CERN Colloquium
Geneva, 09/04/2015

Putting technology and societal dynamics within a biophysical perspective: Is “more of the same” a sustainable perspective?

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* Department of Science and Technology
Parthenope University of Napoli
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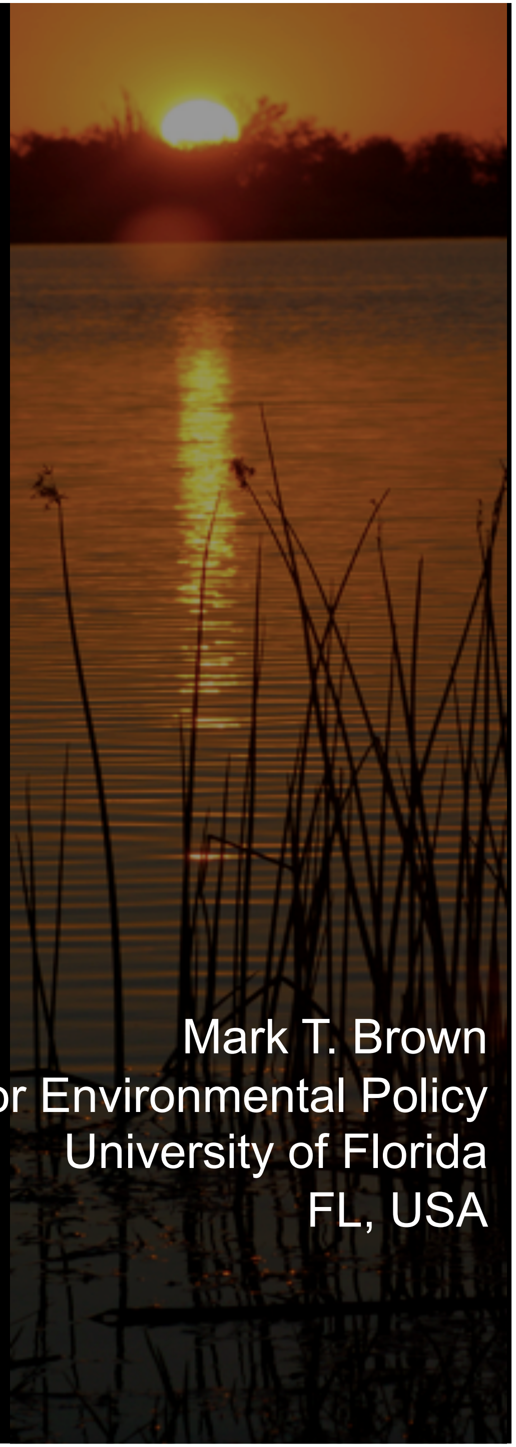
* School of Environment
Beijing Normal University,
China



Mark T. Brown
Center for Environmental Policy
University of Florida
FL, USA

More of the same…

At societal level:

More parking lots help solve the traffic problem

GMOs help solve the worldwide nutrition problem

Antibiotics cure all infection diseases

Monetary liquidity facilitates growth

High Speed Trains help trade and mobility

Within the energy field:

Renewable energies can fully replace fossil energies

Efficiency decreases energy and material consumption

The end of fossil fuels age is beyond the corner

Fossil fuels prices keep increasing

Biomass fuels are renewable and will replace fossil energy

“More parking lots help solve the traffic problem”

The expectation to be able to find a park for their car makes commuters more available to drive to their work place.

This **increases**:

- Road traffic
- Demand for new and better roads
- Fuel consumption
- Airborne emissions

Decreases the economic profitability of mass transport, that becomes “optimized” only over the most profitable lines and times

And ultimately **translates** into a higher demand for new parking lots to host more cars coming.

"GMOs help solve the worldwide nutrition problem"

ELSEVIER

Ecological Informatics

Volume 26, Part 1, March 2015, Pages 35–49

Ecosystem Metabolism towards Sustainable Society Design and Management

Time to re-think the GMO revolution in agriculture

G.C. Rótolo[a], C. Francis[b, c], R.M. Craviotto[a], S. Viglia[d], A. Pereyra[e], S. Ulgiati[d]

According to our results, GMOs do not provide higher yields compared to conventional intensive agriculture, do not decrease resource investment, do not increase pest resistance, do not provide higher income to farmers, do not decrease land cropped, do increase business of biotech seed companies and international trade corporations.

Rótolo, G.C., Francis, C., Craviotto, R.M, Ulgiati, S., 2015. Environmental Assessment of Maize Production Alternatives: Traditional, Intensive and GMO-Based Cropping Patterns. Ecological Indicators, in press.

"Antibiotics cure all infection diseases"

The Epidemic of Antibiotic-Resistant Infections: A Call to Action for the Medical Community from the Infectious Diseases Society of America

Brad Spellberg,[1,2] Robert Guidos,[5] David Gilbert,[7] John Bradley,[3,4] Helen W. Boucher,[8] W. Michael Scheld,[6] John G. Bartlett,[9] and John Edwards, Jr.,[1,2] for the Infectious Diseases Society of America

[1]Division of Infectious Diseases, Harbor–University of California–Los Angeles (UCLA) Medical Center, Torrance, [2]Geffen School of Medicine, UCLA, Los Angeles, and [3]Children's Hospital San Diego and [4]University of California at San Diego, California; [5]Infectious Diseases Society of America, Alexandria, and [6]Division of Infectious Diseases, University of Virginia Health System, Charlottesville, Virginia; [7]Division of Infectious Diseases, Providence Portland Medical Center and Oregon Health Sciences University, Portland, Oregon; [8]Tufts–New England Medical Center, Boston, Massachusetts; and [9]Department of Medicine, Johns Hopkins University School of Medicine, Baltimore, Maryland

The ongoing explosion of antibiotic-resistant infections continues to plague global and US health care. Meanwhile, an equally alarming decline has occurred in the research and development of new antibiotics to deal with the threat. In response to this microbial "perfect storm," in 2001, the federal Interagency Task Force on Antimicrobial Resistance released the "Action Plan to Combat Antimicrobial Resistance; Part 1: Domestic" to strengthen the response in the United States. The Infectious Diseases Society of America (IDSA) followed in 2004 with its own report, "Bad Bugs, No Drugs: As Antibiotic Discovery Stagnates, A Public Health Crisis Brews," which proposed incentives to reinvigorate pharmaceutical investment in antibiotic research and development. The IDSA's subsequent lobbying efforts led to the introduction of promising legislation in the 109th US Congress (January 2005–December 2006). Unfortunately, the legislation was not enacted. During the 110th Congress, the IDSA has continued to work with congressional leaders on promising legislation to address antibiotic-resistant infection. Nevertheless, despite intensive public relations and lobbying efforts, it remains unclear whether sufficiently robust legislation will be enacted. In the meantime, microbes continue to become more resistant, the antibiotic pipeline continues to diminish, and the majority of the public remains unaware of this critical situation. The result of insufficient federal funding; insufficient surveillance, prevention, and control; insufficient research and development activities; misguided regulation of antibiotics in agriculture and, in particular, for food animals; and insufficient overall coordination of US (and international) efforts could mean a literal return to the preantibiotic era for many types of infections. If we are to address the antimicrobial resistance crisis, a concerted, grassroots effort led by the medical community will be required.

The Epidemics of antibiotic-resistant infections - Clin Infect Dis. (2008) 46 (2): 155-164

A recent UK-Downing Street report warns about the emergence of antibiotic-resistant Infections (Escherichia coli, Klebsiella pneumoniae, Staphilococcus aureus). Premier **Cameron warns of medical 'dark ages and** calls for **more research on new antibiotics**.(July 2014, http://www.bbc.com/news/health-28098838

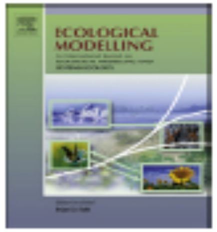
"Monetary liquidity facilitates growth"

Ecological Modelling 223 (2011) 4–13

Contents lists available at ScienceDirect

Ecological Modelling

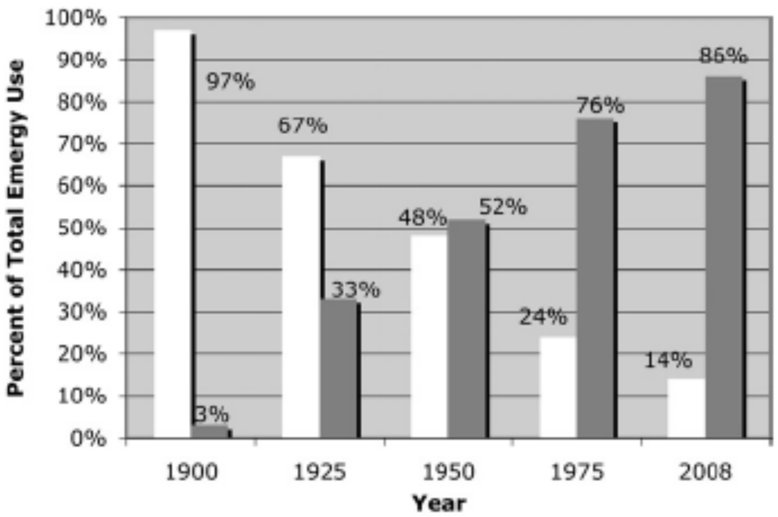
journal homepage: www.elsevier.com/locate/ecolmodel

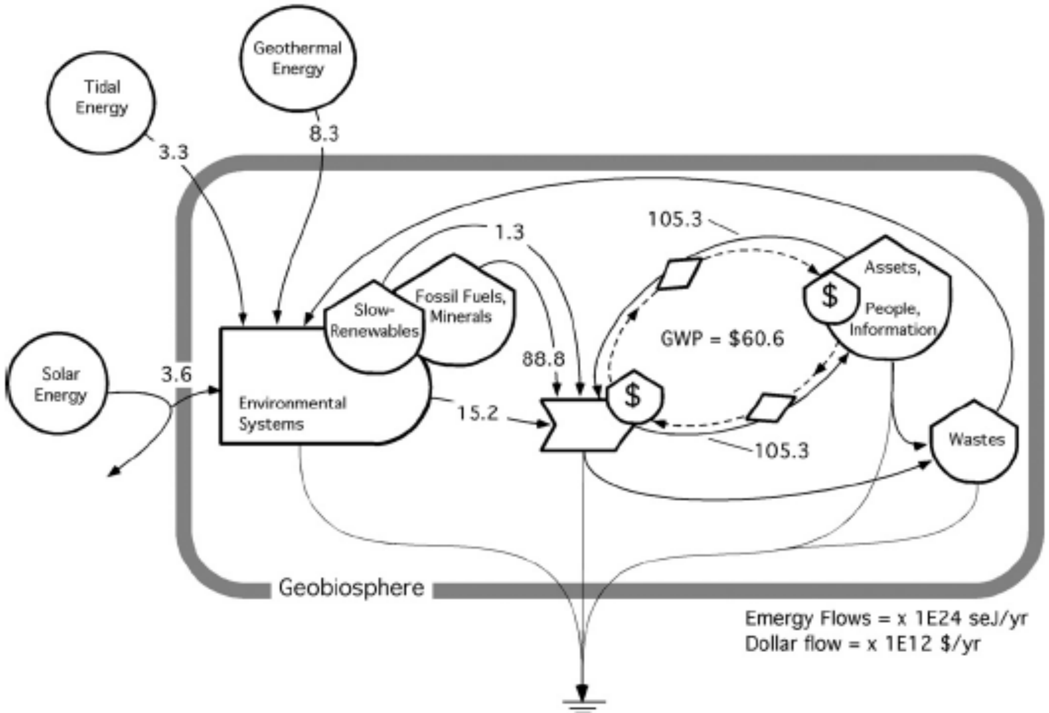


Understanding the global economic crisis: A biophysical perspective

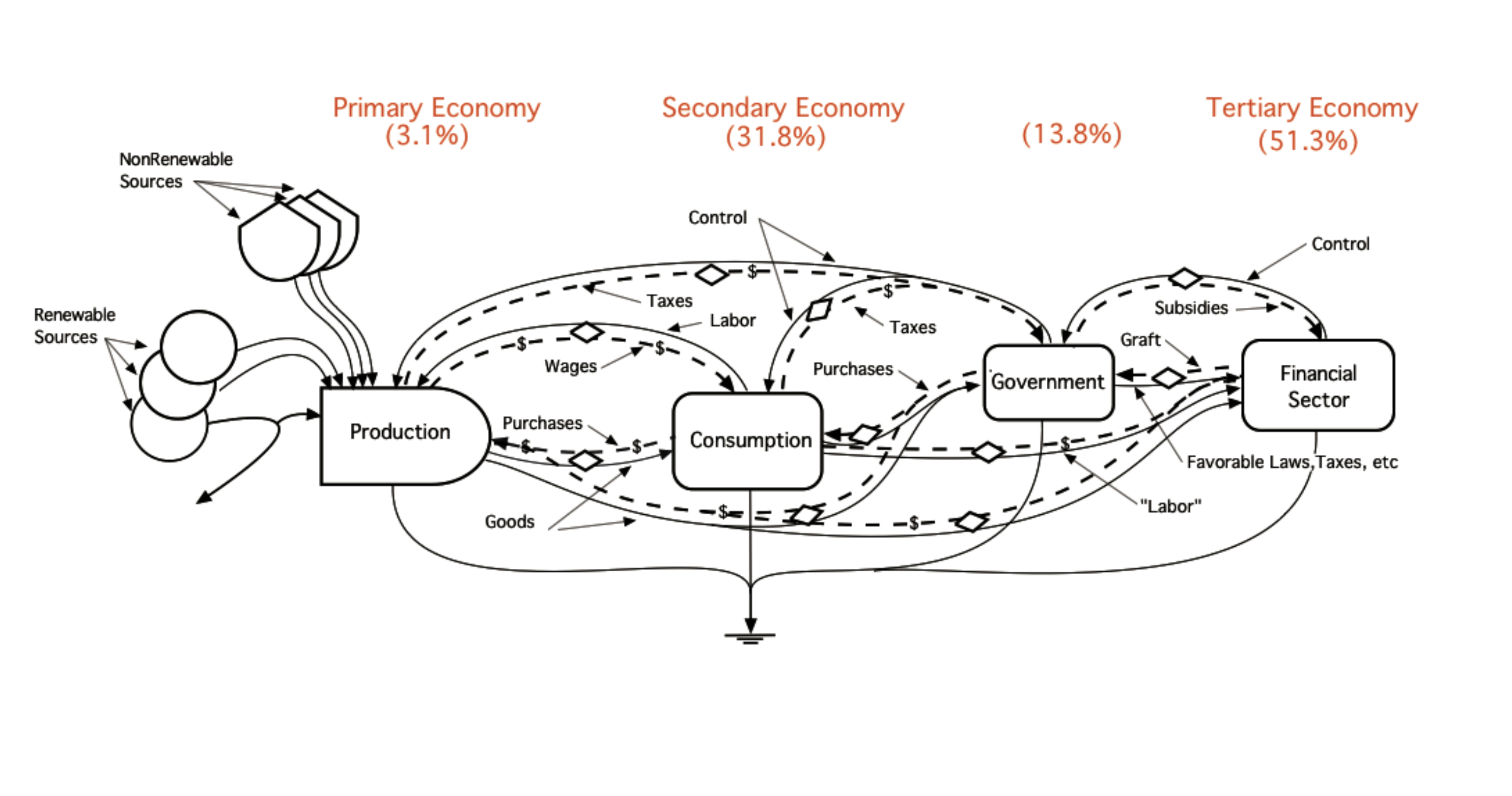
Mark T. Brown [a,*], Sergio Ulgiati [b]

[a] University of Florida, USA
[b] Parthenope University of Naples, Italy



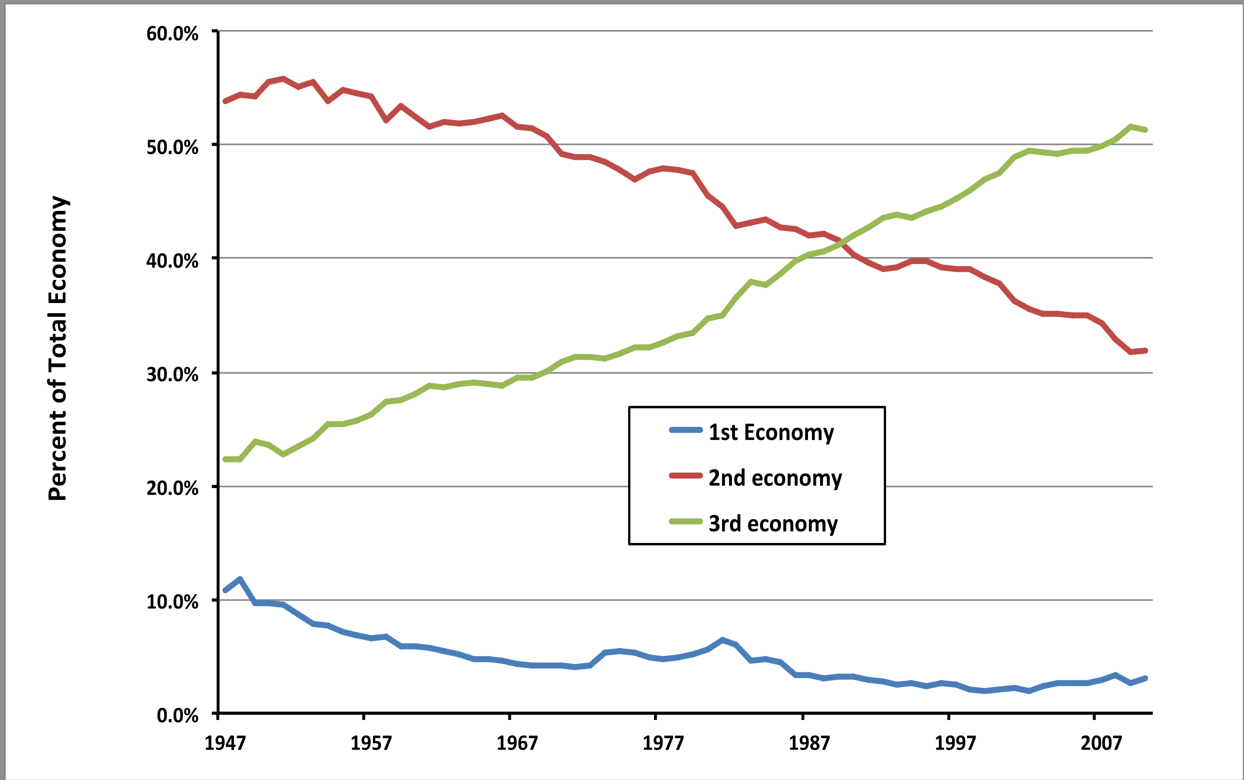


The XXI century economy is dominated by the financial sector, which makes GDP grow and decline and provides constraints to Governments.



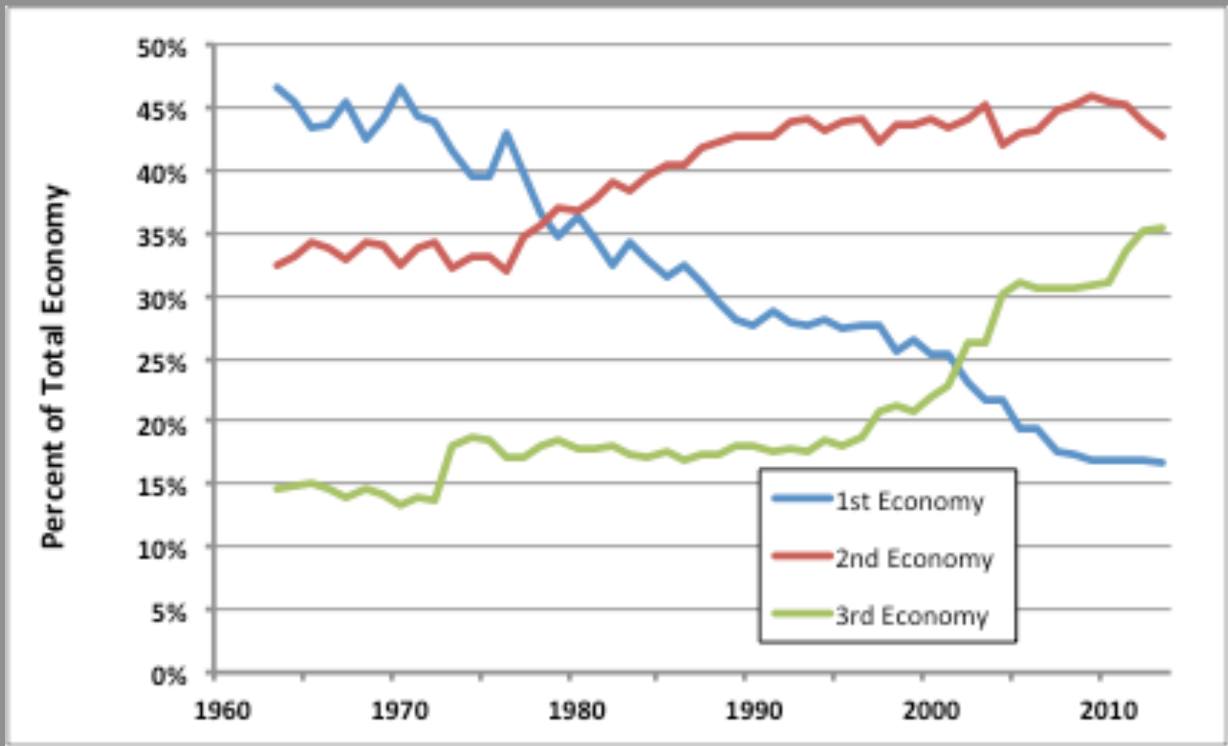
Brown and Ulgiati, 2012, **The Tertiary Economy: A threat to the global economy**. The 8th International Workshop “Advances in Energy Studies” – Mumbai, India, 25-27 October 2012.

The case of USA



Brown and Ulgiati, 2012, **The Tertiary Economy: A threat to the global economy**. The 8th International Workshop "Advances in Energy Studies" – Mumbai, India, 25-27 October 2012.

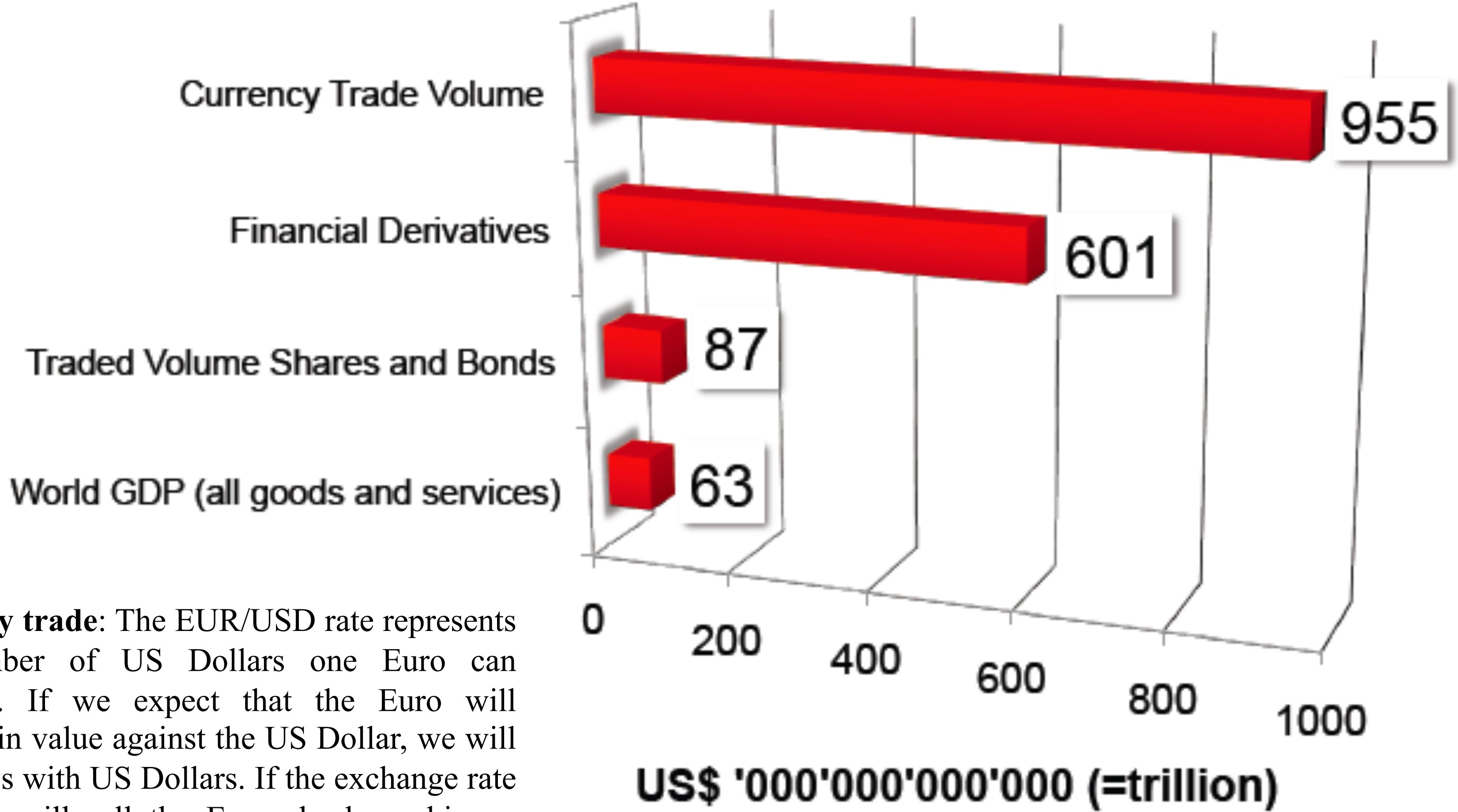
The case of India



Brown and Ulgiati, 2012, **The Tertiary Economy: A threat to the global economy**. The 8th International Workshop "Advances in Energy Studies" – Mumbai, India, 25-27 October 2012.

"What" is actually growing ?

› Some facts among a lot of fiction (for 2010):



Currency trade: The EUR/USD rate represents the number of US Dollars one Euro can purchase. If we expect that the Euro will increase in value against the US Dollar, we will buy Euros with US Dollars. If the exchange rate rises, we will sell the Euros back, making a profit. (http://www.xe.com/currencytrading/)

(Thomas Maschmeyer, 2011)

"High Speed Trains help trade and mobility"

The Economist

World politics | Business & finance | Economics | Science & technology | Culture | The World in 2012 | Blogs | Debate | Multimedia

Print edition

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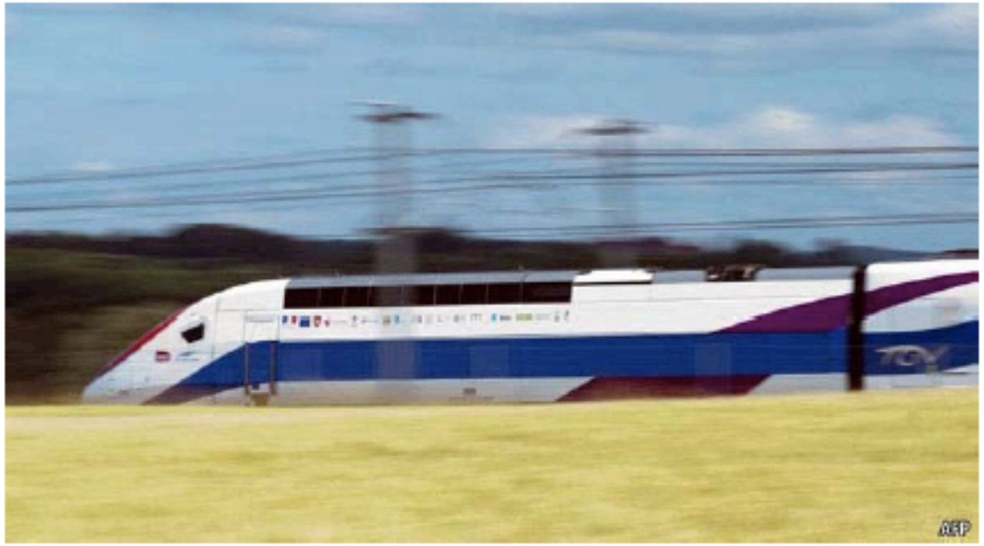
Infrastructure projects

The great train robbery

High-speed rail lines rarely pay their way. Britain's government should ditch its plan to build one

Sep 3rd 2011 | from the print edition



AT THE launch of the Liverpool-Manchester railway in 1830, a statesman was killed when he failed to spot an approaching train. That was not the last time a new train line has had unintended consequences. Victorian railways ushered in a golden age of prosperity; these days politicians across the developed world hope new rapid trains, which barrel along at over 250mph (400kph), can do the same. But high-speed rail rarely delivers the widespread economic benefits its boosters predict. The British government—the latest to be beguiled by this vision of modernity—should think again (see article (http://www.economist.com/node/21528294)).

"Renewable energies can fully replace fossil energies"

Source:

THE ENERGY REPORT
100% RENEWABLE
ENERGY BY 2050

WWF International
Avenue du Mont-Blanc
1196 Gland
Switzerland
www.panda.org
Ecofys
P.O. Box 8408
3503 RK Utrecht
The Netherlands
www.ecofys.com

Table A - 1 Global energy provided by source and year (EJ/a).

Source	2000	2010	2020	2030	2040	2050
Total electricity (EJ/a)	**45.7**	**60.0**	**71.9**	**85.7**	**103.5**	**127.4**
Wind power: On-shore	0.2	1.4	6.7	14.3	22.0	25.3
Wind power: Off-shore	0.0	0.0	0.5	1.3	3.4	6.7
Wave & Tidal	0.0	0.0	0.0	0.1	0.3	0.9
Photovoltaic solar	0.0	0.1	0.7	6.5	16.9	37.0
Concentrated solar: Power	0.0	0.1	0.6	3.9	13.7	21.6
Hydropower	7.9	11.3	13.4	14.4	14.8	14.9
Geothermal	0.1	0.3	0.7	1.7	3.4	4.9
Biomass	0.0	0.0	0.0	0.0	1.7	16.2
Coal	18.2	21.5	14.8	10.0	5.4	0.0
Gas	8.6	14.0	25.6	28.3	20.1	0.0
Oil	4.2	3.1	2.5	1.4	0.5	0.0
Nuclear	6.5	8.2	6.5	3.8	1.2	0.0
Industry fuels & heat (EJ/a)	**63.7**	**79.1**	**82.3**	**74.6**	**63.0**	**59.0**
Concentrated solar: Heat	0.0	0.0	0.1	0.4	2.6	8.8
Geothermal	0.0	0.1	0.2	0.6	1.6	2.9
Biomass	1.0	6.1	16.9	31.3	40.7	34.8
Fossil fuels	62.7	72.9	65.0	42.2	18.0	12.5
Building fuels & heat (EJ/a)	**77.7**	**86.0**	**87.4**	**67.8**	**47.4**	**24.1**
Solar thermal	0.0	0.7	3.3	11.9	16.0	12.6
Geothermal	0.2	0.5	1.5	4.1	10.5	8.4
Biomass	33.4	33.2	29.2	14.2	10.2	3.1
Fossil fuels	44.1	51.6	53.5	37.6	10.6	0.0
Transport fuels (EJ/a)	**86.2**	**102.6**	**111.6**	**91.3**	**62.3**	**50.8**
Biomass	0.7	4.8	12.9	29.7	45.7	50.8
Fossil fuels	85.5	97.8	98.8	61.7	16.6	0.0
Grand total (EJ/a)	**273.4**	**327.6**	**353.3**	**319.4**	**276.2**	**261.4**

Efficiency decreases energy and material consumption (Jevon's paradox and rebound effect)

Jevons paradox: as technology progresses, the increase in efficiency with which a resource is used tends to increase (rather than decrease) the rate of consumption of that resource.

> In 1865, the English economist William Stanley Jevons observed that technological improvements that increased the efficiency of coal-use led to the increased consumption of coal in a wide range of industries.

The issue has been re-examined by modern economists: In addition to reducing the amount needed for a given use, improved efficiency lowers the relative cost of using a resource, which tends to increase the quantity of the resource demanded, potentially counteracting any savings from increased efficiency. Additionally, increased efficiency accelerates economic growth, further increasing the demand for resources.

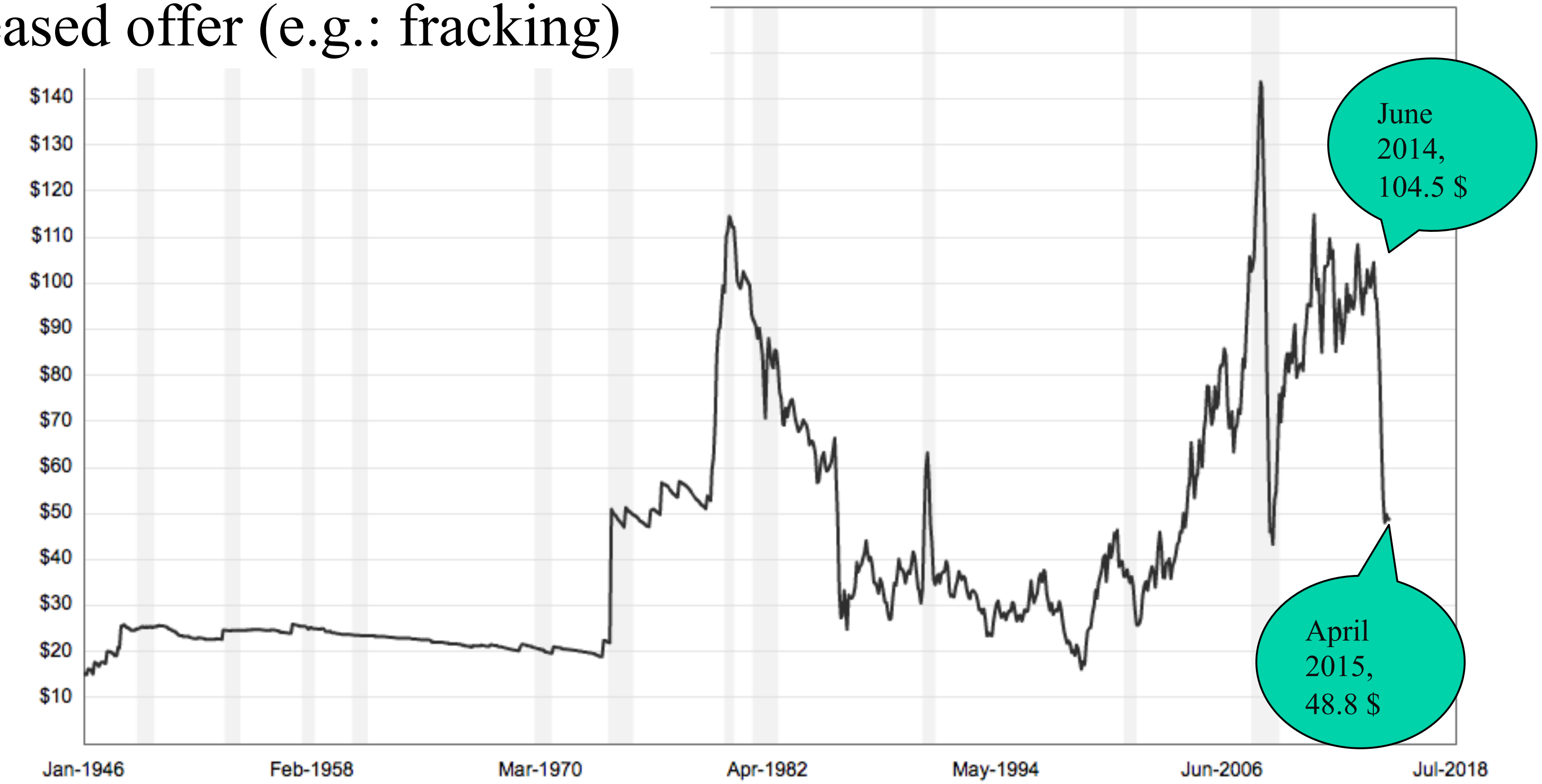
> The rebound effect is the reduction in gains expected from new technologies that increase the efficiency of resource use, because of behavioral or other systemic responses.

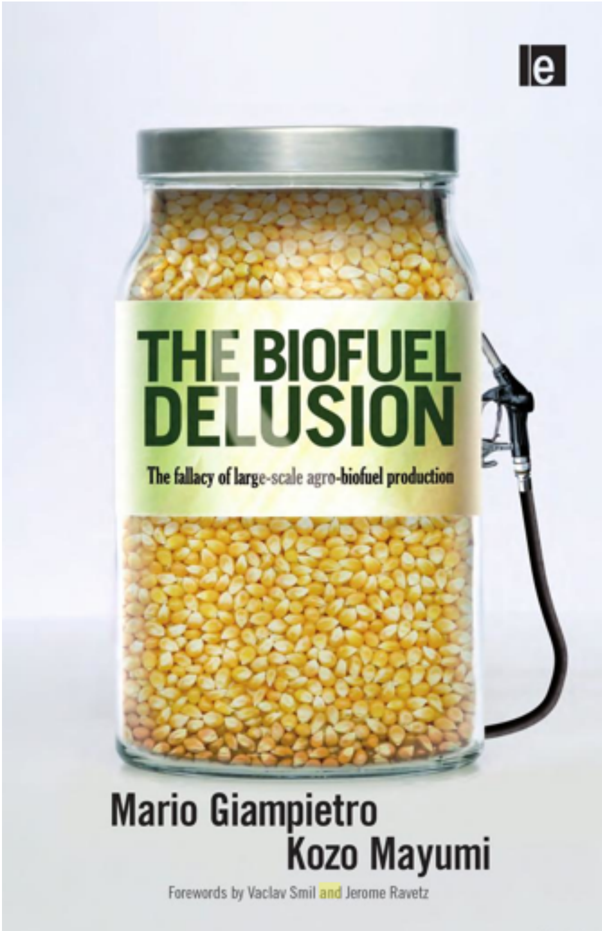
Nevertheless, increased efficiency can improve material living standards.

"The end of fossil fuels age is beyond the corner. Fossil fuels prices keep increasing"

The so called "end of cheap oil" and the "peak oil" seem to have been posponed by:

- Economic crisis
- Political strategies
- Increased offer (e.g.: fracking)





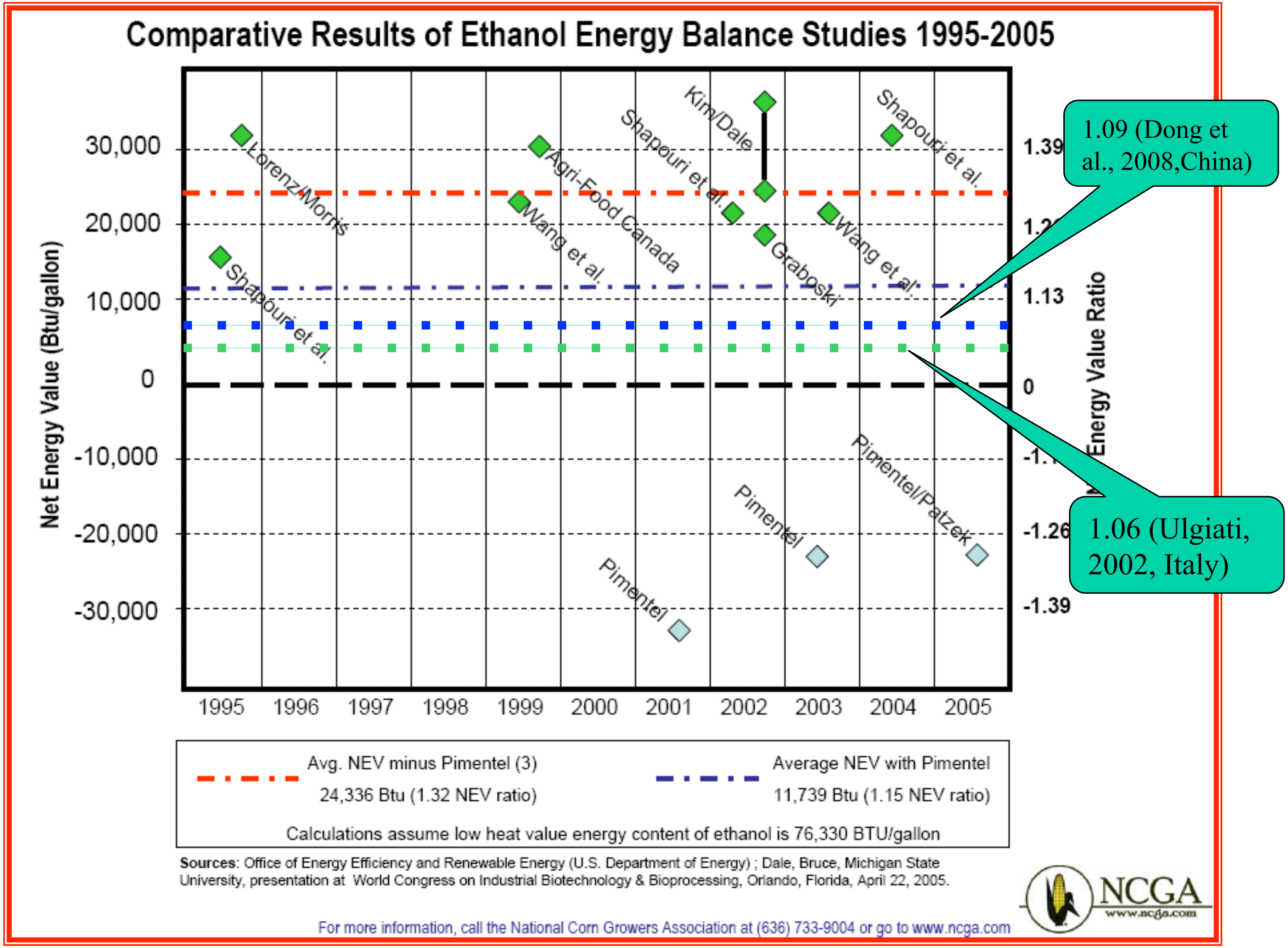
"Biomass fuels are renewable and will replace fossil energy"

Critical Reviews in Plant Sciences, 20(1):71–106 (2001)

A Comprehensive Energy and Economic Assessment of Biofuels: When "Green" Is Not Enough

Sergio Ulgiati

Department of Chemistry, University of Siena, Via Aldo Moro, 53100 Siena, Italy E-mail: ulgiati@unisi.it



Comparative Results of Ethanol Energy Balance Studies 1995-2005
Net Energy Value (Btu/gallon)
30,000
20,000
10,000
0
-10,000
-20,000
-30,000
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
Lorenz/Morris
Shapouri et al.
Agri-Food Canada
Wang et al.
Shapouri et al.
Kim/Dale
Graboski
Wang et al.
Shapouri et al.
Pimentel
Pimentel
Pimentel/Patzek
1.39
1.13
0
-1.26
-1.39
Energy Value Ratio
1.09 (Dong et al., 2008,China)
1.06 (Ulgiati, 2002, Italy)
Avg. NEV minus Pimentel (3)
24,336 Btu (1.32 NEV ratio)
Average NEV with Pimentel
11,739 Btu (1.15 NEV ratio)
Calculations assume low heat value energy content of ethanol is 76,330 BTU/gallon
Sources: Office of Energy Efficiency and Renewable Energy (U.S. Department of Energy) ; Dale, Bruce, Michigan State University, presentation at World Congress on Industrial Biotechnology & Bioprocessing, Orlando, Florida, April 22, 2005.
For more information, call the National Corn Growers Association at (636) 733-9004 or go to www.ncga.com
NCGA
www.ncga.com

Land constraints with biodiesel: the case of Italy

Sunflower: max 2.5 ton seeds/ha; average Italy 1.6 ton seeds/ha

Oil content (40-50%): 0.8-1.3 ton fuel/ha

Net biodiesel production: 0.5-0.9 t fuel /ha

Average individual consumption:
10000 km/yr/15 km/kg = 666 kg fuel/yr => 1 ha

Circulating cars: 25 million =>
Oil seeds needed: 50 million ton seeds
Land needed: 25 million ha

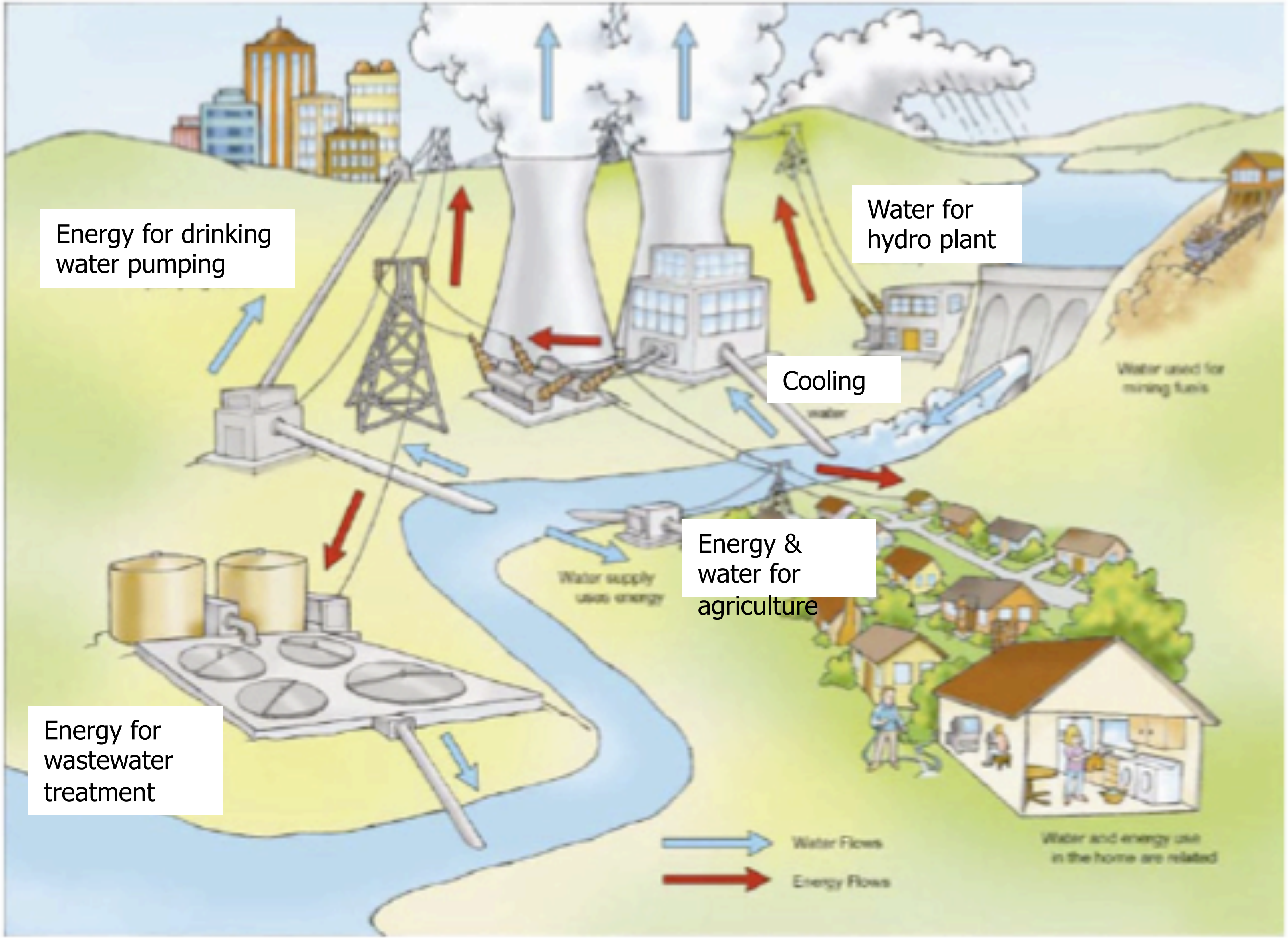
Land constraints with cellulosics: the case of Sweden

(A) Total energy used in the transport sector: 358.6×10^9 MJ

(B) Energy per hectare from switchgrass: 9×10^4 MJ/ha (best value published, Pimentel and Patzek, 2006)

Total land needed= A/B = 35,900 km^2 = 16.6 % of available forest land,
i.e. an ecological nonsense

The Water-Energy Nexus

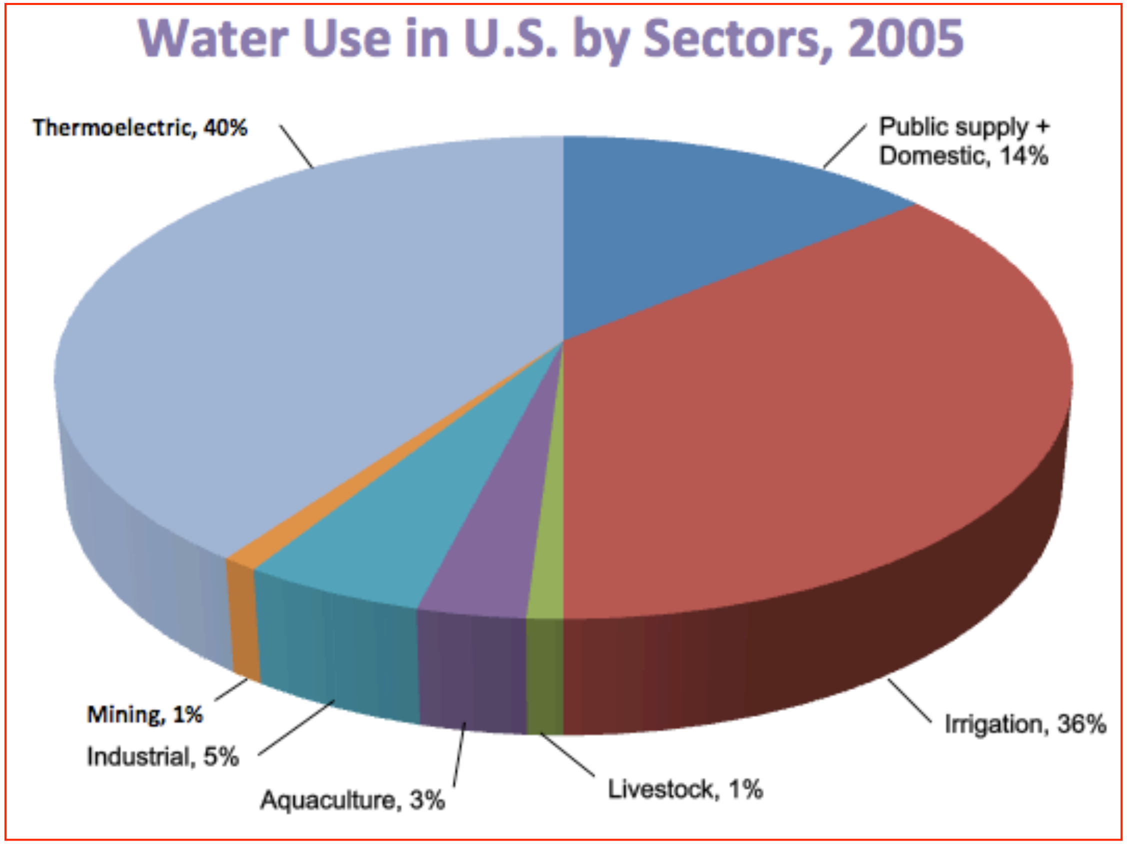


It takes water "to make" energy

One kWh requires 60 liters of water (average).

The global water withdrawal worldwide in the year 2000 has been 4000 km^3, about 30% of total world availability of fresh water.

In the year 2025 this fraction is expected to grow up to 70% and to be returned to the environment with diverse forms of alteration and contamination.



It takes energy "to make" water

In the year 2005 the commercial energy invested for water withdrawal and delivering has been about 655 MTOE, i.e. 7% of total world energy consumption, and about 3.5 times the Italian energy use. For the sake of clarity:

1. Pumping 1 m^3 of water from a 30 m depth at a 50% pump efficiency requires 0.16 kWh. Same to lift water up to 30 m above ground level, for distribution.

3. Potabilization: filtering, disinfecting, imply an energy demand of 0.5 kWh/m^3.

3. Desalination: some foresee that large amounts of water will be extracted by the sea in the near future. At present, 15% of USA water comes from such source. Energy costs are:

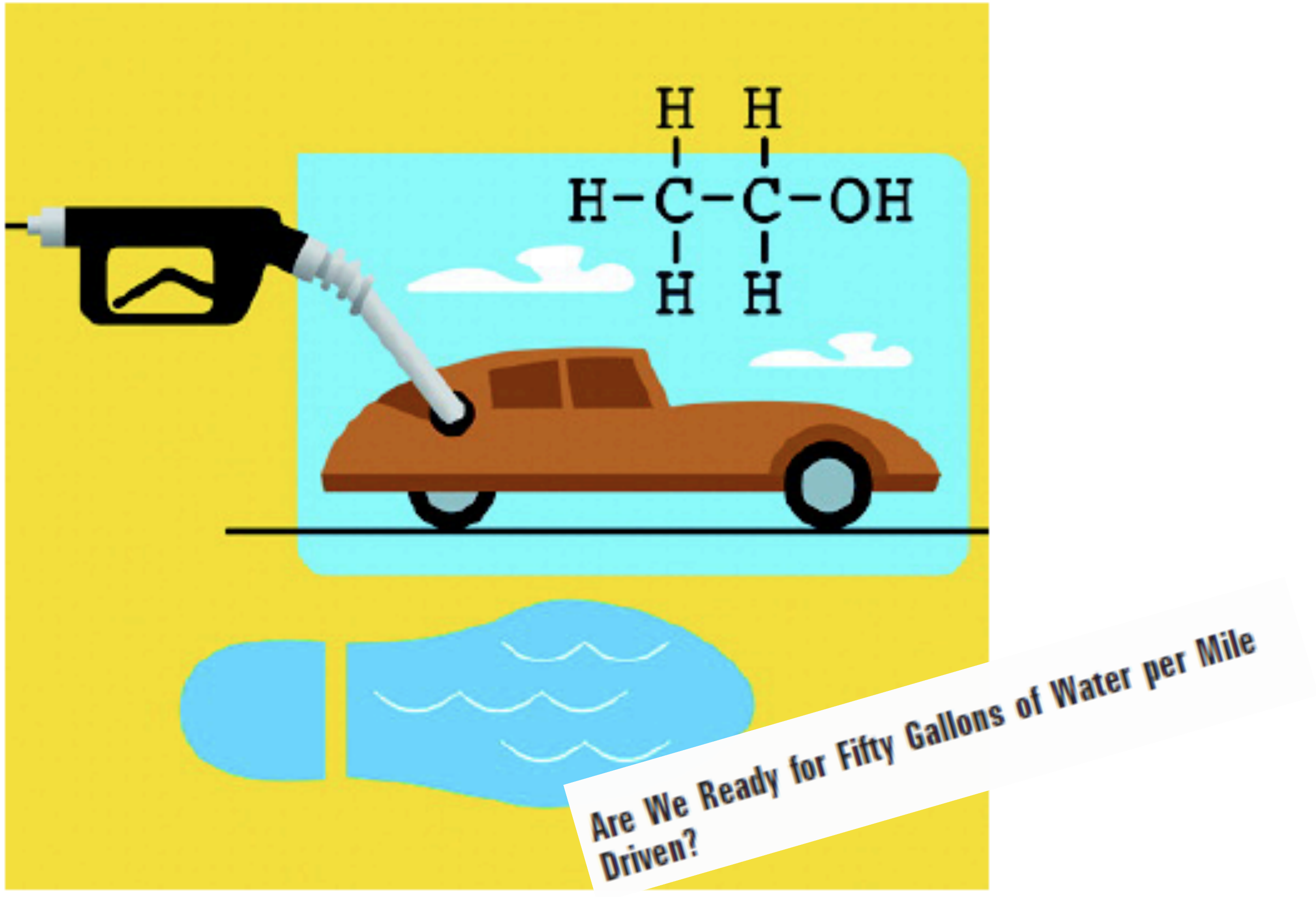
- Reverse osmosis: 5 kWh/m^3.
- Multi-stage flash distillation: 25 kWh/m^3.

SIDE PROBLEM: One m^3 of water contains about 35 kg of salts (NaCl and others). The present worldwide desalination capacity of 40 million m^3 water/yr translates into 1.4 million ton mixed salts/yr, unsuitable for food and hard to dispose of.

The Water Footprint of Biofuels: A Drink or Drive Issue?

R. Dominguez-Faus, Susan E. Powers, Joel G. Burken, and Pedro J. Alvarez

Environ. Sci. Technol., **2009**, 43 (9), 3005-3010• DOI: 10.1021/es802162x • Publication Date (Web): 01 May 2009



More growth…sustainable growth

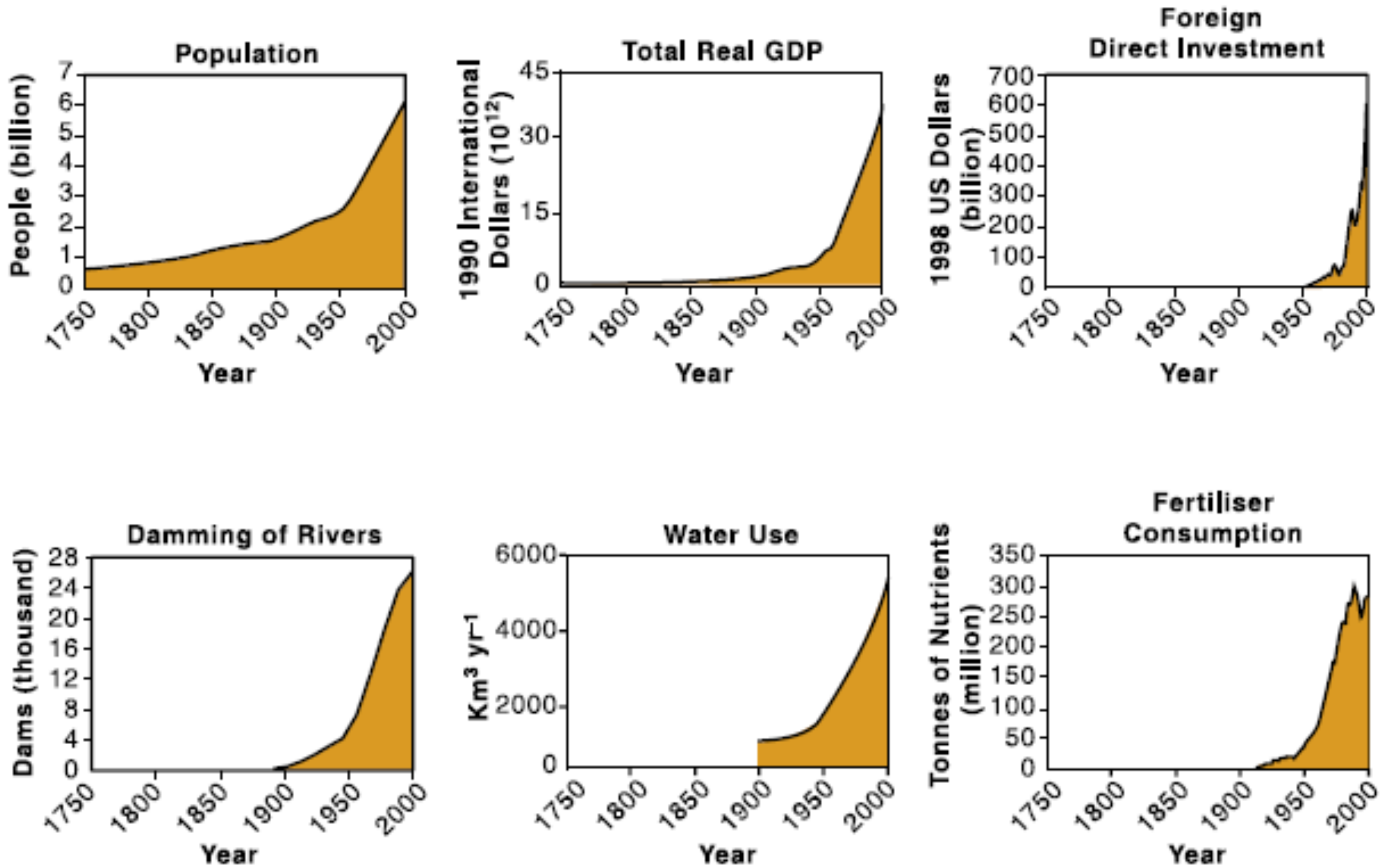
The G-20 Toronto Summit for International Economic Cooperation, June 2010, resulted in 48 resolutions on international economic cooperation. The second resolution was as follows:

2. Building on our achievements in addressing the global economic crisis, we have agreed on the next steps we should take to ensure a full return to growth with quality jobs, to reform and strengthen financial systems, and to create strong, sustainable and balanced global growth. (our emphasis added)

In the 27 pages of resolutions and annexes in support of those resolutions, the term "growth" was used 67 times and the terms "sustain", "sustainable", "sustainability" most often coupled to "growth" were used 43 times. Even more telling, the terms "resource(s)" while used 17 times never once mentioned "natural resources" (only referring to "financial resources"), and the term "energy" was never mentioned at all.

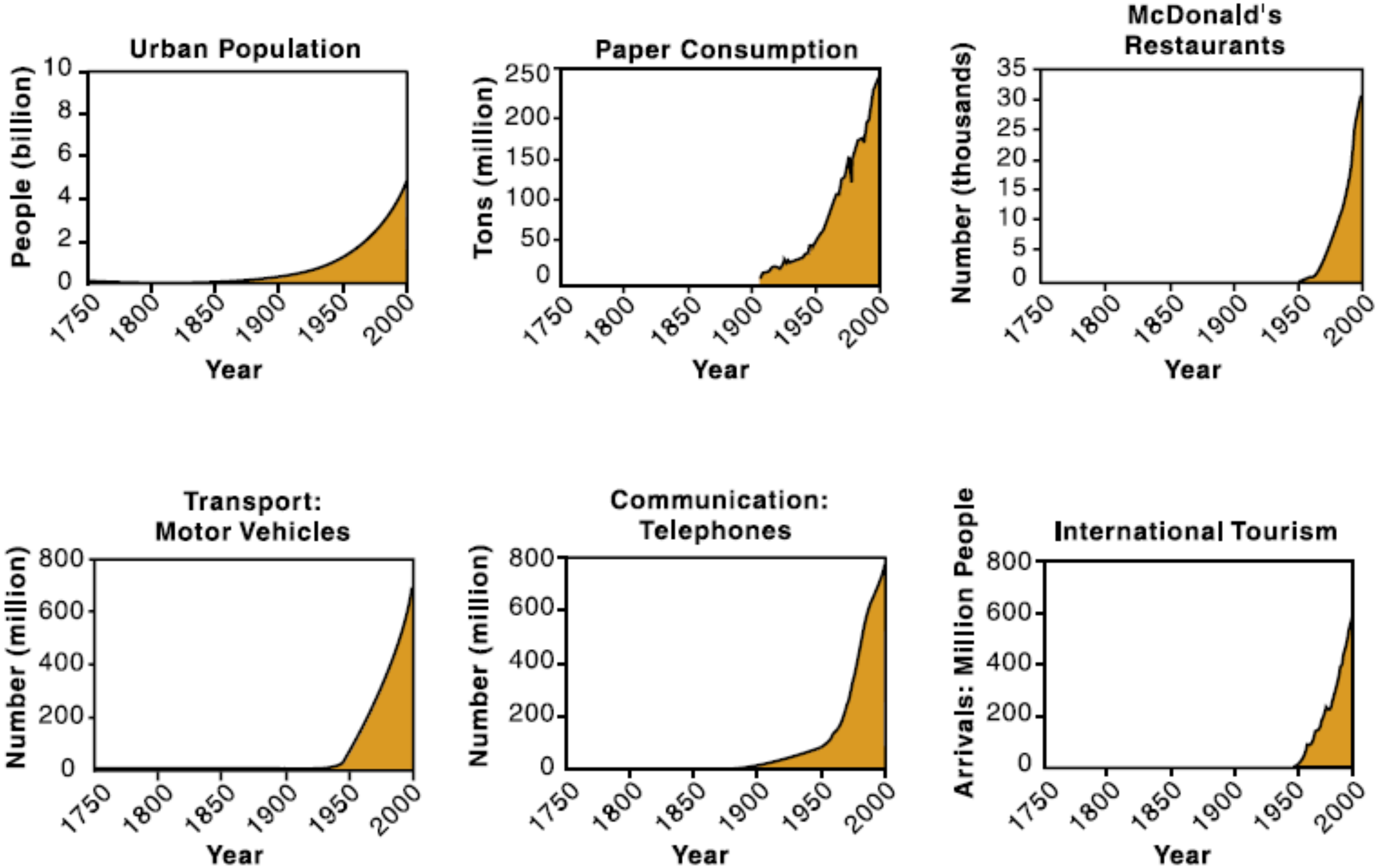
(Brown and Ulgiati, 2011. **Understanding the Global Economic Crisis: A Biophysical Perspective. Ecological Modelling, 223: 4-13)**

Increasing rates of change in human activity since the beginning of the Industrial Revolution. 1



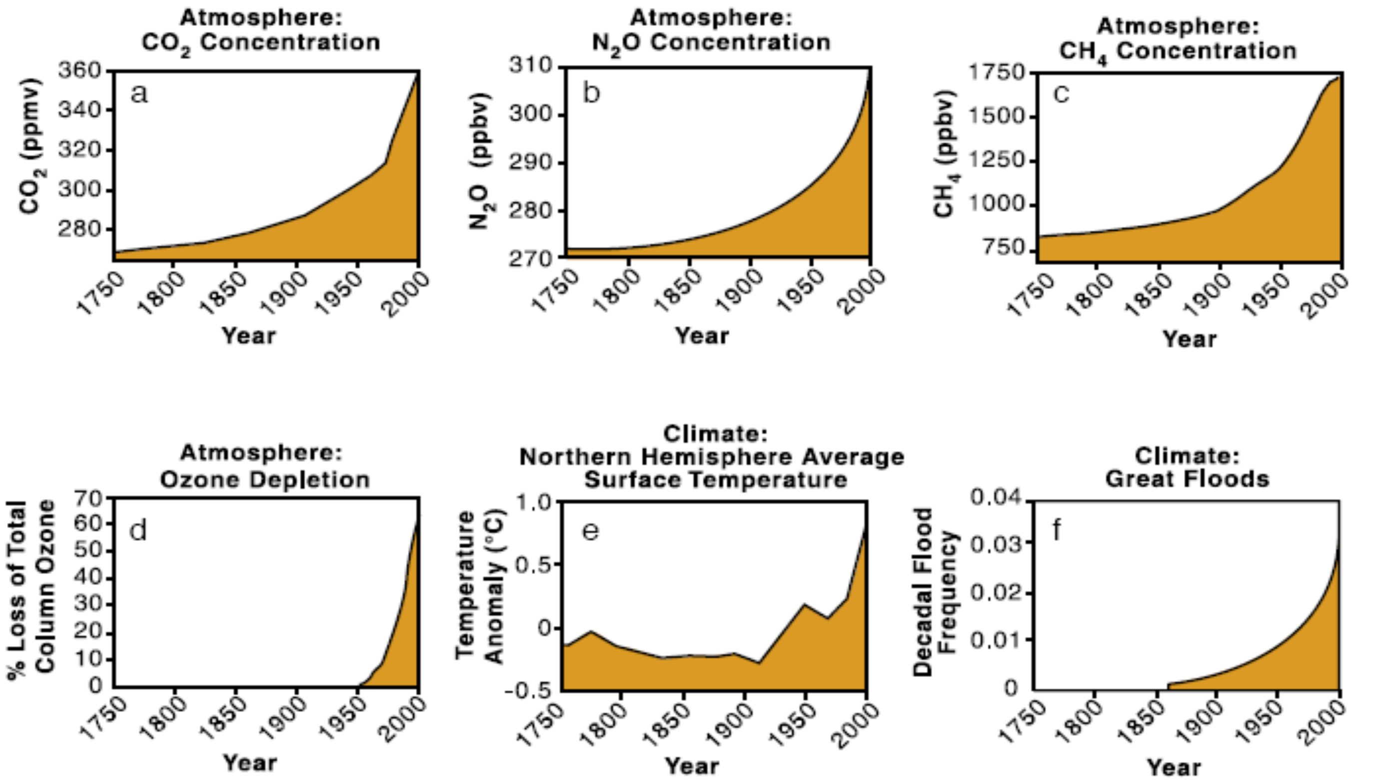
International Geosphere-Biosphere Programme (2004). *Global Change and the Earth System: A Planet Under Pressure*

Increasing rates of change in human activity since the beginning of the Industrial Revolution. 2



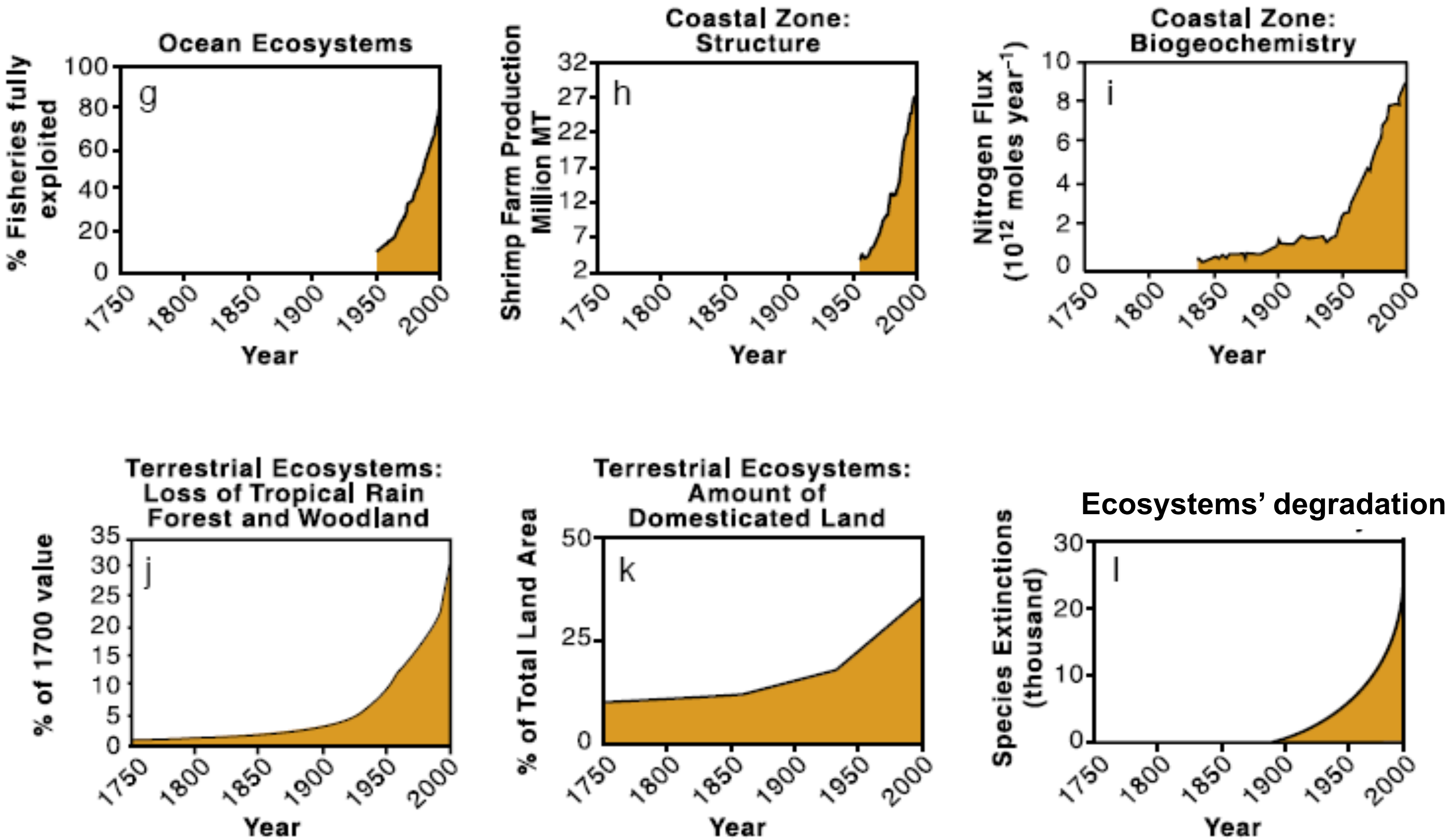
International Geosphere-Biosphere Programme (2004). *Global Change and the Earth System: A Planet Under Pressure*

Global-scale changes in the Earth System as a result of the dramatic increase in human activity (1)



International Geosphere-Biosphere Programme (2004). *Global Change and the Earth System: A Planet Under Pressure*

Global-scale changes in the Earth System as a result of the dramatic increase in human activity (2)



International Geosphere-Biosphere Programme (2004). *Global Change and the Earth System: A Planet Under Pressure*

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Agriculture, Ecosystems and Environment 102 (2004) 213–218

Agriculture Ecosystems & Environment

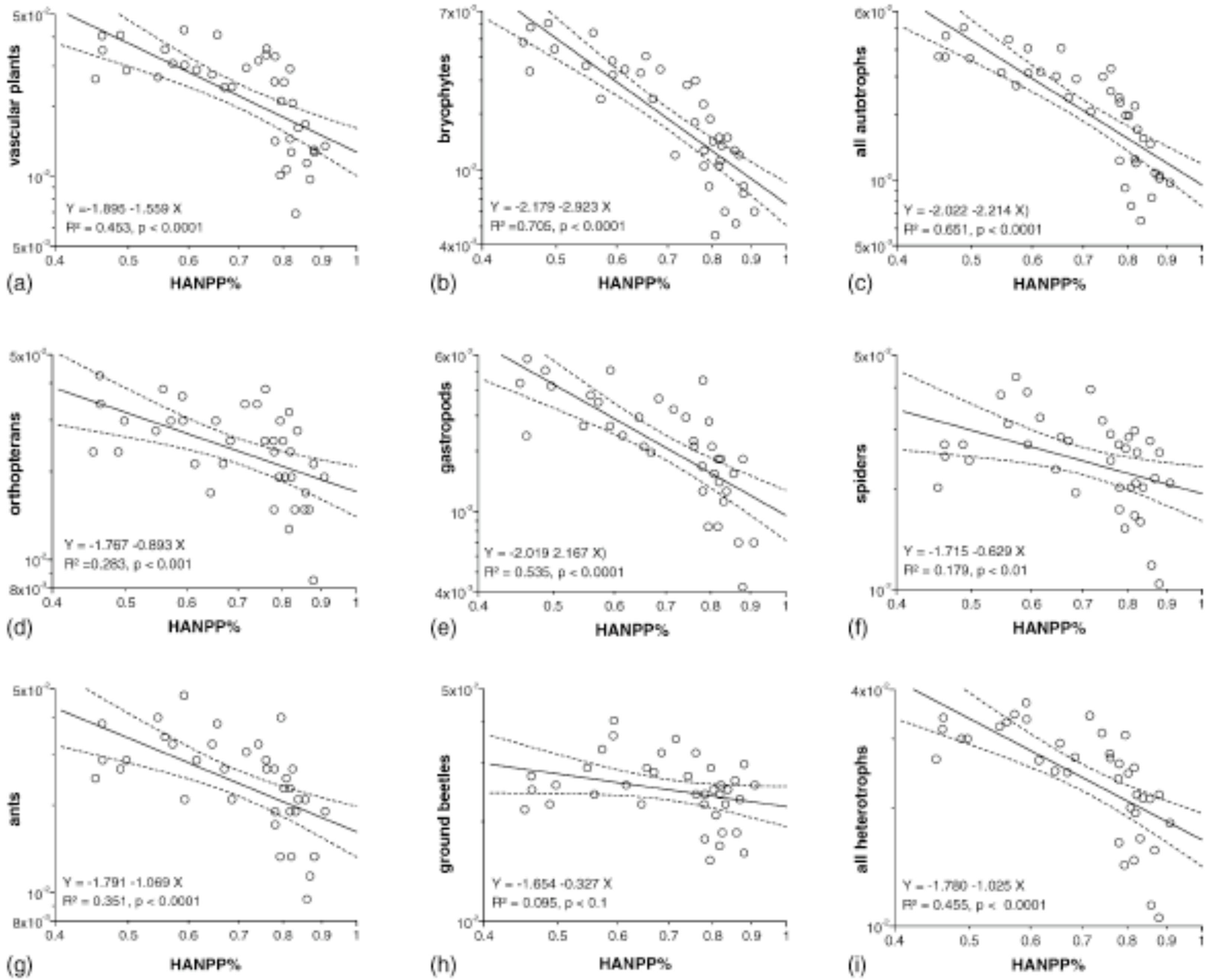
www.elsevier.com/locate/agee

Human appropriation of net primary production and species diversity in agricultural landscapes

Helmut Haberl[a,*], Niels B. Schulz[a], Christoph Plutzar[b], Karl Heinz Erb[a], Fridolin Krausmann[a], Wolfgang Loibl[c], Dietmar Moser[b], Norbert Sauberer[b], Helga Weisz[a], Harald G. Zechmeister[b], Peter Zulka[d]

Rain forest surrounded by hectares of soybean fields in the Mato Grosso state, Brazil.

(John Lee / Aurora Select for TIME, 2008)

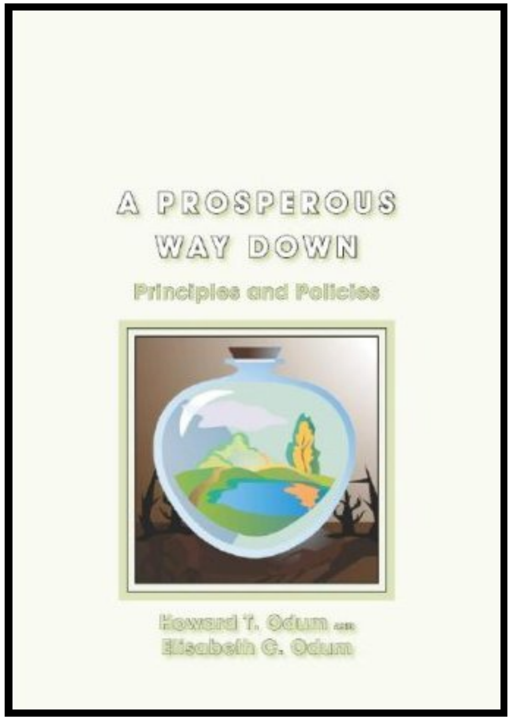


vascular plants
Y =-1.895 -1.559 X
R² = 0.453, p < 0.0001
HANPP%
(a)
bryophytes
Y = -2.179 -2.923 X
R² =0.705, p < 0.0001
HANPP%
(b)
all autotrophs
Y = -2.022 -2.214 X)
R² = 0.651, p < 0.0001
HANPP%
(c)
orthopterans
Y = -1.767 -0.893 X
R² =0.263, p < 0.001
HANPP%
(d)
gastropods
Y = -2.019 2.167 X)
R² = 0.535, p < 0.0001
HANPP%
(e)
spiders
Y = -1.715 -0.629 X
R² = 0.179, p < 0.01
HANPP%
(f)
ants
Y = -1.791 -1.069 X
R² = 0.351, p < 0.0001
HANPP%
(g)
ground beetles
Y = -1.654 -0.327 X
R² = 0.095, p < 0.1
HANPP%
(h)
all heterotrophs
Y = -1.780 -1.025 X
R² = 0.455, p < 0.0001
HANPP%
(i)

The paradigm of growth

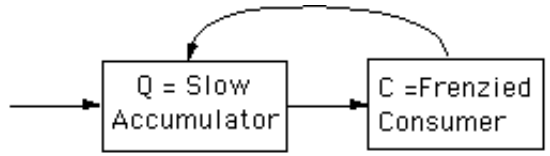
- The paradigm of growth is so deeply ingrained in our lifestyle that we are unable to think any differently.
- We have been taught that science would allow a continuous growth, removing all technological obstacles and solving all problems, for a prosperous life ahead.

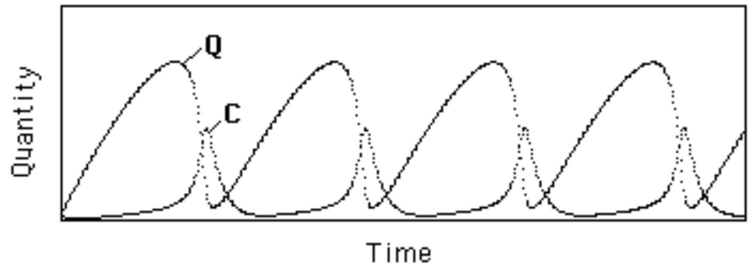
Howard T. Odum (1925-2002):
the impossibility of business-as-usual
and the search for alternatives.



Howard T. Odum and Elisabeth C. Odum (2001)
A Prosperous Way Down: Principles and Policies.
Boulder, Colorado: University Press of Colorado.

The pulsing paradigm





Sustainability is not achieved once for ever.

Systems follow oscillating patterns and adopt different sustainability strategies

(Odum & Odum, 2001)

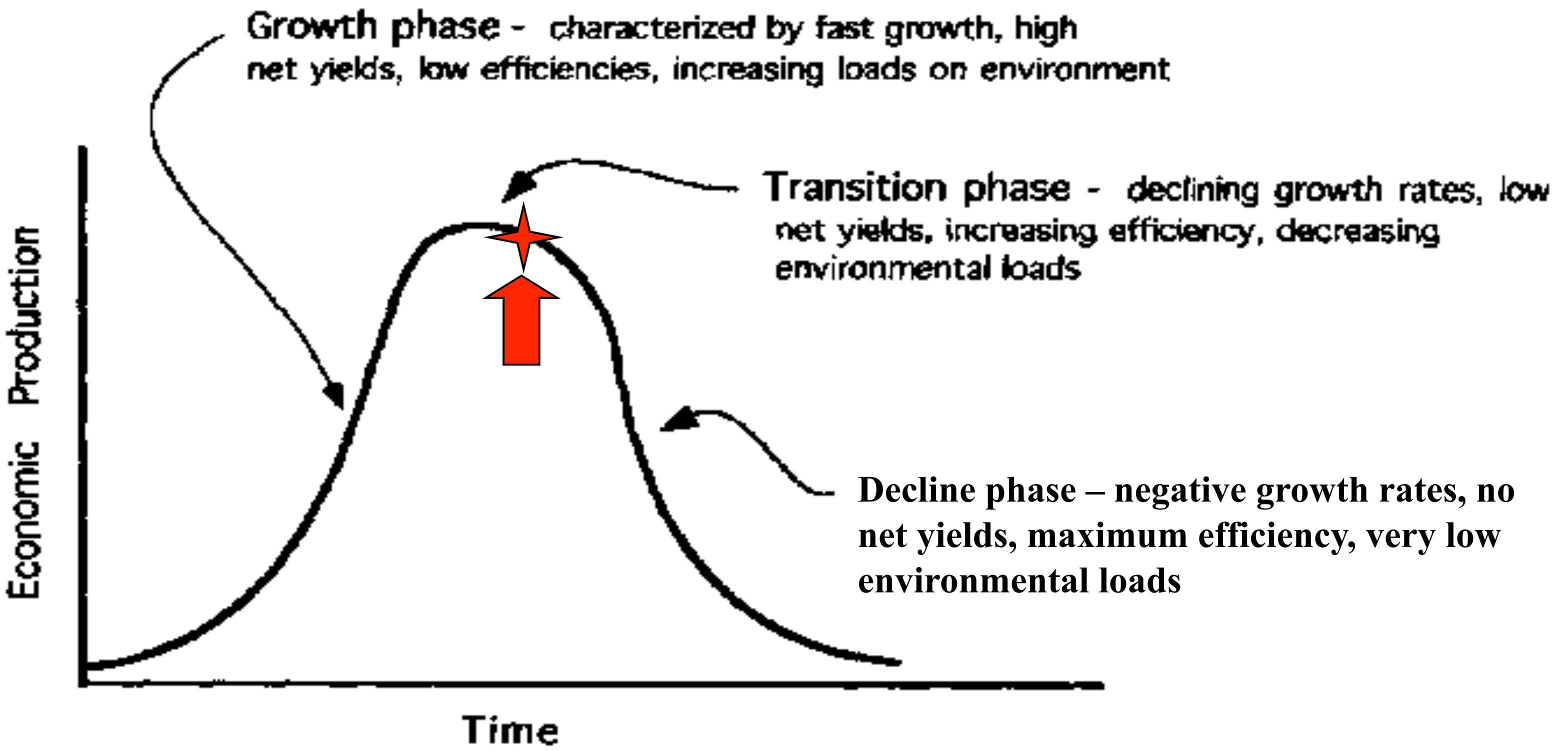
(1) **growth on abundant available resources**: increase of population, structure, and assets, low-efficiency, high-competition;

(2) **climax and transition**: the system reaches the maximum size allowed by available resources, increases efficiency, develops collaborative patterns, and prepares for descent by storing information;

(3) **descent**: less resources available, decrease of population and assets, increased recycling, transmission of information in a way that minimizes losses;

(4) **low-energy restoration**: no-growth, consumption smaller than accumulation, storage of resources for a new cycle ahead.

Cycles of growth and descent



A Growth Ethic…

"There are no great limits to growth because there are no limits of human intelligence, imagination, and wonder."

(Ronald Reagan 40th president of US, 1911-2004)

"Growth for the sake of growth is the ideology of the cancer cell."

(Edward Abbey, USA writer, 1927-1989)

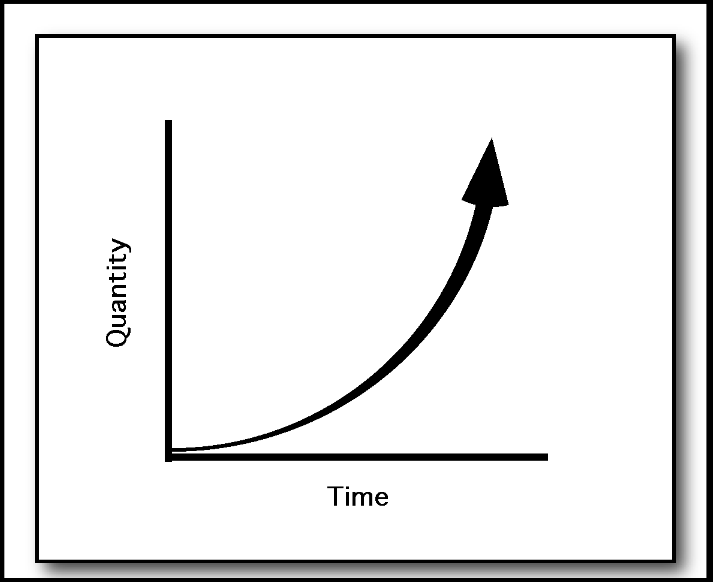

Growth of Total Research Programs
1,500,000
1,000,000
500,000
Millions of Dollars
PROFITABLE GROWTH IS EVERYONE'S BUSINESS
10 TOOLS YOU CAN USE MONDAY MORNING
RAM CHARAN
daily viewers
3K
45K
499K
956K
987K
1.1M
1.4M
1998
1999
2000
2001
2002
2003
2004
A GROWING COMPANY
Our steady growth ensures stability for staff and reliability for clients.
Growth: 1980 - Present
1988
1990
1992
1994
1996
1998
2000
2002
2003
TALLAHASSEE
Sugarmill Woods
FL 39.3% POP. INCREASE BY: 2010
ORLANDO
FORT LAUDERDALE
NAPLES
MIAMI
7 Keys to Company Growth
Internet Economy Growing at an Astounding Rate
174%
Internet Economic Growth
World Economic Growth
3.8%
Center for Research on Electronc Commerce, University of Texas

Exponential Growth…

The failure to understand the concept of exponential growth by those "in charge" may be the single biggest problem we face…

Doubling Time = (70/n) years

Growth rate, n	D time
3%	24 yrs
5%	14 yrs
7%	10 yrs
10%	7 yrs



"…this is not a proposal for less growth.
It is recognition that general systems principles
of energy, matter, and information
are operating to force society into a different
stage in a long-range cycle".

(Odum and Odum, 2001).

The difficult art of making choices:

Remember where did we fail…

A few examples:

- Oil prices
- Biomass fuels
- “Sustainable” Growth
- ……

Benefits and costs of purchasing a dog:

- Makes me happy, when I am alone
- Plays with my kids
- Protects my house
- Has a good smell to find things
- I like it
- Forces me to walk

- Eats a lot of food
- Bites my shoes
- Requires expensive medical care
- Disturbs my neighbors by barking
- Needs to be walked every day
- I pay taxes on it

Price ?

When shopping,
how do we make decisions ?

Environmental concerns ?

Making Choices

(and policy decisions)

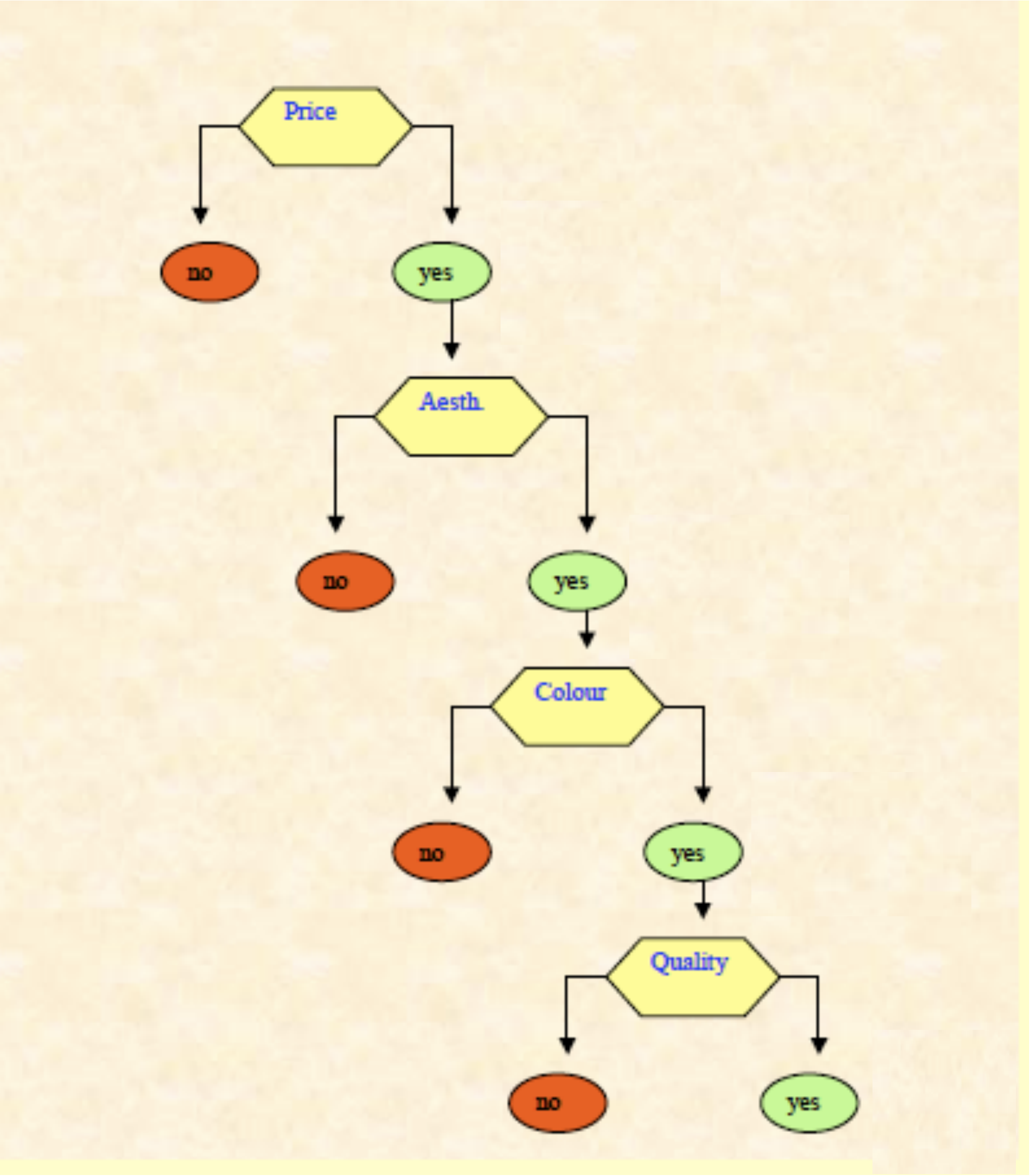
is difficult

because of:

* different criteria,

* different benefits,

* different costs



Points of view in decision making

User-side perspective:

value of resources is defined according to their use: costs and benefits to the user

Donor-side perspective:

value of resources is defined according to the environmental work done by the biosphere to produce them and make them available to human societies

The economic system

air

water

food

materials

energy

Land Use,

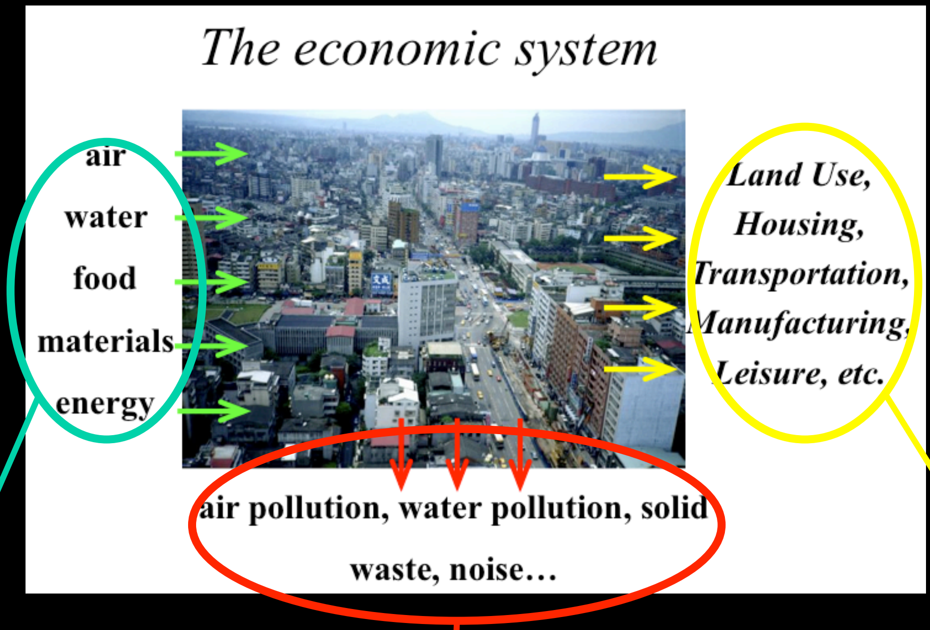
Housing,

Transportation,

Manufacturing,

Leisure, etc.

air pollution, water pollution, solid waste, noise…



* Where do resources come from?

* How much is needed? How much is available?

* Who decides about resource use?

* Who is affected by the impacts?

* Is there a critical threshold?

* To what extent can we increase production?

* There will be enough for everybody?

USER SIDE:

Life Cycle Assessment

Includes:

- **Material Resource Depletion,**
- **Cumulative Energy Analysis,**
- **Emissions and impacts**

- **ABIOTIC DEPLETION**: extracted minerals, overburden, fuels, etc, all expressed in terms of their mass.

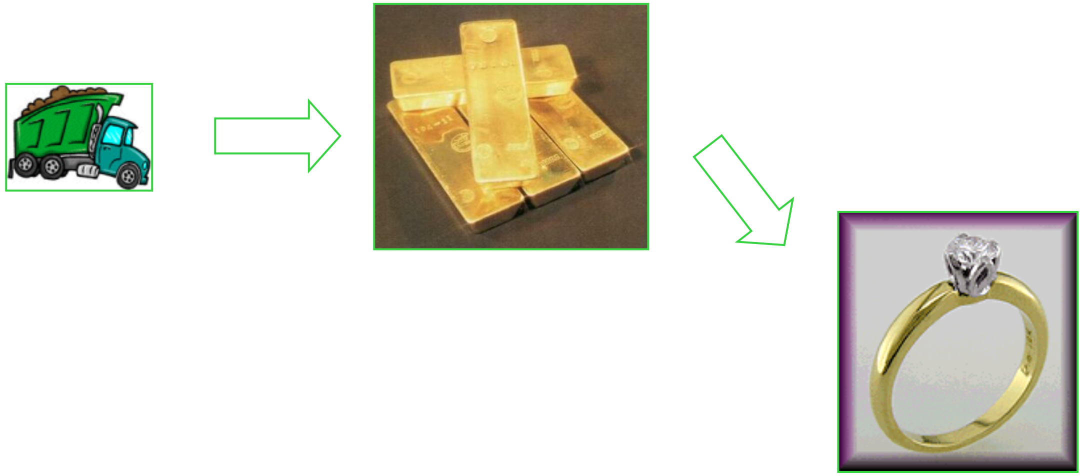
Examples (*):

Gold:	540 000 g/g_{Au}
Diamonds:	5 260 000 g/g_{D}
Pig Iron:	4.04 g/g_{G}

http://wupperinst.org/uploads/tx_wupperinst/MIT_2014.pdf

Gold:

540 000 g/g_{Au}



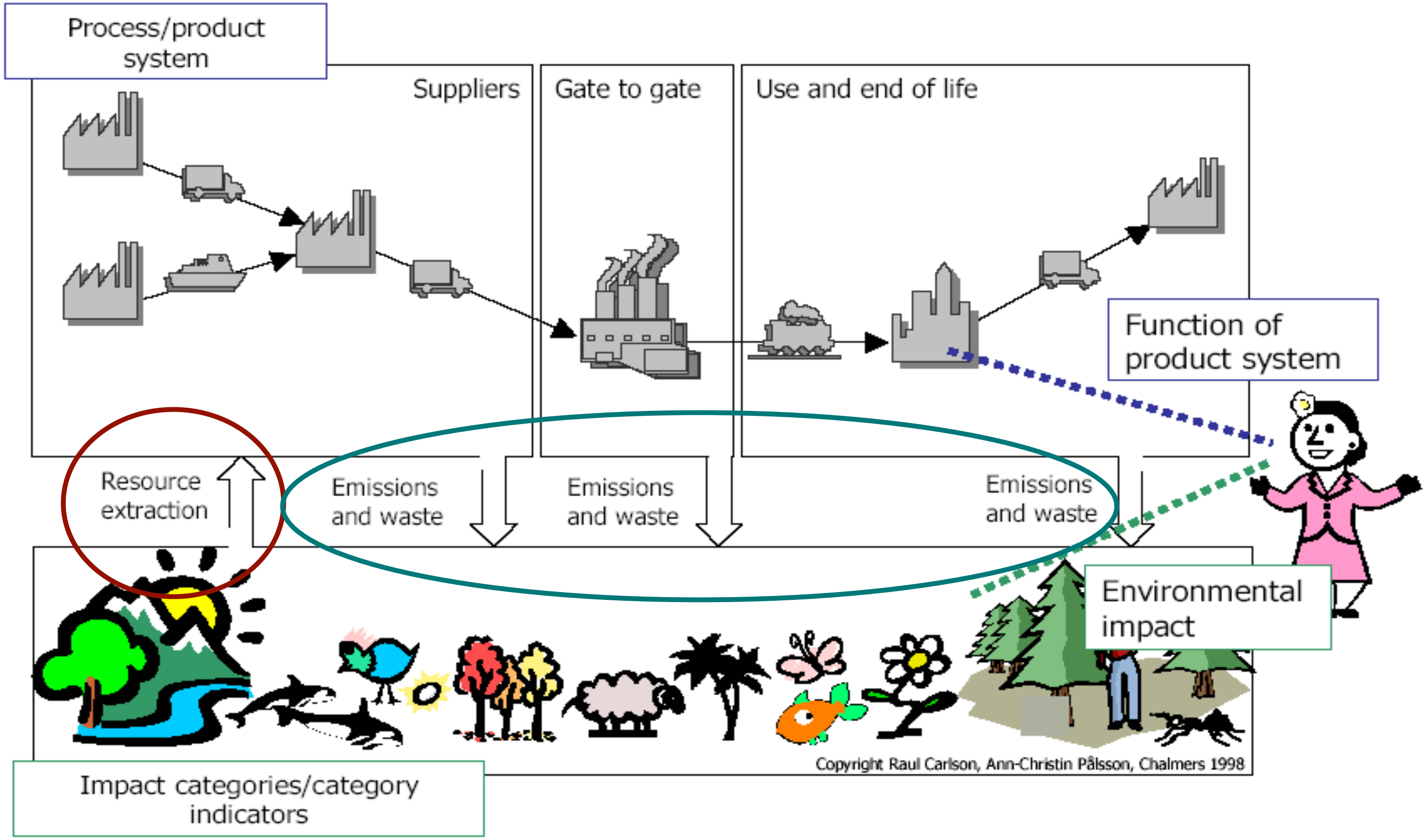
Diamonds:

5 260 000 g/g_D

http://wupperinst.org/uploads/tx_wupperinst/MIT_2014.pdf

Life Cycle Assessment (LCA)

LCA assesses environmental impacts by means of selected damage categories that describe the effect of processes, products and services on the environment.



Environmental impacts of a product are the irreversible changes generated by all the substances extracted from the environment and emissions to the environment over the entire life cycle of the product.

LCA – International Standards

UNI EN ISO 14040:2006

- Definitions, Concepts, framework of LCA
- Goal, Scope and inventory in LCA

UNI EN ISO 14044:2006

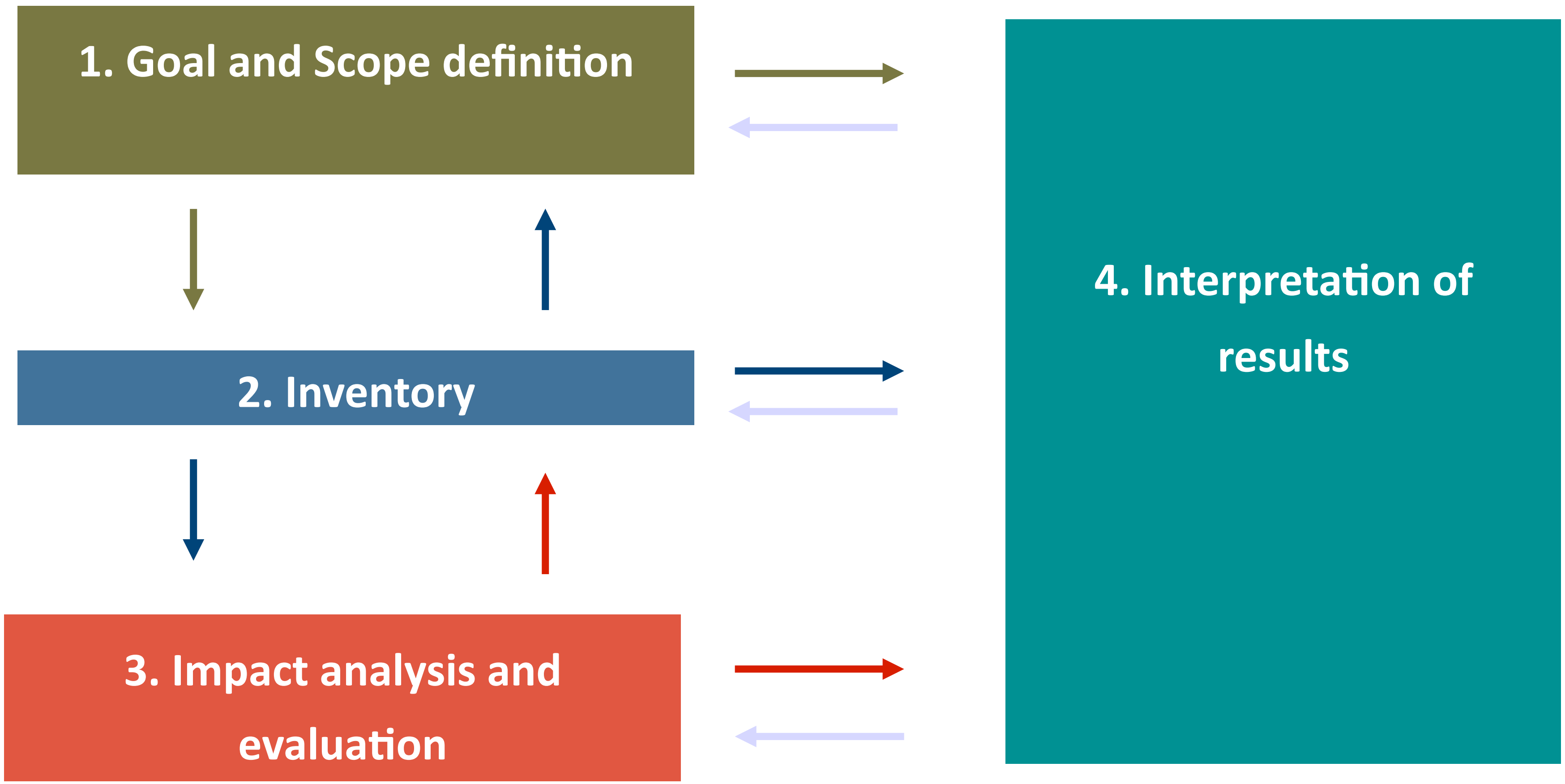
- LCA Impacts Assessment
- LCA interpretation

The International Reference Life Cycle Data System.

ILCD Handbook: General guide for Life Cycle Assessment: detailed guidance. Joint Research Center-Institute of Environment and Sustainability, European Commission. European Commission, Ispra, Italy, 2010. 414pp.

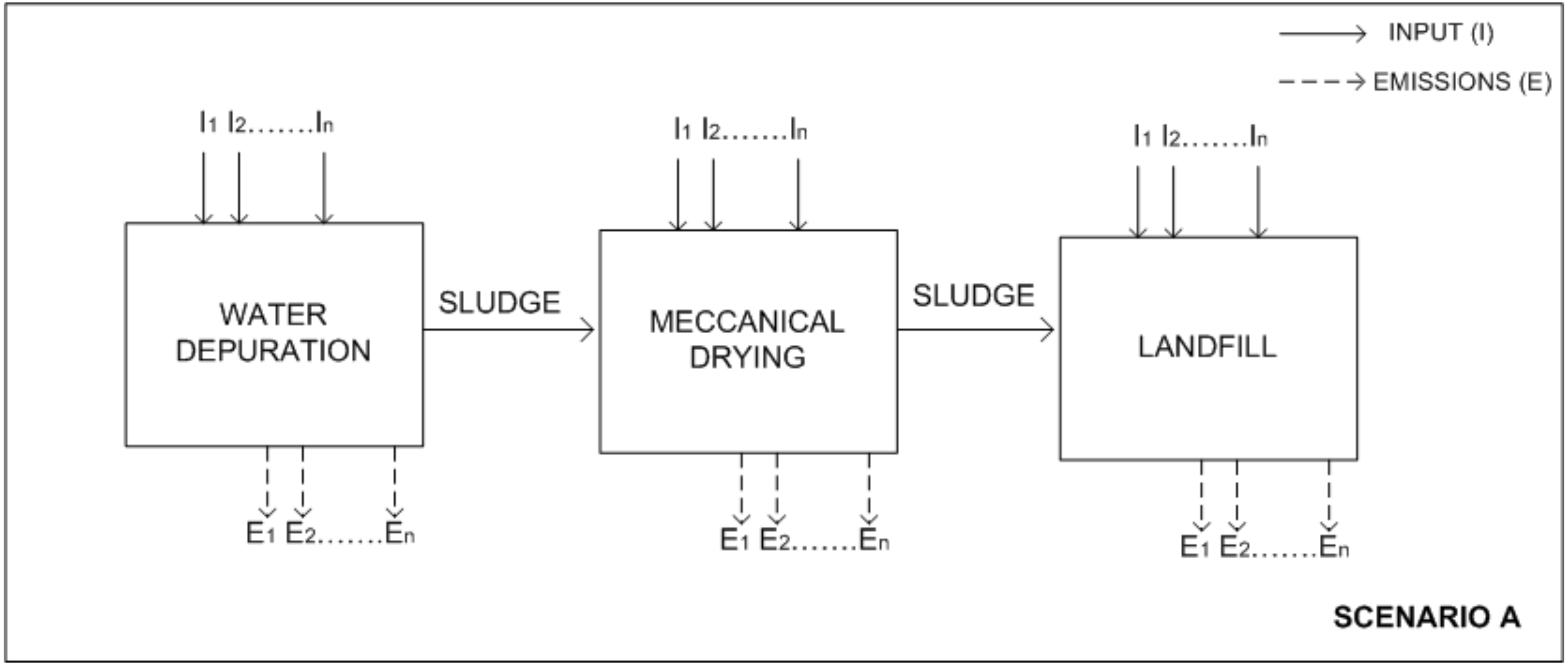
LIFE CYCLE ASSESSMENT - Method structure

The ISO 14040:2006 standard describes the general criteria for an LCA to be acceptable and states a four-step structure. All steps interact to each other.

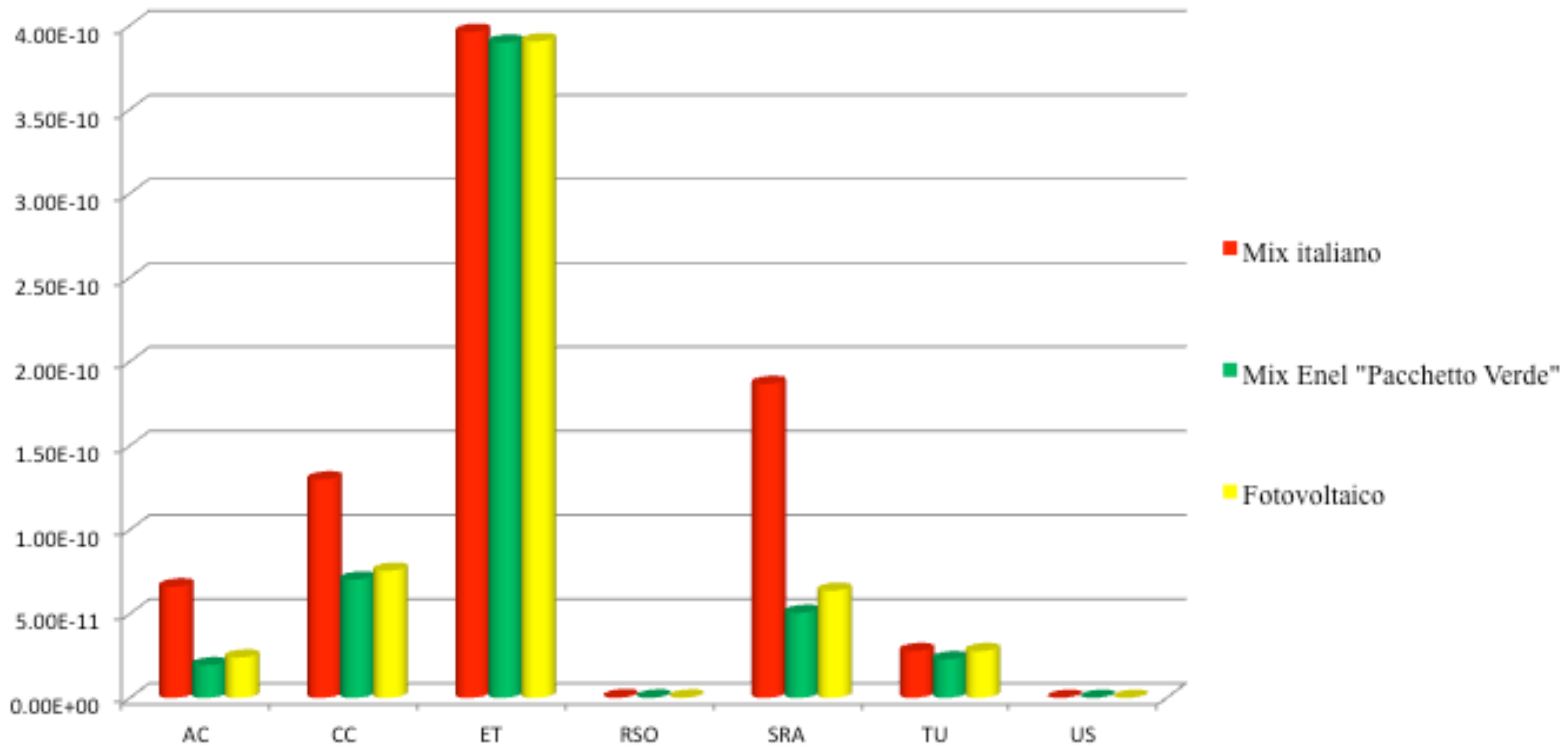


Using LCA to explore integrated solutions: a case study of wastewater treatment

Conventional wastewater treatment with sludge landfilling (plant located in Napoli, Italy)

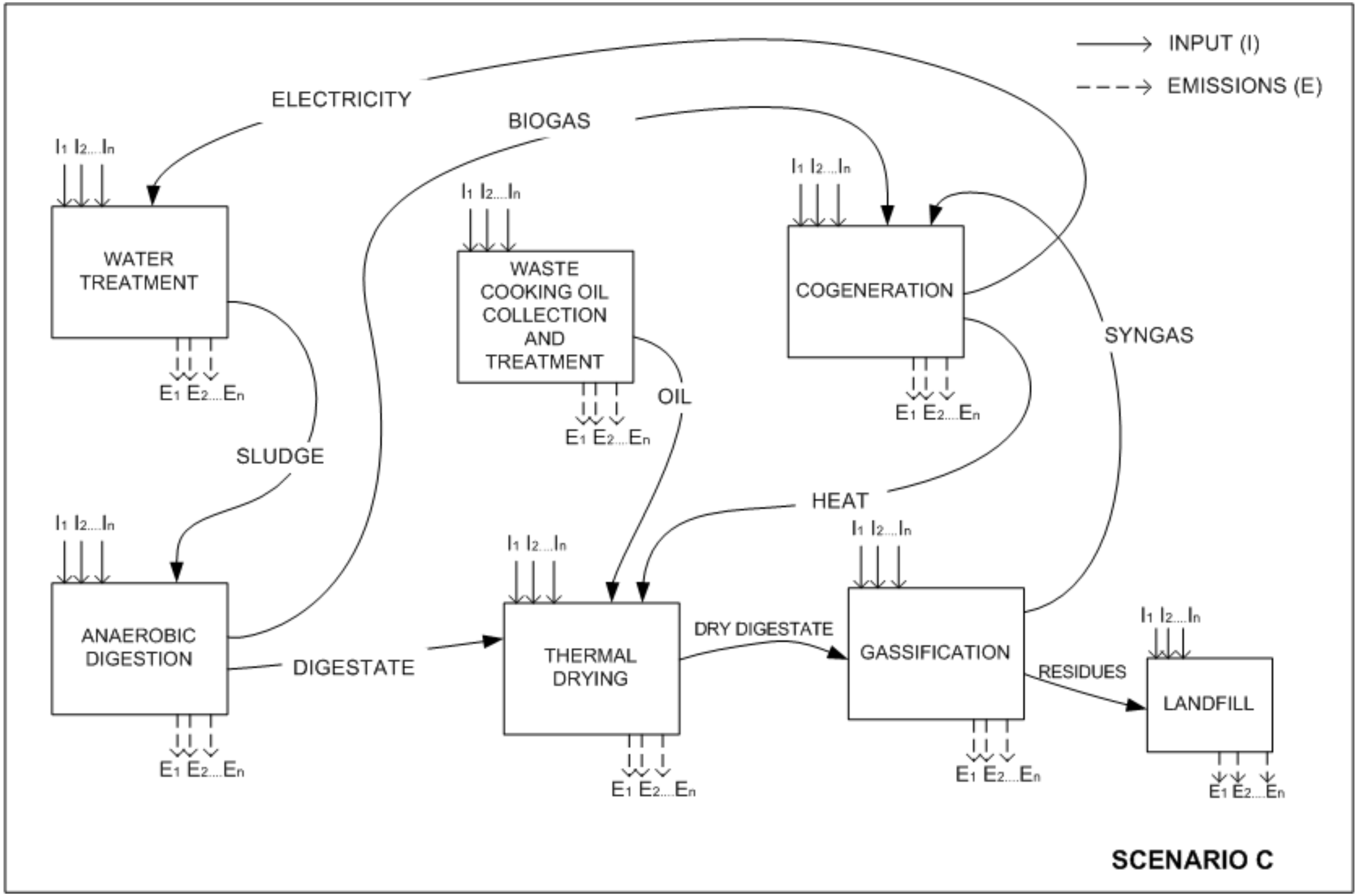


Conventional wastewater treatment with sludge landfilling and improvement scenarios



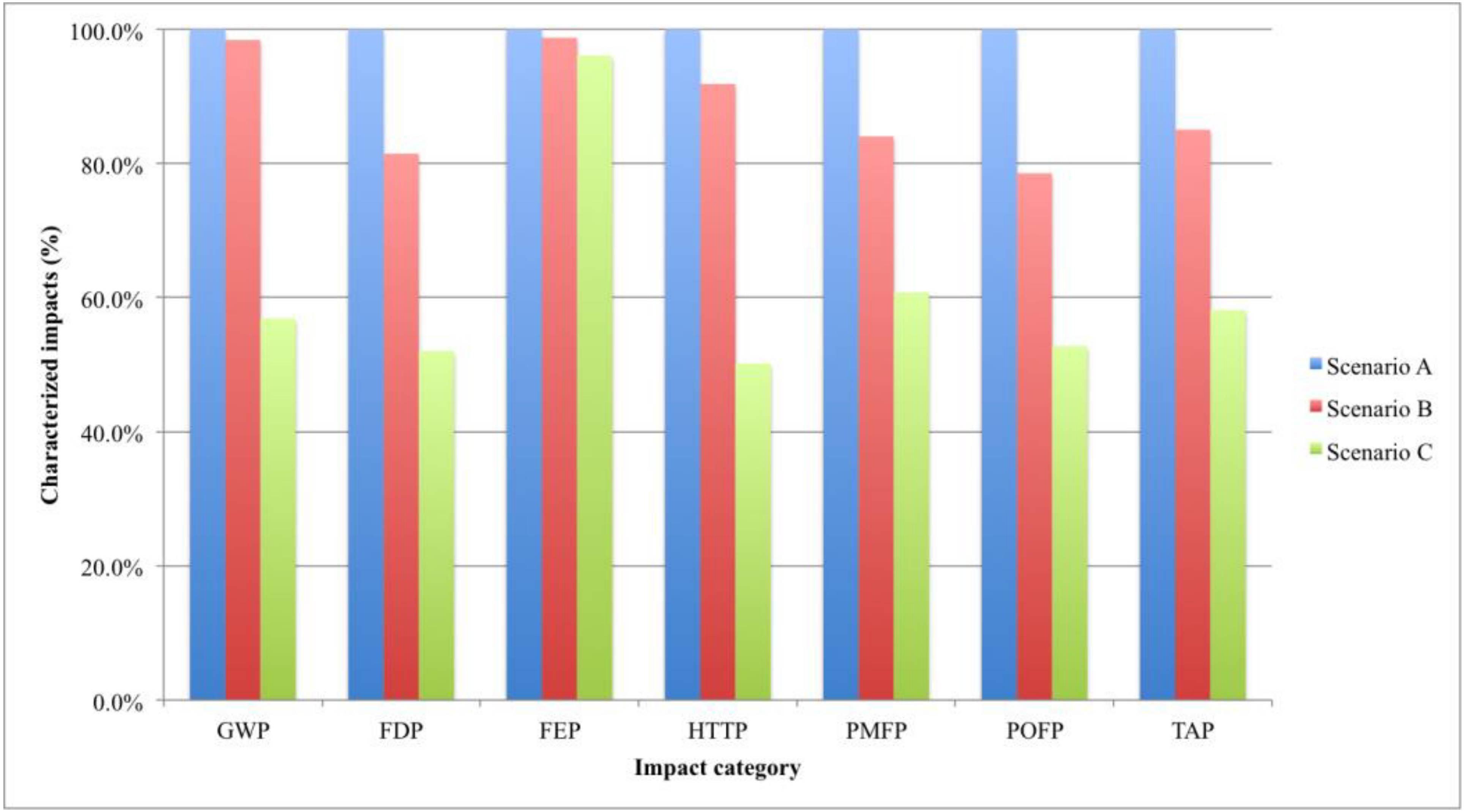
LEGENDA
AC = Acidificazione
CC = Cambiamenti Climatici
ET = Eutrofizzazione
RSO = Riduzione dello Strato di Ozono
SRA = Sfruttamento delle Risorse Abiotiche
TU = Tossicità Umana
US = Uso del Suolo

A proposal for further improvement



Mellino et al., 2015. Alternative Options for Sewage Sludge Treatment and Process Improvement Through Circular Patterns: LCA-based Case Study and Scenarios. Journal of Environmental Accounting and Management 3(1): 1-8

LCA results for "circular scenarios"



Mellino et al., 2015. Alternative Optionsfor Sewage Sludge Treatment and Process Improvement Through Circular Patterns:LCA-based Case Study and Scenarios. Journal of Environmental Accounting and Management 3(1): 1-8

A case study of High Speed Train

The Transportation "System"

Vehicle

- Manufacturing
- Operation
- Maintenance
- …

Infrastructure

- Mining, processing of raw materials
- Construction processes
- Operation and maintenance
- …

Energy Production

- Raw fuel extraction, processing
- Transport and Distribution
- …

Image source: American Institute of Architects, 1997 Environmental Resource Guides

LCA impacts of High Speed Train Construction in Norway. 1

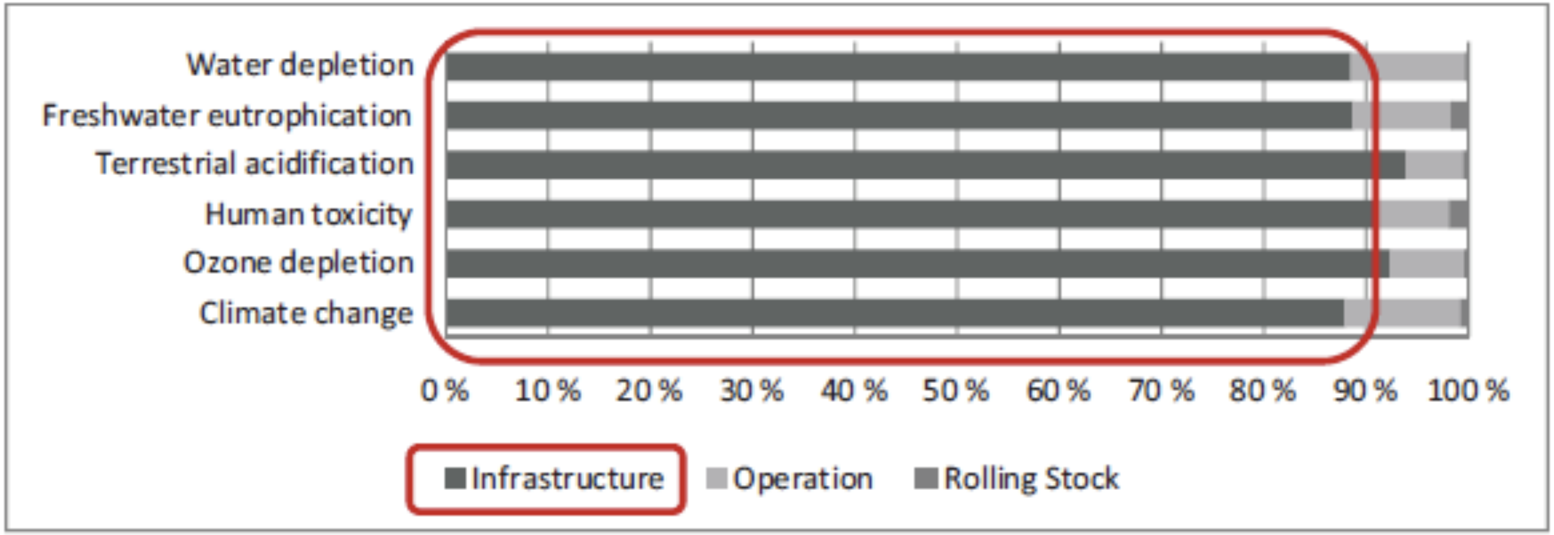


Figure 3-2: HSR-LCA - Life-cycle

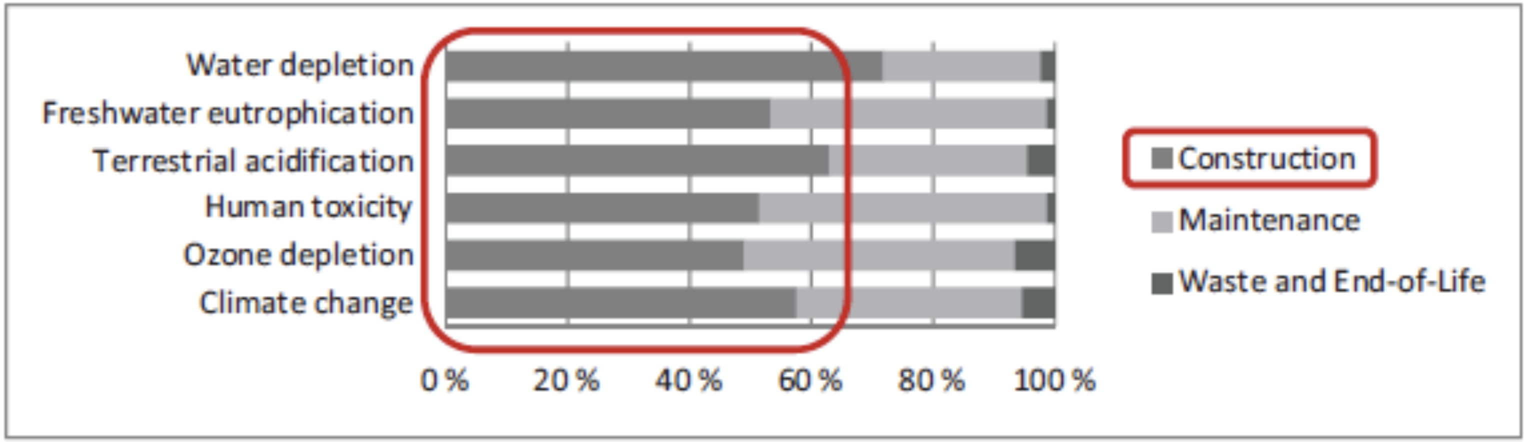


Figure 3-3: HSR-LCA - Life-cycle phases of the infrastructure

Carine Grossrieder, 2011, **Life-Cycle assessment of Future Highspeed Rail in Norway,** Norwegian University of Science and Technology, Department of Energy and Process Engineering

LCA impacts of High Speed Train Construction in Norway. 2

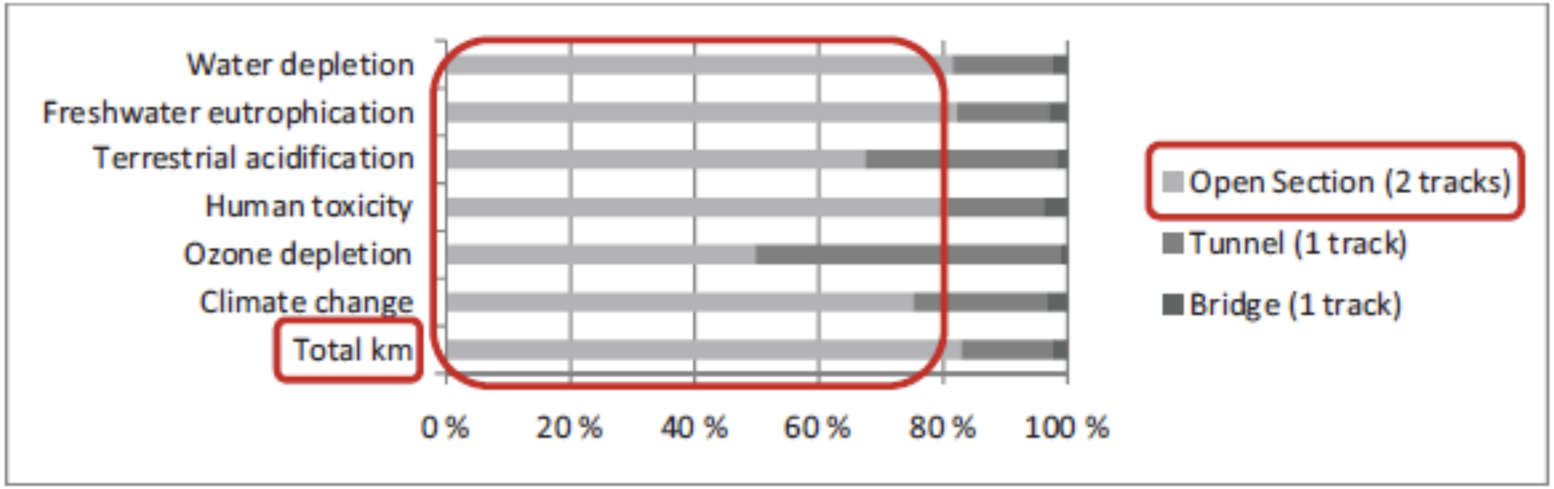
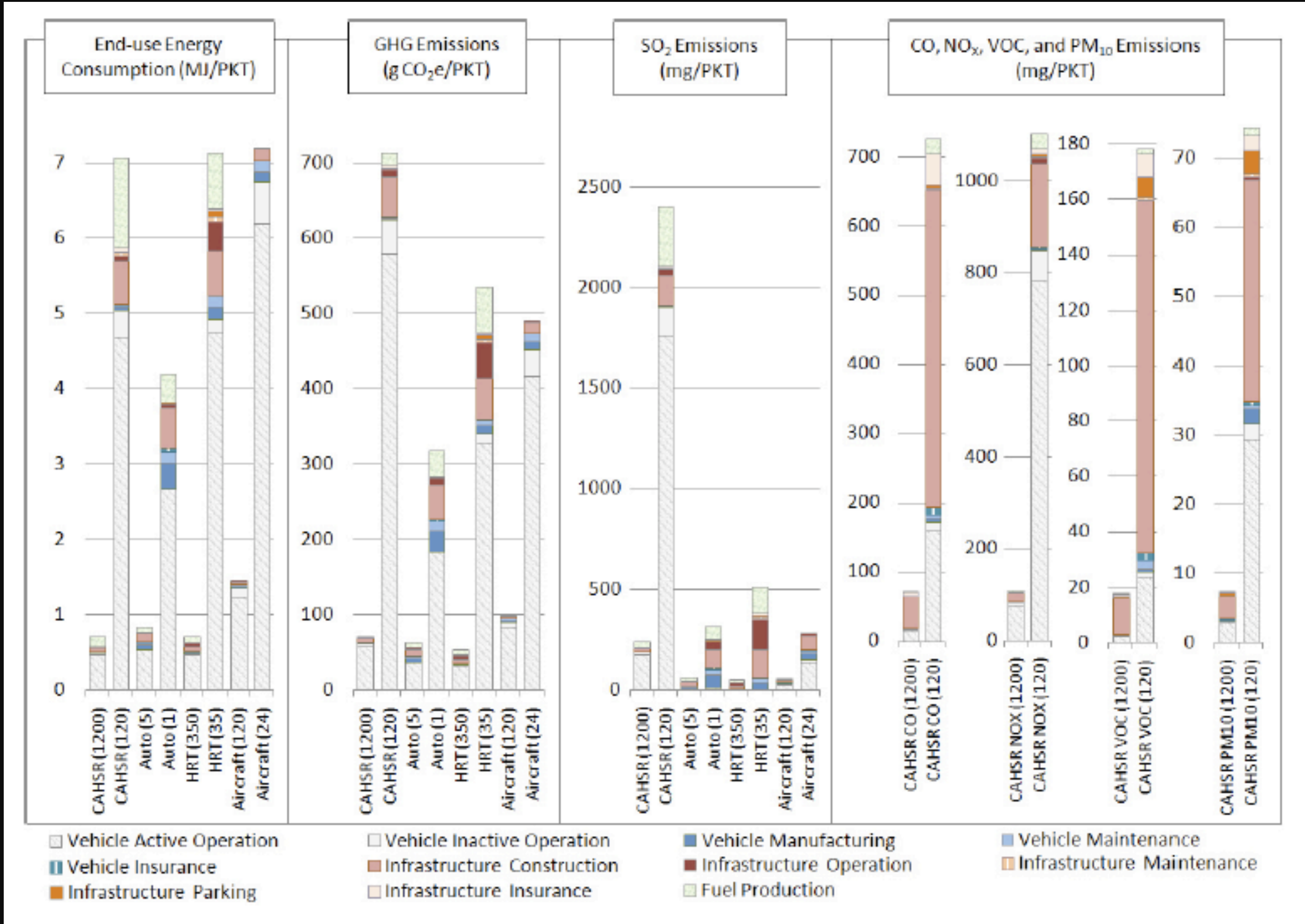


Figure 3-4: HSR-LCA - Impacts of the construction of the sections

Table 3-3: HSR-LCA - Impacts of the construction of the sections

		Bridge (1 track)	Open Section (2 tracks)	Tunnel (1 track)
Climate change	kg CO2 eq/m*y	146	131	167
Ozone depletion	kg CFC-11 eq/m*y	0,000006	0,000009	0,000040
Human toxicity	kg 1,4-DB eq/m*y	85	71	60
Terrestrial acidification	kg SO2 eq/m*y	0,40	0,69	1,41
Freshwater eutrophication	kg P eq/m*y	0,049	0,057	0,046
Water depletion	m3/m*y	1,99	2,40	2,12

High Speed Train performance in California



Chester, M. and Horvath, A., 2010. Life-cycle assessment of high-speed rail: the case of California. Environ. Res. Lett. 5: 1-8.
http://iopscience.iop.org/1748-9326/5/1/014003

High Speed Train performance in Italy

Table 1. Average load factors and selected LCA impact categories for passenger road and rail transport modalities

	Load factor (passengers per trip)	Abiotic material depletion (kg/p-km)	Cumulative Energy Demand (MJ/p-km)	CO_2 emissions (g CO_2/p-km)	SO_2 emissions (g SO_2/p-km)
Car	1.8	0.53	1.87	89.40	0.24
IC train	400	0.85	0.77	30.30	0.34
HS train	250	1.40	1.44	48.20	0.56

(*) [16]

Table 2. Average load factors and selected LCA impact categories for freight road and rail transport modalities

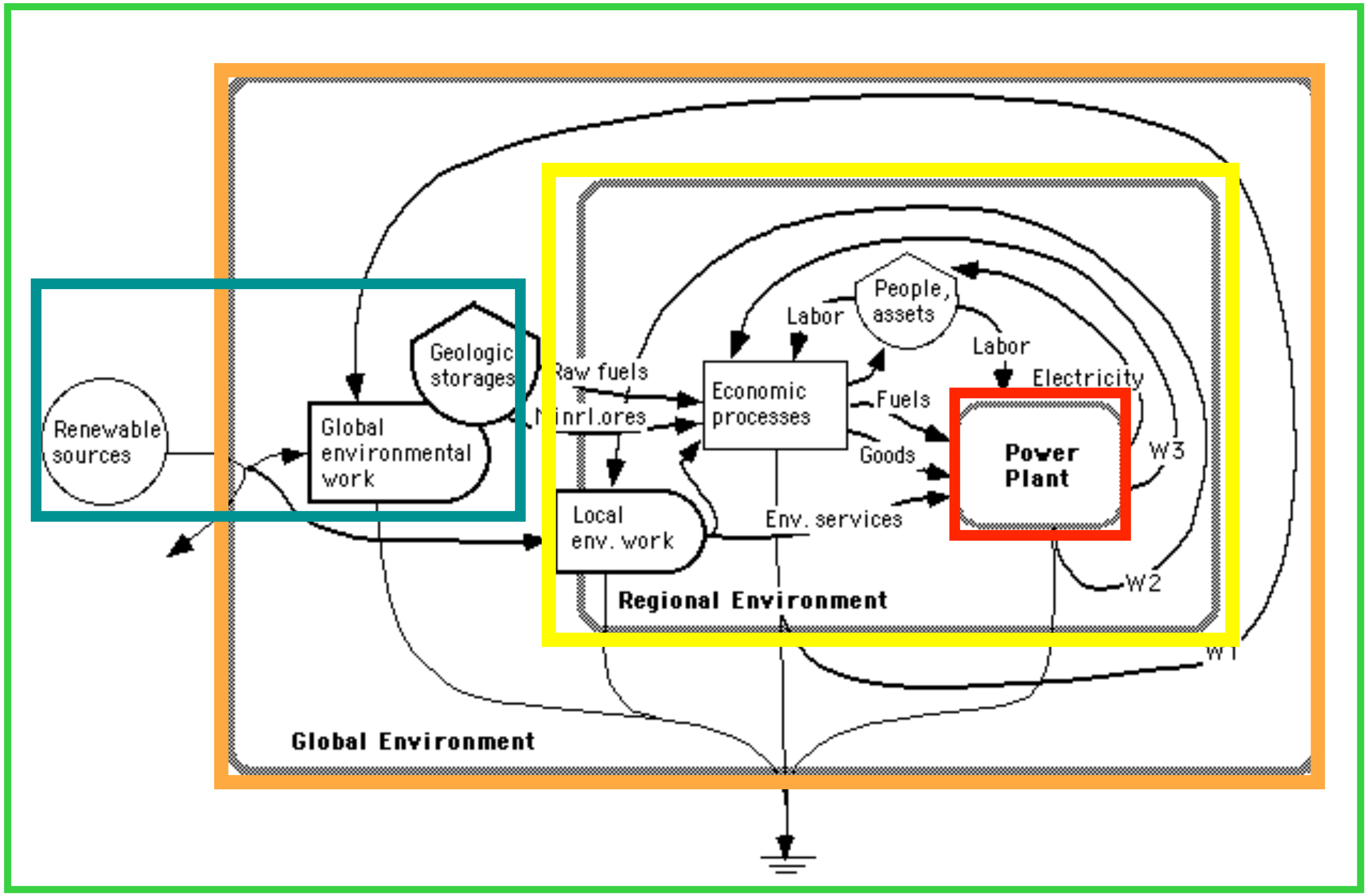
	Load factor (ton per trip)	Abiotic material depletion (kg/t-km)	Cumulative energy Demand (MJ/t-km)	CO_2 emissions (g CO_2/t-km)	SO_2 emissions (g SO_2/p-km)
Lorry (average)	8.8	0.60	1.25	72.10	0.21
Regular freight train	350	7.65	2.50	150.00	0.85
HS train	350	8.65	3.09	189.00	1.05

(*) [16]

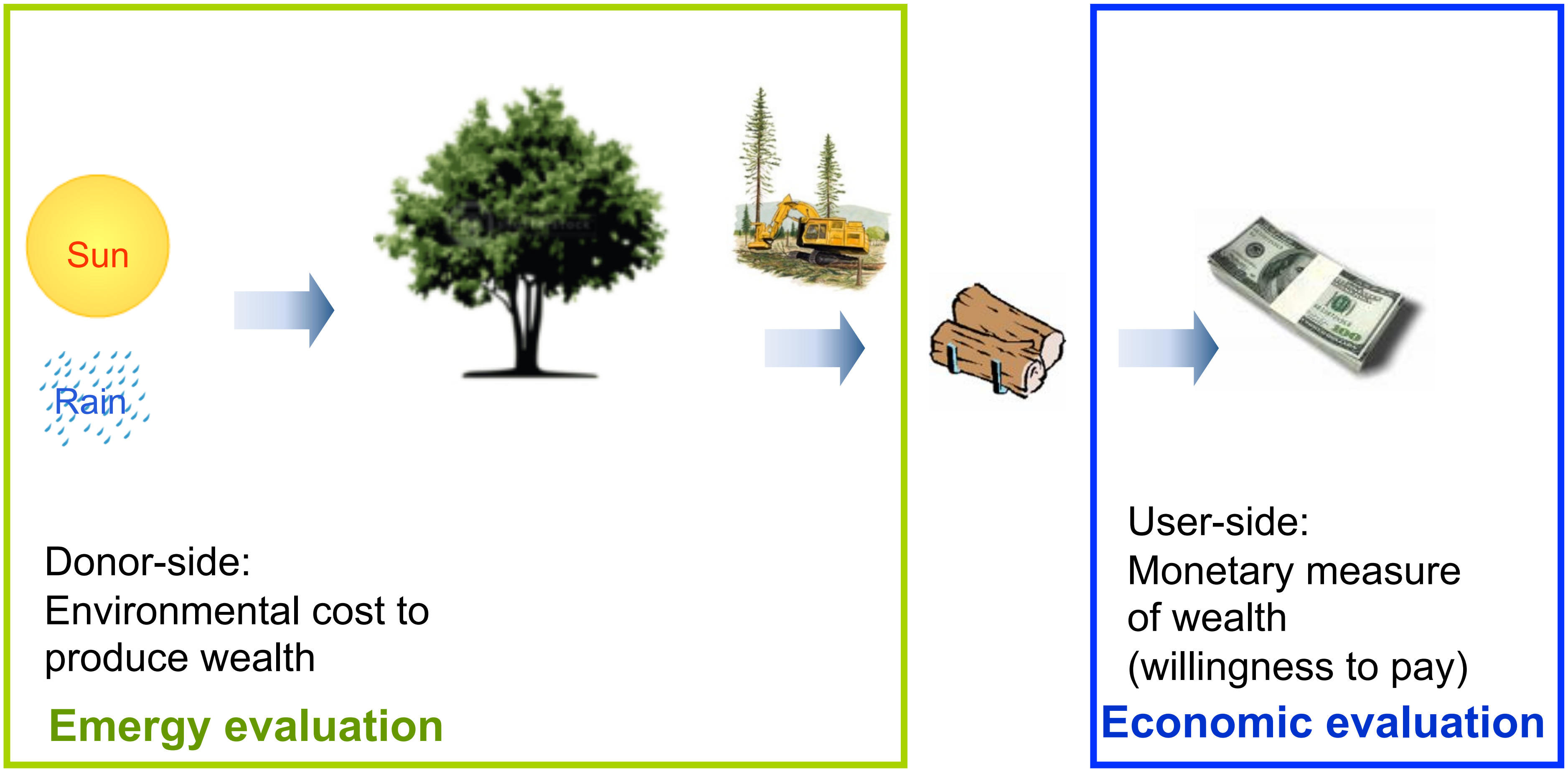
Federici M., Ulgiati S., Basosi R., 2008. A thermodynamic, environmental and material flow analysis of the Italian highway and railway transport systems. Energy, 33(5):760–75.

Emergy, the environmental support

Looking at the next larger scale

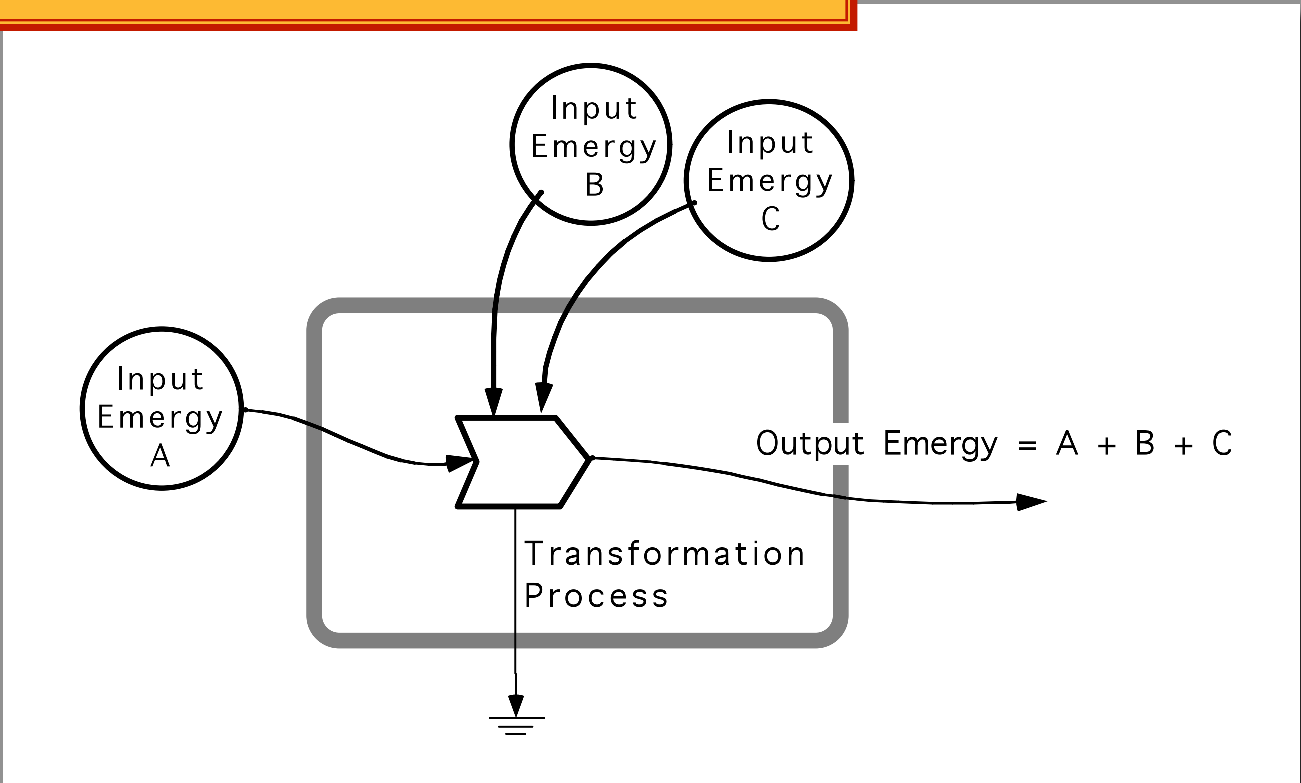


Environmental cost



A. Emergy Concepts and Principles…

EMERGY - The energy (of one form) required directly and indirectly to make something



http://www.emergydatabase.org/

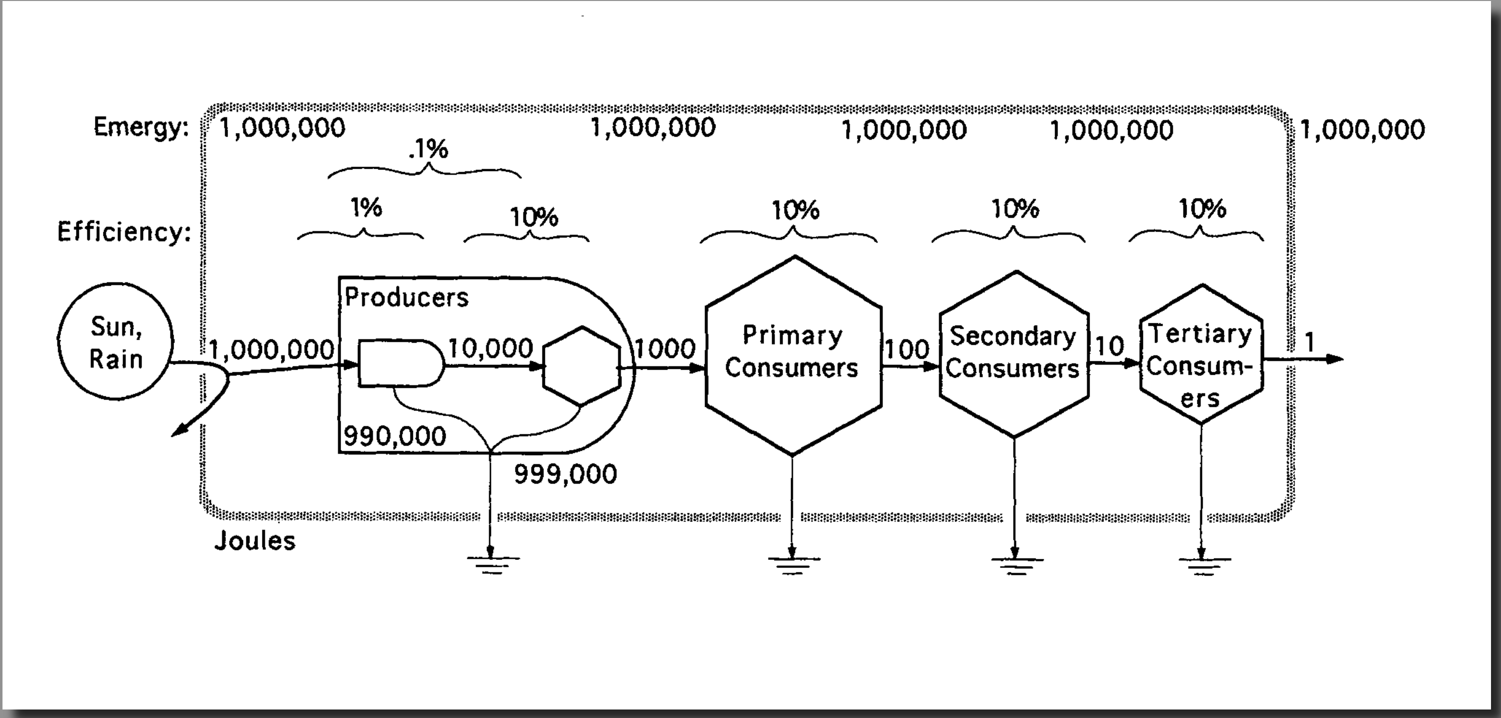
Solar transformities

	Solar equivalent joules per joule (seJ/J)
Sunlight	1
Plant production	6,700
Wood	36,000
Coal	67,000
Oil	90,000
Electricity	300,000

Typical Solar Transformities

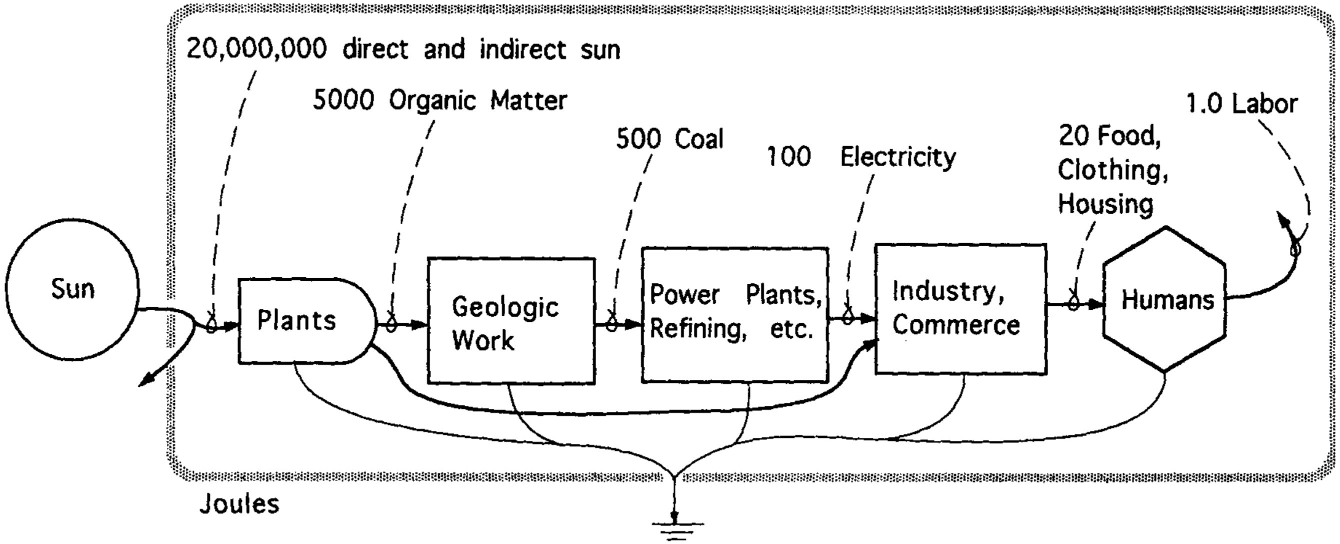
B. Emergy Concepts and Principles…

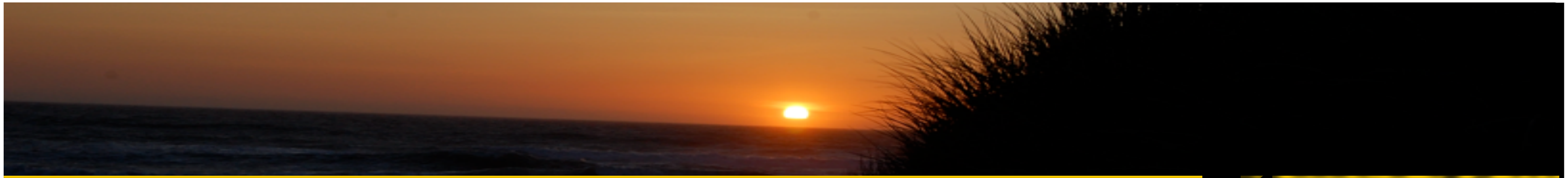
Energy Chain…the food chain can be thought of as an energy transformation chain. At each transformation step some energy is degraded and some is passed to the next step in the chain.



B. Emergy Concepts and Principles…

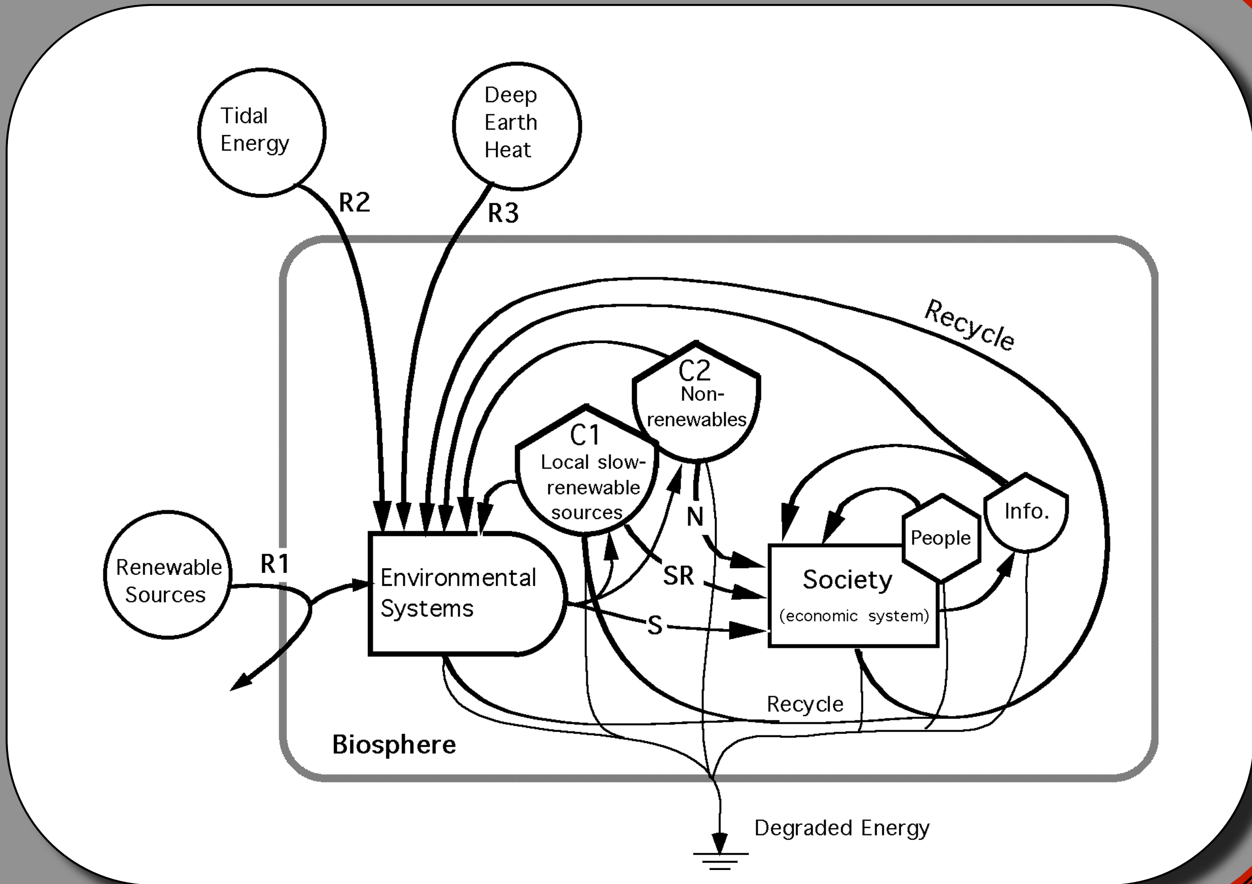
The 20th century energy food chain of techno-humans…



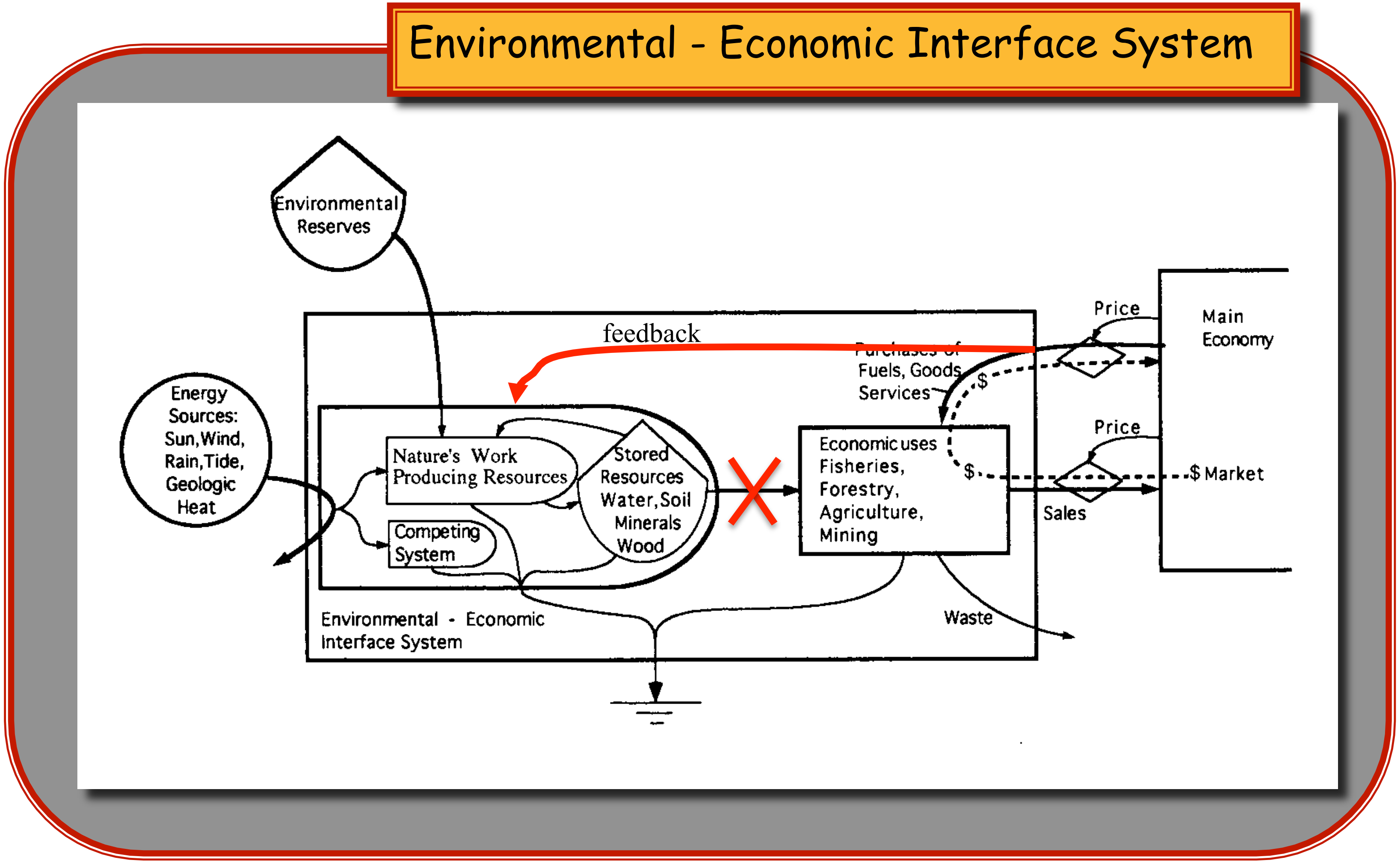


Emergy = the value of resources in common units of solar equivalent energy (solar emjoules)

Ultimately, our wealth depends on three sources of emergy…the sun, tidal momentum, and deep heat



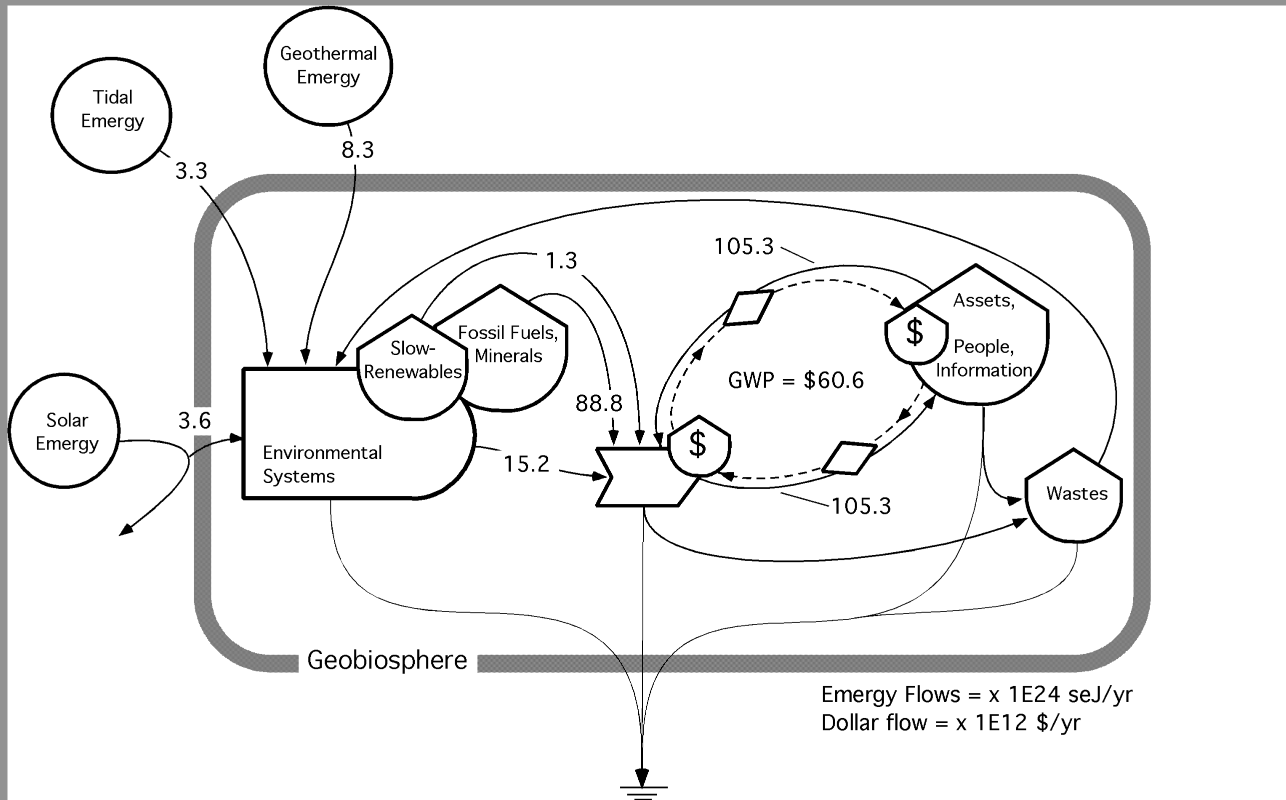
Prosperity comes from resources, not from money



The global economy: fair trade

Global Economy...

Environmental support to human economy...



National Emergy Money Ratio…

National EMR = Total Emergy Use/ GDP

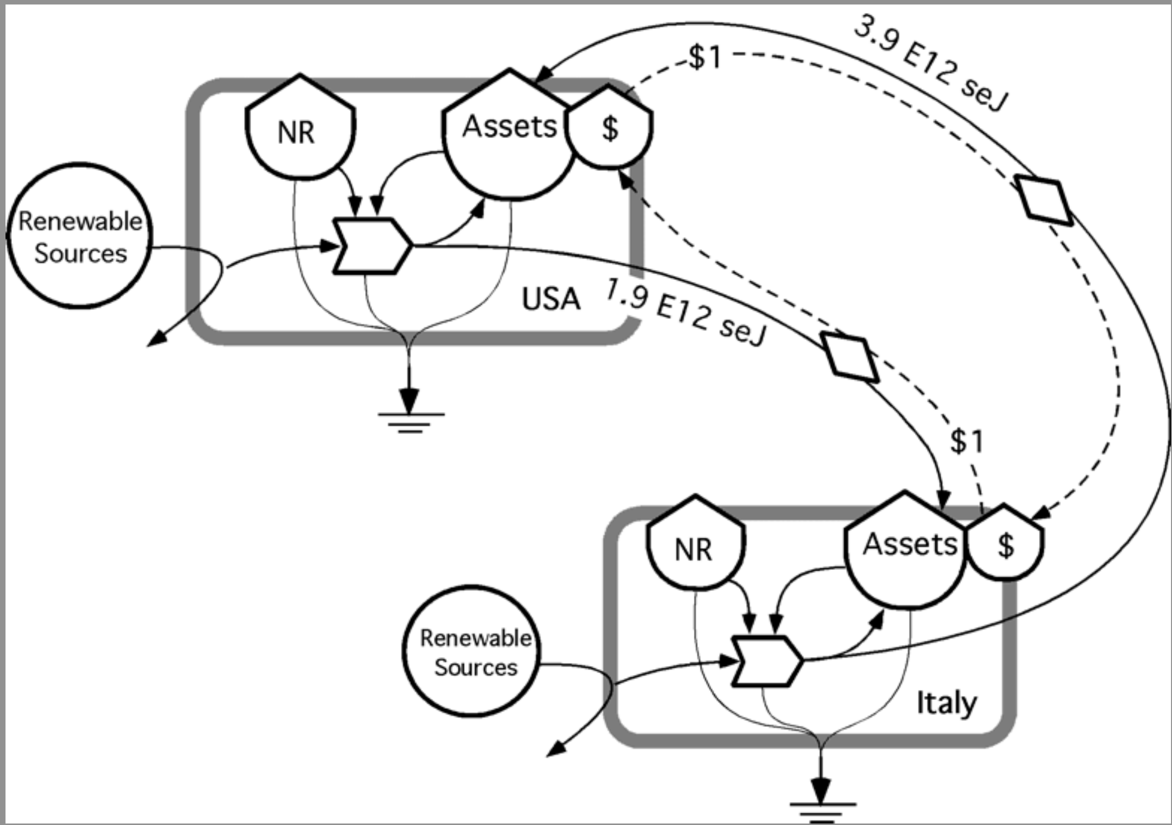
Table 5-2. Emergy use, GDP and emergy money ratio for selected countries (2000)[1.]

Country	Renewable (E22 seJ/yr)	Nonrenewable (E22 seJ/yr)	GDP (E09 $/yr)	Emergy/money (E12 sej/$)
Japan	19.8	690.2	4760.0	1.5
United States	227.0	1653.0	9760.0	1.9
Germany	5.2	519.8	1870.0	2.8
Sweden	4.2	80.5	239.0	3.5
United Kingdom	238.0	307.0	1430.0	3.8
Italy	6.8	407.3	1070.0	3.9
Kuwait	0.3	24.5	35.8	6.9
Costa Rica	4.7	7.9	15.9	7.9
South Korea	97.8	317.2	461.0	9.0
Brazil	353.0	354.0	601.0	11.8
China	335.0	945.0	1080.0	11.9
New Zealand	39.3	22.8	51.6	12.0
Australia	236.0	246.0	388.0	12.4
Ireland	75.4	43.6	94.7	12.6
Mexico	40.7	876.3	580.0	15.8
South Africa	16.3	190.7	128.0	16.2
Panama	9.9	6.3	10.0	16.2
Botswana	4.5	6.2	5.0	21.5
Russia	259.0	483.0	259.0	28.6
Mali	7.0	2.3	2.4	38.0

Emergy Exchange Ratio…

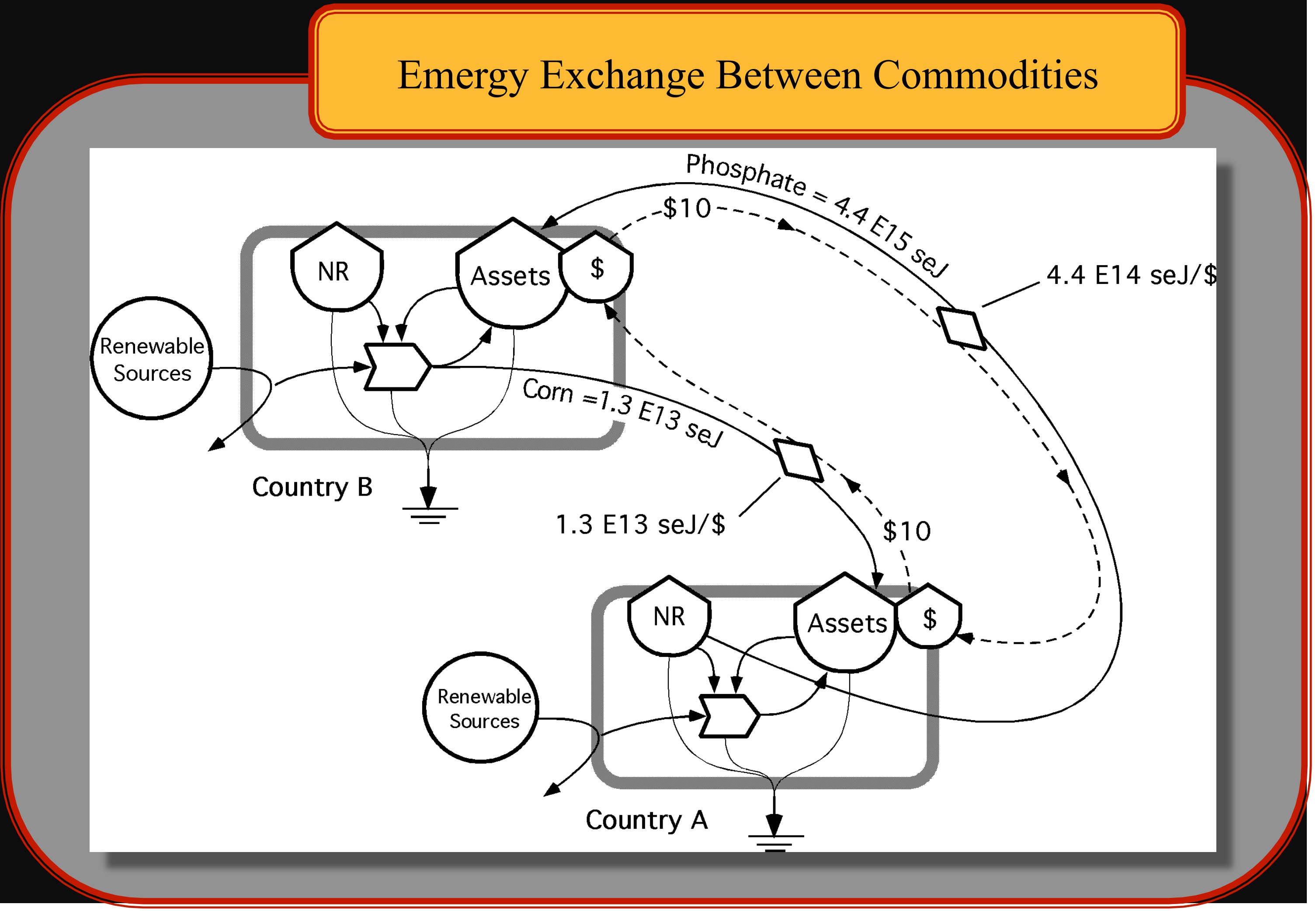
An example of the trade between nations (Italy and USA) where the monetary value of trade balances but the emergy of trade is imbalanced. In this example using the emergy money ratios of the two countries, Italy is at a emergy disadvantage of about 2 to 1.

Trade Between Nations



Emergy Exchange Ratio…

Country B Exchange Advantage =4.4E15/1.3E13 = 338/1



What's Next… ?

Summary/ conclusions….

There is not enough renewable energy to go around… (ultimately only about 25% of current demand …at max)

All increases in order cause greater increases in disorder… (i.e. you cannot get ahead…the 2nd Law).

Living sustainably takes time and space… (the time, energy, & space tradeoff)

We cannot rely on the "Market"… (Adam Smith's invisible hand is corrupt and uncaring)

What's Next… ?

1. Everything is connected to everything

Systems science education is essential

2. Everything has to go somewhere

Recycle, recycle, recycle

3. There is no such thing as a free lunch

Live within your energy means (no credit)

4. Energy is important and matter matters

Restructure the economy around biophysical realities

5. Quality counts

Match the quality of energy to the quality of the task

6. Net Energy not gross energy

There is no Silver Bullet to "peak oil"

7. Complexity is costly

Small is beautiful, Less is more

8. Grow or Die

Bury the growth ethic

What's Next… ?

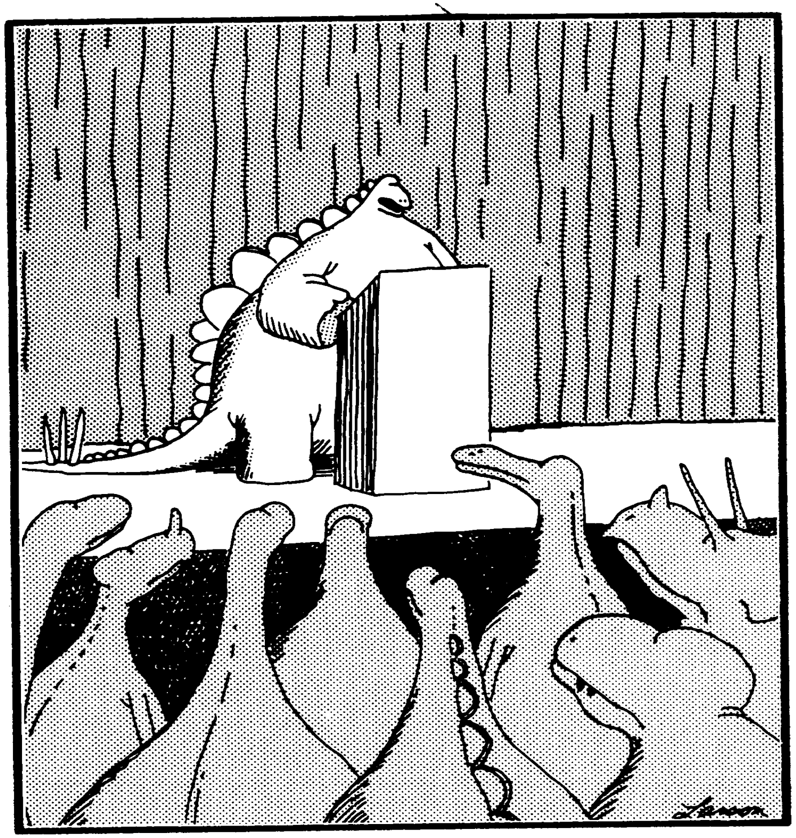
The problem is not just resource availability nor finding another cheap source of energy.

The problem is BUSINESS AS USUAL.

Our fascination and addiction with continued growth may have unbelievable consequences in the long run.

Our focus must turn to living within the planet's carrying capacity.

The real issue is do we want to be part of the solution or continue to be the problem?



"The picture's pretty bleak, gentlemen. … The world's climates are changing, the mammals are taking over, and we all have a brain about the size of a walnut."

Questions?

Comments?

Concerns?