

The Roots of Circular Economy

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Agenda: Where do we come from?

Sources behind circular economy – practices vs concepts

- 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.
- Towards a system perspective (Manufacturing over products to systems/IE/SCP/Sustainable transitions)



The "LINEAR" economy

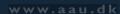
The linear economy has been the dominant model since the 50íes. The circular economy was back in time the "normal"

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

ALBORG UNIVERSITY

To maintain unit sales GM head Alfred P. Sloan Jr. suggested annual modelyear 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



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 productionconsumption system with inbuilt environmental deterioration at both ends:

FIGURE A: THE FAST-REPLACEMENT SYSTEM

depletion of natural resources

high energy and water consumption

production - use "as is" - dump according to life of was weakest component

accumulation waste

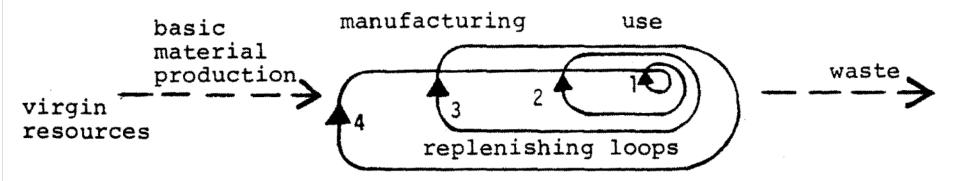
Walter Stahel: The Product Life Factor. 1981

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

2. 3. **OPERATIONAL** ORGANIZATIONAL SYSTEMS Approach OPTIMIZATION TRANSFORMATION BUILDING "New Market "Eco-Efficiency" "Societal Change" Opportunities" Novel products, services or Compliance, efficiency Novel products, services business models that are "Doing the same or business models Innovation impossible to achieve alone things better' "Doing good by doing Objective "Doing good by doing new new things' things with others" Innovation Creates shared value Reduces harm Creates net positive impact Outcome Innovation's Fundamental shift in Extends beyond the firm to Relationship drive institutional change to business as usual firm purpose to the Firm

Eco-design/cleaner products

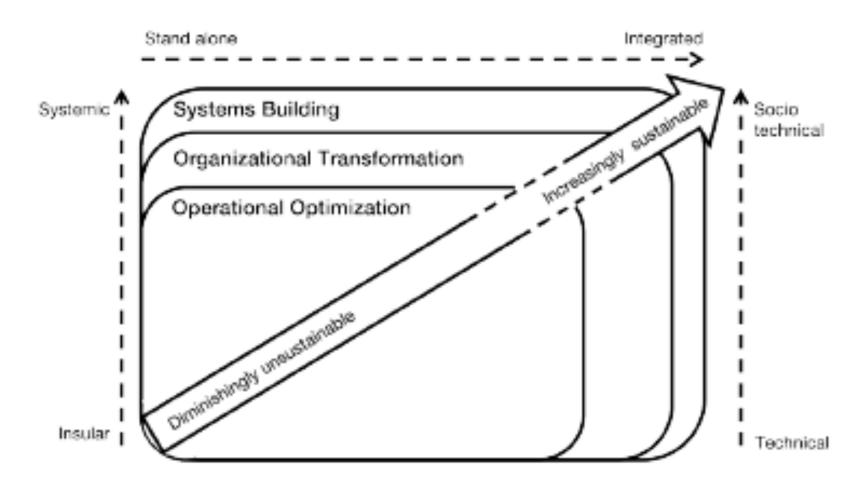
Circular economy /Industrial ecology

CSR + Life cycle management

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 railying 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.



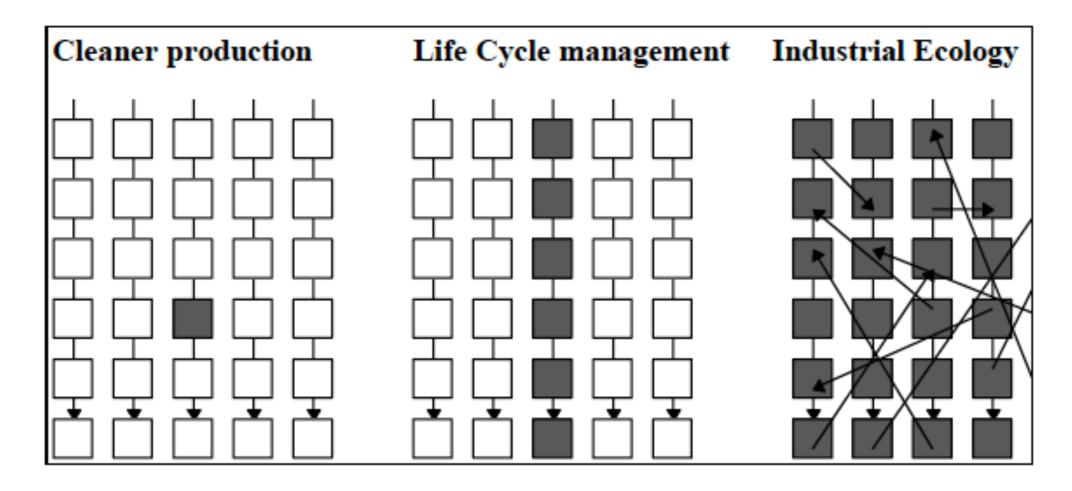


Figure 1.1 From Cleaner Production to Industrial Ecology, Hanssen and Abrahamsen (2012).



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:

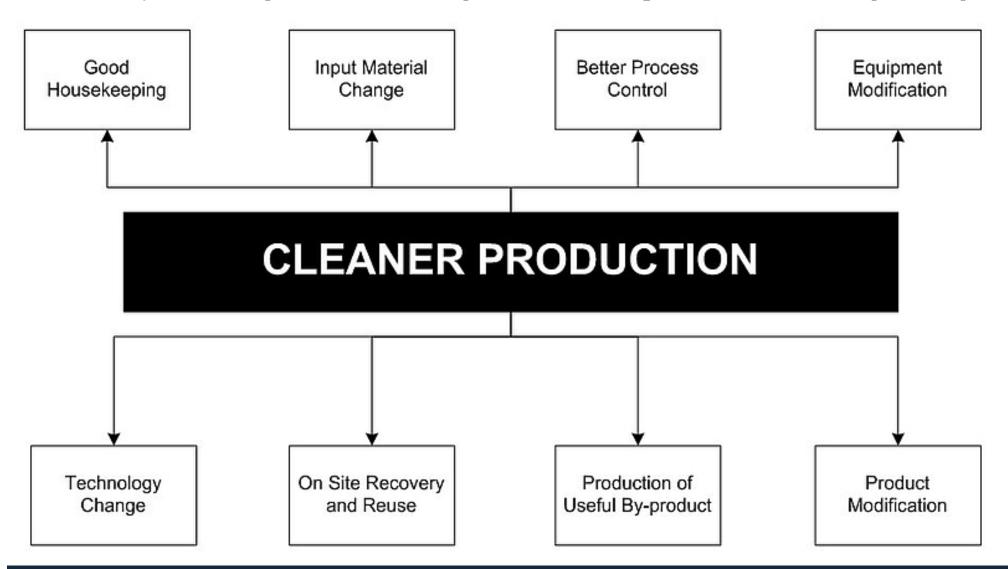
- Good Housekeeping: appropriate provisions to prevent leaks and spills and to achieve proper, standardized operation and maintenance procedures and practices;
- Input Material Change: replacement of hazardous or non-renewable inputs by less hazardous or renewable materials or by materials with a longer 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

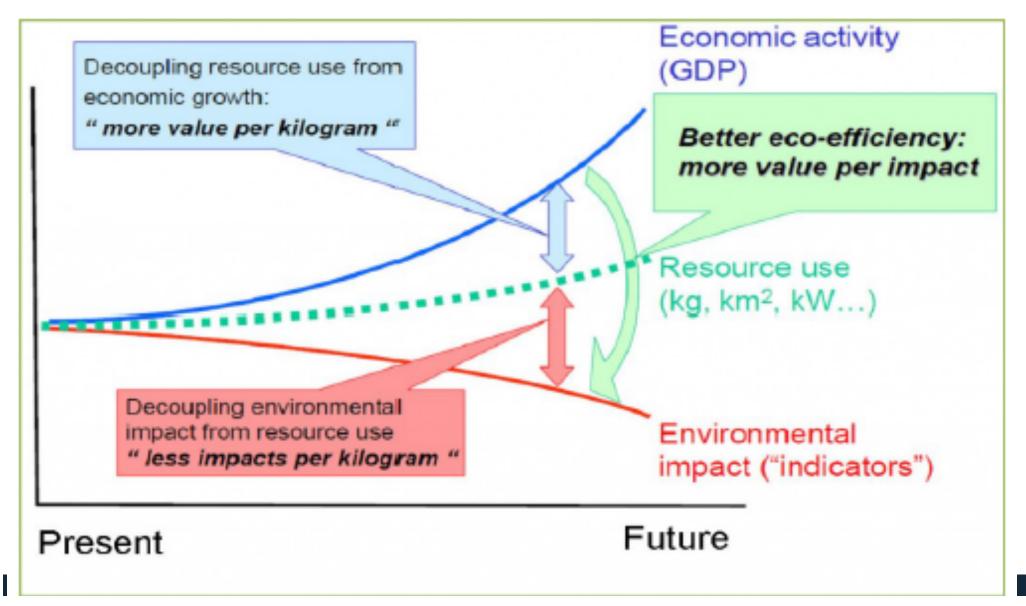
World Business Council for Sustainable Development (WBCSD) defined in 1992 (before Rio) eco-efficiency in the book 'Changing Course'. "Creating more value with less impact".

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.

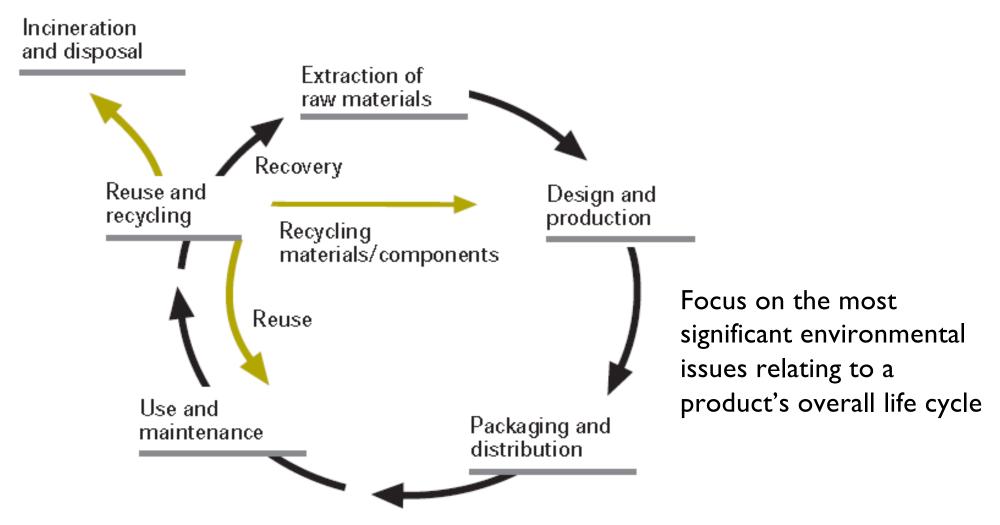


Decoupling – improved eco-efficiency





Life cycle perspective



Optimization of end-of-life system

Reuse of product

Remanufacturing/refurbishing

Recycling of materials

Clean incineration

New concept development

- Dematerialization
- Shared use of the product
- Integration of functions
- Functional optimization of product (components)

Optimization of initial life time

- Reliability and durability
- Easy maintenance and repair
- Modular product structure
- Classic design

User taking care of product

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

Efficient distribution system

- Efficient transport mode
- Efficient logistics

Selection of low-impact materials

- Non-hazardous materials
- Non-exhausible materials
- Low-energy content materials
- Recycled materials
- Recyclable materials

Reduction of material

- · Reduction in weight
- Reduction in (transport) volume

Optimization of production techniques

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







Designing-out-waste 14RE

- eco-design principles
- **Re-**think functions
- Reduce 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/Reconditioning
- 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





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	Collaboration - mid-term	Partnerships - long-term



PRODUCT

SERVICE

SYSTEM

- Price
- Quality
- Design
- Eco-label

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

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

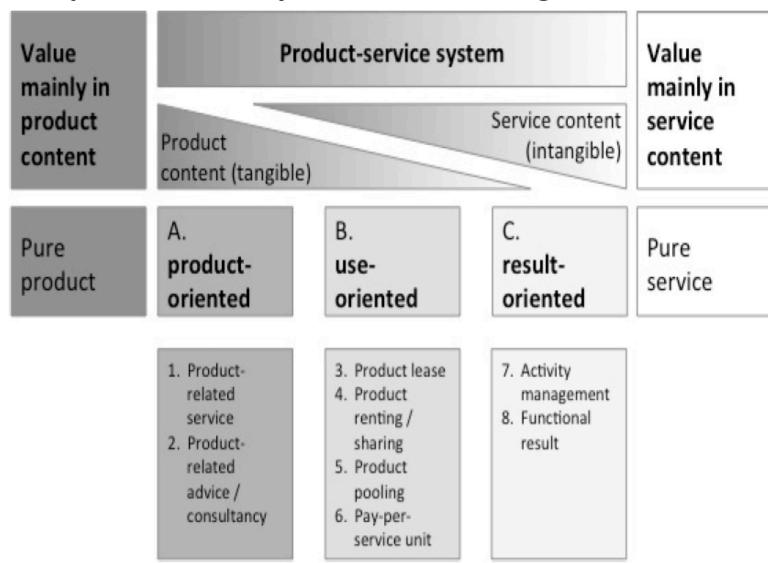
 SALE of product

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

Groupings	Technological			Social			Organisational	
Archetypes	Maximise material and energy efficiency	Create value from waste	Substitute with renewables and natural processes	Deliver functionality rather than ownership	Adopt a stewardship role	Encourage sufficiency	Repurpose for society/ environment	Develop scale up solutions
Examples	Low carbon manufacturing/ solutions Lean manufacturing Additive manufacturing De-materialisation (of products/ packaging) Increased functionality (to reduce total number of products required)	Circular economy, closed loop Cradle-2-Cradle Industrial symbiosis Reuse, recycle, re-manufacture Take back management Use excess capacity Sharing assets (shared ownership and collaborative consumption)	Move from non- renewable to renewable energy sources Solar and wind- power based energy innovations Zero emissions initiative Blue Economy Biomimicry The Natural step Slow manufacturing Green chemistry	Product-oriented PSS- maintenance, extended warrantee Use oriented PSS-Rental, lease, shared Result-oriented PSS-Pay per use Private Finance Initiative (PFI) Design, Build, finance, Operate (DBFO) Chemical Management Services (CMS)	Biodiversity protection Consumer carepromote consumer health and well-being Ethical trade (fair trade) Choice editing by retailers Radical transparency about environmental/ societal impacts Resource stewardship	Consumer Education (models); communication and awareness Demand management (including cap & trade) Slow fashion Product longevity Premium branding/limited availability Frugal business Responsible	Not for profit Hybrid businesses, Social enterprise (for profit) Alternative ownership: cooperative, mutual, (farmers) collectives Social and biodiversity regeneration initiatives ('net positive') Base of pyramid solutions	Collaborative approaches (sourcing, production, lobbying) Incubators and Enterpreneur support models Licensing, Franchising Open innovation (platforms) Crowd sourcing/ funding "Patient/slow capital" collaborations
		Extended producer responsibility				product distribution/ promotion	Home based, flexible working	



Business models (link to consumption patterns and volume)

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

Priorities

Unless something else is better for the environment

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



Preparation for reuse

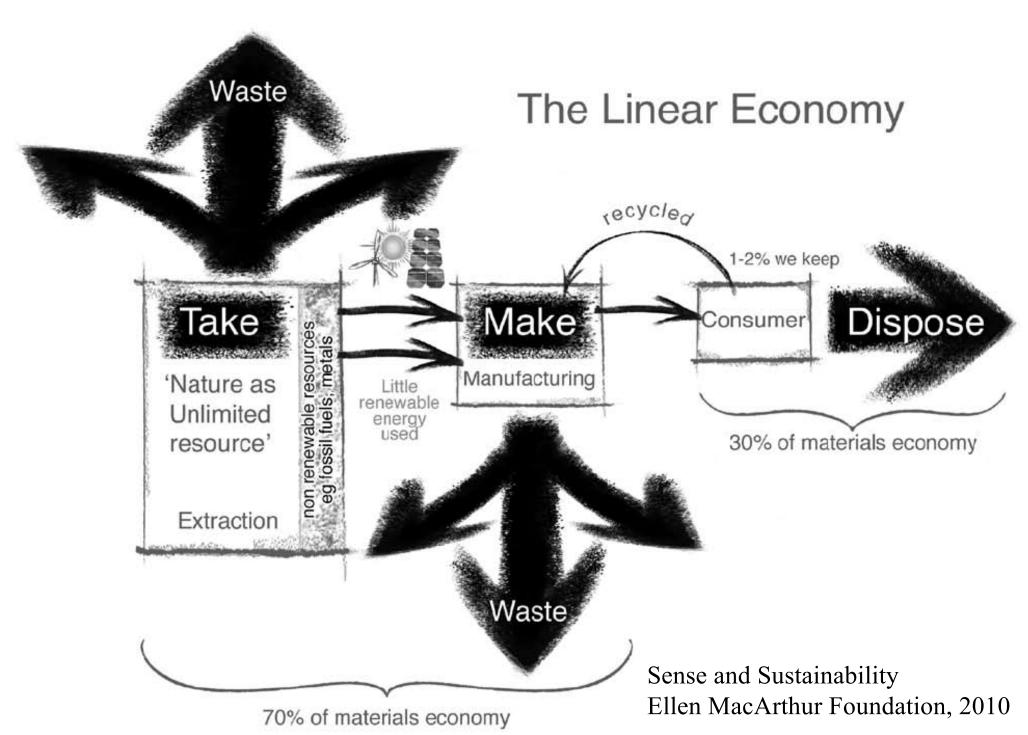
Recycling

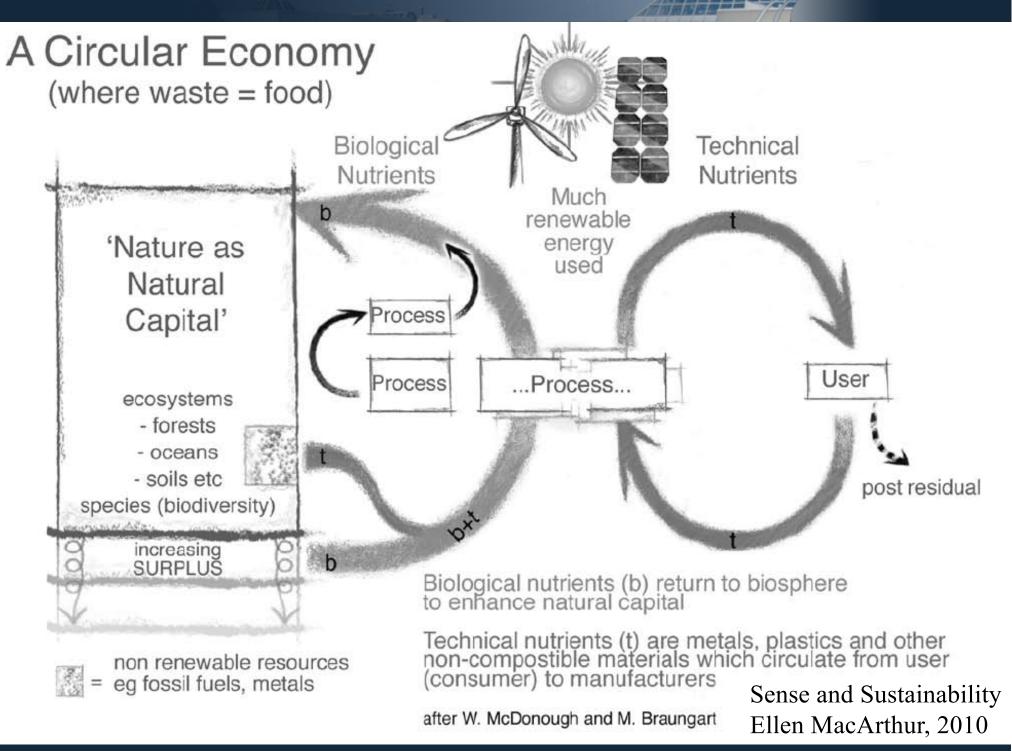
Incineration

Disposal











Initial mapping of Circular Economy possibilities

- Mostly long-term options jute/hemp or lyocell . Use of FSC paper and cardboard for Farming/collection packaging and advertising materials Biological nutrients . Use of Bio-plastic for packaging Biochemical feedstock Bicsphere Restoration · Tell the stories and get shops and customers engaged: re-selling/ · Bio-degradable recycling/ repair packaging and possibilities and what is clothing achieved thereby Biogas Cascades Anaerobic Minimize leakage diaestion/ · Work with authorities and waste composting companies to ensure biological components of products and Extraction of packaging are handled in the biochemical feedstock² best possible way by: o Knowledge Cotton o Customers o Waste companies/authorities 1 Hunting and fishing 2 Can take both post-harvest and post-consumer waste as an input Source: Ellen MacArthur Foundation circular economy team Modified illustration McKinsey & Company, 2012. The circular economy-an industrial system that is restorative by design'.
- · Eco-design of products: o Choice of material (e.g. organic, non-toxic, recyclable/recycled, mono-material, durable) o Design for repair and upgrading/refreshment o Dematerialization (reducing weight of apparel and o Easy sorting into material fractions when reused (no welding, no gluing, sewing techniques) Mining/materials manufacturing Parts manufacturer Technical nutr Product manufacture Recycle Service provider Refurbish/ remanufacture Reuse/redistribute Maintenance Collection
 - Collect and recycle garments
 - o From own collections (50% recycled organic material, 50% virgin organic)
 - o From other manufacturers
 - o Work with collection companies (e.g. I:CO) or continue own initiative
 - · Sell used garments to other companies for up cycling (e.g. Globe Hope) or down cycling (rags, insulation)
 - · Use recycled materials from other sources (synthetic or natural fibres such as PET, polyamide, polyester, cotton, wool...)
 - · Collect used garments (leasing model, vouchers, voluntarily)
 - o Refurbish
 - o Sell to others for refurbishment/ reuse
 - Designs with long-term appeal
 - · Durability due to high product quality
 - Facilitate sale/swap btw. Customers via website and
 - Collect used garments (leasing) model, vouchers, voluntarily) o Re-sell
 - o Give away for charity

Energy recovery



Landfil

Collection

Leakage to be minimised

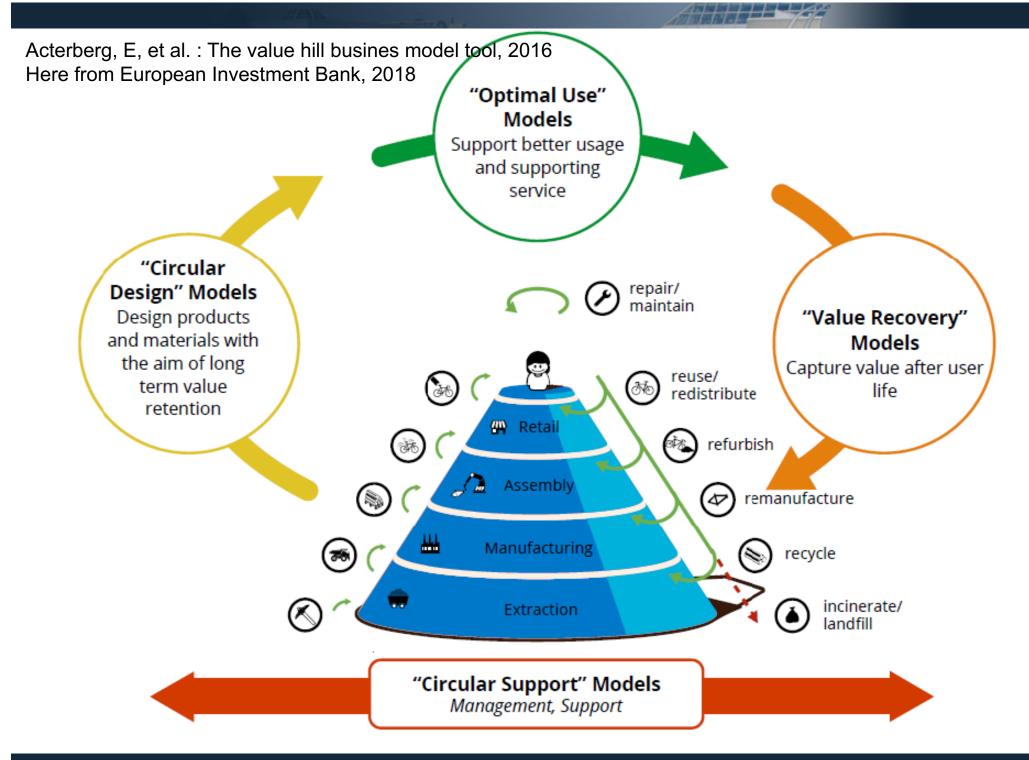
- Easy maintenance
- · Designed for wear and tear of everyday use and wash
- · Easily repair available
 - o Buttons, zippers, patches...
 - o Offered by stores/ via 'mail to tailor'

- Minimize leakage
- Work with authorities and waste companies to ensure recyclable components are handled in the best possible way by:
 - o Knowledge Cotton
 - o Customers
 - o Waste companies/ authorities

Support long product life with the individual customer by:

- Maintaining high product quality
- Ensuring emotional durability
- o Classical styles and colours
- o Include last season styles in new season advertising to show combo possibilities and 'is not out-dated' attitude
- o Community forums and events for experience sharing

CE Inspirational illustration KnowledgeCottonApparel 1.0.docx/ Eva Guldmann



Resource flows & loops

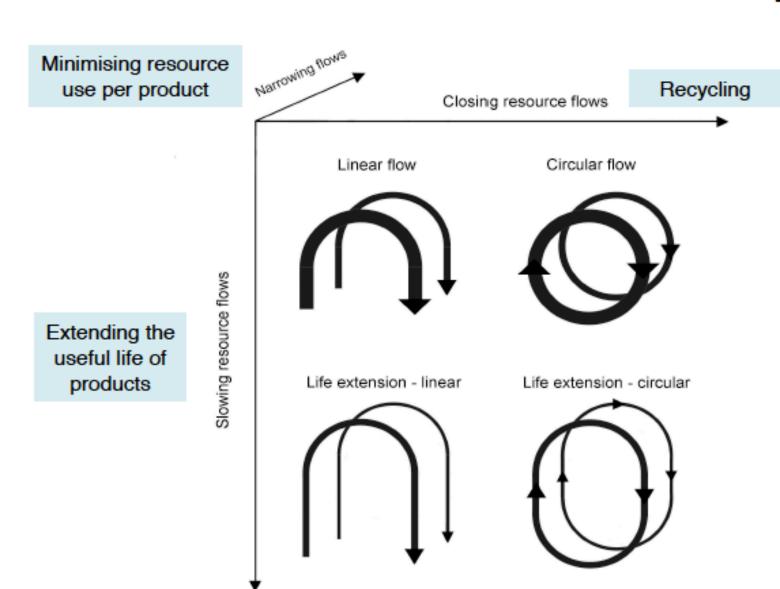








Figure: Circular Economy framework. Source: Bocken, N.M.P., de Pauw, I., van der Grinten, B., Bakker, C. 2016. Product design and business model strategies for a circular economy. J. Industrial & Production Engineering, 32 (1), 67-81. + Kraaijenhagen et al. 2016. Circular Business. Available at: www.circularcollaboration.com



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

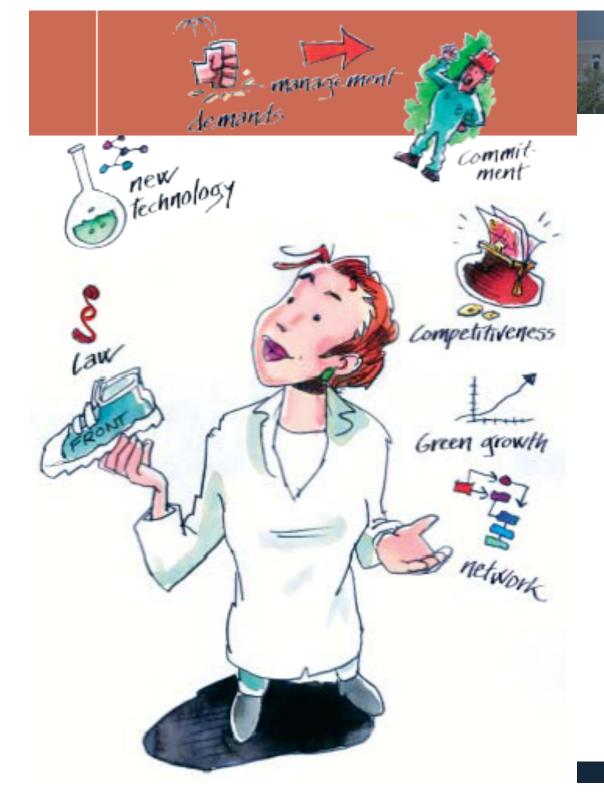


Circular economy - what is new?

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



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