The Roots of Circular Economy

Professor Arne Remmen
ar@plan.aau.dk
Research group Sustainability, Innovation & Policy
Department of Development and Planning
Aalborg University

Agenda: Where do we come from ?

Sources behind circular economy – practices vs concepts

1. ***Resource efficiency:*** a) Cleaner production / Pollution prevention b) Waste hierarchy c) Closing the loop (Stahel) d) Decoupling
2. ***Product design***: eco-design / Design for Environment /Sustainability / c2c
3. ***Business strategies***: PSS + Sustainable BM
4. ***Integrated Product Policies and Circular Economy*** in EU: WEEE, ROHS, eco-design directive, labels, etc.
5. ***Towards a system perspective*** (Manufacturing over products to systems/IE/SCP/Sustainable transitions)

The ”LINEAR” economy

The linear economy has been the dominant model since the 50íes
The circular economy was back in time the ”normal”

To some extent CE is ”reinventing the wheel” to

- Use high quality materials
- for manufacturing durable products
- that easily can be repaired and maintained

The challenge of CE is to

- ***design*** products and services on CE principles
- create ***business models*** that makes this feasible

Planned obsolescence

To maintain unit sales GM head Alfred P. Sloan Jr. suggested annual model-year design changes to convince car owners that they needed to buy a new replacement each year. Critics called his strategy "planned obsolescence". Sloan preferred the term "dynamic obsolescence"

The 1923 Chevrolet is cited as one of the earliest examples of annual facelifts in the car industry, because it had a restyled body covering what essentially was nine-year-old technology

(Wikipidia)

Innovation = ”Creative destruction”

Joseph A. Schumpeter (father to the first innovation theories)

Henry Ford:
”Your car can have whatever colour you like, as long as you buy a black”
The relation: mass production versus innovations

Radical innovations will often make earlier products or technologies obsolete, and they then loose value on the market

- The value of old products is destroyed by the creativity (Lazonick 2005)
- Disruptive innovation (Clayton Christensen) is today describing market innovation instead of technological innovation

Circular economy is an indicator of a need for creative destruction of old design strategies and business models in the linear economy

AALBORG UNIVERSITY

Throwaway Living

Time Magazine, 1955

A man, woman and child toss "disposable" items into the air.

Peter Stackpole
The LIFE Picture Collection/Getty Image

WHY prevention + circular economy ??

Climate change
Scarcity – rare earth elements + other resources
World Overshoot Day
Increasing loss of biodiversity
More billions in the world
More billions in the middle class
Price fluctuations – increases from 2000 to 2010
HUGE sector problems: BBC
Inefficiency of the current systems (e.g. cars/transport)
?

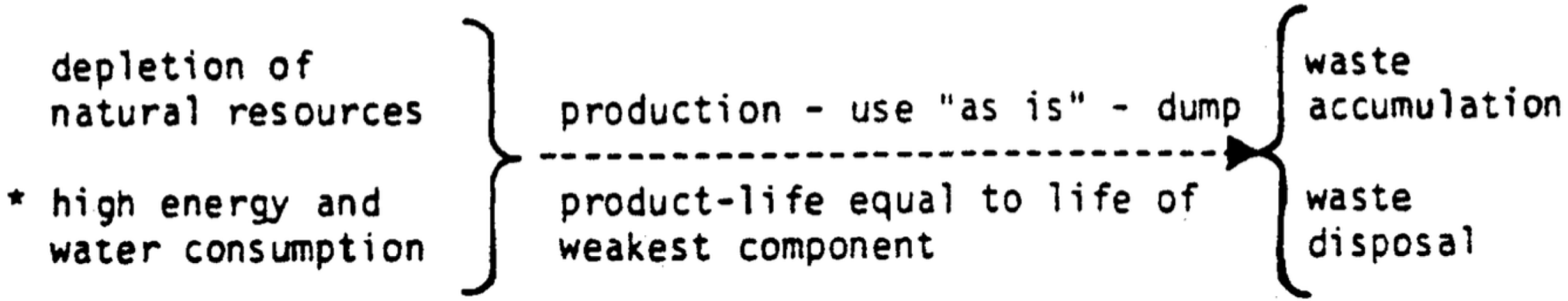
The environmental turn – new discourse

1962 Rachel Carson: Silent spring
1967 Summer of love + 1968 Student revolts
1969 Environmental NGOs (NOAH, OOA/OVE, Greenpeace)
1972 Limits to Growth
1972 UN Conference on the Human Environment
1975 Pollution prevention (3M – 3P)
1987 The Brundtland Report, Our Common Future
1989 Cleaner production (1986: Clean Tech program in DK)
1992 UN Conference on Environment and Development, Rio
2002 World Summit in Johannesburg
Since 1991: Greening of Industry Conference
Since 1994: European Roundtable for Sustainable Consumption and Production

Linear production-consumption system

Today, industrial activity involves a linear production-consumption system with inbuilt environmental deterioration at both ends:

FIGURE A: THE FAST-REPLACEMENT SYSTEM

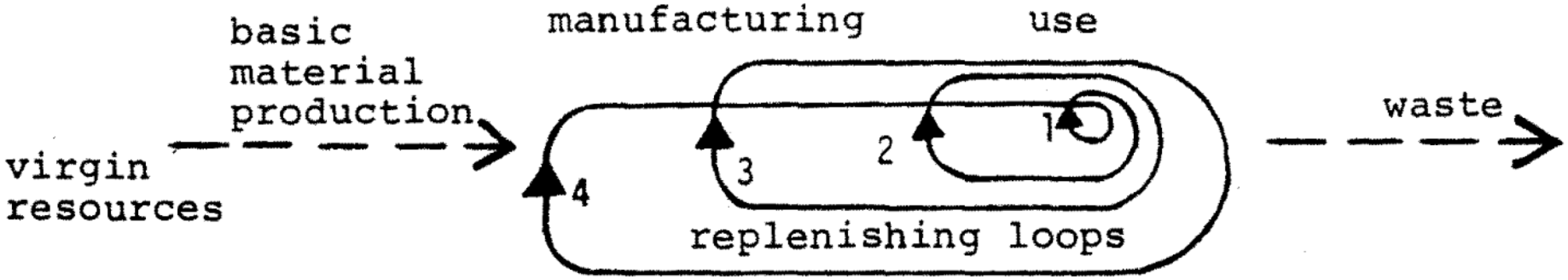


Walter Stahel: The Product Life Factor. 1981

http://www.product-life.org/

Spiral loop system

FIGURE C: THE SELF-REPLENISHING SYSTEM (PRODUCT-LIFE EXTENSION)



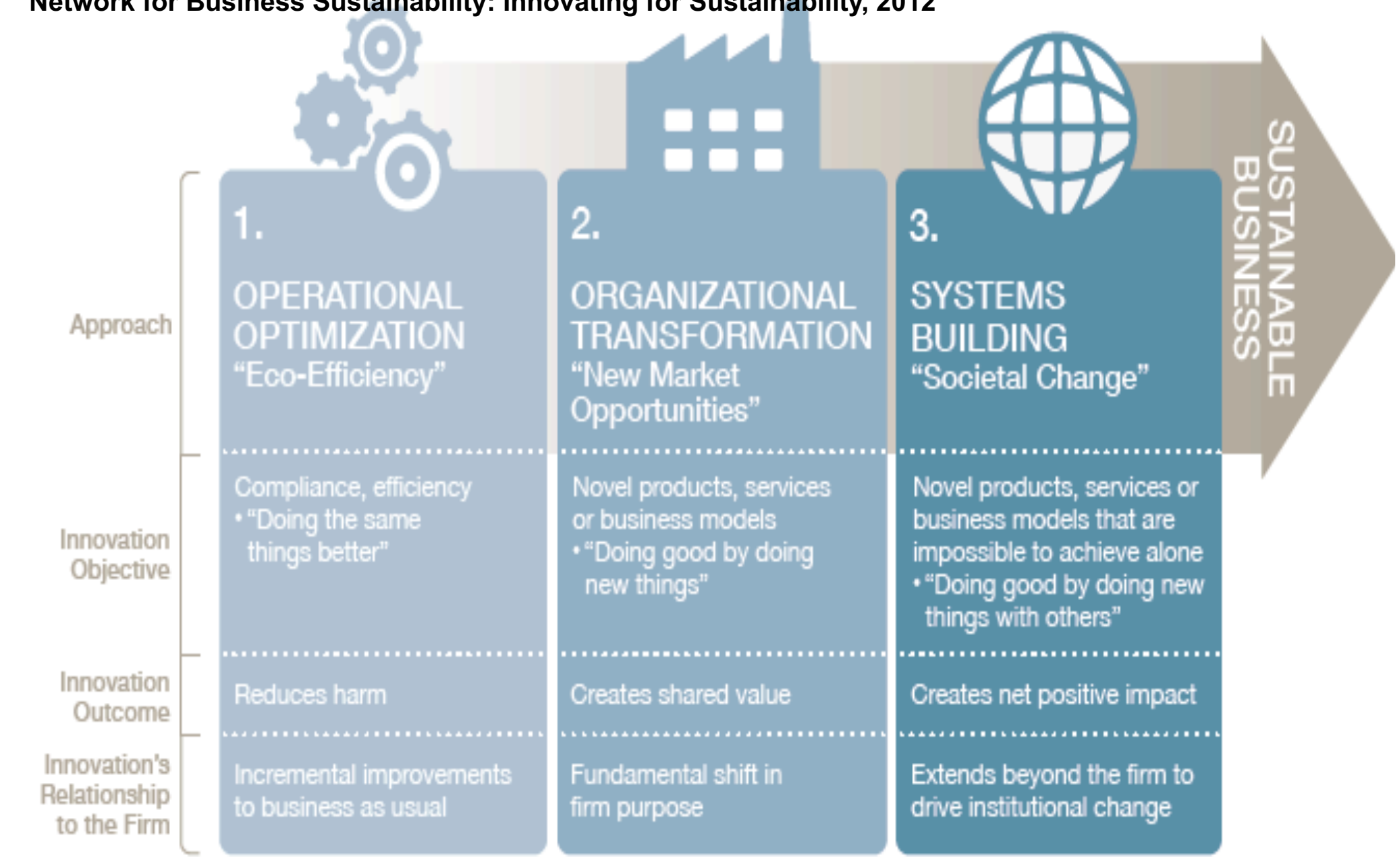
independence of the life-times of inter-compatible systems, products and components

Creates an economy based on a spiral-loop system that minimizes matter, energy-flow and environmental deterioration without restricting economic growth or social and technical progress:

REUSE (loop 1), REPAIR (loop 2) and RECONDITIONING (loop 3) utilize used products or components as a source for new ones, and RECYCLING (loop 4) uses scrap as locally-available raw material.* A society relying on this self-replenishing economy is building on existing wealth and applying economics to optimize the total life-span of goods and products. Financial

Walter Stahel: **The Product Life Factor 1981**

Network for Business Sustainability: Innovating for Sustainability, 2012



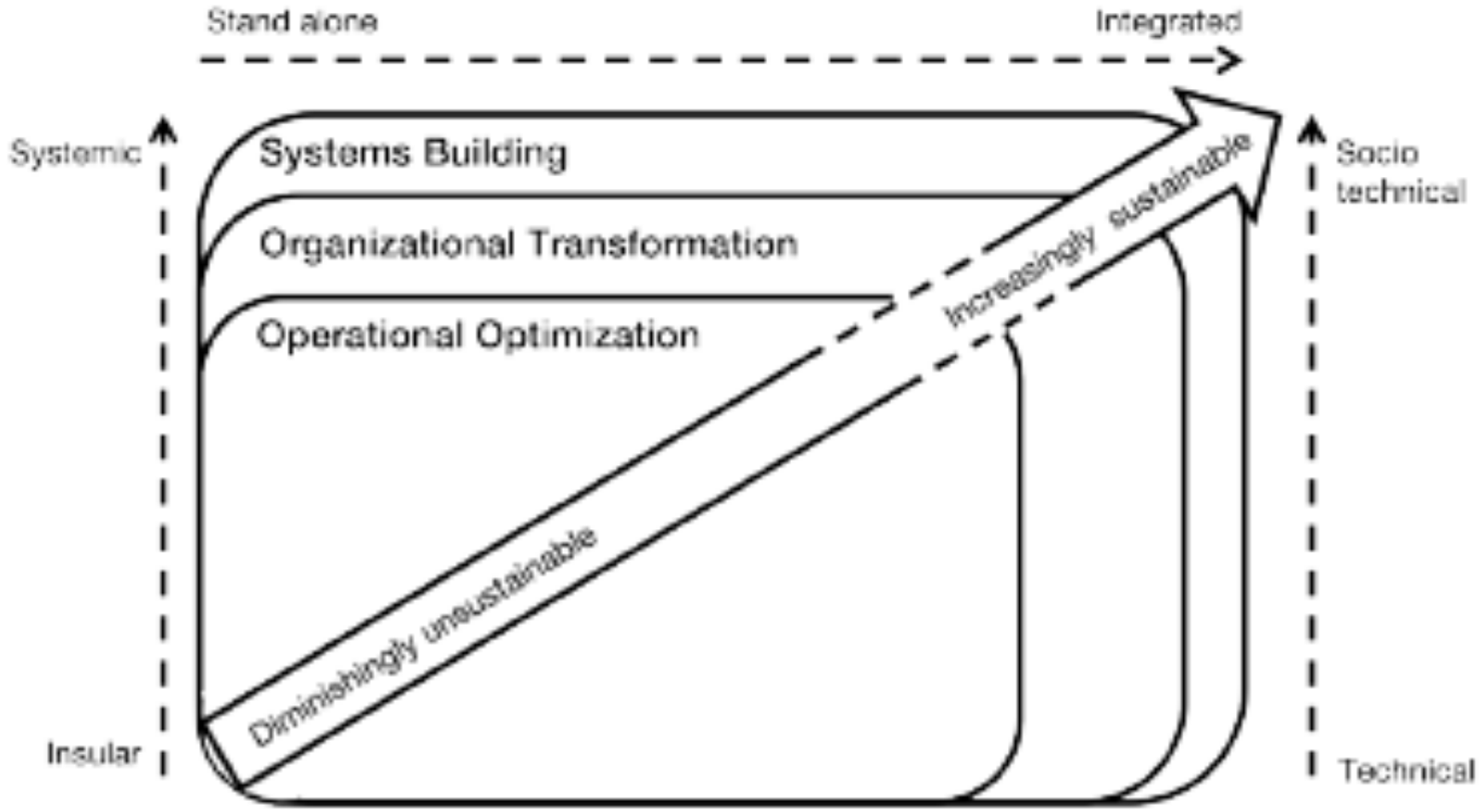
Cleaner production/Waste minimisation
Energy and water savings

Eco-design/cleaner products
CSR + Life cycle management

Circular economy /Industrial ecology
Product service systems

Figure 1

THREE CONTEXTS OF SUSTAINABILITY-ORIENTED INNOVATION



[2] The use of the word green is something of a double-edged sword. It is a powerful symbolic articulation of one aspect of sustainability thinking, a rallying post around which debate and action can muster. On the other hand, it obscures the wider meaning of sustainability, and the social dimension is often lost.

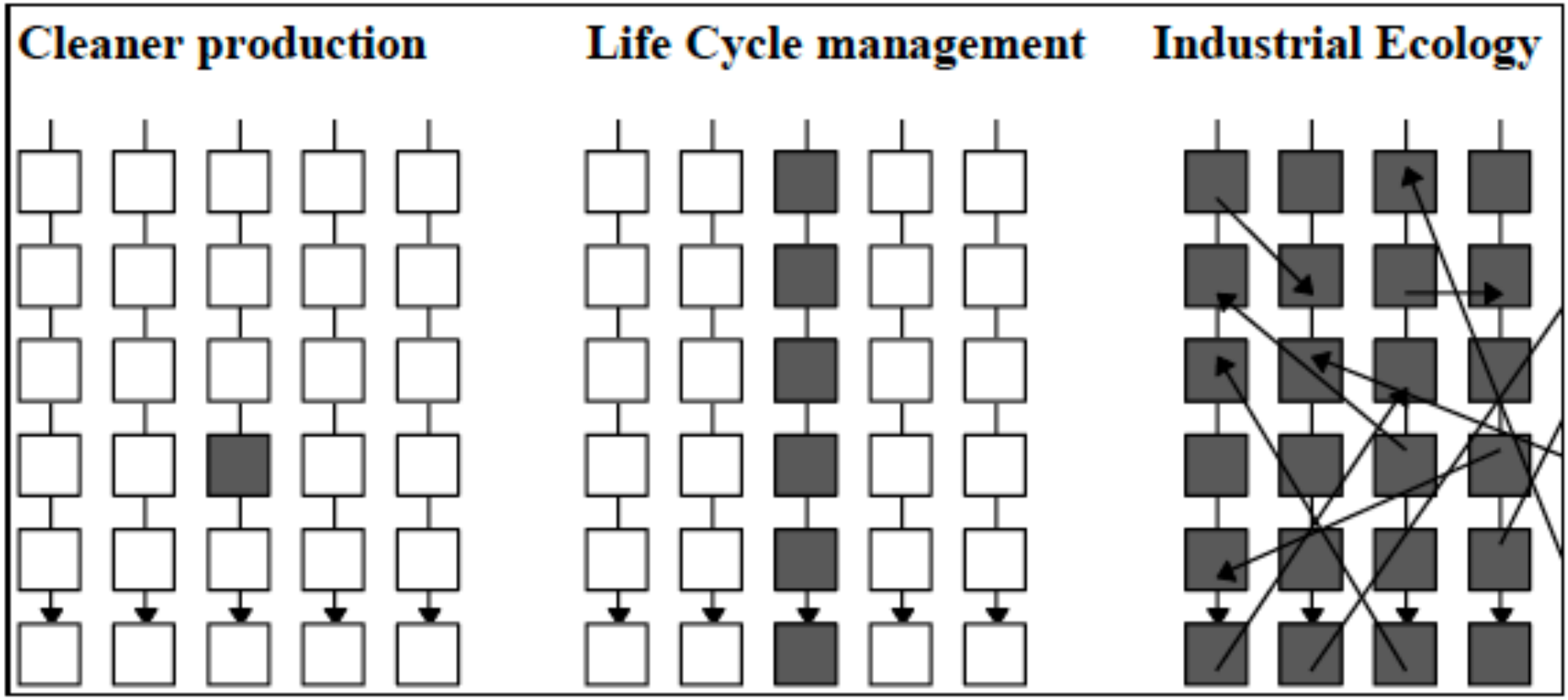


Figure 1.1 From Cleaner Production to Industrial Ecology, Hanssen and Abrahamsen (2012).

Sustainable production 3.0

1.0 FACTORY – Manufacturing

- ***Cleaner production***, lean and green, waste minimisation, etc.
- Environmental management systems (ISO 14001)
- Eco-efficiency – incremental improvements

2.0 PRODUCT – Supply/value chain

- Product innovation - Eco-design
- ***Life cycle management***
- Responsibility in the value chain, CSR etc.

3.0 SYSTEM – Network

- Integrated solutions and system innovations
- Circular economy, Business models, Product Service Systems, etc
- Public-private partnerships**, *Industrial Ecology***, symbiosis, etc.

Cleaner Production (CP) UN, 1991

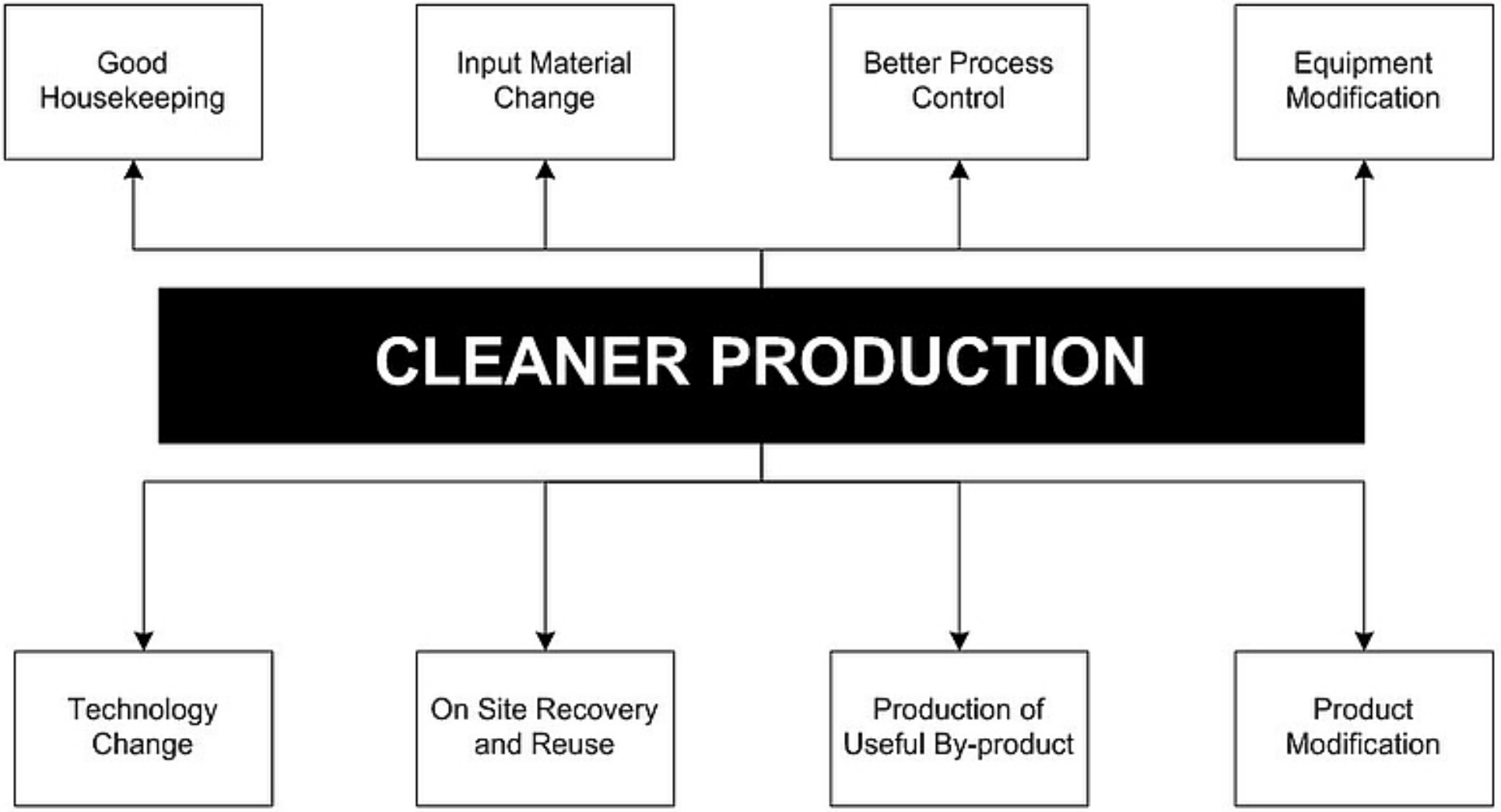
"CP is the continuous application of an integrated preventative environmental strategy to processes, products and services to increase efficiency and reduce risks to humans and environment".

CP implementation :

- **Good Housekeeping:** appropriate provisions to prevent leaks and spills and to achieve proper, standardized operation and maintenance procedures and practices;
- **Input Material Change:** replacement of hazardous or non-renewable inputs by less hazardous or renewable materials or by materials with a longer service life-time;
- **Better Process Control:** modification of the working procedures, machine instructions and process record keeping for operating the processes at higher efficiency and lower rates of waste and emission generation;

- **Equipment Modification:** modification of the production equipment so as to run the processes at higher efficiency and lower rates of waste and emission generation;
- **Technology Change**: replacement of the technology, processing sequence and/or synthesis pathway in order to minimize the rates of waste and emission generation during production;
- **On-Site Recovery/Reuse**: reuse of the wasted materials in the same process or for another useful application within the company;
- **Production of Useful By-Products**: transformation of previously discarded wastes into materials that can be reused or recycled for another application outside the company; and
- **Product Modification:** modification of product characteristics in order to minimize the environmental impacts of the product during or after its use (disposal) or to minimize the environmental impacts of its production.

Projects (clan tech) versus processes (ISO)



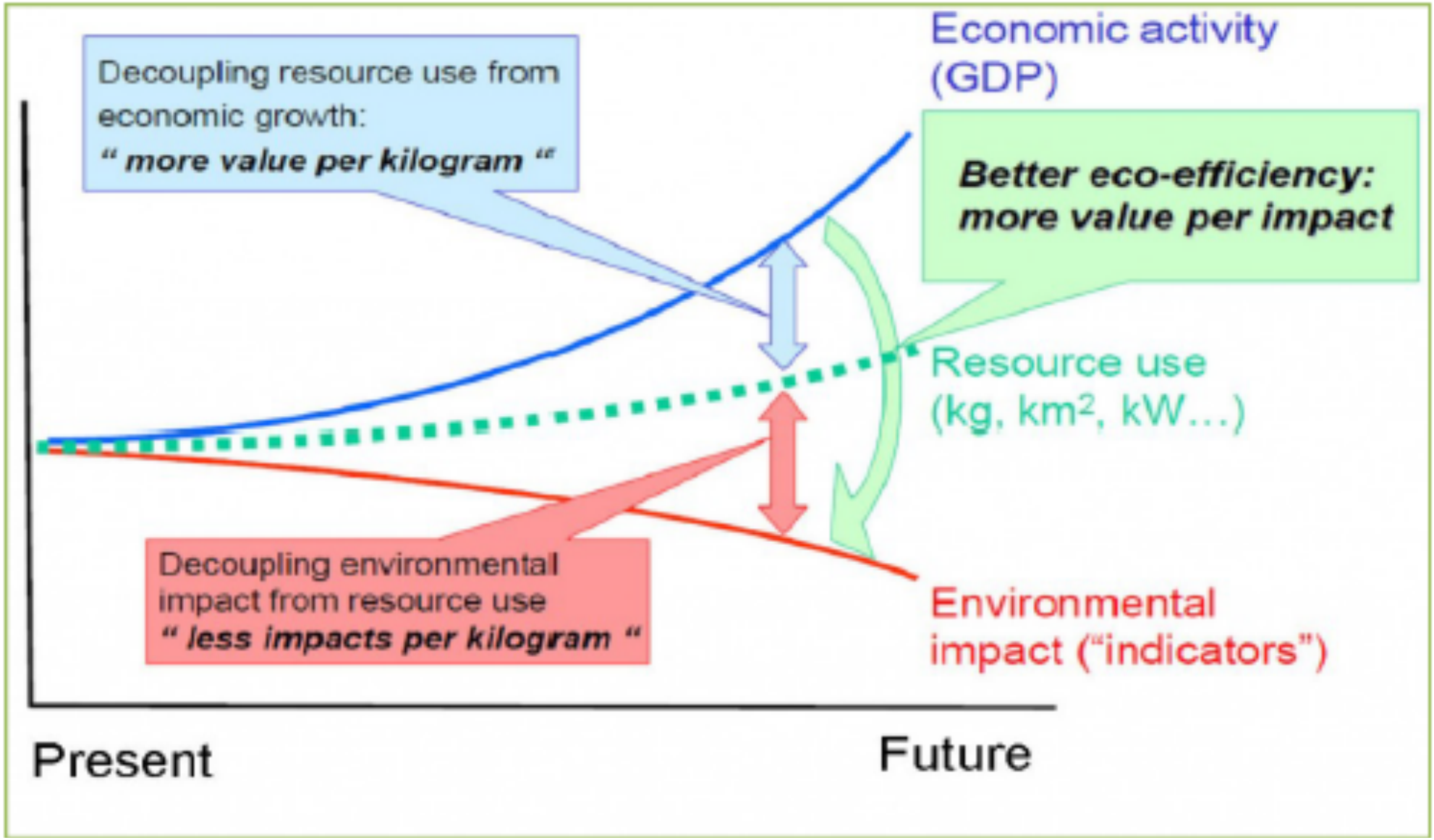
Eco-efficiency – in 1992

World Business Council for Sustainable Development (WBCSD) defined in 1992 (before Rio) eco-efficiency in the book ***'Changing Course'.***
"Creating more value with less impact".

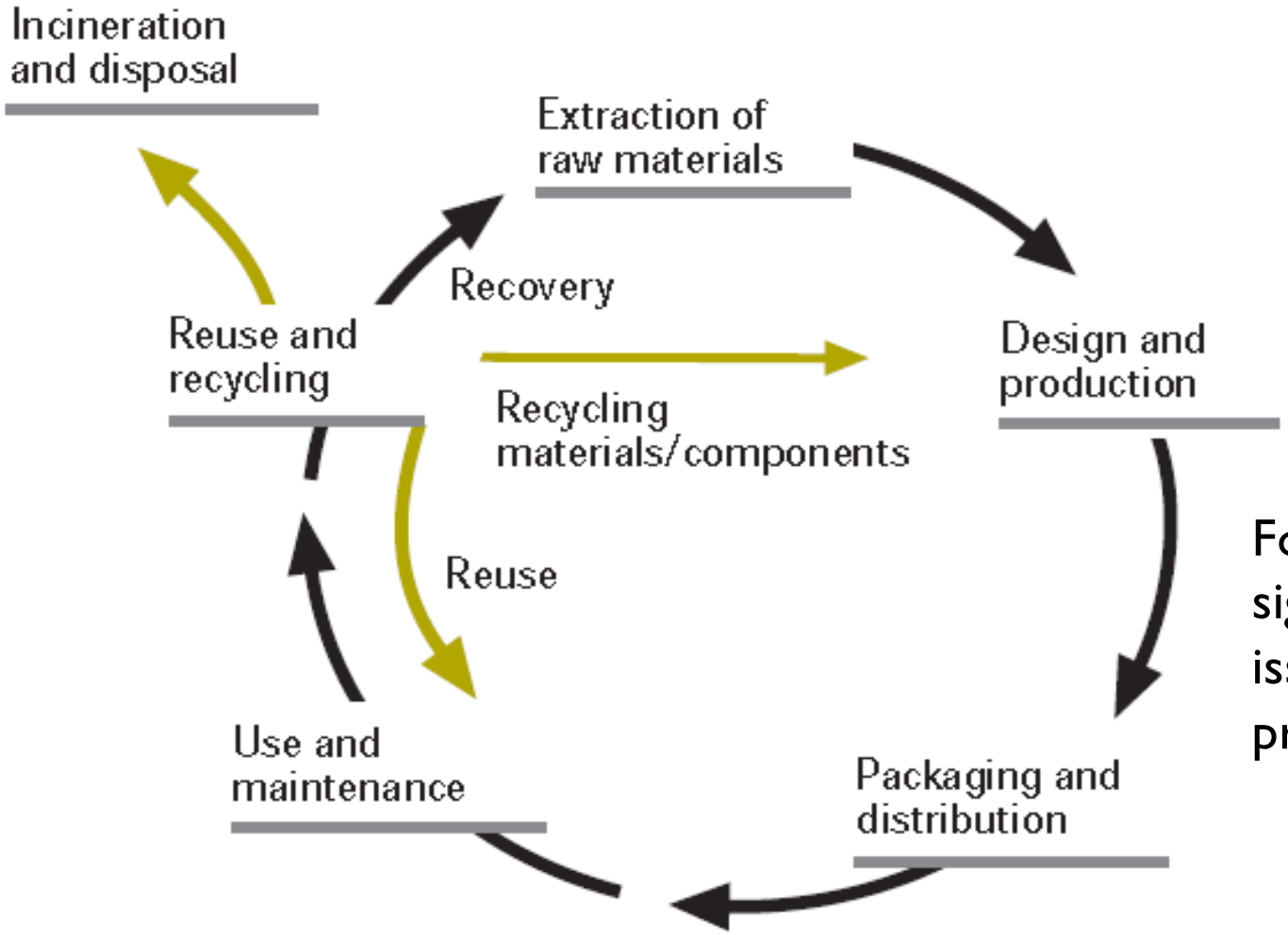
Three objectives are defined by (WBCSD) regarding Eco-efficiency.

- **Reduce the consumption of resources.** The material and energy consumption should be reduced through enhancing recyclability. Producing products with higher quality and longer life times may also lead to improvements within the area.
- **Reduce the impact on nature**. Improvements can be performed using renewable resources which are sustainably managed, as well as minimizing emissions, waste disposal, and toxic substances.
- **Provide customers with higher quality products and services.** The customer benefit can be improved through providing the user additional services of the product such as e.g. functionality or/and increased overall life time. It is however important that higher customer benefit must not interfere with the two former objectives.

Decoupling – improved eco-efficiency

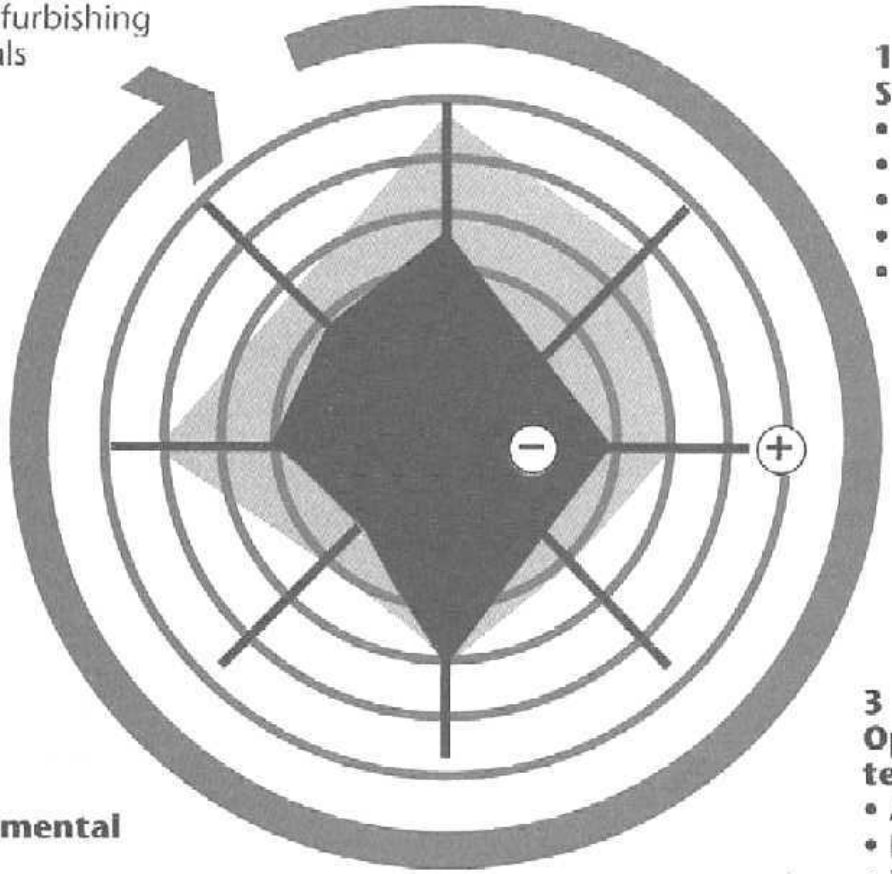


Life cycle perspective



Focus on the most significant environmental issues relating to a product's overall life cycle

Design for the Environment /eco-design



0
New concept development
- Dematerialization
- Shared use of the product
- Integration of functions
- Functional optimization of product (components)

1
Selection of low-impact materials
- Non-hazardous materials
- Non-exhausible materials
- Low-energy content materials
- Recycled materials
- Recyclable materials

2
Reduction of material
- Reduction in weight
- Reduction in (transport) volume

3
Optimization of production techniques
- Alternative production techniques
- Fewer production proceses
- Low/clean energy consumption
- Low generation of waste
- Few/clean production consumables

4
Efficient distribution system
- Less/clean packaging
- Efficient transport mode
- Efficient logistics

5
Reduction of the environmental impact in the user stage
- Low energy consumption
- Clean energy source
- Few consumables needed during use
- No energy/auxiliary material use

6
Optimization of initial life time
- Reliability and durability
- Easy maintenance and repair
- Modular product structure
- Classic design
- User taking care of product

7
Optimization of end-of-life system
- Reuse of product
- Remanufacturing/refurbishing
- Recycling of materials
- Clean incineration

Priorities for the new product

Existing product

Source: Breset et. al., 1994, Hemel and Keldmann, 1996

Designing-out-waste 14RE - eco-design principles

- **Re-**think – functions
- **Re**duce resource use and impacts / **RE**-place / **RE**-fuse
- **Re**-pair – durability, service and maintenance (modular design, upgrading, etc.) (inner cycles)
- **Re**-use / **Re**-sale / **RE**-distribute (products or parts)
- **Re**-trofit/**Re**-furbish/**Re**-manufacturing/**Re**conditioning
- **Re**-cycle / **Re**-covery of materials (outer cycle)

Better World Fashion

Why business models ?

The dilemma between
Sale versus long durability

For enterprises to get a *competitive advantage* of durable, high quality and easy-to-repair products, then innovative business models are required !

Lej et Læringsmiljø

- oplæg til et bæredygtigt koncept for Aalborg Kommune, fordi "Vi kan, vi vil og vi tør" [1]

[1] Citat fra Aalborgs skolers visionsdag

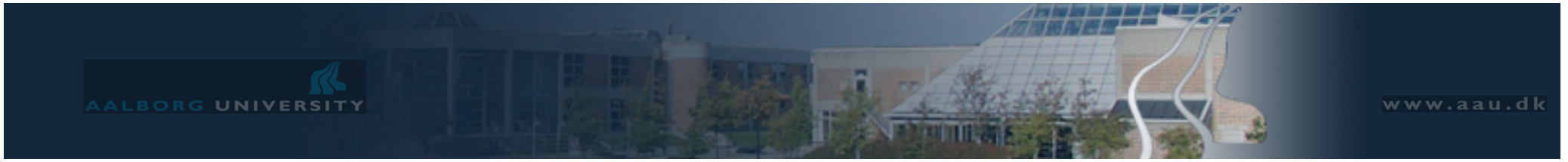
http://www.hojermobler.dk/

From furniture to learning environment
– Jens Højers' ideas

Challenges in primary schools: Longer days = demands to space

From products over services to system solutions

- Activate passive areas
- "Rent" pr. student – change & supplement inventory
- Long product life time – minimum 20 years
- Eco-materials of high quality
- Modular design – change parts and upgrade
- Repair and maintenance
- Reuse components + materials – take back system
- Social responsibility – socio-economic work spaces
- Participation of students (app, box for excursions, design space)



From furnitures to learning environments

	Product Chair & table	Service	System Learning
Profit	Price Investment Quality	Total Cost of Ownership, TCO Service contract	Lease – flexibility Improved space Value for users: students + teacher
People	Design Ergonomi Comfort	Service work at supplier	Pedagogy & learning Improved wellbeing Socio-economic work places
Planet	FSC wood Eco-label	Durability Repair Maintain	Take-back Refurb
Relation	Sale = transfer ownership	Collaboration – mid-term	Partnerships - long-term

- Price
- Quality
- Design
- Eco-label

- Total cost of ownership (TCO)
- Maintenance
- Reparation

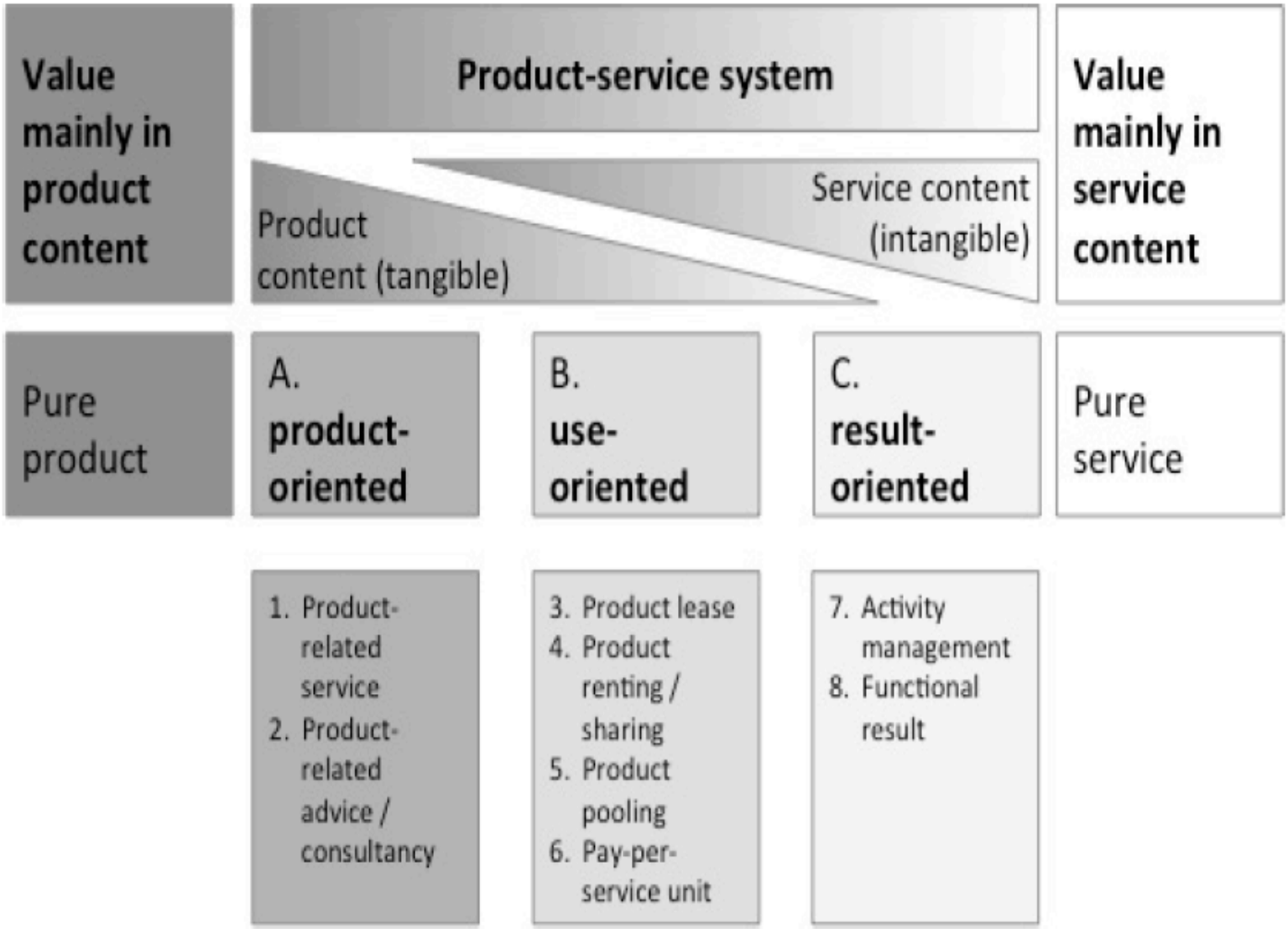
- Leasing/ renting
- Circularity
- Use value
- User participation

- **SALE of product**

- **SERVICE contacts**

- **Sustainable VALUE creation**

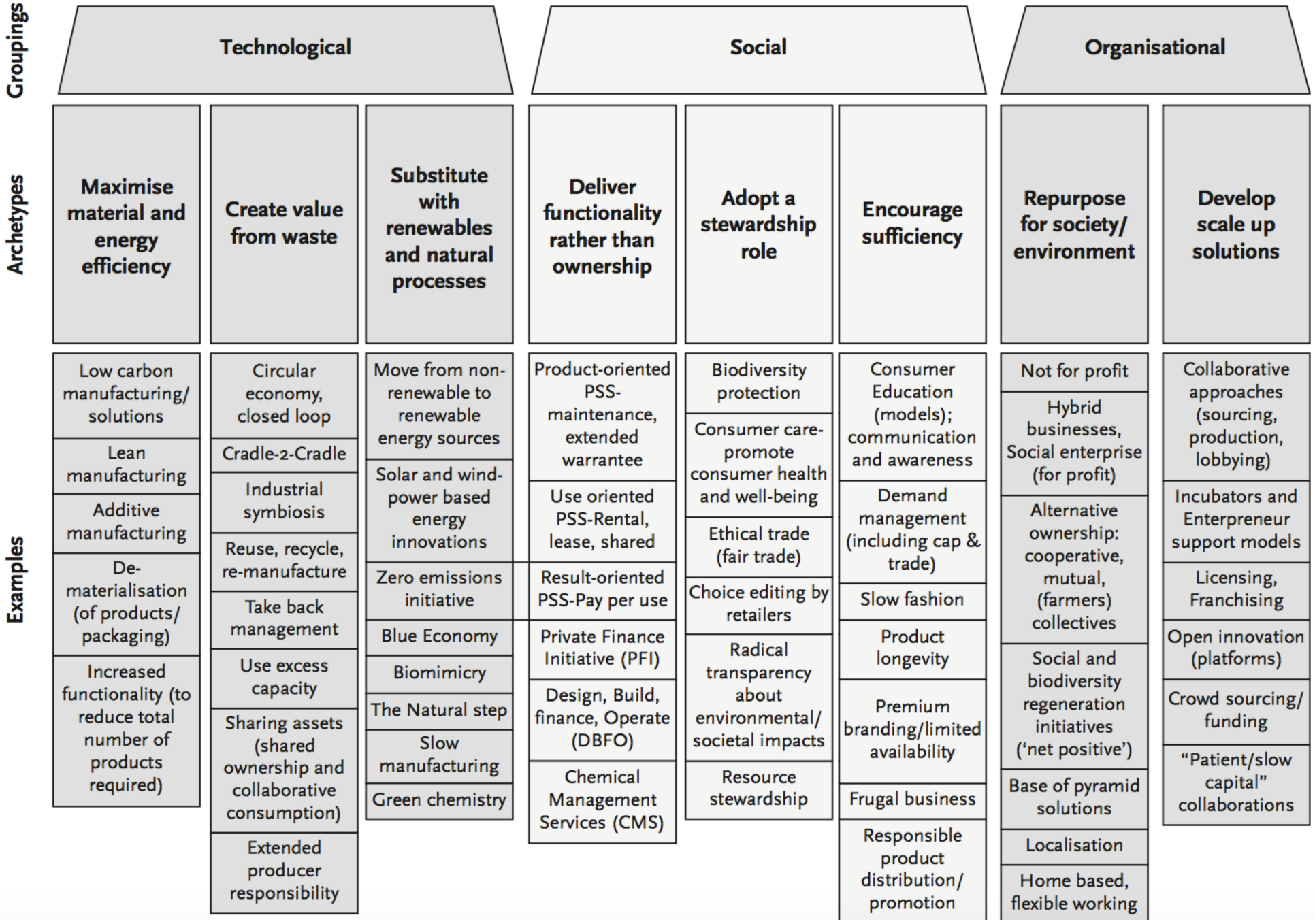
Figure 1: The product-service system and its subcategories



Source: Tukker et al. 2006

Figure 1 Sustainable business model archetypes

Source: Bocken *et al.* 2013



Business models (link to consumption patterns and volume)

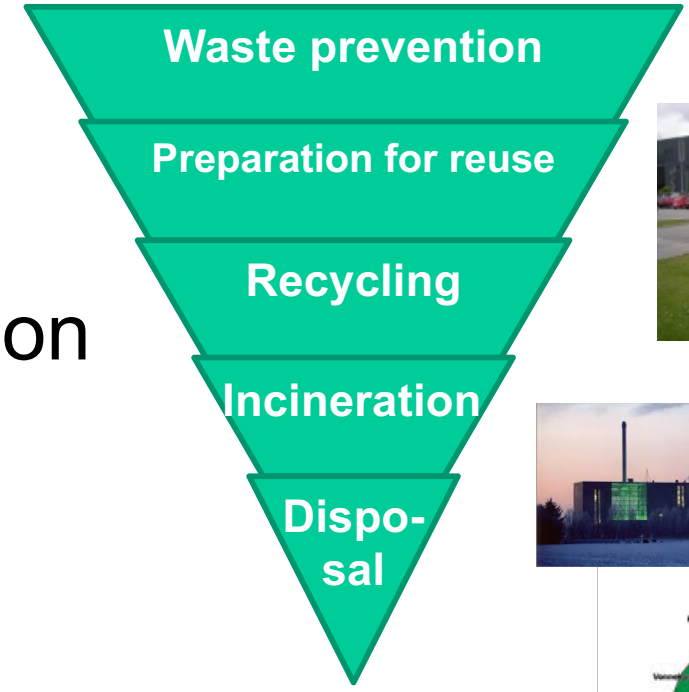
- Durability (classical models, service, etc.)
- After-sale services
- Functional sales
- Product sharing / collaborative consumption
- Leasing

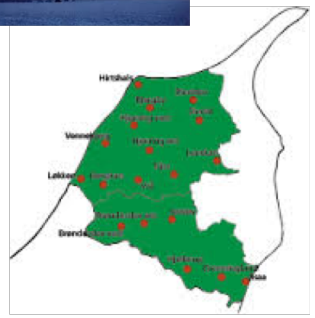
Waste Hierarchy – 40 years old

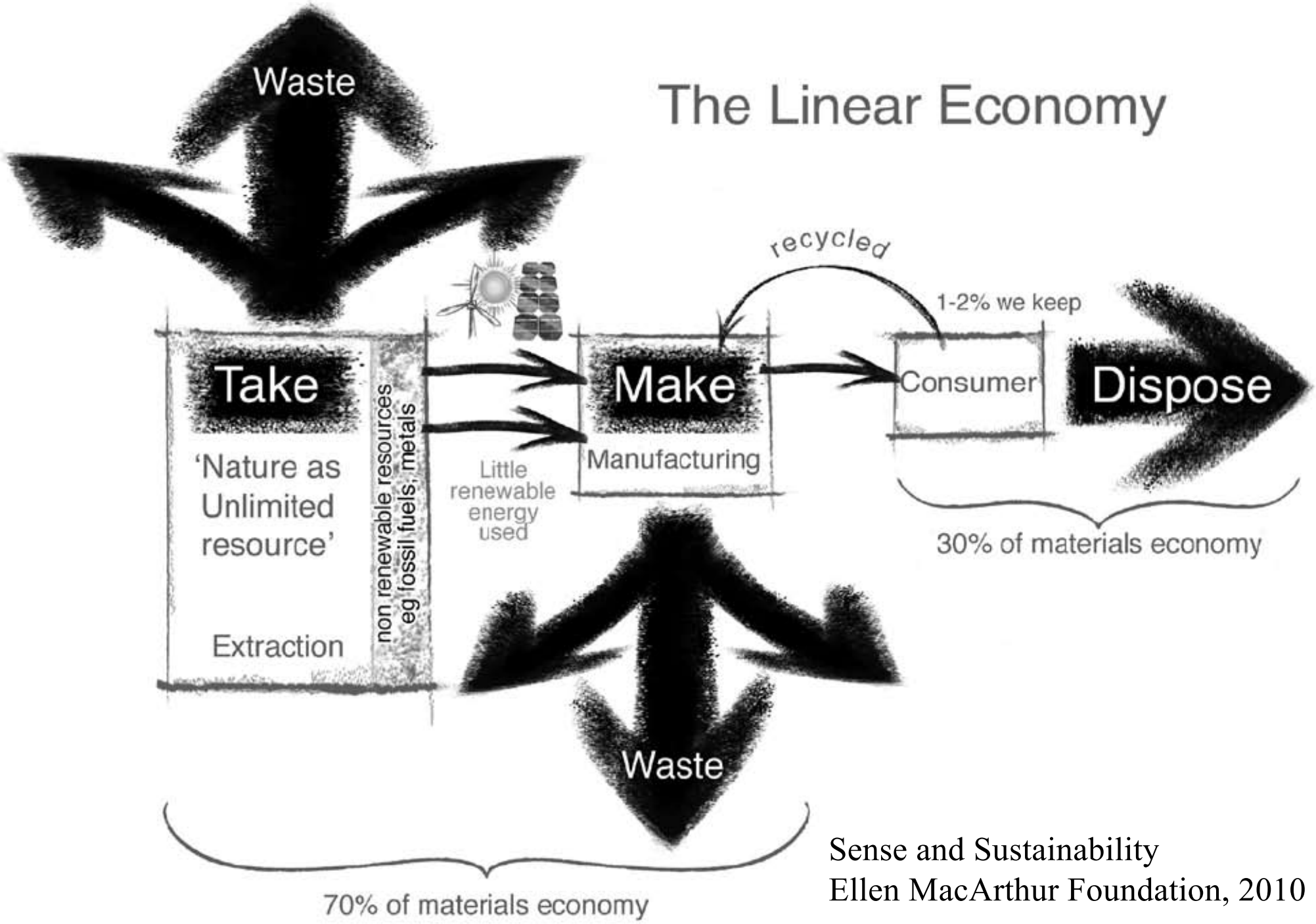
- **Priorities**

Unless something else is better for the environment

- In EU's waste framework directive from 2008
- In Environmental Protection Act § 6b
- Affaldsbekendtgørelsen



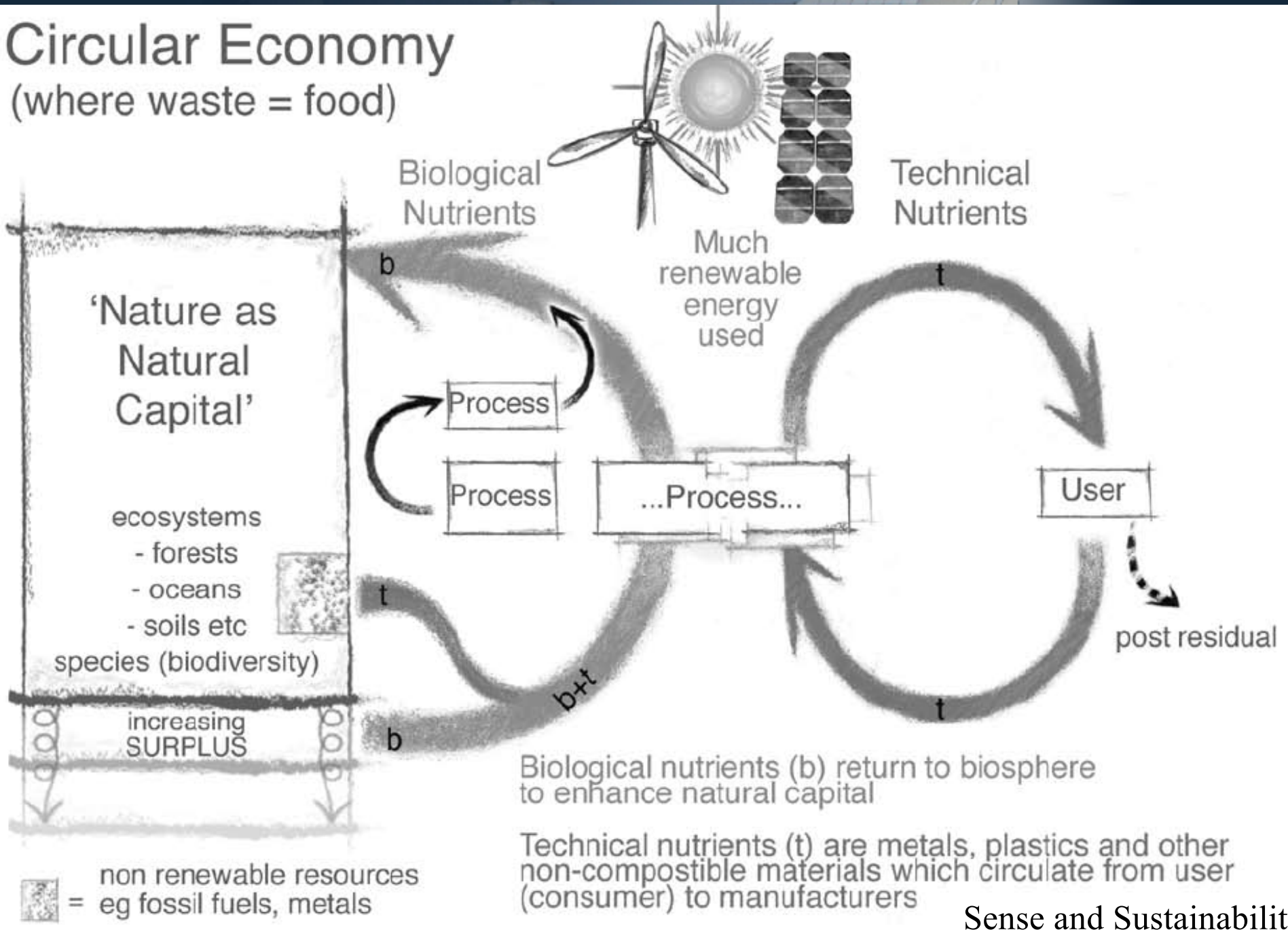




Sense and Sustainability
Ellen MacArthur Foundation, 2010

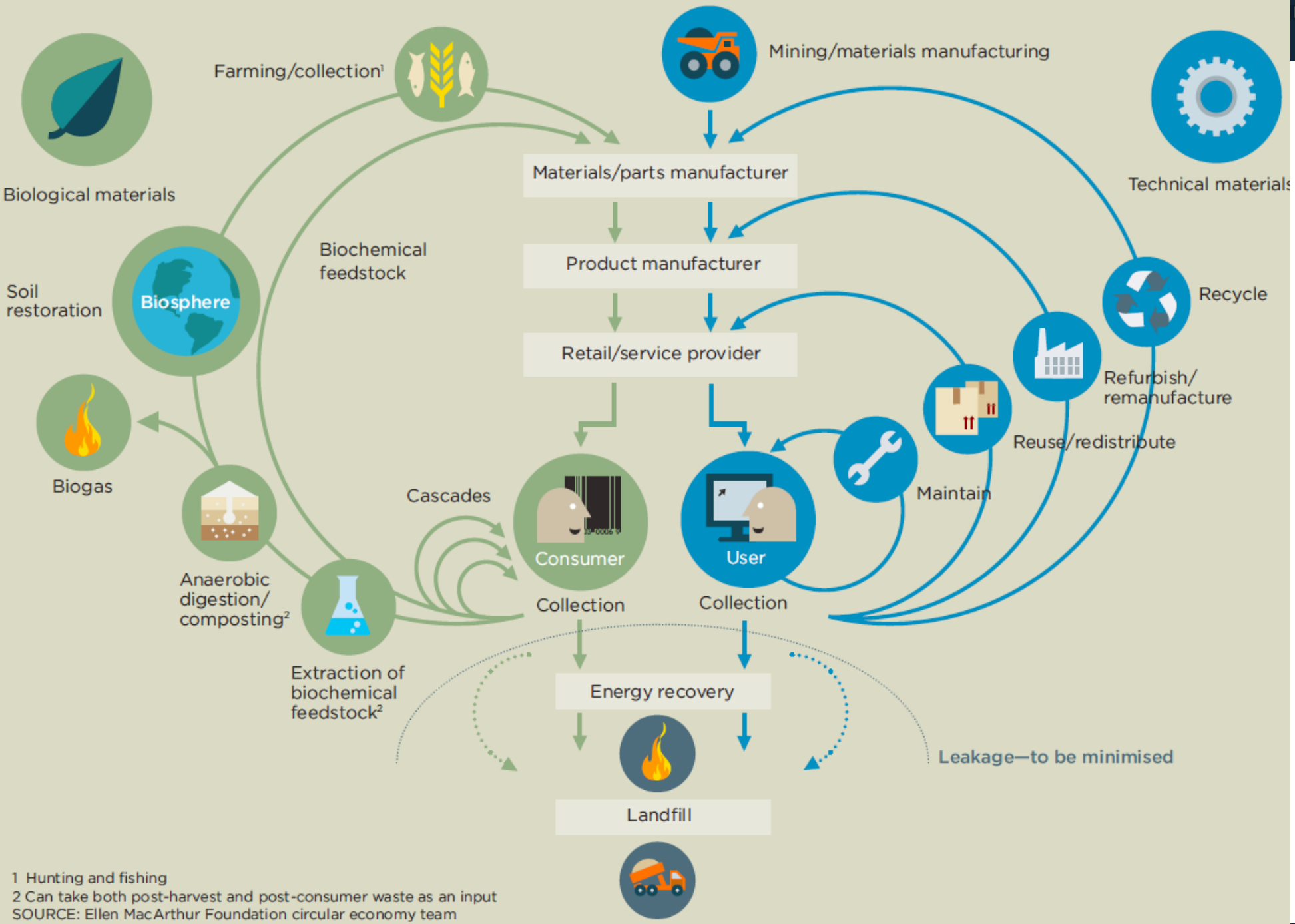
A Circular Economy

(where waste = food)



Sense and Sustainability
Ellen MacArthur, 2010

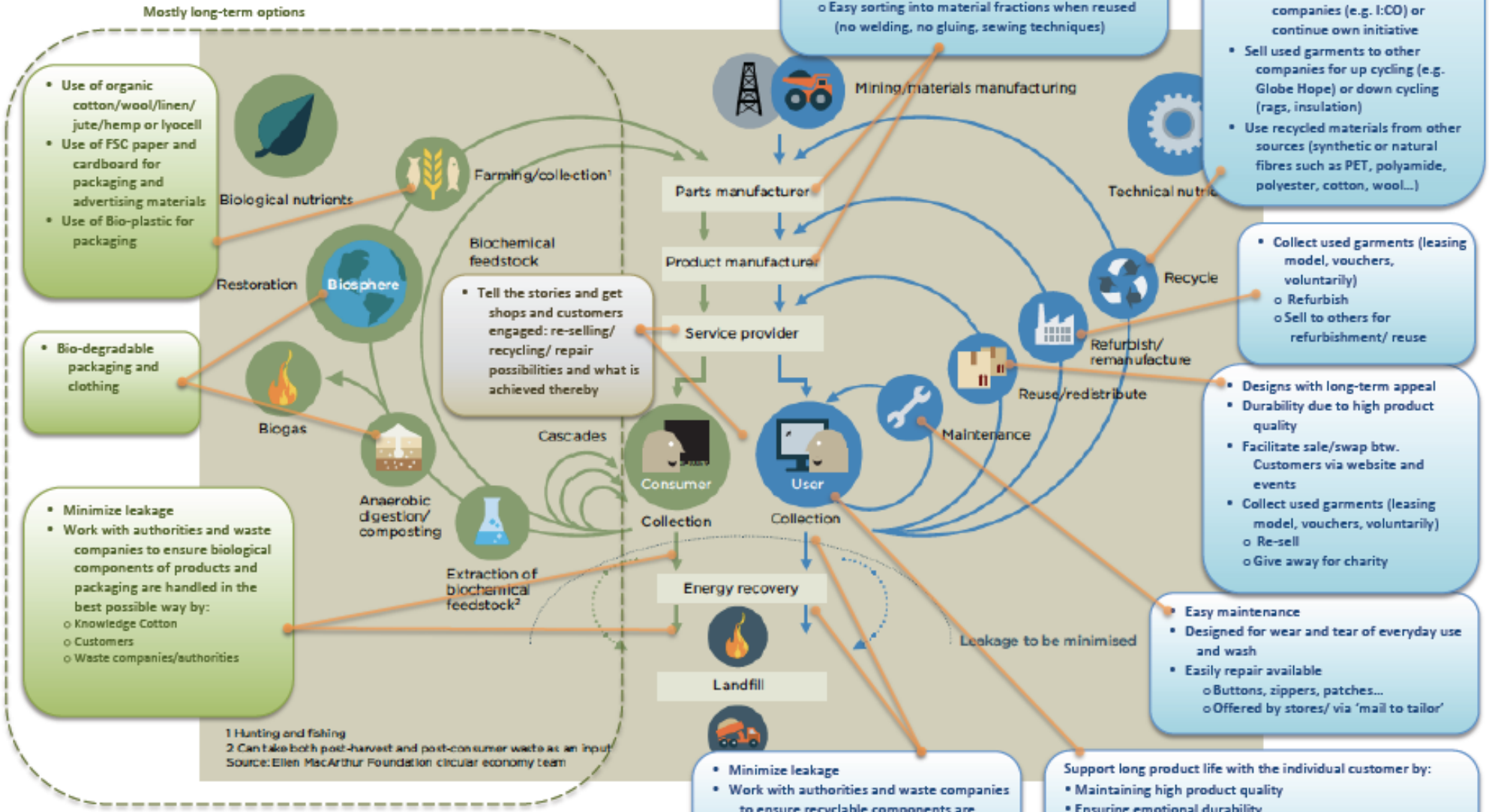
FIGURE 4 **The circular economy—an industrial system that is restorative by design**



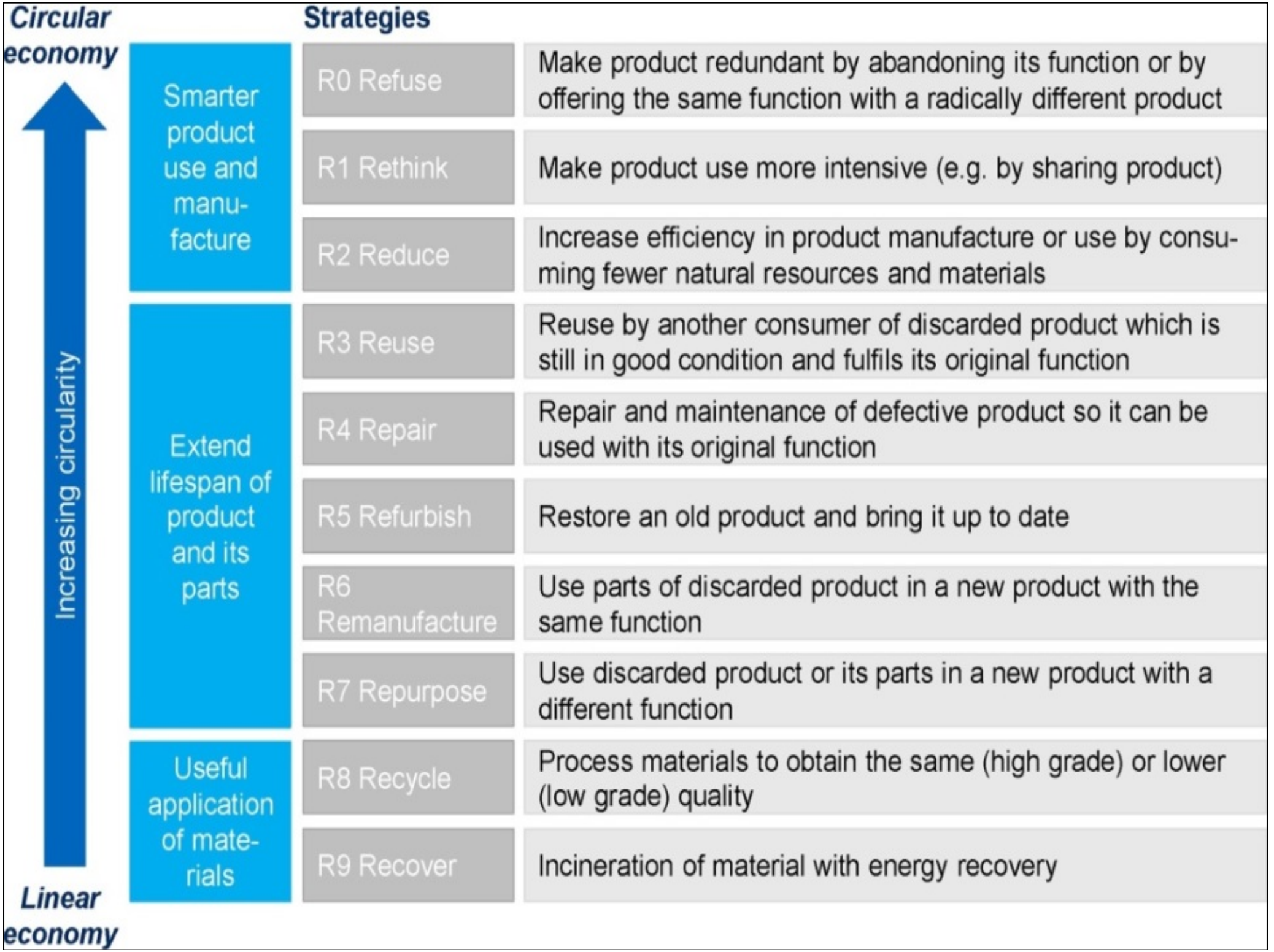
1 Hunting and fishing
2 Can take both post-harvest and post-consumer waste as an input
SOURCE: Ellen MacArthur Foundation circular economy team

KnowledgeCotton Apparel

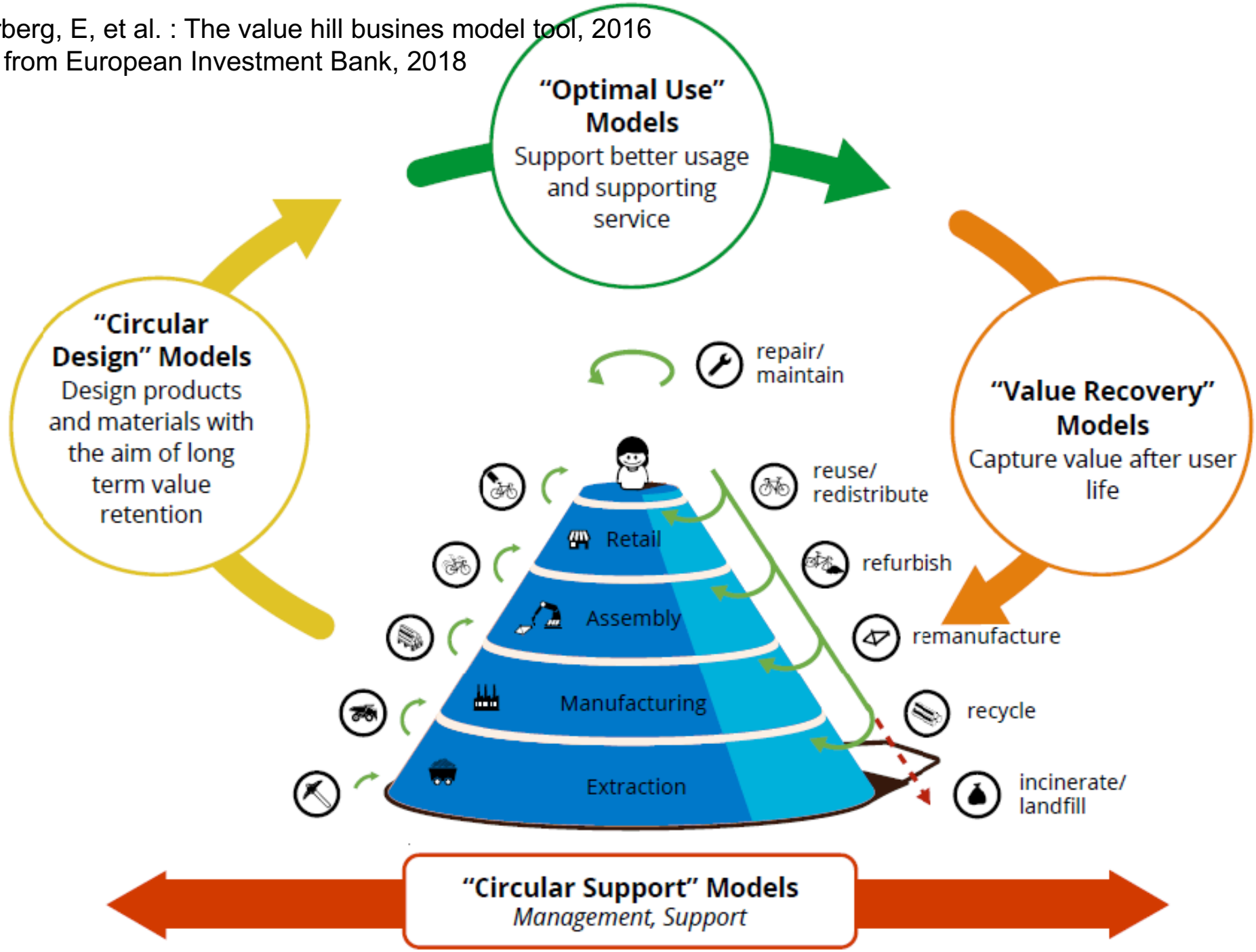
Initial mapping of Circular Economy possibilities



Modified illustration McKinsey & Company, 2012. 'The circular economy—an industrial system that is restorative by design'.


Circular economy
Linear economy
Increasing circularity
Strategies
Smarter product use and manu-facture
Extend lifespan of product and its parts
Useful application of mate-rials
R0 Refuse
Make product redundant by abandoning its function or by offering the same function with a radically different product
R1 Rethink
Make product use more intensive (e.g. by sharing product)
R2 Reduce
Increase efficiency in product manufacture or use by consu-ming fewer natural resources and materials
R3 Reuse
Reuse by another consumer of discarded product which is still in good condition and fulfils its original function
R4 Repair
Repair and maintenance of defective product so it can be used with its original function
R5 Refurbish
Restore an old product and bring it up to date
R6 Remanufacture
Use parts of discarded product in a new product with the same function
R7 Repurpose
Use discarded product or its parts in a new product with a different function
R8 Recycle
Process materials to obtain the same (high grade) or lower (low grade) quality
R9 Recover
Incineration of material with energy recovery

Acterberg, E, et al. : The value hill busines model tool, 2016
Here from European Investment Bank, 2018



Resource flows & loops

Minimising resource use per product

Extending the useful life of products

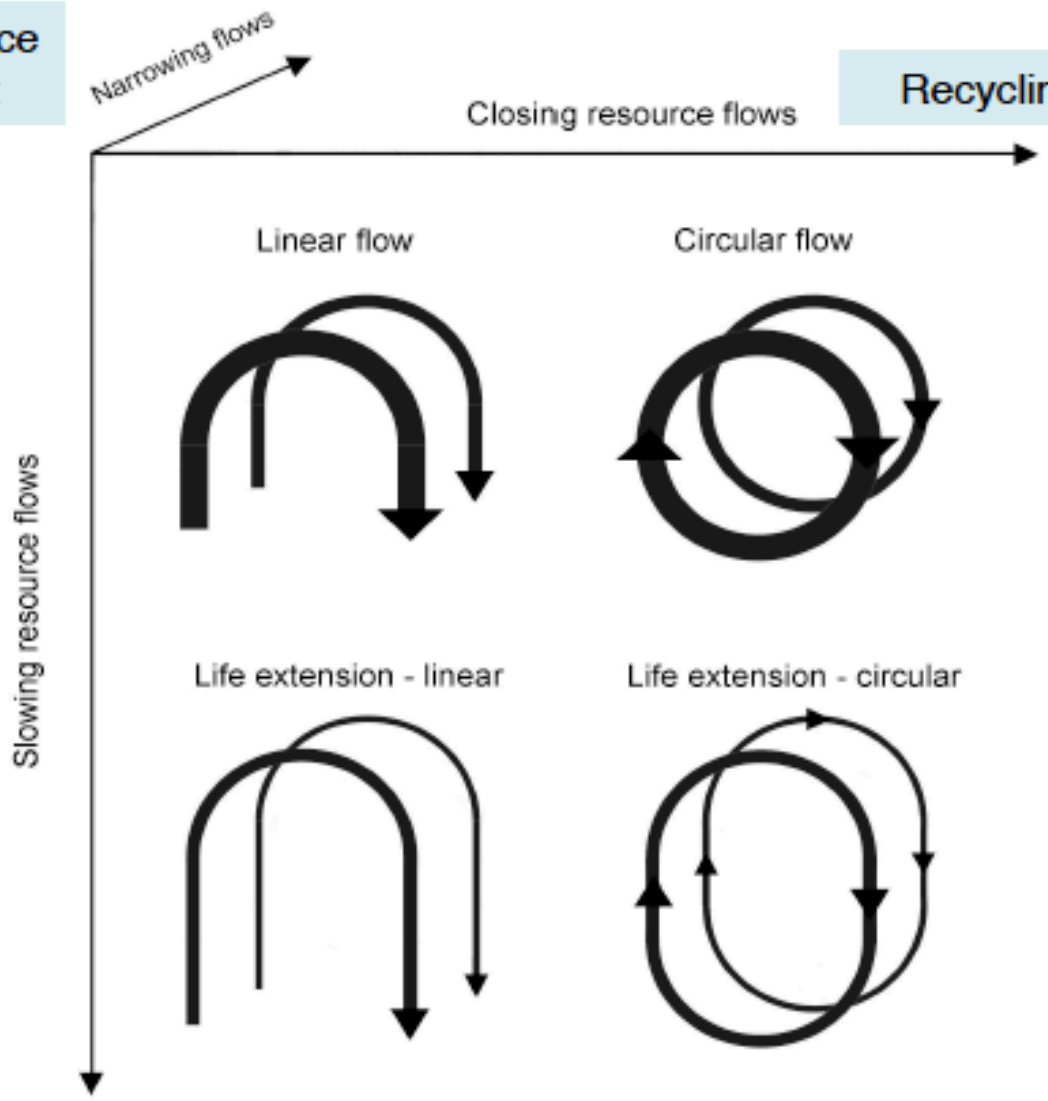


Figure: Circular Economy framework. Source: Bocken, N.M.P., de Pauw, I., van der Grinten, B., Bakker, C. 2016. Product design and business model strategies for a circular economy. J. Industrial & Production Engineering, 32 (1), 67-81.
+ Kraaijenhagen et al. 2016. Circular Business. Available at: www.circularcollaboration.com

LUND UNIVERSITY

iiiee
THE INTERNATIONAL INSTITUTE FOR INDUSTRIAL ENVIRONMENTAL ECONOMICS

Narrowing, closing and slowing

Narrowing:

- Reducing / Cleaner Production / Energy + resource efficiency / Pollution prevention /Waste minimisation /
- Eco-design / optimisation of tech + products /

Closing:

- Cradle to cradle /
- Closed loops / material recycling /
- Industrial symbiosis

Slowing:

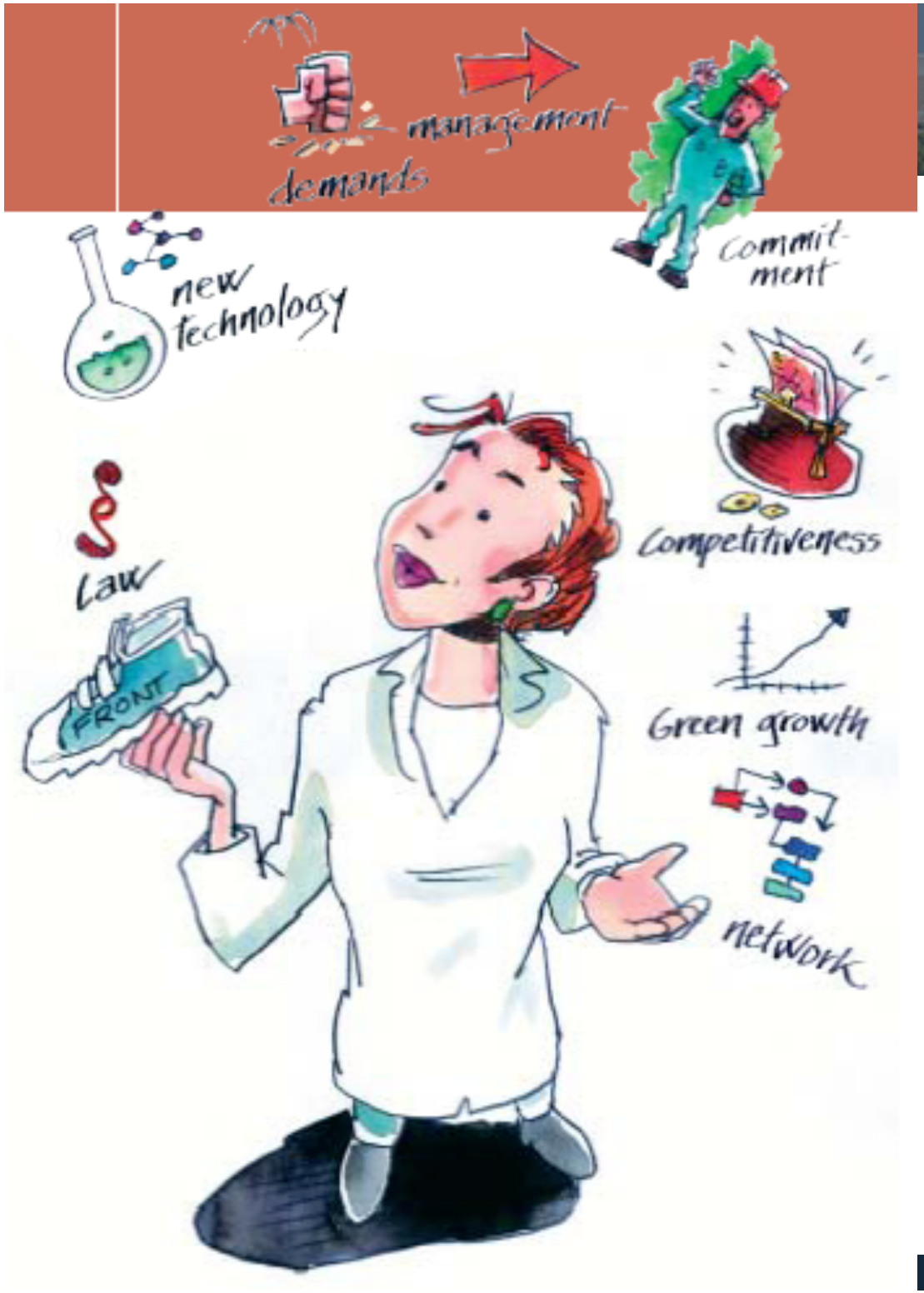
- Repair / durability / modular systems, etc. /
- Product Service Systems / Business models /Repair cafés
- Sharing economy

Circular economy - what is new?

Several experiences from cleaner production, eco-design, product-service systems, industrial ecology etc. *runs together*.

CE gives MUCH more attention to:

- Combining waste management and pollution prevention
- Revival of circular (eco)design strategies
- Business priority and business models
- System innovation
- Partnerships in the value chain and private-public



Arne Remmen
ar@plan.aau.dk
Department of
Development and Planning
Aalborg University
Denmark