Cleaner Production and Industrial Ecology:

Two Pillars for a Sustainable Industry

3rd International Workshop
Advances in Cleaner Production
19 May 2011

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University of Linköping,

Environmental Technology & Management

From Two Natural Systems to….:

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.....One *natural symbiosis* system:
Can Industrial Ecology Mimick Nature?

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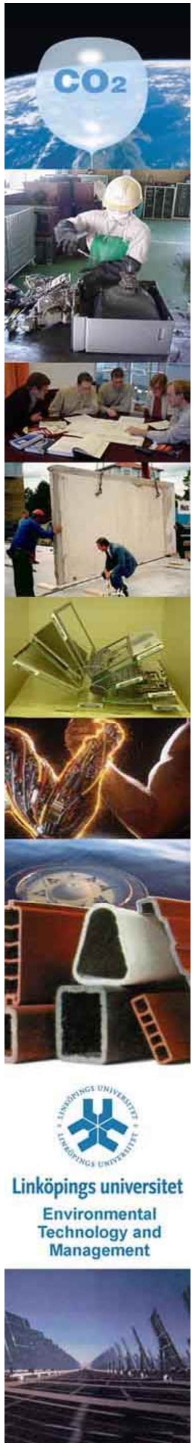

Cleaner production

Pollution control		Waste management		Cleaner production	
Disposal	Treatment	Energy recovery	Use/reuse	On-site recycling	Source reduction
		Off-site recycling	Reclamation	Energy & raw material conservation	Resource recovery

Shifting emphasis to sustainable development

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Cleaner production

A systems approach

Improving the efficiency of resource utilisation

Minimising creation of waste and pollution

Cost reductions and marketing advantage

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Cleaner production as Innovation process

Cleaner Production definition :

Cleaner Production is an INNOVATION process in which Quality, Pollution prevention, Clean Technology and Organisational change are tuned to Improvement of Process, Product, Service, Environmental Quality and Organisational results

- Journal of Cleaner Production (since 1992)
- Regional Roundtables on Cleaner Production (since 1994)
  - →: Sustainable Consumption & Production

NCPC Network world-wide

Joint UNIDO-UNEP Cleaner Production Programme

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Case Study 1 – food sector (small company): production of bread and confectioning

Before

High consumption and waste of flour in mixing process.

Oven fuelled by petrol liquefied gas.

High energy consumption in freezing chambers.

Picture: Gas cylinders stored on the premises (hazard risk).

SENAI document 2008

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Case Study 1 – food sector (small company): production of bread and confectioning

After

- Reduction in flour consumption and in flour waste generation in the mixing process by training and adopting best practices.
- Reduction of power consumption through regulation of temperature in chilling chamber.
- Substitution of petrol liquefied gas for electric power in the oven.

Electric power in Brazil has a clean matrix (hydro-electric generation).

BENEFITS ACHIEVED

Economic: Savings in flour costs = R$ 2.327/year (€ 964)

Savings in energy costs - R$ 6.000/year (€ 2.485)

Environmental:

- Reduction in flour consumption in mixing – 2.300 kg/year
- Reduction in flour waste generation – 368 kg/year
- Use of clean energy for oven operation
- Reduction in energy consumption.

Case Study 2 – metal-mechanical sector (large company): agricultural machines

Before

Steel sheet cutting with guillotine machines.

Amount of waste generated:
226,54 kg per machine manufactured.

After

Steel sheet cutting with punching machines.

SENAI, 2008

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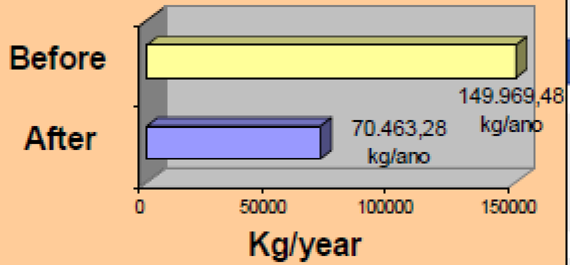
Case Study 2 – metal-mechanical sector (large company): agricultural machines

BENEFITS ACHIEVED

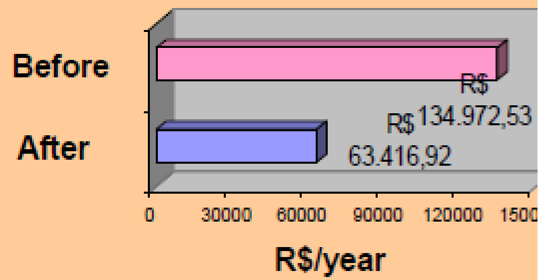
Amount of waste generated: 106 kg per machine manufactured, nearly 47% reduction in relation to the former process.

Environmental benefit



79.506 Kg/year

Economic benefit



R$ 71.555/year (€ 29.633)

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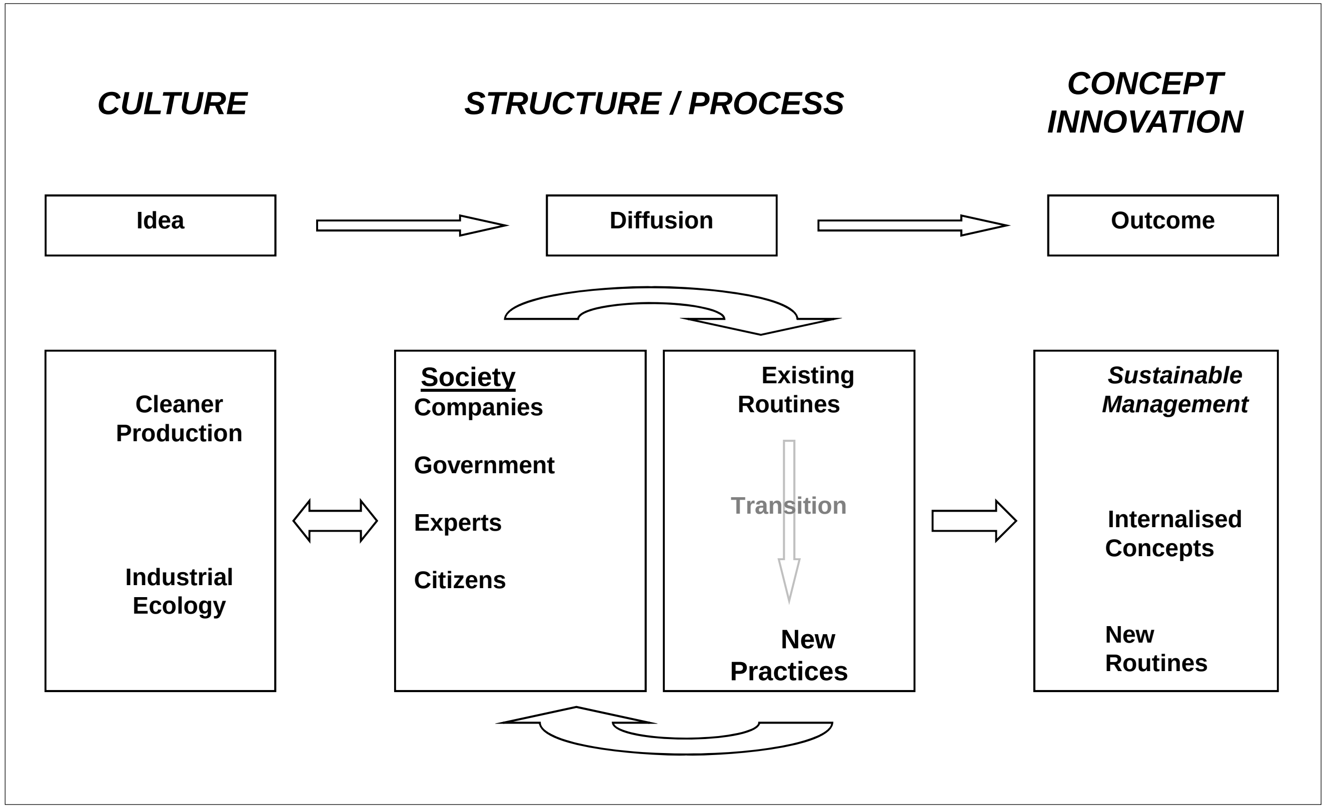
Some findings in cleaner production dissemination projects

a) The *you cannot find when you do not know where to look* theorem:

engineers who are reasonably - but not intimately - familiar with the process may conclude that there are no cleaner production opportunities because they cannot see them;

b) When an organisation does not internalise cleaner production, the ability for changing a failure into a cleaner production opportunity cannot be seen.

Transition processes: from Idea to New Routines



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Industrial Ecology definition

Industrial ecology is described as:

An integrated system, in which the consumption of energy and materials is optimised and the effluents of one process serve as the raw material(s) or energy for another process

(Frosch & Gallopoulos, Scientific American:1989)

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Industrial Ecology definition II

Industrial ecology is the science that studies the metabolism of society, involving the structure and evolution of industrial and consumer activities and their effects on the environment, and ways to steer the metabolism into a sustainable direction

(M.Sc. Industrial Ecology, 2004)

Close links to other Concepts I: Circular Economy

- *Circular economy* which originates from the industrial ecology paradigm, building on the notion of loop-closing emphasized in German and Swedish environmental policy, and has been pursued by China's environmental policy makers as a potential strategy to solve existing environmental problems

(In China, the central government formally accepted in 2002 the concept, formal promotion law in 2008)

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Close links to other Concepts II: Cradle-to-Cradle

- The concept of *Eco-effectiveness* proposes the transformation of products and their associated material flows such that they form a supportive relationship with ecological systems and future economic growth
- The goal is to generate *cradle-to-cradle* “metabolisms” that enable materials to maintain their status as resources and accumulate intelligence over time (*up-cycling*)

McDonough & Braungart, 2002

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Industrial Symbiosis

Industrial Symbiosis is seen as a process whereby materials, water, energy in the techno-sphere and informational, organizational and management flows at the institutional level between and among companies are investigated with the objective of developing and improving co-operative links between/among them

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Industrial Ecology: Interconnectedness of Physical & Social Systems

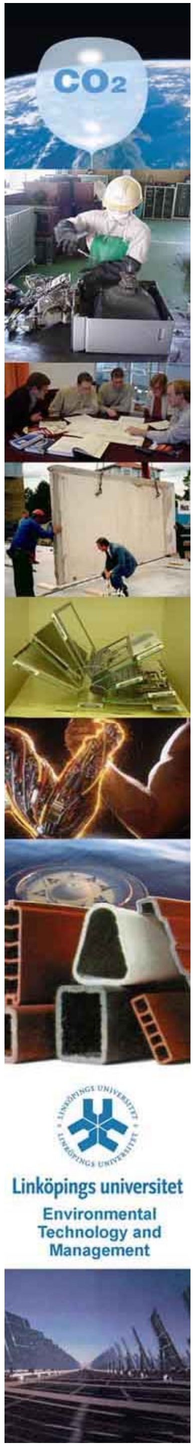
- *Physical Systems*:

Technology, Material and Energy Flows

interconnectedness

- *Social Systems*:

Individuals, Organisations, Culture, Values, Institutions



Embeddedness

- *Human activities are embedded*:

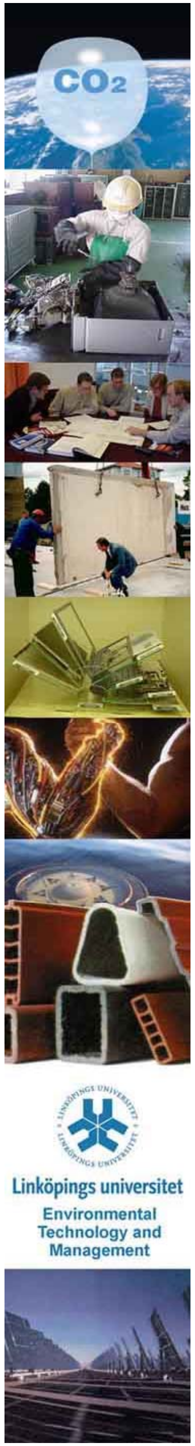
  They are shaped by the context in which they occur

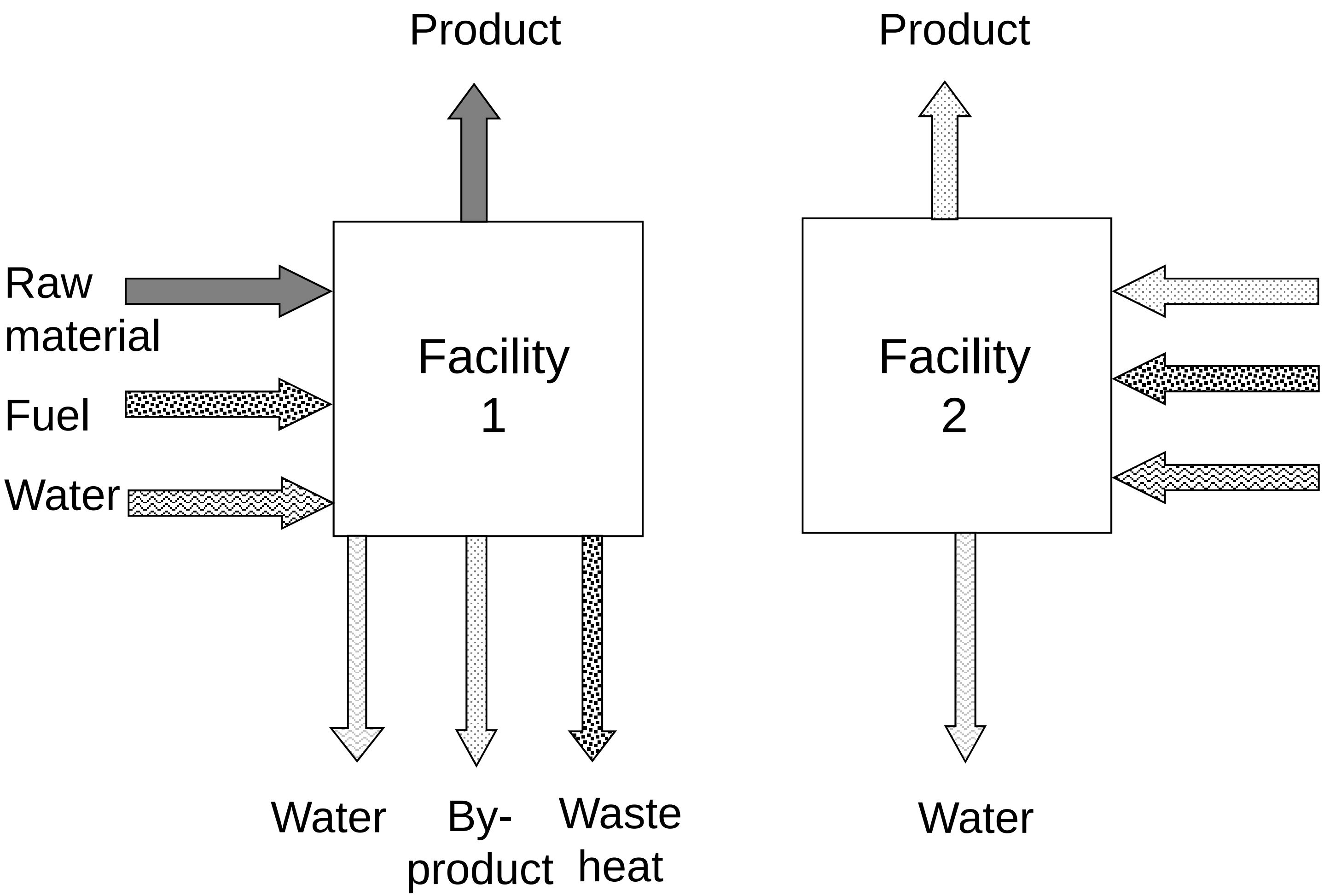
- *Cognitive embeddedness*:

  * The way in which individuals and organisations collect and use information (making sense)

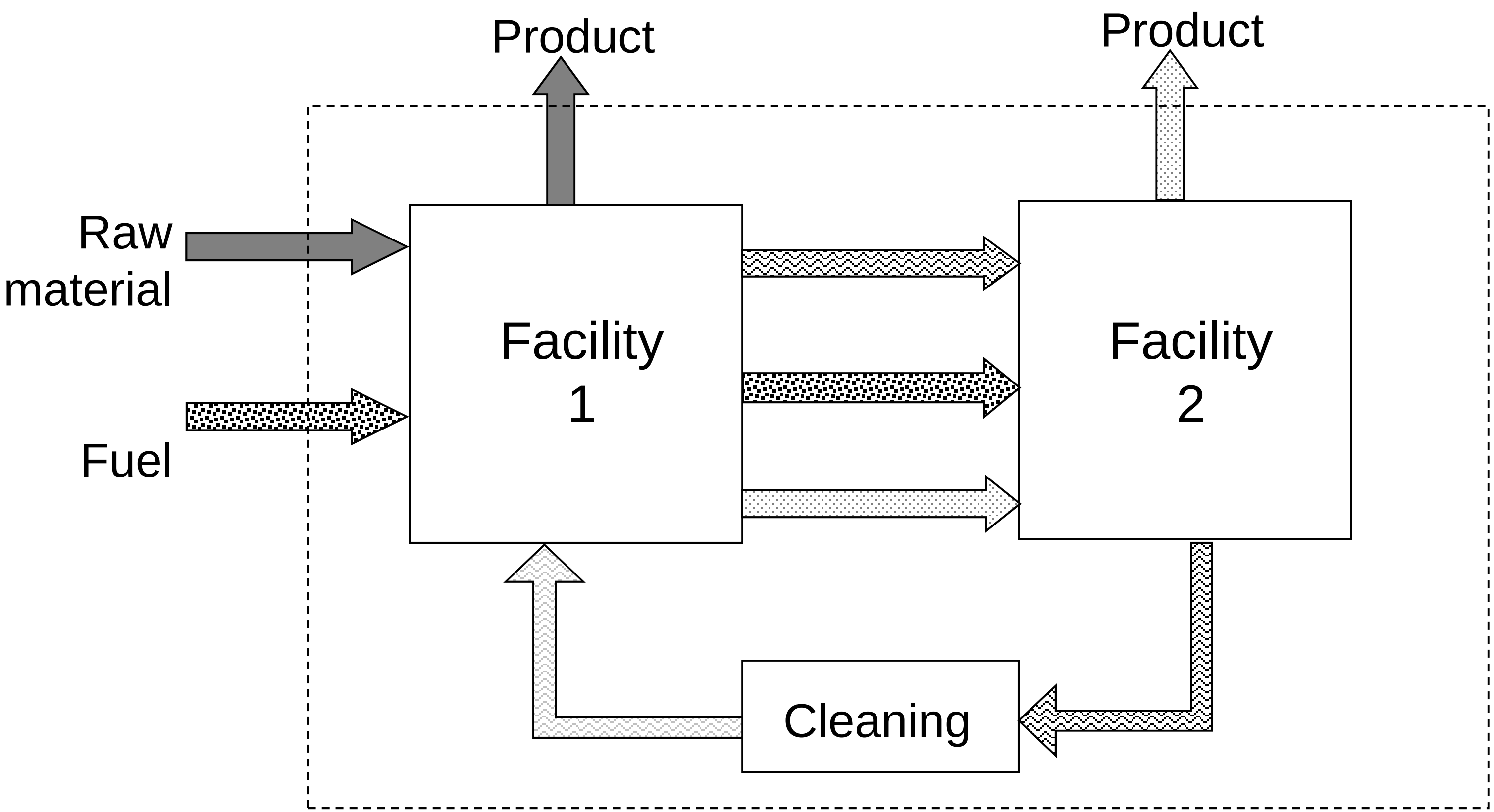
  * A rational actor model, however, individuals and organisations have limited capacities for information processing and decision-making

Example of Separate Production





Example of Exchanges



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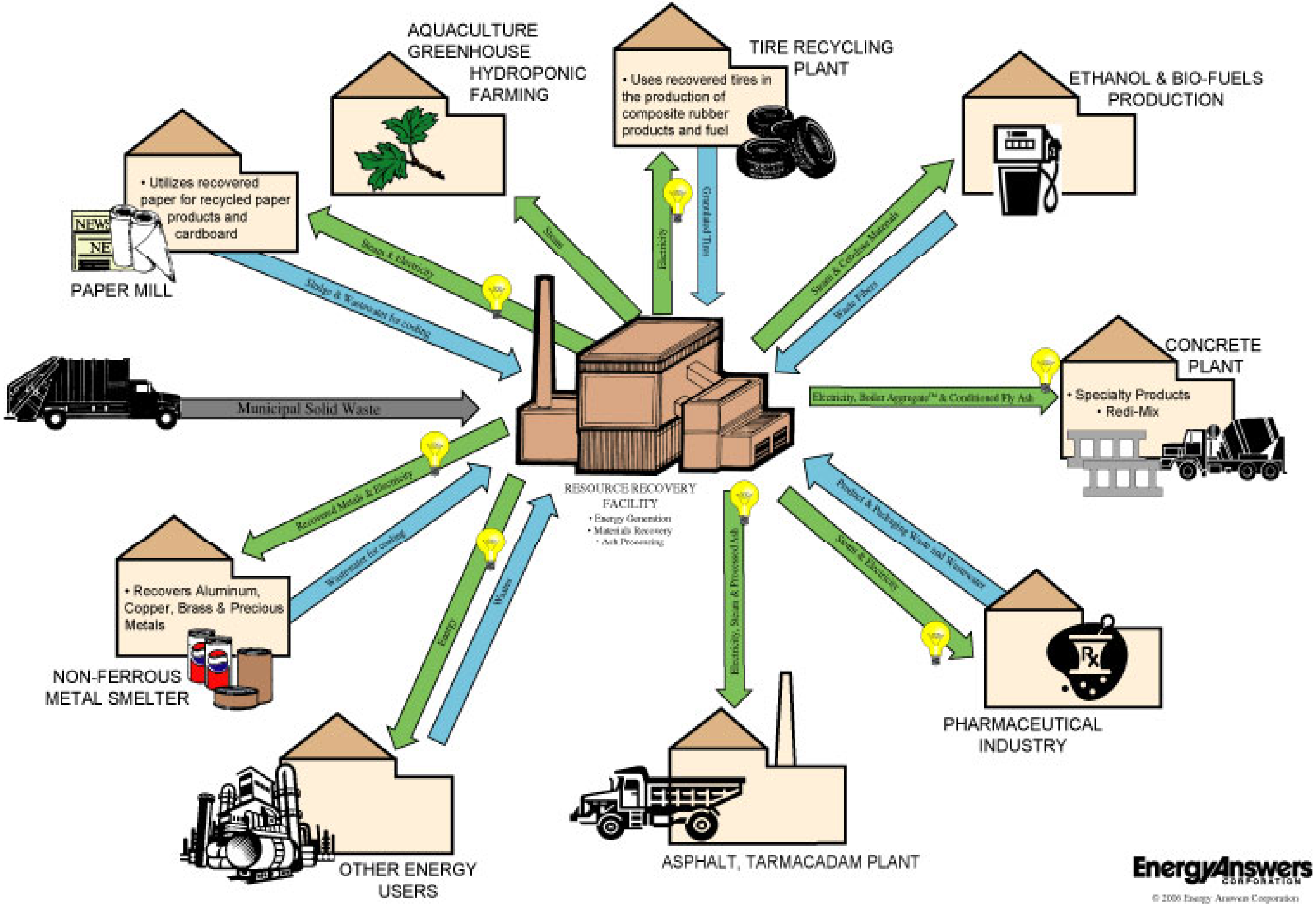
Development strategies

- **The planned project approach**: management by industry, government or special organization: by-products sharing and links of utilities
- **The uncovering resource links approach**: detection of by-product synergy as illustration for further IS development
- **The anchor tenant approach**: links around a big company
- **The co-siting approach**: restructuring an industrial site with new companies and IS links
- **The Synthesis approach**: learning from the approaches above

Resource Recovery Based Eco-Industrial Park



EnergyAnswers CORPORATION

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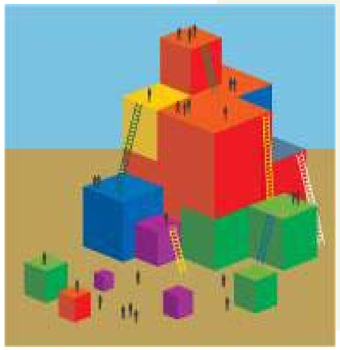
Why Eco-Industrial Parks?

EIPs are being promoted as one of the means of achieving sustainable development:

Higher resource & economic efficiency

Community Partnerships leading to better economic development & quality of life

Expanded use of renewable energy



Ecological site planning & green buildings

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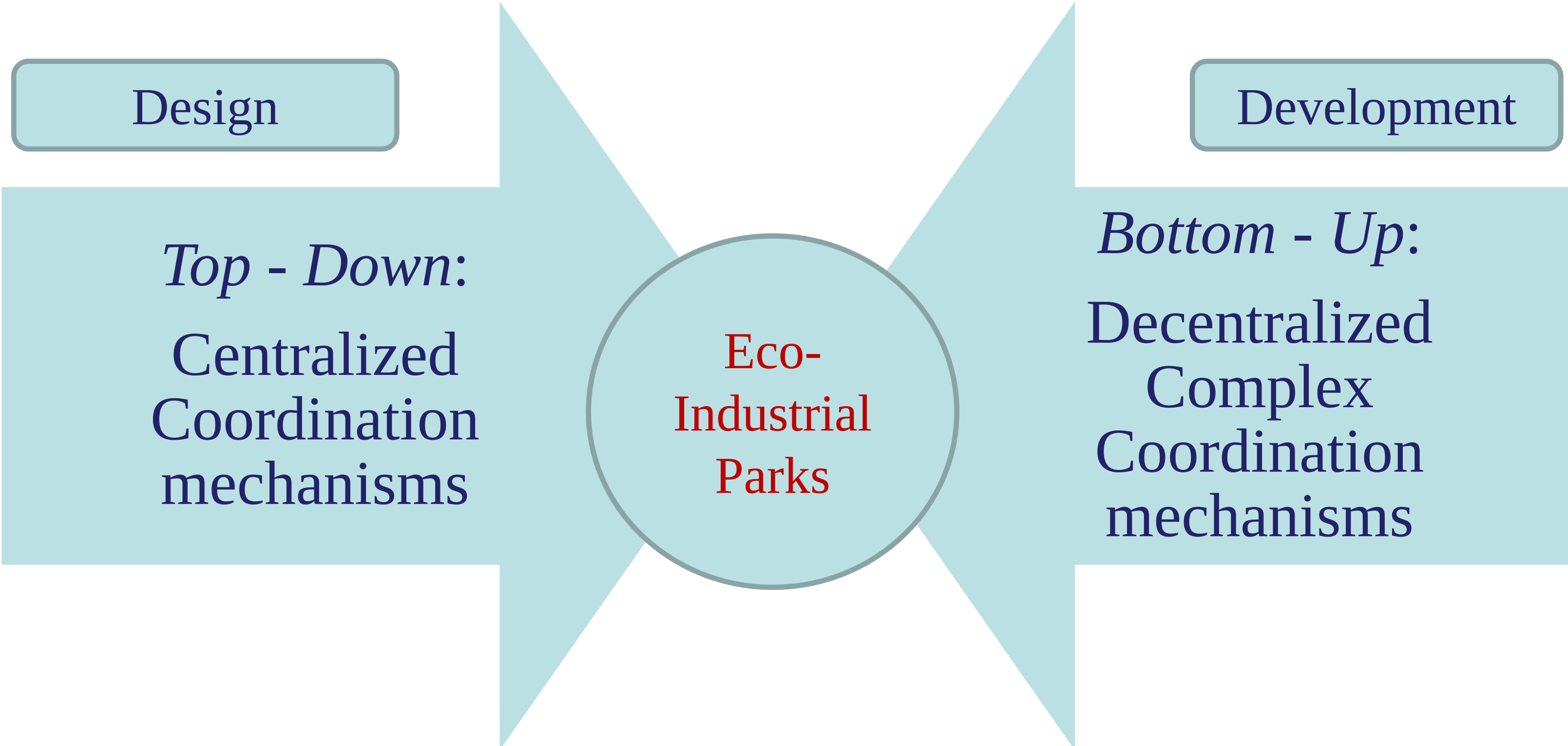
Industrial Symbiosis approaches



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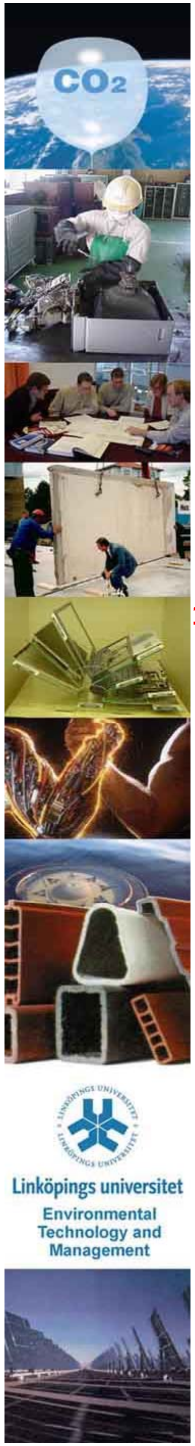
Example: Kalundborg Industrial Symbiosis

- 25 connections of material and energy flows in 2009
- Main actors:
  - –a coal fired power plant
  - –an oil refinery
  - –a medical/biochemistry industry
  - –a gypsum board manufacturer
  - –a soil cleaning company
  - –the municipality of Kalundborg



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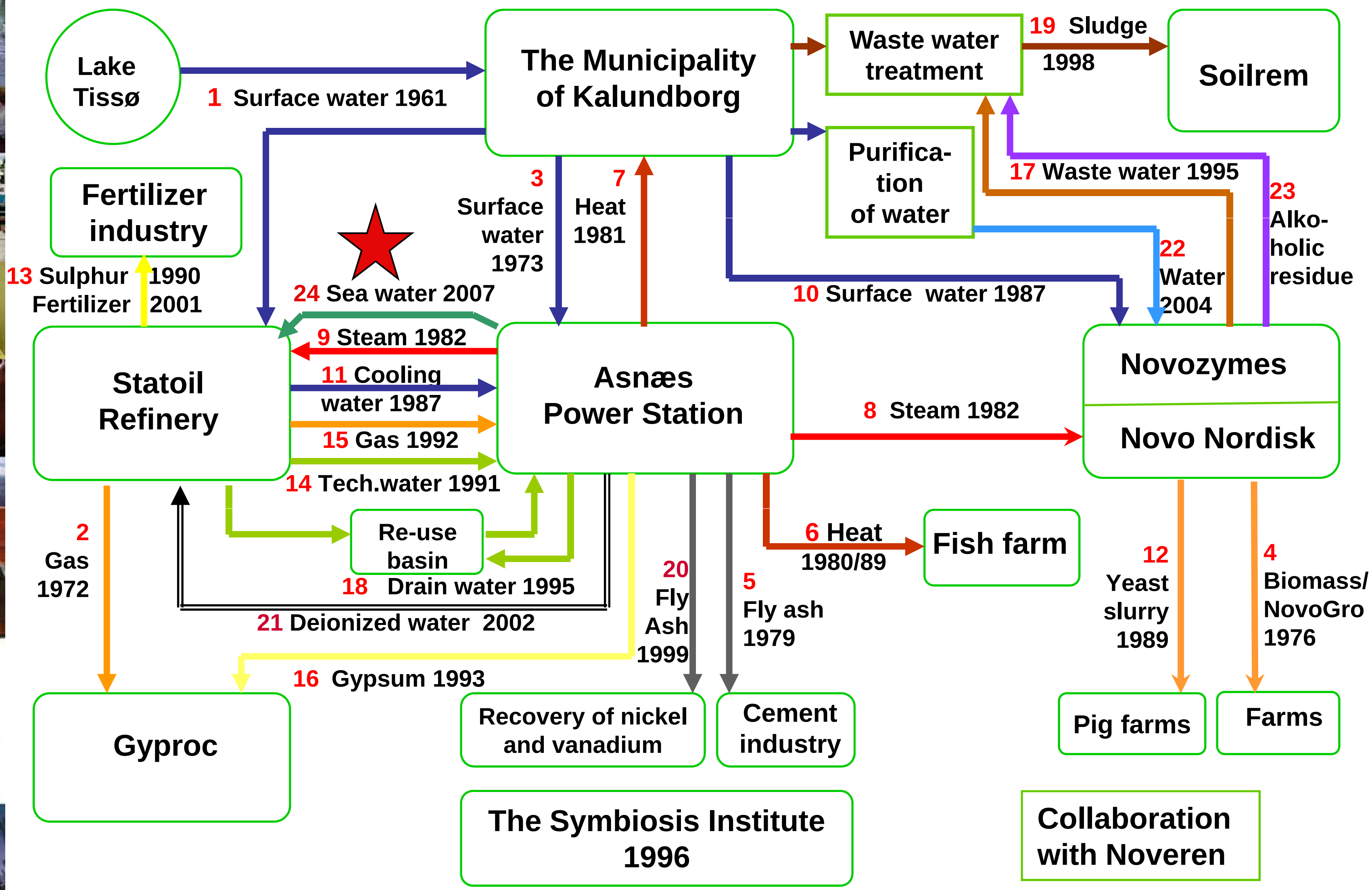
INDUSTRIAL SYMBIOSIS: STATUS 2007



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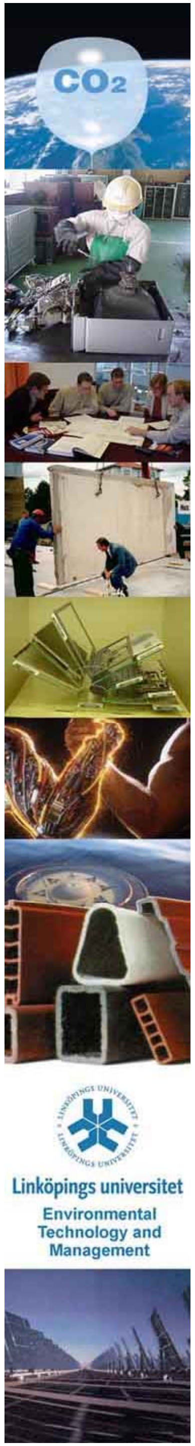
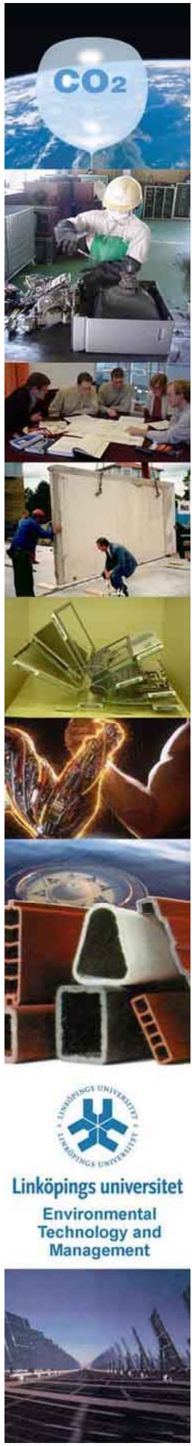
Distribution of warm water from waste heat



Annual Resource Savings in Kalundborg

- 1.9 million m^3 ground water
- 1 million m^3 surface water
- 200 000 ton natural gypsum
- 20 000 ton oil equivalents
- Reduced emissions to air and water, e.g. 240,000 ton CO_2
- Economic Savings >15 million US dollars



Concepts on Different Levels

Level	Concept	Structure	Process
Macro	Sustainability	•Society •Power •Stakeholder	•Rationality •Policy strategy •Dissemination
Meso	Industrial Ecology	•Management •Stakeholder •Perception	•Mimicking •Dissemination •Learning
Micro	Cleaner production	•Perception •Information •Decision-making	•Translation •Learning

Rotterdam Industrial Symbiosis

- *INES Project* 1994-1997

  Research & Feasibility Projects (Delft/EUR)

- *INES Mainport Project* 1999-2002

  Dissemination & Stakeholder building

- *Sustainable Enterprises* 2003-2010

  Innovation through Strategic Decision-making platform

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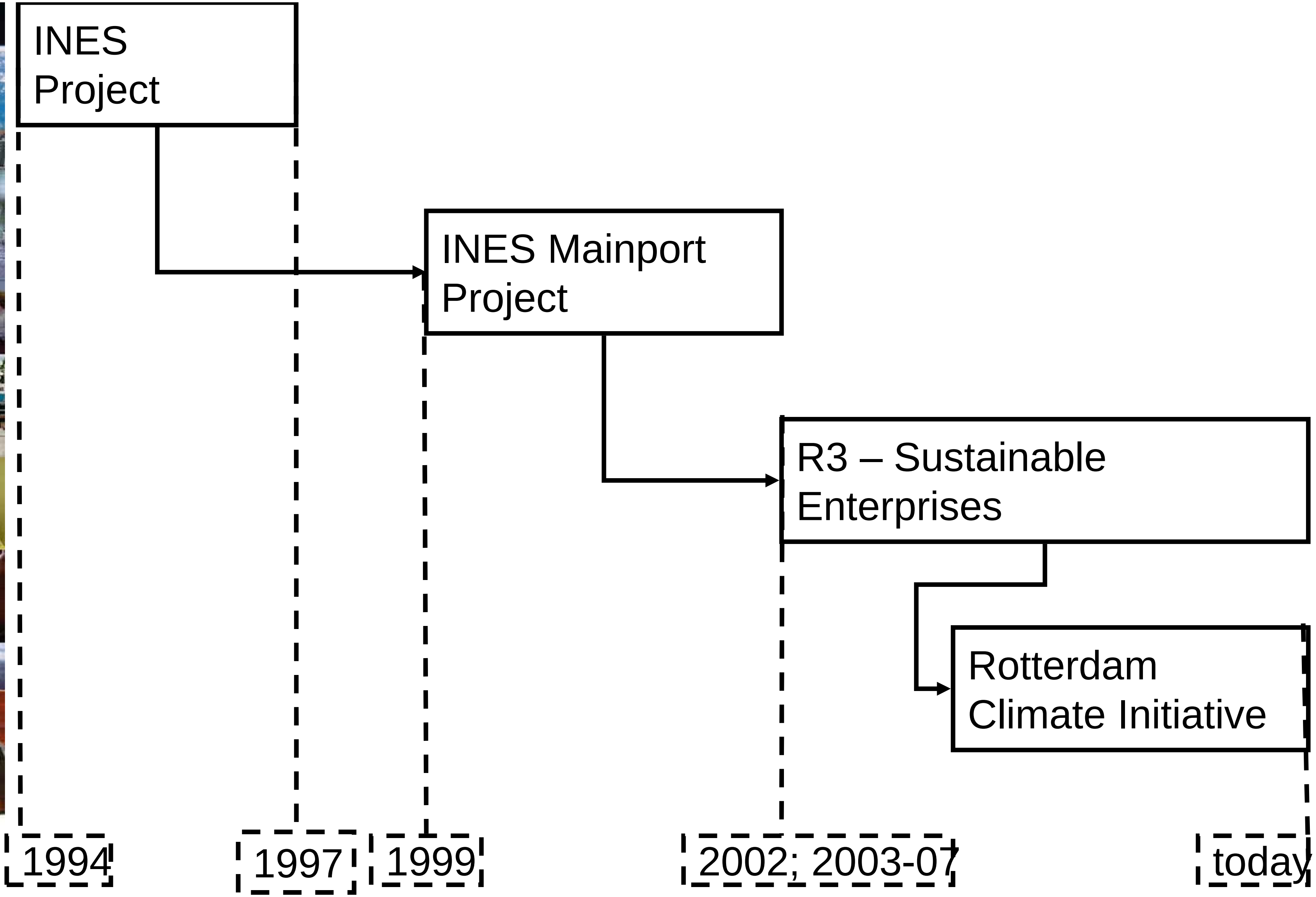

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Some INES programme results

- A compressed air supplier grows from the delivery of 4 companies in 2000 to 17 companies in 2005
- Application low-calories gas in oil-drilling process
- Lyondell designs a new plant on I.S. Principles: Outsourcing utilities in a new plant
- Heat delivery from a chemical company to a truck cleaning company
- Happy Shrimp farm

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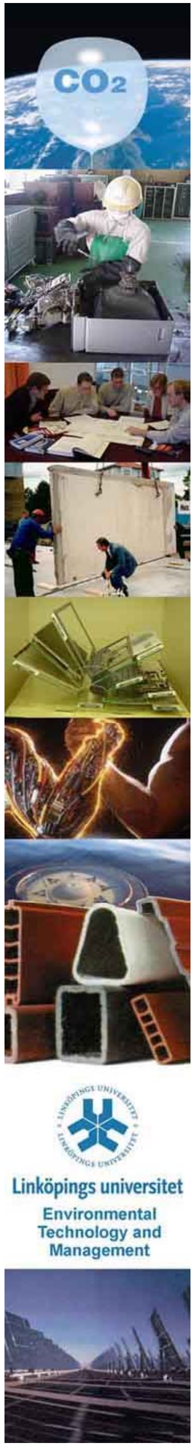
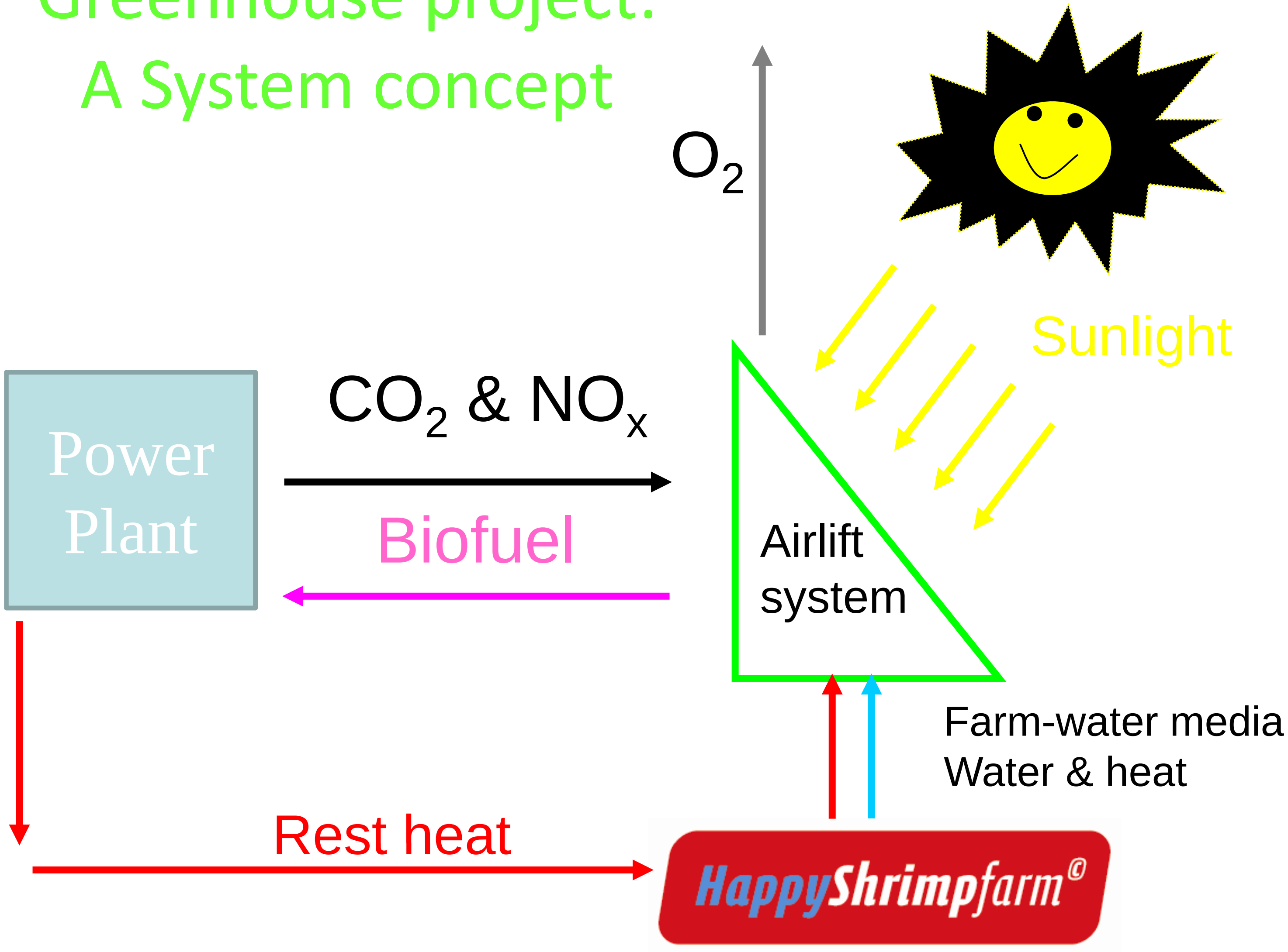


Greenhouse project:
A System concept



Bass+Gill

Decoupling CO_2

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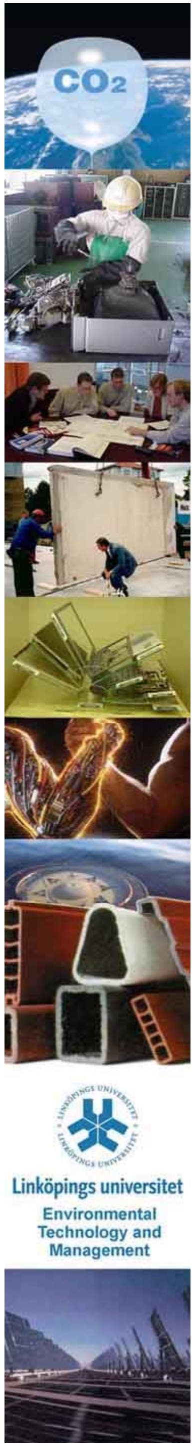
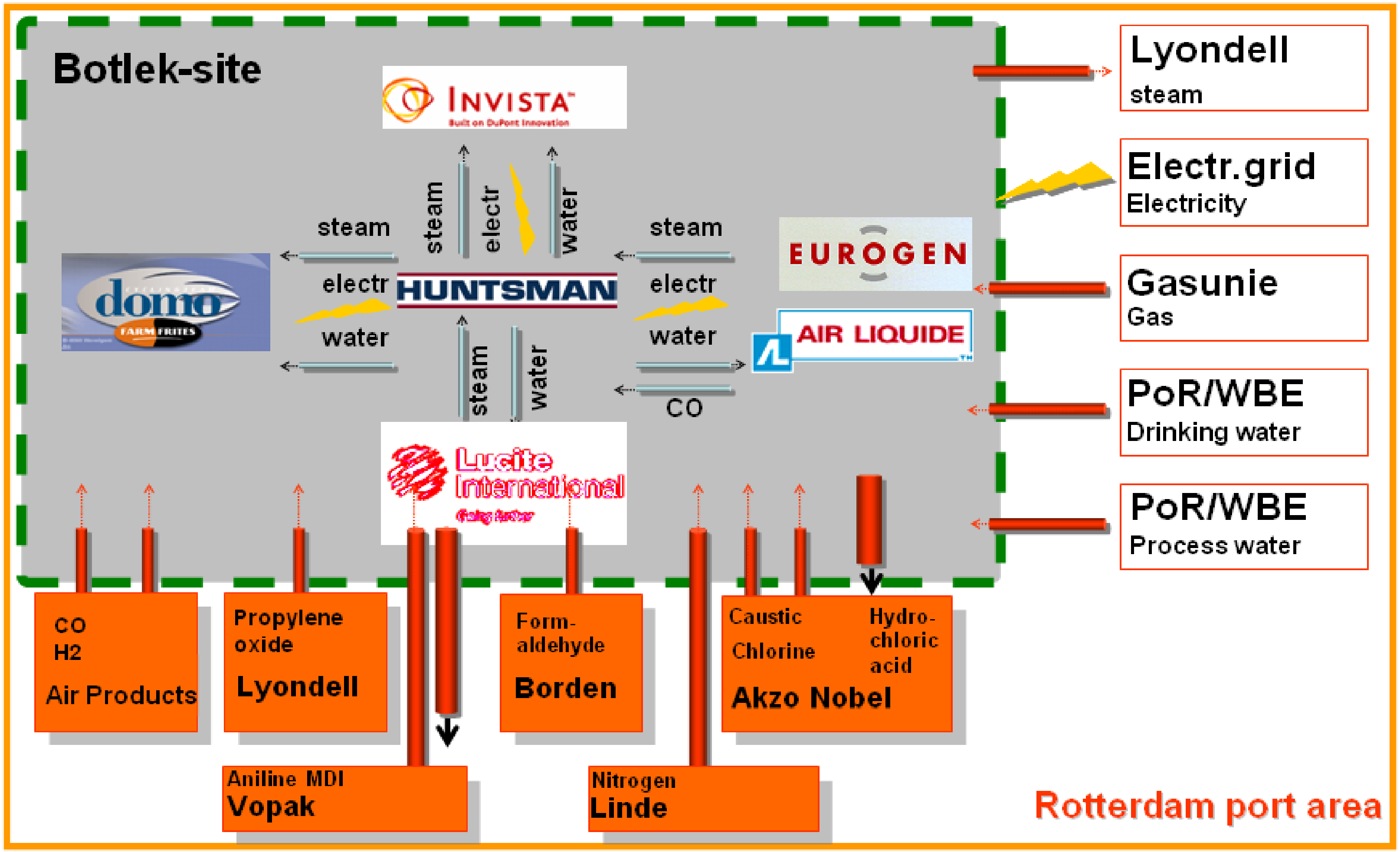
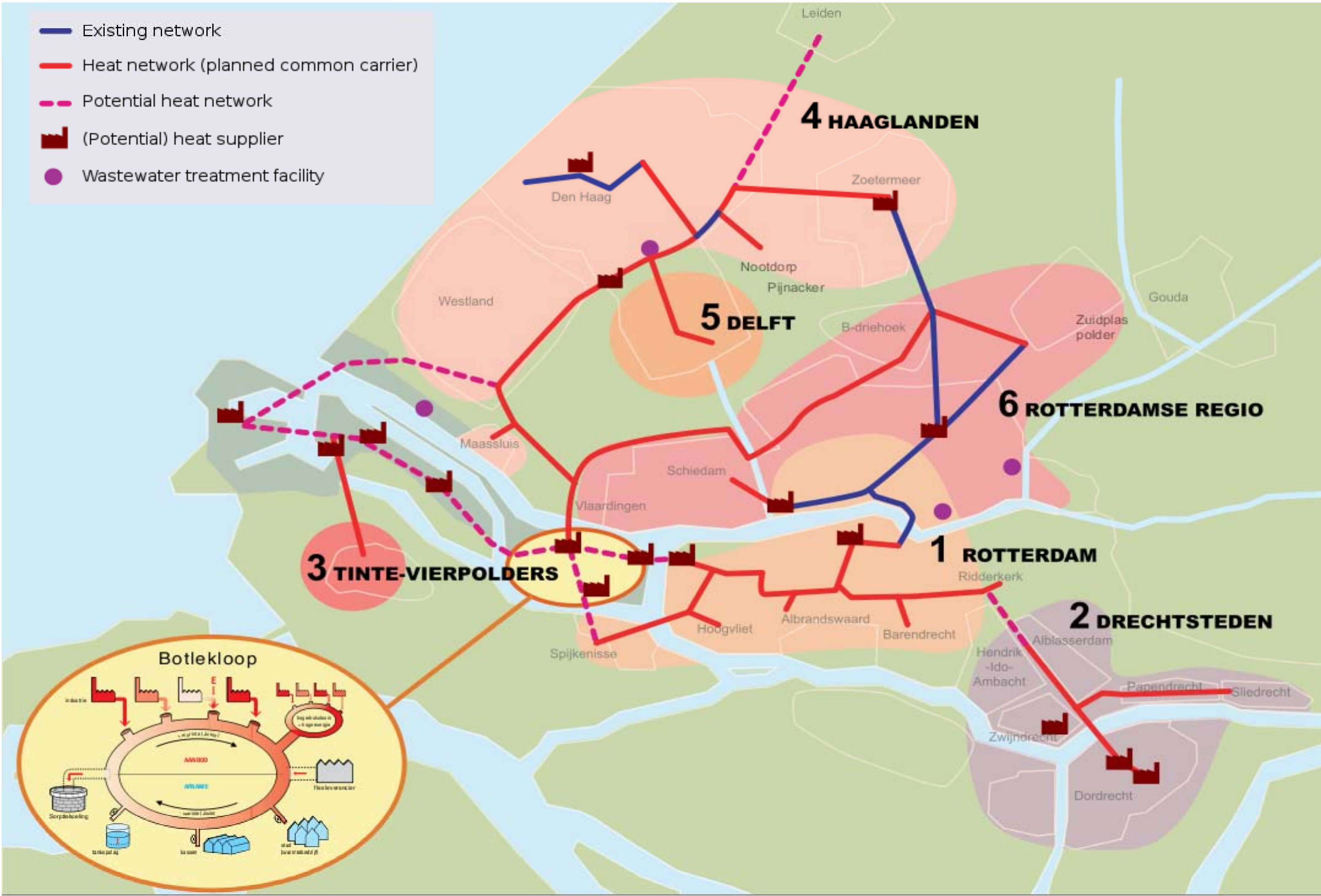


Decoupling CO_2

Co-siting at the Huntsman site



Waste Heat Infrastructure



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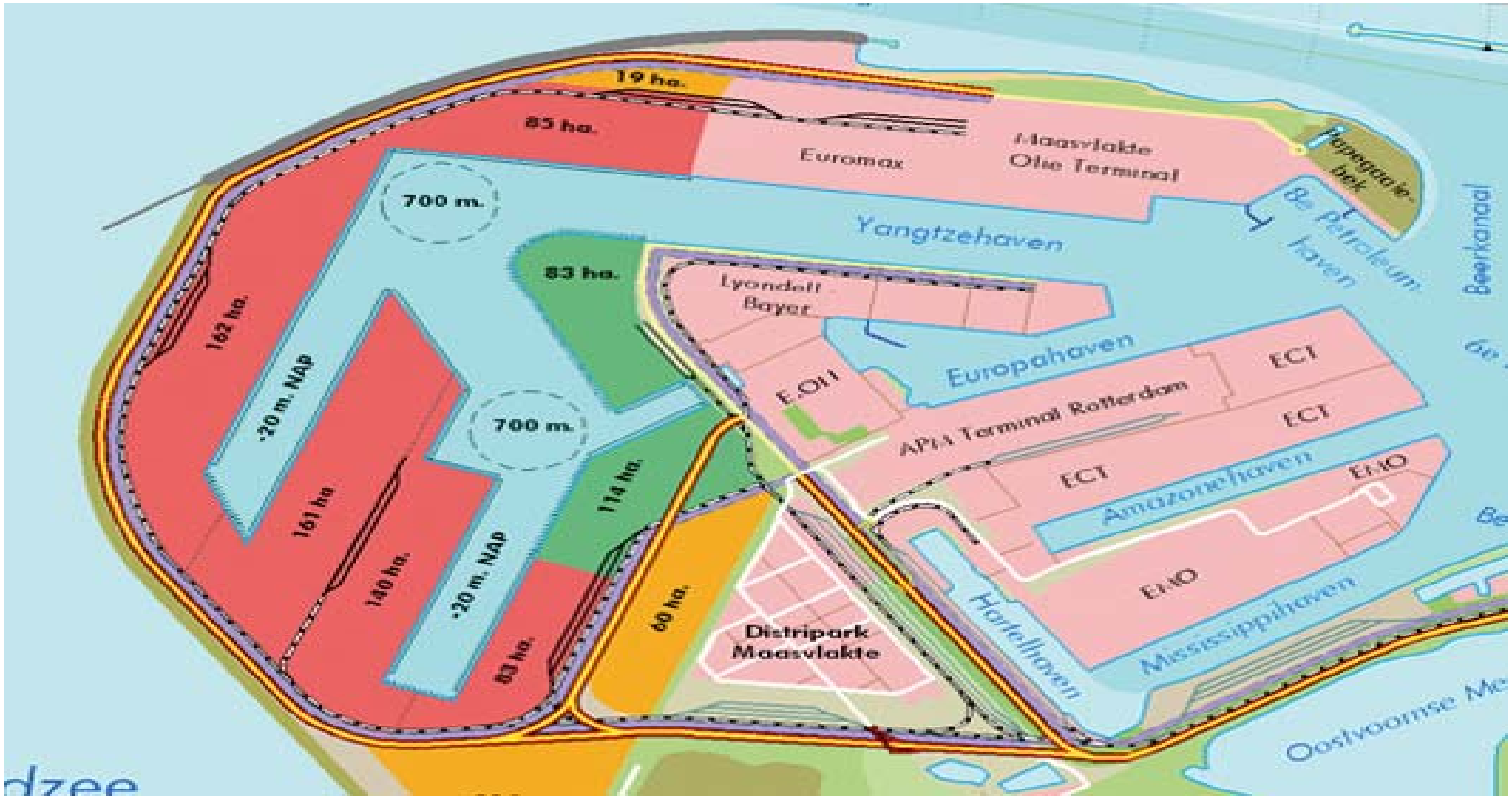
www.
deltalinqs.
nl

Maasvlakte2 on Industrial Ecology basis

- Industrial Ecology as attractor for industry
- Industrial cluster of Maasvlakte2



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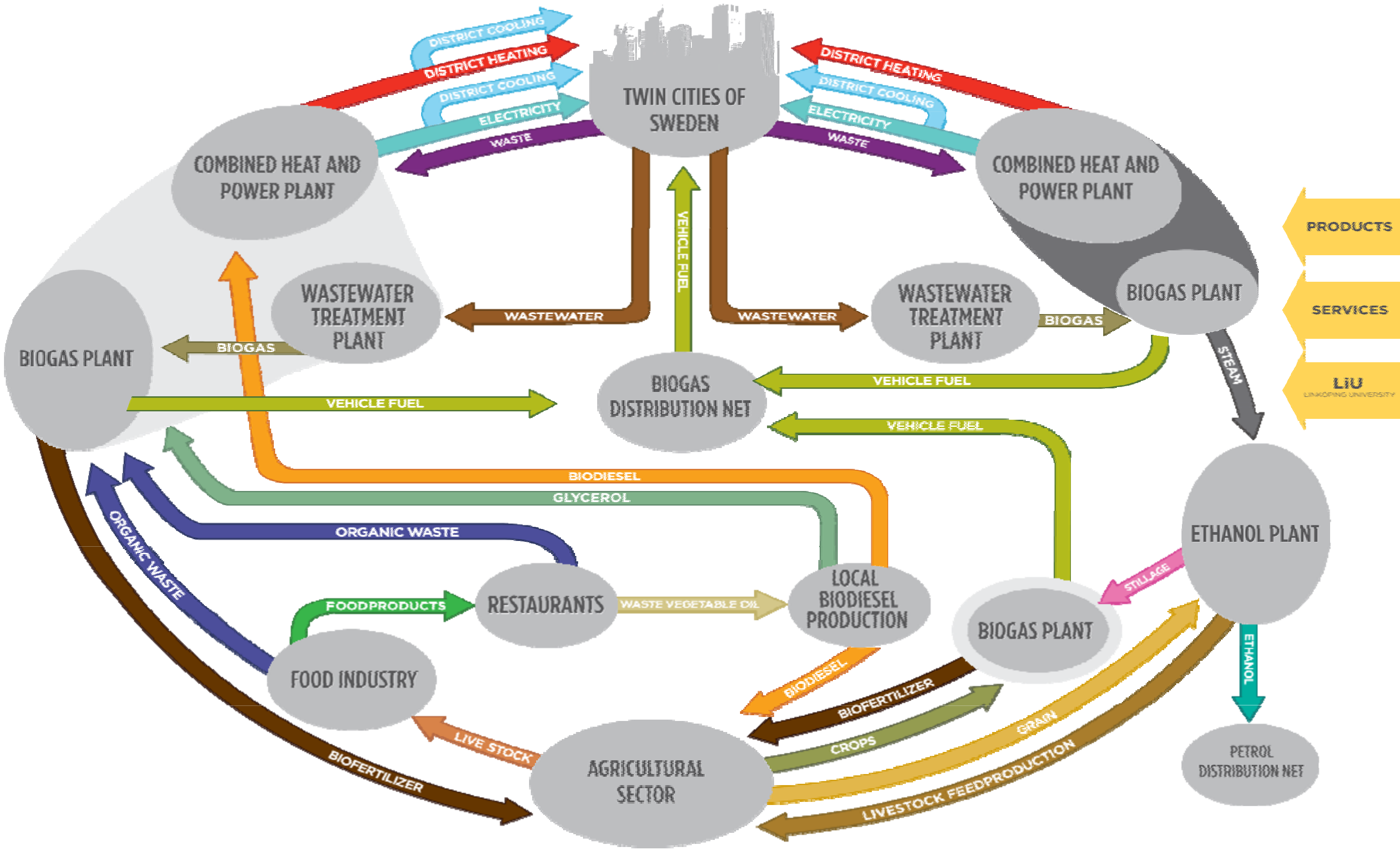
Östergötland Links



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Industrial symbiosis definition

Characteristics of industrial ecology is to turn environmental problems into business opportunities by applying wide system boundaries, using resources efficiently and co-operate through resource sharing

– Definition used in the ”marketing” of the concept as an umbrella for environmentally driven regional development in Östergötland

Bio-gas production plants in Linköping and Norrköping

Production site at Åby, Linköping

55 000 tonnes of organic materials processed annually.

50 000 tonnes of certified bio-fertilizer sold annually on a regional market.

Production in operation since 1997.

Total sales of 7,2 million Nm^3

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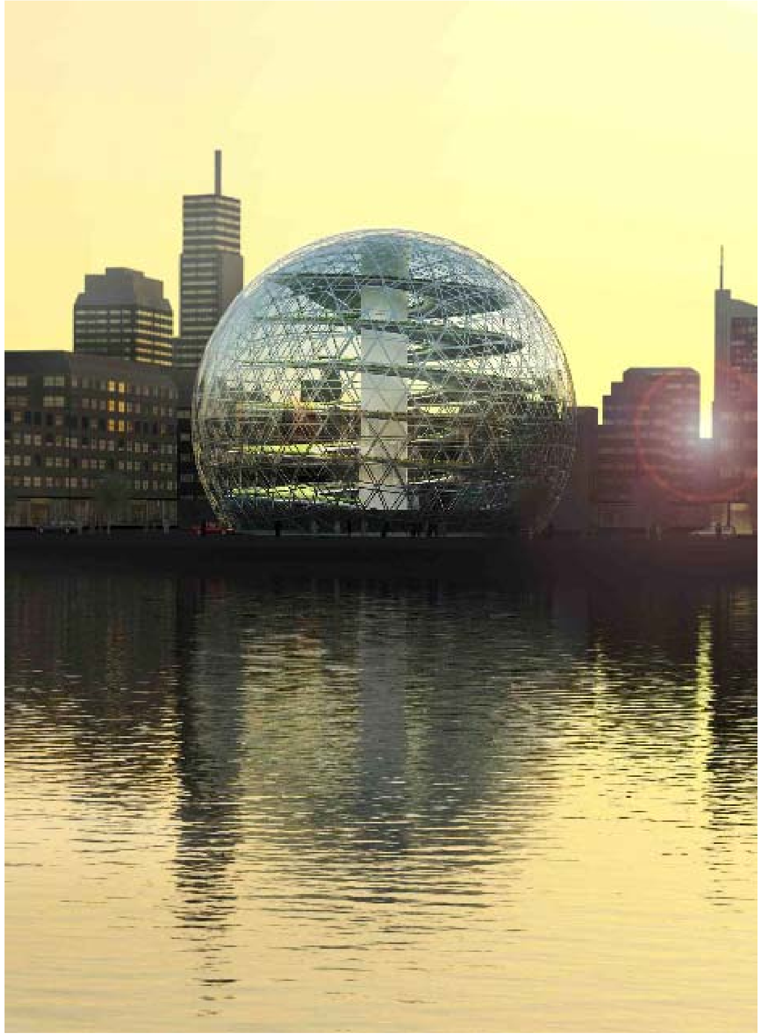
Spiral carrier of growing vegetables in round greenhouse



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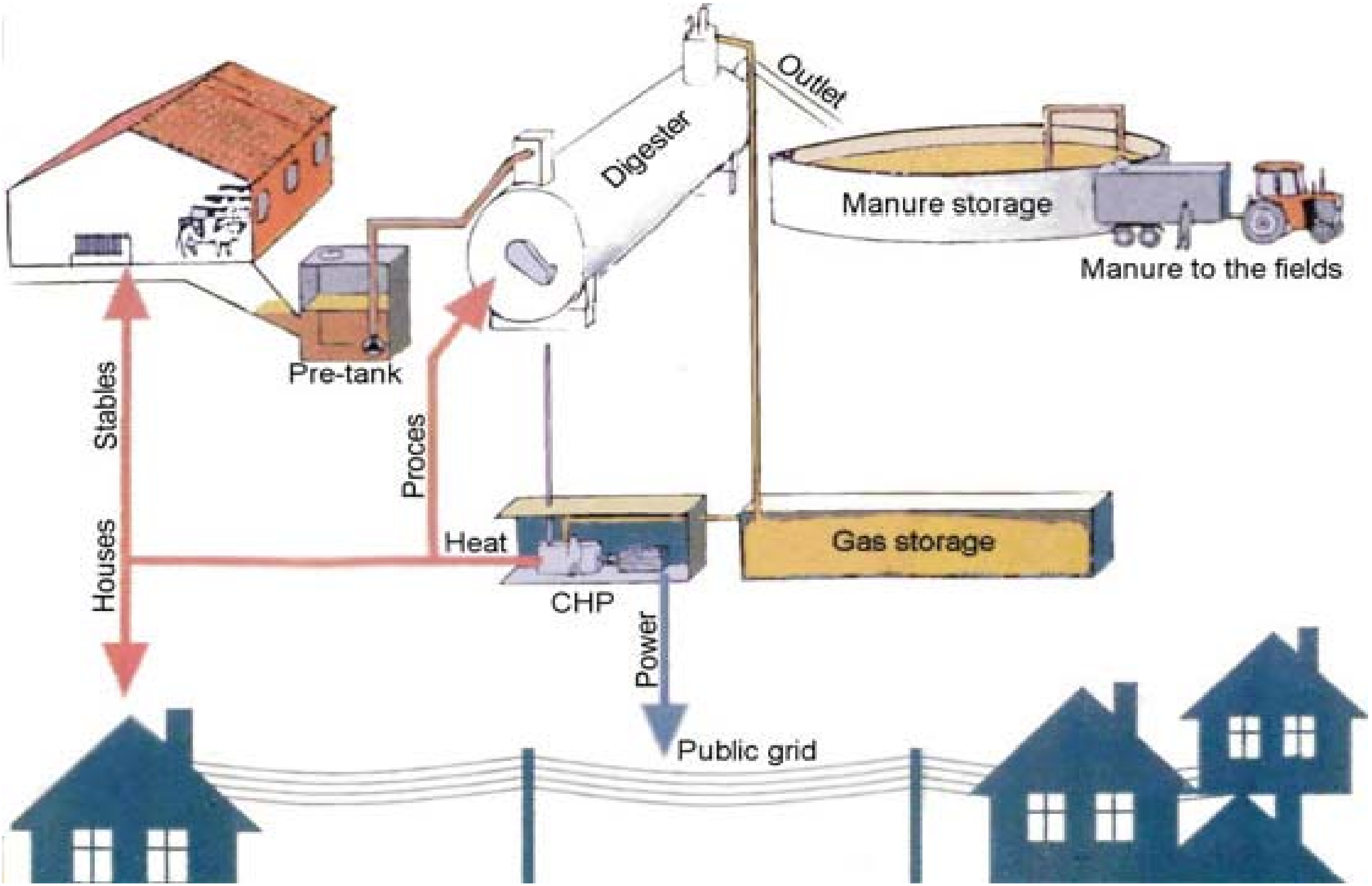
Farm Biogas Digester



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Ageratec –
Turning environmental problems to business

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AMANDA:
Biogas train Linköping – Västervik
In operation since 2005

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Brief facts from Svensk Biogas

- 13 years full-scale experience
- 9.5 percent of all car fuel in Linköping
- 64 buses, ~1400 cars, 13 filling stations (5 in Linköping) and 1 bus depot

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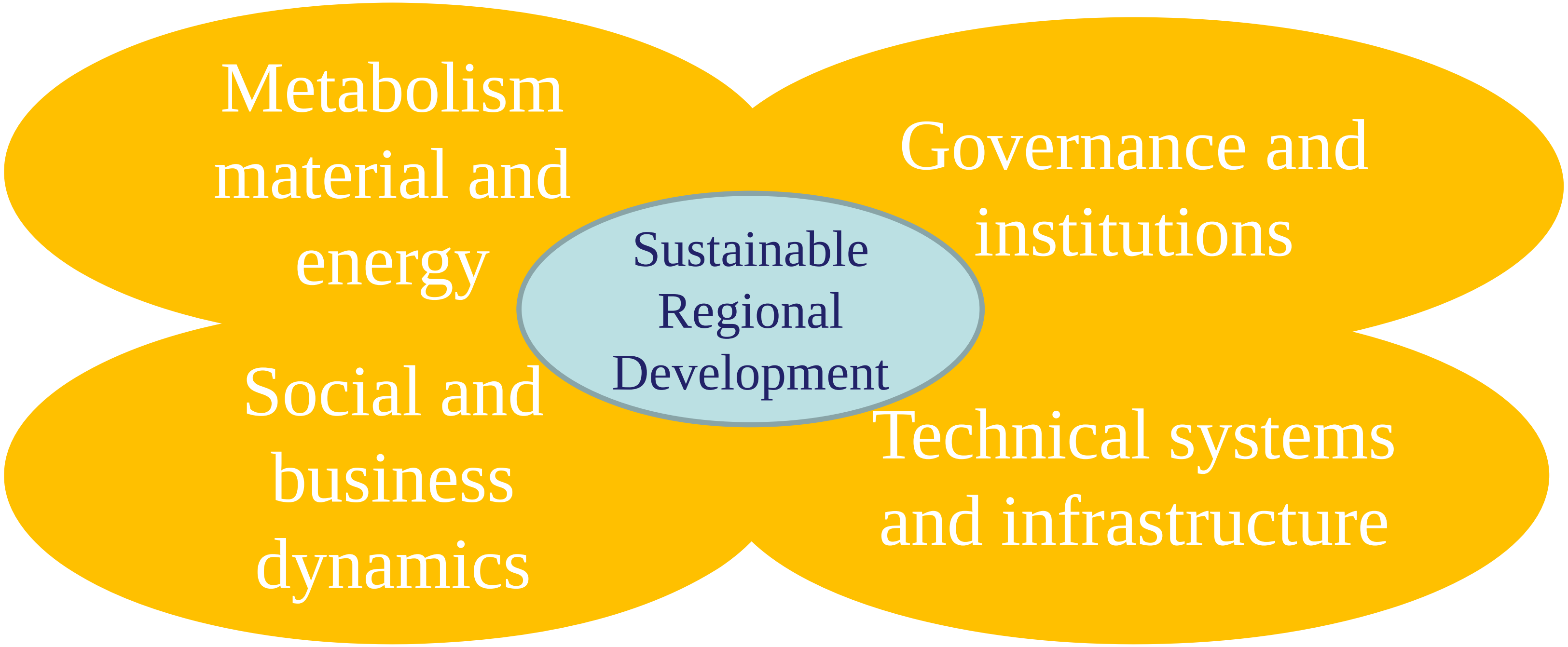
Sustainable Regional Development



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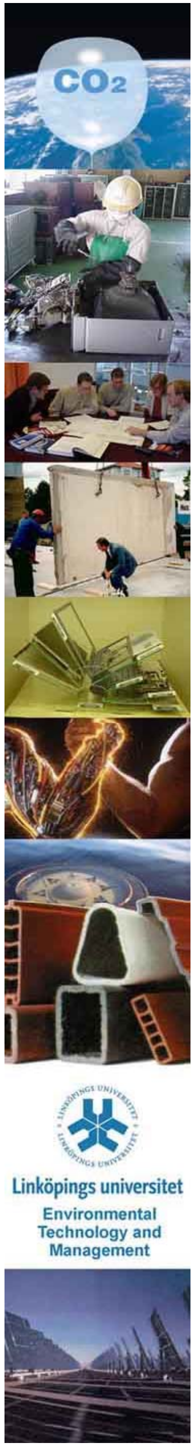
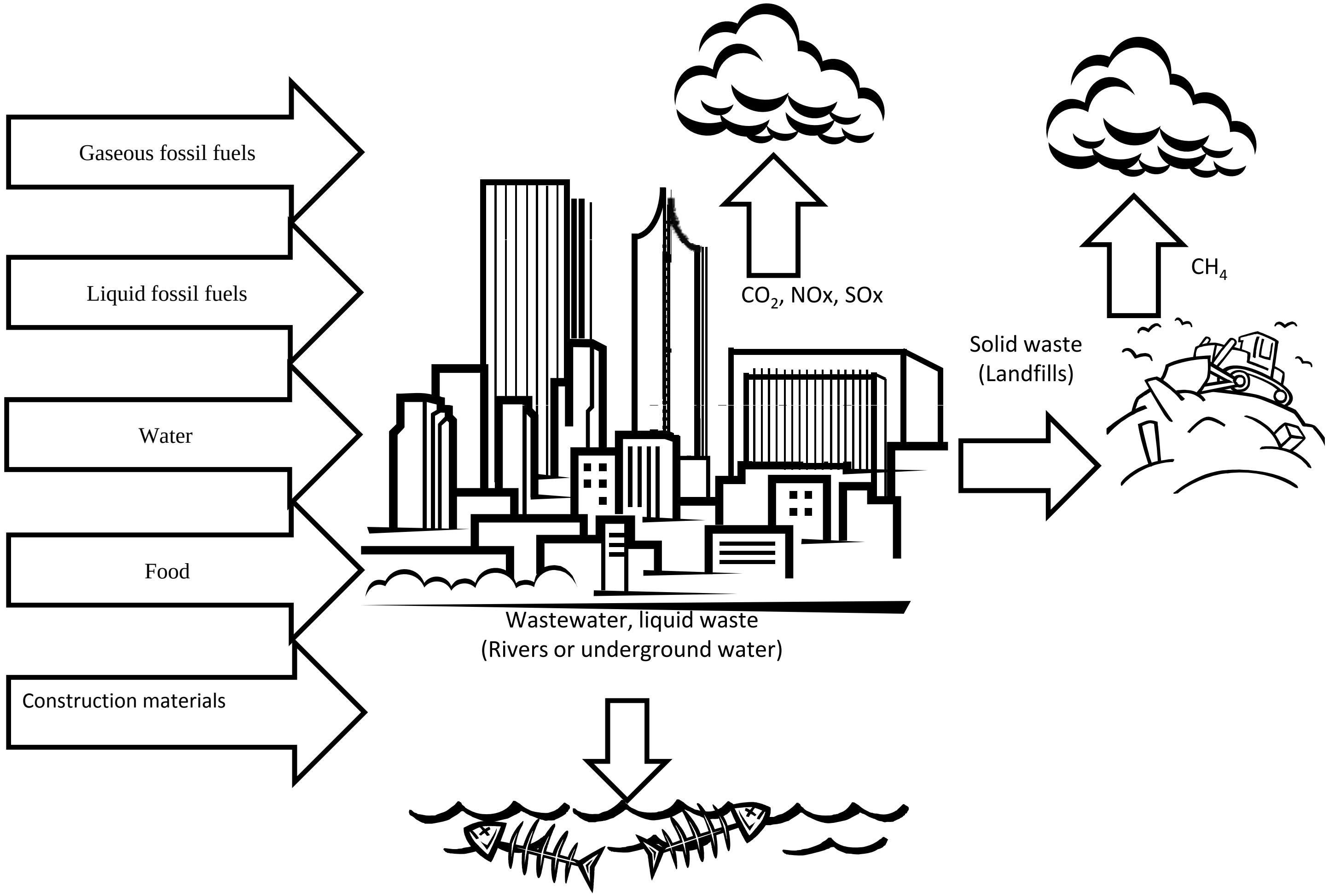
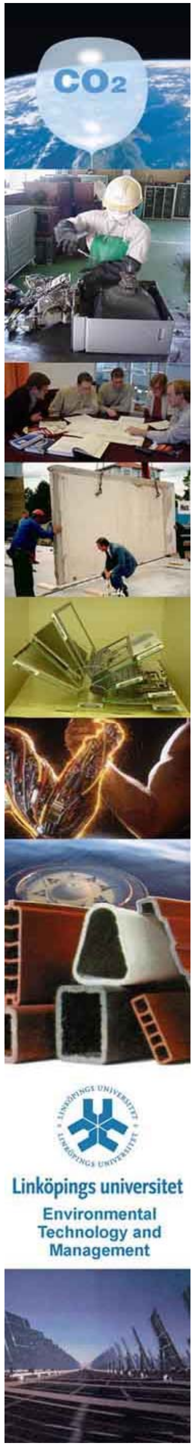
Current energy and material flows in cities



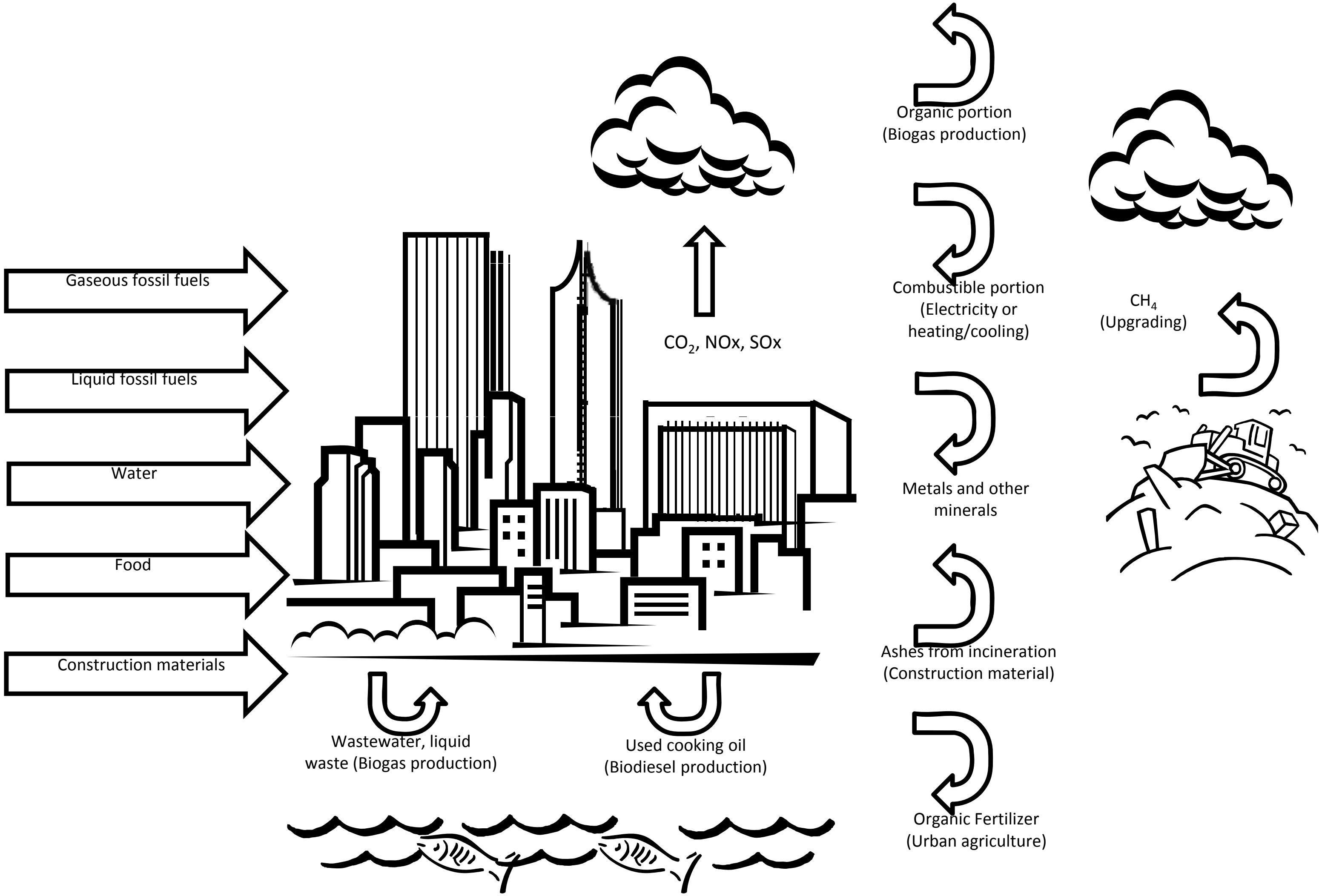


Through an industrial ecology approach…

- The urban environment is treated as an interconnected system, not isolated subsystems
- Linear behaviours are transformed into circular ones
- Energy and material waste is minimized
- Links are given special importance
- Products/materials are converted to another use when their initial use is completed



Circularization of energy and material flows



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Turning Identified Problems into Opportunities

Water shortage/quality

Food shortage

Air pollution

Fossil fuel dependency

Waste management

Source: Free photos bank

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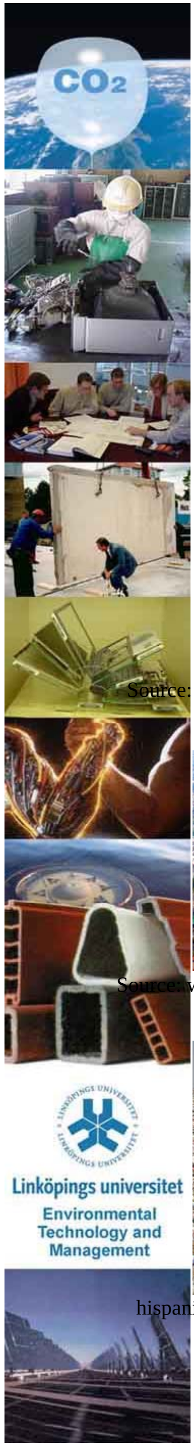
Benefits for megacities

- Reduction of their dependence on fossil fuels and virgin materials
- Protection of part of their social, economic and productive systems from external factors (e.g. political drawbacks, shortage/distribution problems, volatility of international prices)
- An increased effectiveness of their planning activities–as they would be based to a large extent on their own resources
- Reduction of their environmental burden (Quality of life)



A new way of addressing environmental problems gives new solutions, not always self-evident

An example of a scenario with the best technology in Mexico City: **Biogas**

Source: corona.com.co

270 000 tons BOD with a potential of 135 MNm^3 CH_4/year (1.3 TWh/year). Energy needed to pump 18% of the city's water. Around 13% is treated

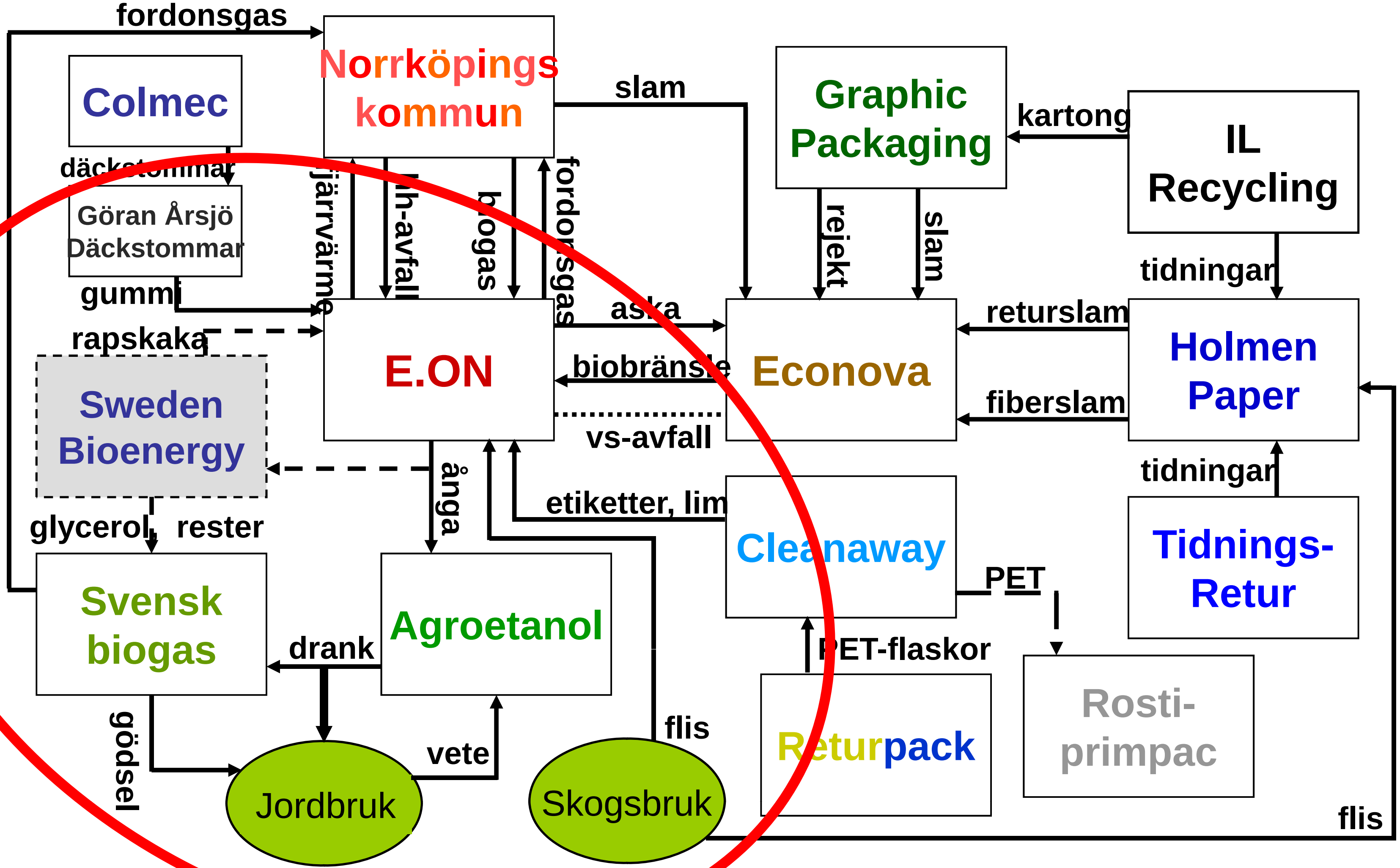
Source: www.chilangabanda.com

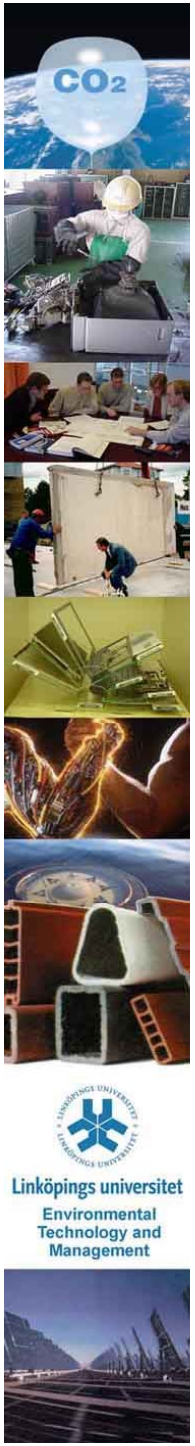
700 tons/day of organic waste from the wholesale market. Potential production of 20 MNm^3 CH_4/year

hispanicallyspeakingnews.com

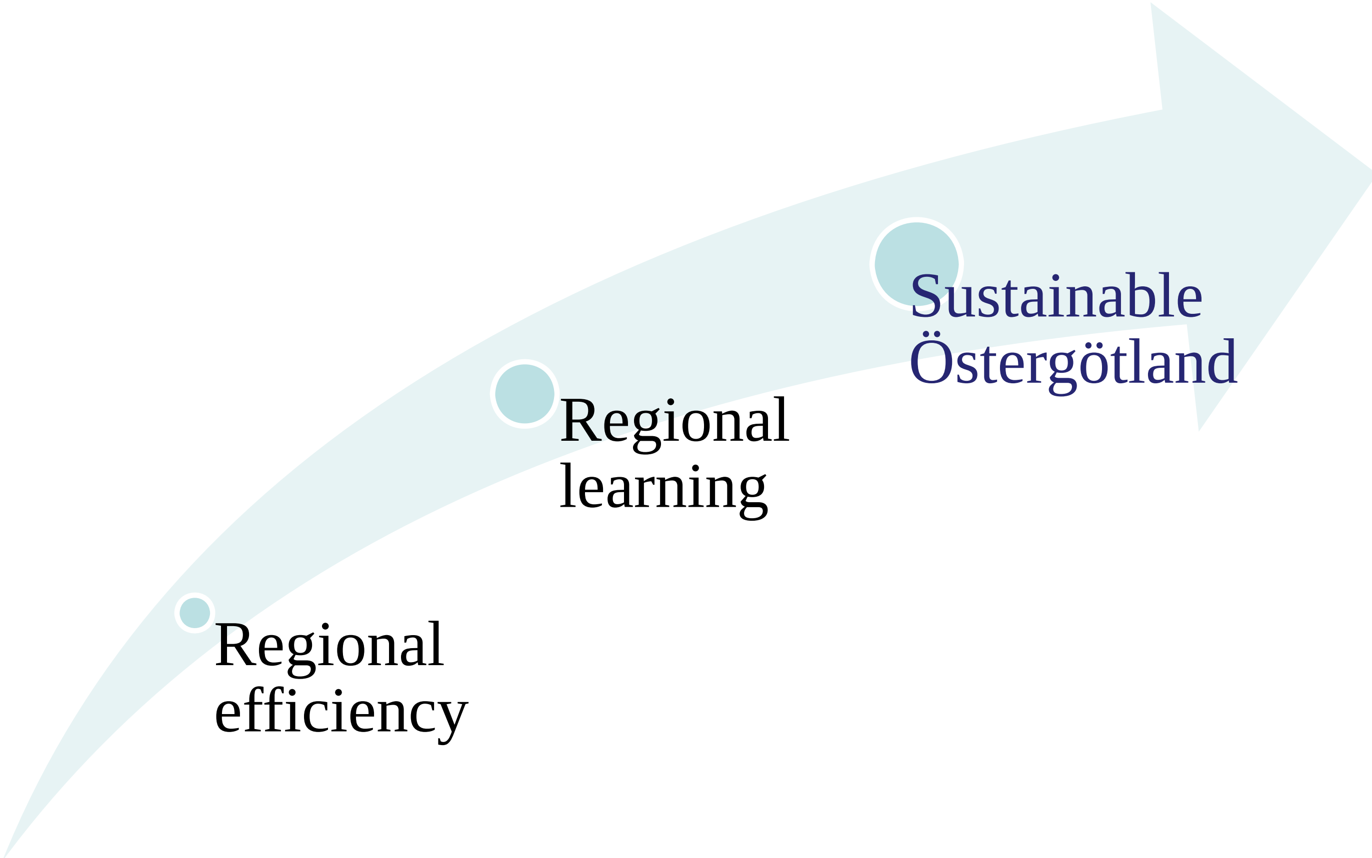
30 000 tons/day of solid waste being poured at the landfill. Potential extraction of 90 MNm^3 CH_4/year. Potential electricity production of more than 3 TWh/year. Roughly 10% properly recycled or composted.

Norrköpings Industrial Symbiosis





From regional efficiency to a sustainable region



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Industrial Symbiosis Capabilities

- *Technical capability*:

  The ability to mobilise and apply knowledge related to diminishing the ecological impact of existing production and consumption processes, and the development of more sustainable products and services

- *Value capability:*

  The ability to integrate the concerns around the sustainability values of industrial activities

Industrial Symbiosis Capabilities

- *Boundary capability:*

  The ability to look at activities in terms of the selection of an optimal system boundary by actors when they develop Sustainability goals and form clusters

- *Actualisation capability:*

  Given the selection of a system boundary, actors need to be able to mobilise the players that are part of the present or envisioned future system

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Industrial Symbiosis Capabilities

- *Trust capability:*

  This capability refers to the ability to build up, and be part of inter-organisational relationships based on trust

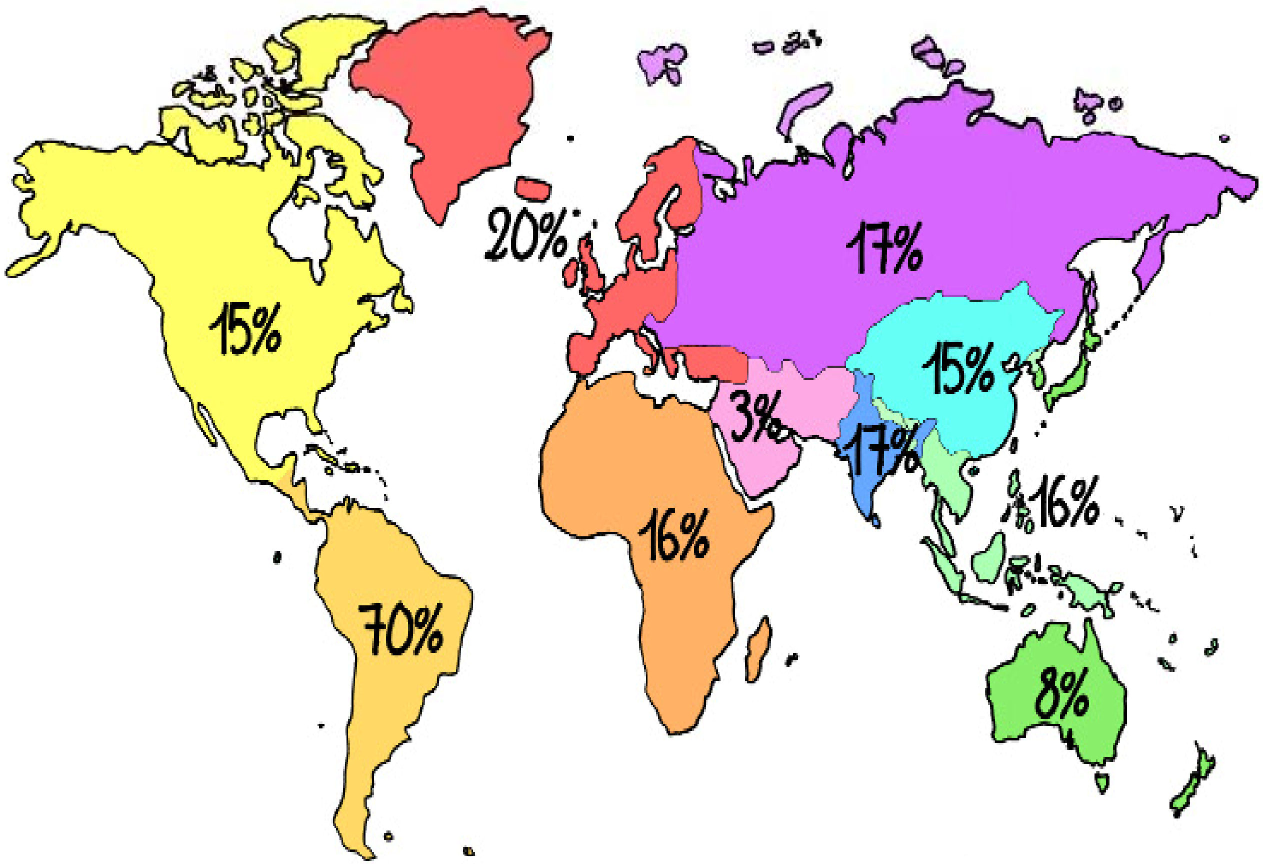
- *Regulatory capability*:

  This capability refers to the ability of organisations to shape regulations in such a way that they contribute to the cluster's goals

- *Unlearning capability:*

  Learning processes within regions include unlearning processes: the questioning and shedding of institutionalised routines that provide a barrier to collaborative approaches to sustainable development

Electricity from renewable energy *Today*



www.findinginfinity.com

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Electricity from renewable energy Expected and Potential in 2050

Region/country	Today	Expected	Potential
North America	15	25	98
South America	70	47	98
Europe	20	42	97
Africa	16	36	94
Middle East	3	7	99
Russia	17	22	93
China	15	18	90
India	17	12	93
Pacific	16	21	94
Australia	8	16	98

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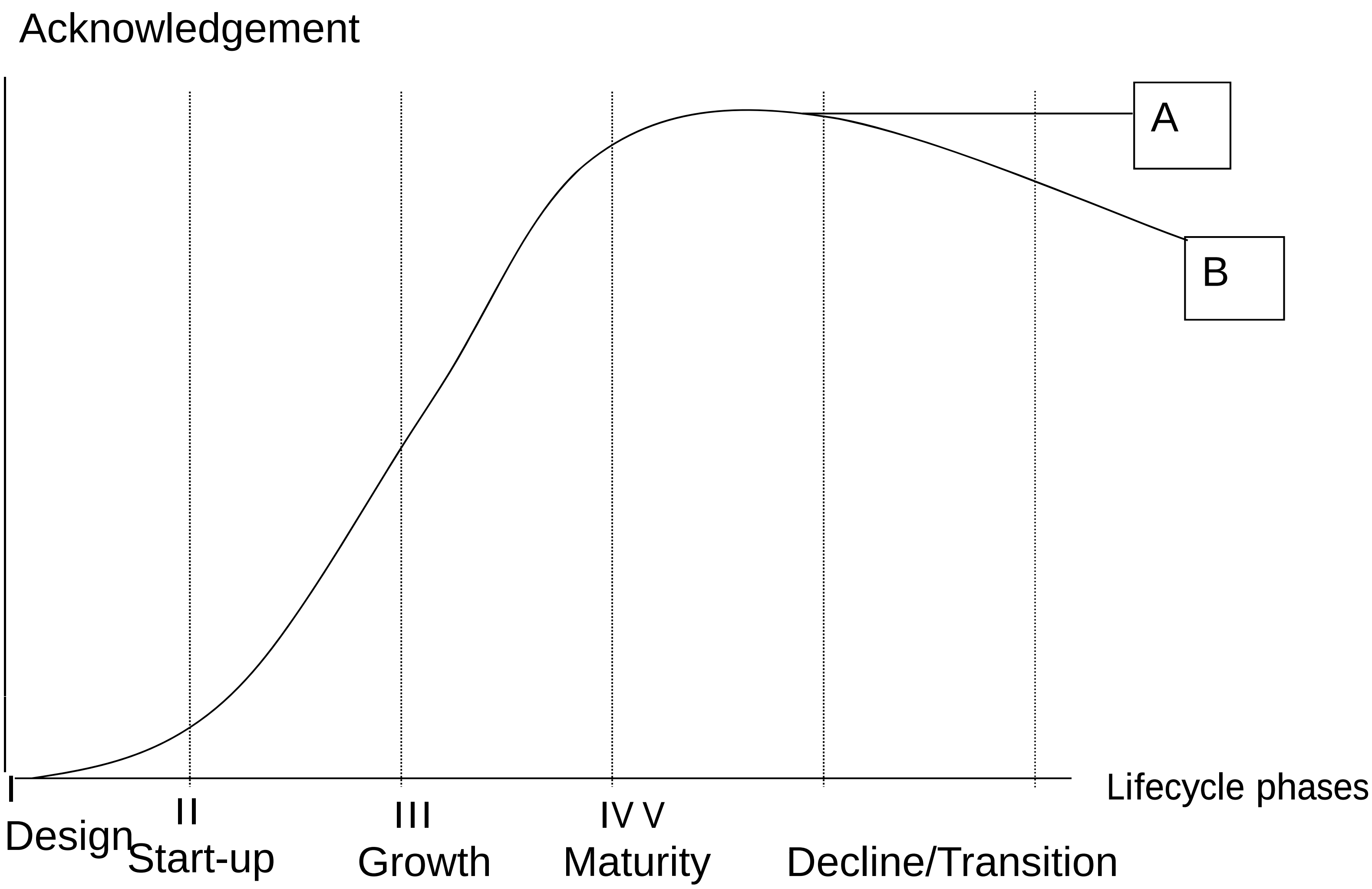
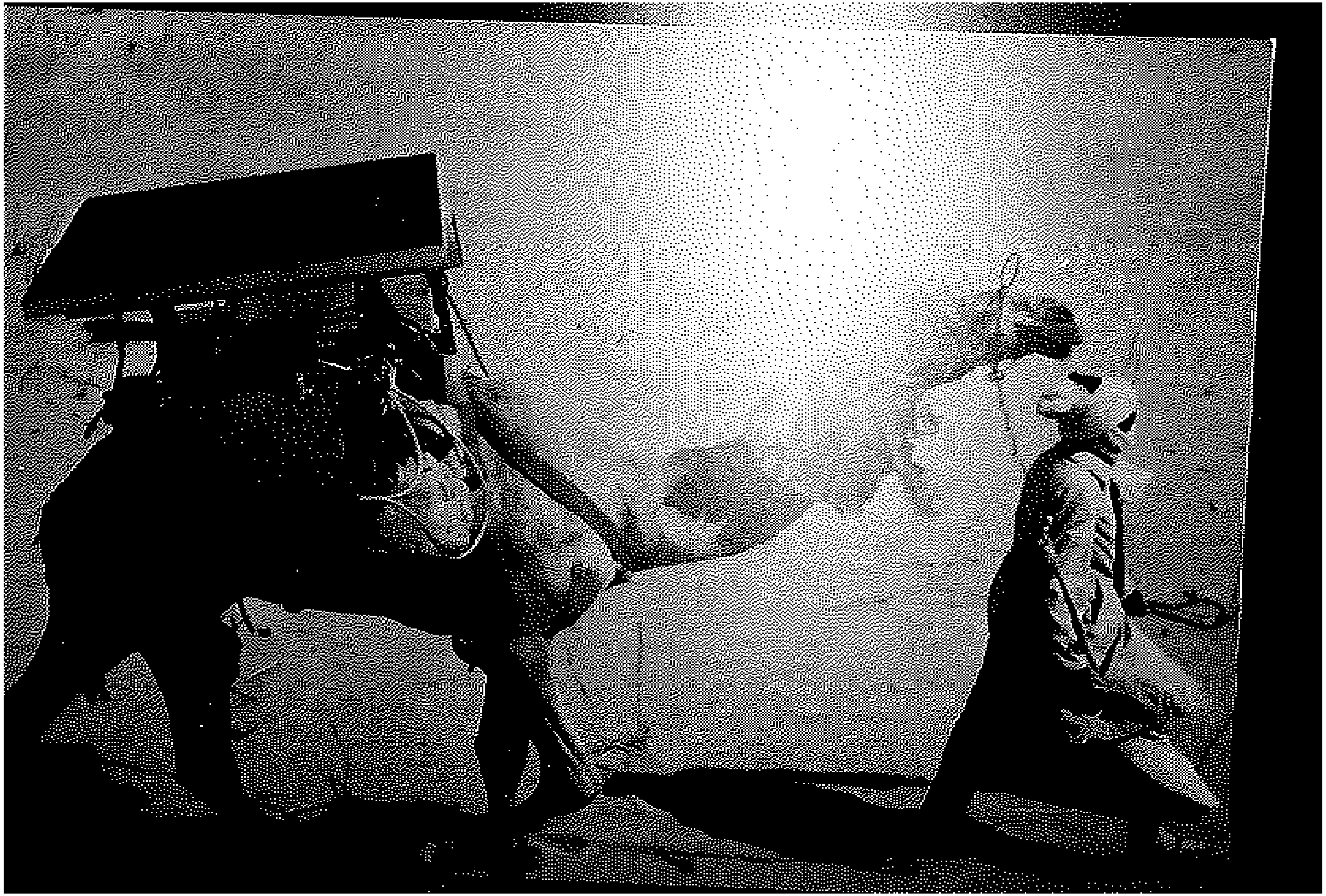
Concept Life Cycle



Innovations: Out of the Box thinking



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Saudi Arabia is running out of sand

Recent studies are showing that sand, once Saudi Arabia’s most common commodity (outside of oil) is now becoming almost as scarce as water.

It now appears that due to the high quality of Saudi sand for building projects in Bahrain and other Persian Gulf locations the specific Saudi sand is now becoming scarce.

SBA no.67

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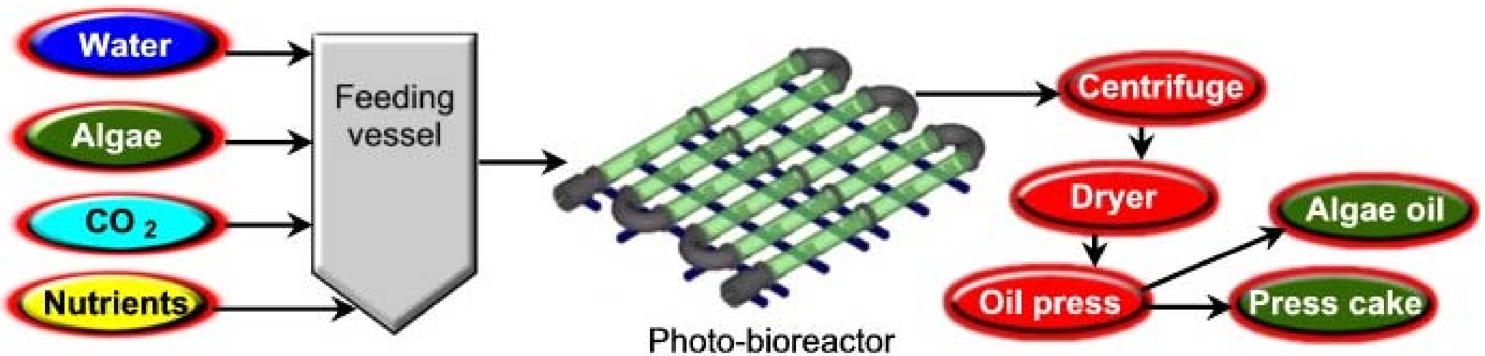
?The Future?: C0$_2$ and Heat → Algae



Conclusion of Cleaner Production dissemination

- Integration with quality, safety and energy is weak
- Implementation is fragmented into different practical paradigms (organisation, technology, policy)
- Single-loop learning process in assessment (mainly good-housekeeping, no organisational change)
- Integrated theoretical framework is missing

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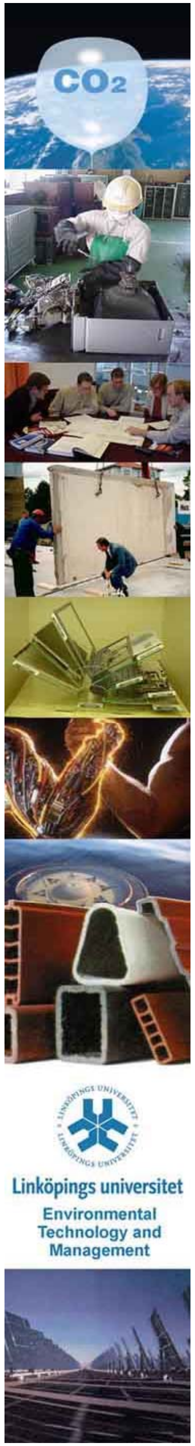
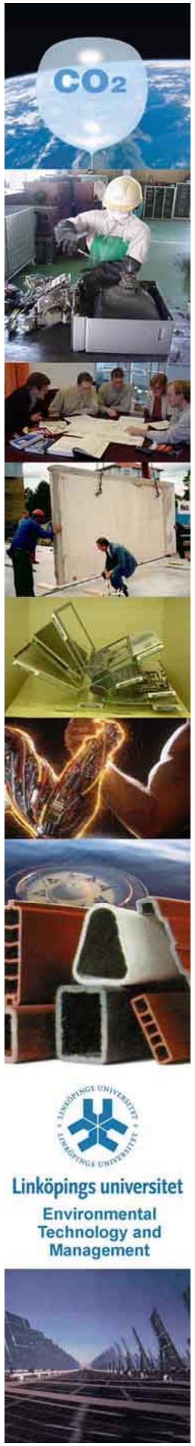


Integrating Policies & partnerships

At the macro level:

- The integration of International policies and agreements, such as the United Nations Millennium Declaration, Clean Development Mechanism, and Environmental Sound Technologies

- Where UNESCO initiated the UN Decade on Sustainability in Higher Education 2005-2014, the concepts of Cleaner Production, Industrial Ecology and Sustainability can be educated within a Cleaner Production Systems approach



Integrating Policies & partnerships

At the meso level:

- ➢Municipalities, industry associations, and education institutes/knowledge centres can join in integrated public private partnerships (government-industry- or stakeholder-driven).
- ➢Regional approaches for cleaner production in partnerships can have a broad scope

At the micro level:

- ➢Various disciplinary approaches such as industrial (eco) design, environmental management accounting and sustainable banking must be integrated

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Recommendations

- A comprehensive organisational involvement, support and management, including stakeholders’ participation
- It is a journey: Multi-loop learning processes
- Vertical and horizontal integration in organisations
- The implementation of industrial ecology should be integrated within the economy, ecology, technology, culture, and sustainability plans of the region in long-term programmes
- Trust, transparency and confidence must be developed through an open, reflective and on-going dialogue designed to ensure involvement of stakeholders in charting the future of their organisations and regions as part of the transition to sustainable societies.

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Panel Discussion with Kalundborg ”Veterans” – June 2009

- Social proximity
- Overwhelmed by world-wide attention

- Needed for success?:

➢ Awareness, Willingness, Feasibility

- Lessons learnt:

➢ Systems make it possible –

➢ People make it happen!

Nature learning from nature

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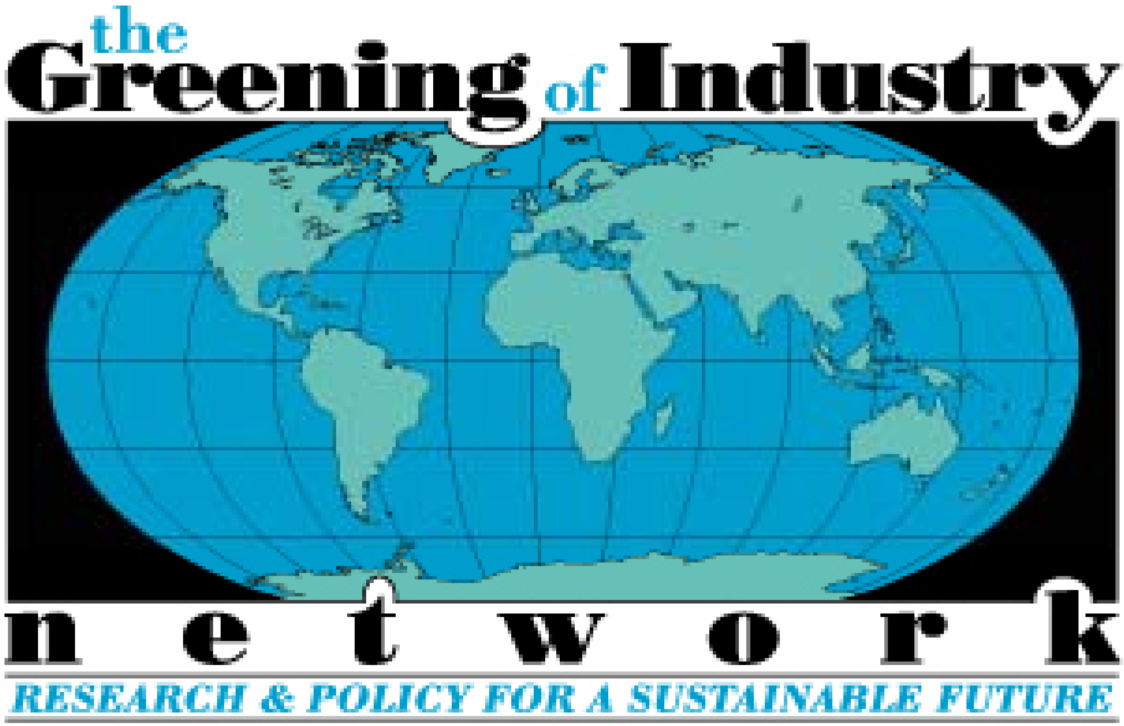
Welcome to the 20th Greening of Industry Network Conference, organized in Linköping, Sweden, 21-24 October, 2012



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Do not miss the point!

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Nothing is more practical than a good theory !

Thank you/Obrigado