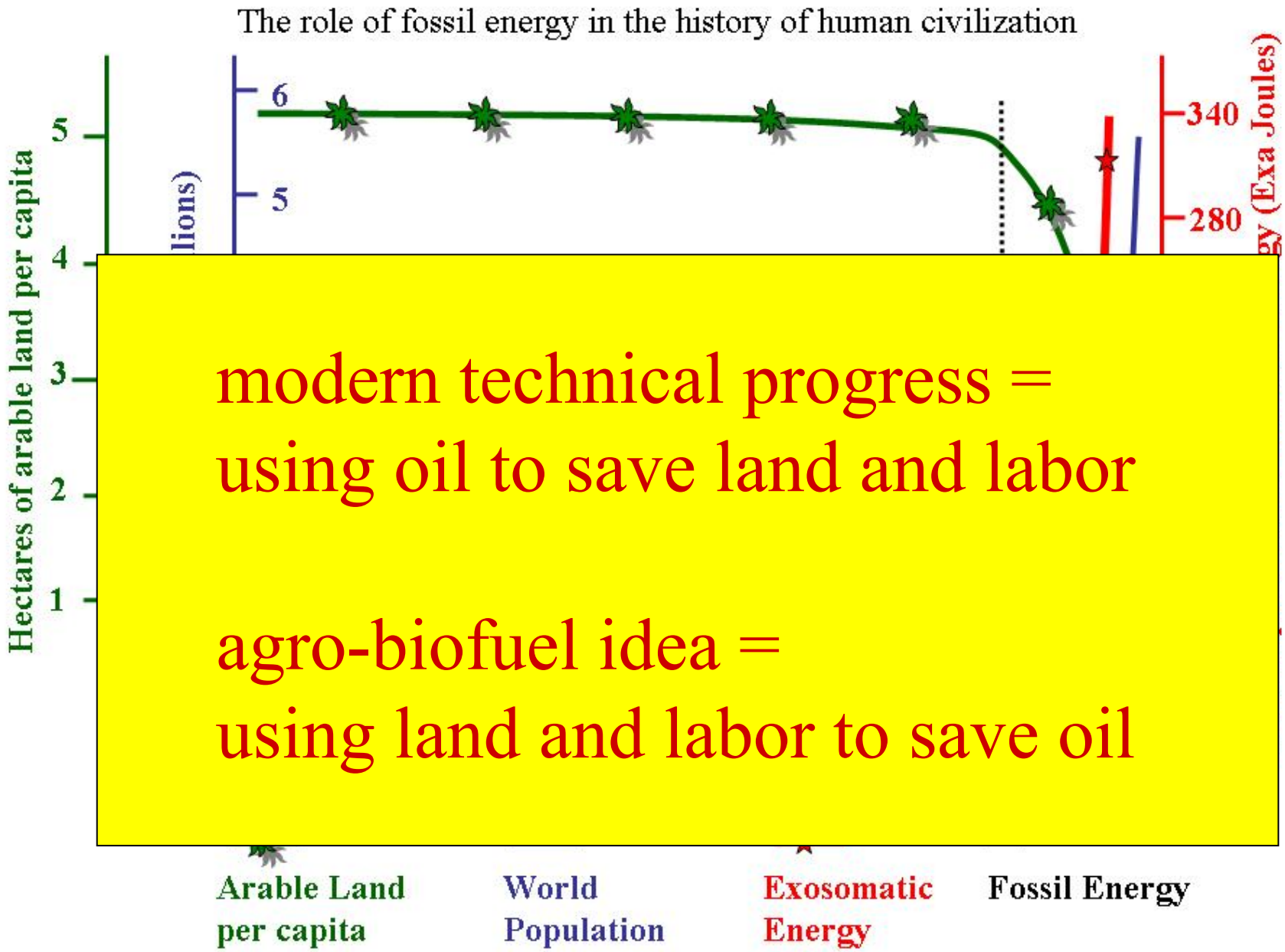
nutrients
W/m²
nutrients
W/m²
<10% of world population was urban


nutrients
FARMS
W/m²
leakage
ENVIRONMEN
SERVICES
nergy
W (fossil energy)
50% of world population is urban
CITIES
W/m²
W/m²
nutrients
W/m²
leakage
FARMS
leakage
FARMS


The role of fossil energy in the history of human civilization
Hectares of arable land per capita
5
4
3
2
1
6
5
340
280
gy (Exa Joules)
modern technical progress =
using oil to save land and labor
agro-biofuel idea =
using land and labor to save oil
Arable Land per capita
World Population
Exosomatic Energy
Fossil Energy

Consumption of grain in the world

Year 2000

Consumption per capita 380 kg/year

Population: 6 billion

(800 x 1 billion) + (300 x 5 billion) = 2,300 million tonnes

developed **developing**

Year 2030

Consumption per capita 437 kg/year

Population: 8 billion

(800 x 1 billion) + (600 x 2 billion) + (300 x 5 billion)

developed **middle** **developing**

3,500 million tonnes = 1.5 times the consumption in 2000!

The Second Generation of Biofuels

Liquid fuels produced by alternative types of biomass which are not competing with food production:

CELLULOSIC ETHANOL

* Switchgrass
* Wood (e.g. short rotation poplars)

BIODIESEL from MICROALGAE

THEY ARE NOT IN AN INDUSTRIAL PHASE YET!

SWITCHGRASS

Phase 1 – (tillage, sowing) fertilizer

Phase 2 – bailing, loading, transportation

Phase 3 – making ethanol from cellulose (various methods but it is more difficult than with corn)

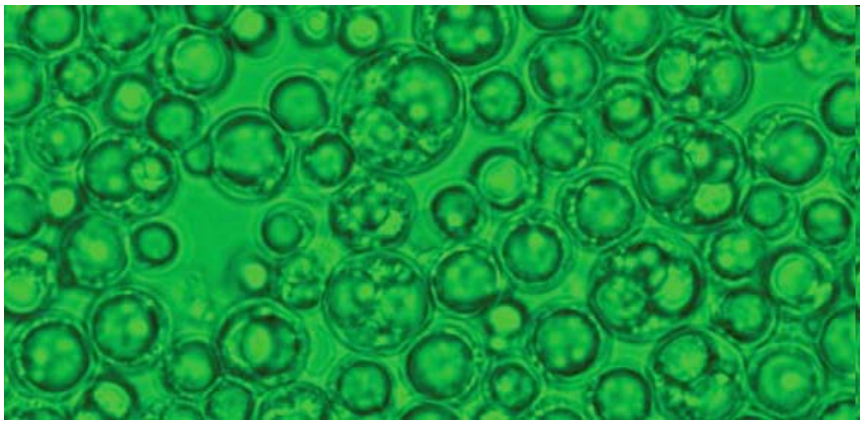
SHORT ROTATION TREES

Phase 1 – fertilizers, harvest

Phase 2 – bailing, loading, transportation

Phase 3 – making ethanol from cellulose (various methods but it is more difficult than with corn)

BIODIESEL from MICRO ALGAE



PHASE 1

* Fertilizer
* Make-up water
* Flocculant
* Pumping
* Mixing
* Centrifuging

PHASE 2

?

Conclusions about biofuels and bioenergy

The crucial difference between fossil fuels and biofuels

Fossil energy has a tremendous advantage over all alternative energy sources. When assessing the biophysical cost of production of energy carriers, **oil has not to be produced, it is already there!**

Because of this fact, the EROI of fossil energy is much higher than alternative energy sources

Fossil fuels are energy carriers with a very low biophysical cost of production *(e.g. extraction → oil → gasoline)*

Biofuels are energy carriers with a very high biophysical cost of production *(e.g. soil + sun → biomass → beer → ethanol)*

Agro-Biofuels First Generation

They may make sense in special situations in developing countries, but only for local production and consumption – e.g. for enabling mobility. They will not make the country rich!

Brazil is among the very few countries having the option to go for large scale production, but at certain risks

In developed countries, agro-biofuels depend on the political support for subsidies, so it is unlikely that they will last

The import of biofuels from developing countries into developed countries should raise serious ethical concerns

THE FUTURE OF BIOENERGY

Biomass has always been used for energetic purposes and always will be.

After having produced biomass (non competing with food) it would be better to make electricity with it, burn it directly or use it in an integrated way with other processes.

Special production of biomass (e.g. bioalgae) will have a future for the production of valuable chemicals

There is a large opportunity for increasing the utilization of residues and various types of wastes, but this has nothing to do with the substitution of fossil energy

BUT WE MUST NEVER FORGET THAT:

Land is crucial for food security

→ 99% of the world's food supply comes from land
→ arable land per capita, at the global level, is less than half a hectare per capita
→ additional arable land for feeding 8 billions will have to be obtained by reducing the amount of land not yet colonized
→ a switch to a diet with more animal products will boost such a demand

BUT WE MUST NEVER FORGET THAT:

Natural biomass is crucial for environmental security

Millennium Ecosystem Assessment

Strengthening Capacity to Manage Ecosystems Sustainably for Human Well-Being

Conclusions of 1,360 experts from 95 countries

#1 Human impact over the environment is really bad;

#2 When they say "really bad" they mean it: water, N, P cycles out of balance, biodiversity loss, pollution, climate change, severe loss of environmental services

THE LESSON TO BE LEARNED . . .

What can we say about the first generation of agro-biofuels?

IT IS NOT A GOOD ECONOMIC INVESTMENT

In the USA "Investors are sitting **on billions of dollars losses** after buying into the corn-based ethanol industry that George W. Bush embraced as the answer to US energy woes. . . . Investor losses come as taxpayers have paid billions to support the ethanol industry. More than $11.2bn has been spent since 2005 on tax breaks for companies that blend ethanol into petrol. Billions more have been spent on direct state and federal subsidies for US ethanol production. "We're looking at an industry that's **cost $80bn to get to this point**" said Bob Starkey, a fuels analyst at Jim Jordan &Associates, a research group in Houston" (Allison and Kirchgaessner, 2008).

IT IS AFFECTING FOOD SUPPLY

"Biofuels have forced global food prices up by 75% − far more than previously estimated − according to a World Bank report

http://image.guardian.co.uk/sysfiles/Environment/documents/2008/07/10/Biofuels.PDF

World Bank President Robert Zoellick, in a letter written to the western leaders, said: "What we are witnessing is not a natural disaster – a silent tsunami or a perfect storm. It is a man-made catastrophe, and as such must be fixed by people"
(Spiegel on line International, 2008).

IT IS DISTURBING FROM AN ETHICAL POINT OF VIEW

The previous UN Special Rapporteur for the Right to Food, Jean Ziegler called biofuels a **"crime against humanity"** earlier this spring (Spiegel on line International, 2008).

The newly appointed UN Special Rapporteur for the Right to food, Oliver de Schutter, has argued that the EU's policy is misguided: "The production of rapeseed, palm oil destroys the forests in Indonesia. The use of one-quarter of corn in the United States **is a scandal**, in which taxpayers' money is used solely to serve the interests of **a small lobby**. I call for a freeze on all investment in this sector" (Cronin, 2008).

IT IS NOT HELPING IN RELATION TO CO2 EMISSIONS

The effects of the conversion of natural land covers, such as rainforest, grassland, peatland, and savanna, into monocultures or plantations for biofuel feedstock production in Brazil, USA and Southeast Asia has **been systematically neglected**.

According to a recent study by Fargione et al (2008), published in *Science*, this conversion can create a "biofuel carbon debt" by releasing **17 to 420 times more CO2** than the annual greenhouse gas (GHG) reductions that these biofuels would provide by displacing fossil fuels. Applying a similar method of analysis based on a worldwide agricultural model which estimates emissions from land-use change, Searchinger et al (2008) calculate that corn-based ethanol, instead of producing a 20% savings (as claimed by biofuel supporter), nearly **doubles greenhouse emissions over 30 years** and increases greenhouse gases for 167 years. Biofuels from switchgrass, if grown on US lands, will increase emissions by 50%.

If agrobiofuels are neither feasible or desirable as large scale replacement of fossil fuels, what is going on?

#1 – Humans look always for the easy solution

Two problems: “peak oil” and “climate change”
One solution: Agro-biofuels

→People want to believe that agro-biofuels are the needed silver bullet generating “renewable” and “zero emission” carriers

Letter from US Senator Ken Salazar to the Gazette of Colorado Spring

"Our national security demands that we meet the challenge of generating 25 percent of our nation's energy from renewable sources by 2025.

. . .

According to a recent national survey, **98 percent of voters feel** that meeting 25 percent of our energy needs from renewables by 2025 is important for the country, and 90 percent of voters **believe** this goal is achievable. This kind of bipartisan support is almost unprecedented and signals a willingness to move our country forward toward greater energy independence.

. . .

Is it practical? Certainly!"

(Source: Gazette.com 2006 - Opinion June 22, 2006 Letters)

Why scientific research is not effective in preventing the formation of granfalloons?

BP Selects Strategic Partners For Energy Biosciences Institute
Press Release date: 01 February 2007

University of California Berkeley, the University of Illinois and the Lawrence Berkeley National Lab join research effort

BP today announced it has selected the University of California Berkeley and its partners the University of Illinois, Urbana-Champaign and the Lawrence Berkeley National Laboratory to join in a **$500 million research program** that will explore how bioscience can be used to increase energy production and reduce the impact of energy consumption on the environment.

The Energy Biosciences Institute will perform ground-breaking research aimed at the production of new and cleaner energy, initially focusing on renewable biofuels for road transport.

#2 – Biofuels from energy crops represent the last hope for the agonizing paradigm of industrial agriculture (High External Input Agriculture)

WTO Trade Talks
Doha Round → Amber Box

Commodity support programs,
such as:

- crop insurance
- export subsidies
- loan deficiency payments
- countercyclical payments

are considered to distort production and trade

They will be restricted by WTO Trade Agreements

US = 19 billions/year **EU = 80 billions/year**

Who is gaining from the agro-biofuel granfalloon?

Commodities Send Syngenta Earn Soaring

"*Agrochemical company Syngenta AG on Thursday posted a 75 percent rise in annual net profit on soaring commodity prices and strong demand. The Swiss company reported a profit of 1.1 billion compared with 634 million in the same period a year earlier. Nina Baiker, an analyst with Zuercher Kantonalbank, said Syngenta's performance is very good. The company's crop protection division is well positioned* ***to take advantage of farmers' need to boost yield per acre for food and biofuels****, she added*".

(Associated Press, February, 7th, 2008).

THE WALL STREET JOURNAL. Digital Network

Grain Companies' Profits Soar As Global Food Crisis Mounts

By DAVID KESMODEL, LAUREN ETTER and AARON O. PATRICK

April 30, 2008; Page A1

At a time when parts of the world are facing food riots, Big Agriculture is dealing with a different sort of challenge: huge profits.

On Tuesday, grain-processing giant Archer-Daniels-Midland Co. said its fiscal third-quarter profits jumped 42%, including **a sevenfold increase in net income** in its unit that stores, transports and trades grains such as wheat and corn, as well as soybeans.

Monsanto Co., maker of seeds and herbicides, Deere & Co., which builds tractors, combines and sprayers, and fertilizer maker Mosaic Co. **all reported similar windfalls** in their latest quarters.

Who is giving the advice
to make more agro-biofuels?

"The Biofuels Research Advisory Council (BIOFRAC) created by DG Research in early 2005.

A "group of high level experts representing widely different of the biofuel chain" was invited "to develop a foresight report – a vision for biofuels up to 2030 and beyond, to ensure a breakthrough of biofuels and increase their deployment in the EU."

In addition to this 'foresight report', the Commission also invited BIOFRAC to prepare the ground for the so-called 'Strategic Research Agenda', and to provide considerable input for the Seventh Framework Research Programme (FP7), the EU's main instrument **for funding research in Europe** from 2007 to 2013."

WHO ARE THE MEMBERS OF THIS PANEL?

http://www.corporateeurope.org/agrofuelfolly.html

Affiliation of Members of the Biofuels Research Advisory Council
(as for the date of publication of the Vision Report)

Chair: Volvo Technology Corporation;
Vice-chair: Institut Francais du Petrole – and - Abengoa Bioenergy;
Members: British Sugar, PSA Peugeot Citroen, EuropaBio,
CHOREN, SVEASKOG, Volkswagen AG, European Biodiesel Board,
COPA-COGECA, SHELL, CRES, Neste Oil Corporation,
IVECO Powertrain, ECN, INRA, Fraunhofer UMSICHT,
Nova Energie, EC-BREC, Lund University, VTT Biotechnology

IN THE PAST
it was Marie Antoinette lack of understanding:

"If the people is without bread, then let them eat cake . . ."

BUT TODAY . . .

THIS ADVICE IS GIVEN BY THOSE MAKING THE CAKE!

'In our rush to "do something" about energy and climate, we are tinkering with complex systems that we do not fully understand. This leads to consequences that are unintended and undesirable. Giampietro and Mayumi show that using biofuels effectively requires calculating how that usage integrates into a society's overall metabolism. Beyond biofuels, the book has a broad and enduring lesson: we will achieve better results if knowledge precedes policy.'

– Joseph A. Tainter, author of *The Collapse of Complex Societies*

'Thanks to Mario Giampietro and Kozo Mayumi for a cogent analysis of why large-scale biofuels are one more false panacea put forward by the growth addicts.'

– Herman E. Daly, University of Maryland, USA

'Giampietro and Mayumi are world authorities on the use of energy in the economy. This book is the product of many years of scholarly work, and it gives well-argued reasons against the misguided agrofuel policies of the European Union and the United States.'

– Joan Martinez-Alier, Universitat Autonoma de Barcelona and former President, International Society for Ecological Economics

Faced with the twin threats of peak oil and climate change, many governments have turned for an answer to the apparent panacea of biofuels. Yet the progressive implementation of this solution demonstrates that the promise of biofuels as a replacement to fossil fuels is a mirage that, if followed, risks leaving us short of power, short of food and doing as much damage to the climate as ever – not to mention the consequent impacts on biodiversity (due to additional loss of habitat for agricultural production) and on rural development (due to the additional stress on traditional farming systems). Worse still, these risks are being ignored.

In this definitive exposé, Mario Giampietro and Kozo Mayumi present a theoretical framework and exhaustive evidence for the case against large-scale biofuel production from agricultural crops. This book will be vital, sobering reading for anyone concerned with energy or agricultural policy.

Mario Giampietro is an ICREA Research Professor at the Universitat Autonoma Barcelona, Spain.

Kozo Mayumi is a Professor at the University of Tokushima, Japan.

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THE BIOFUEL DELUSION

Giampietro/Mayumi

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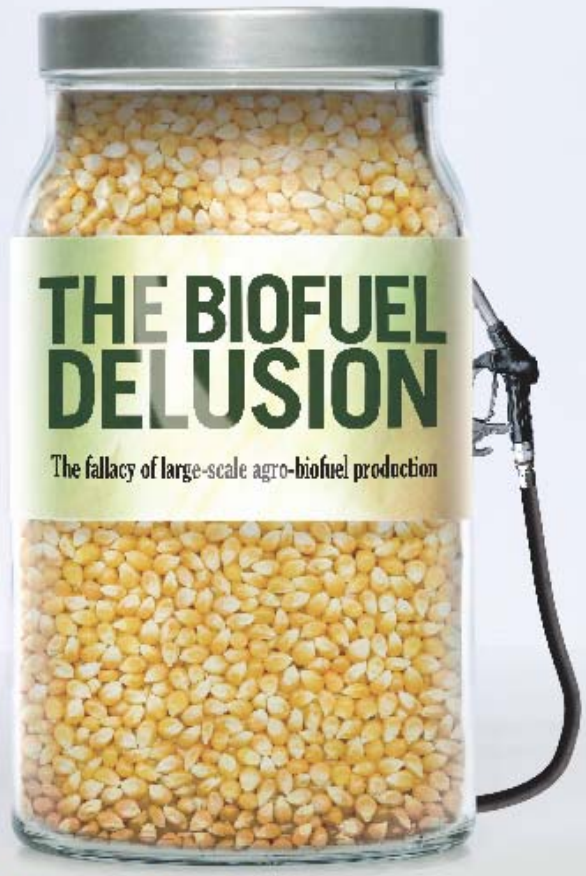

Mario Giampietro
Kozo Mayumi

Forewords by Vaclav Smil and Jerome Ravetz