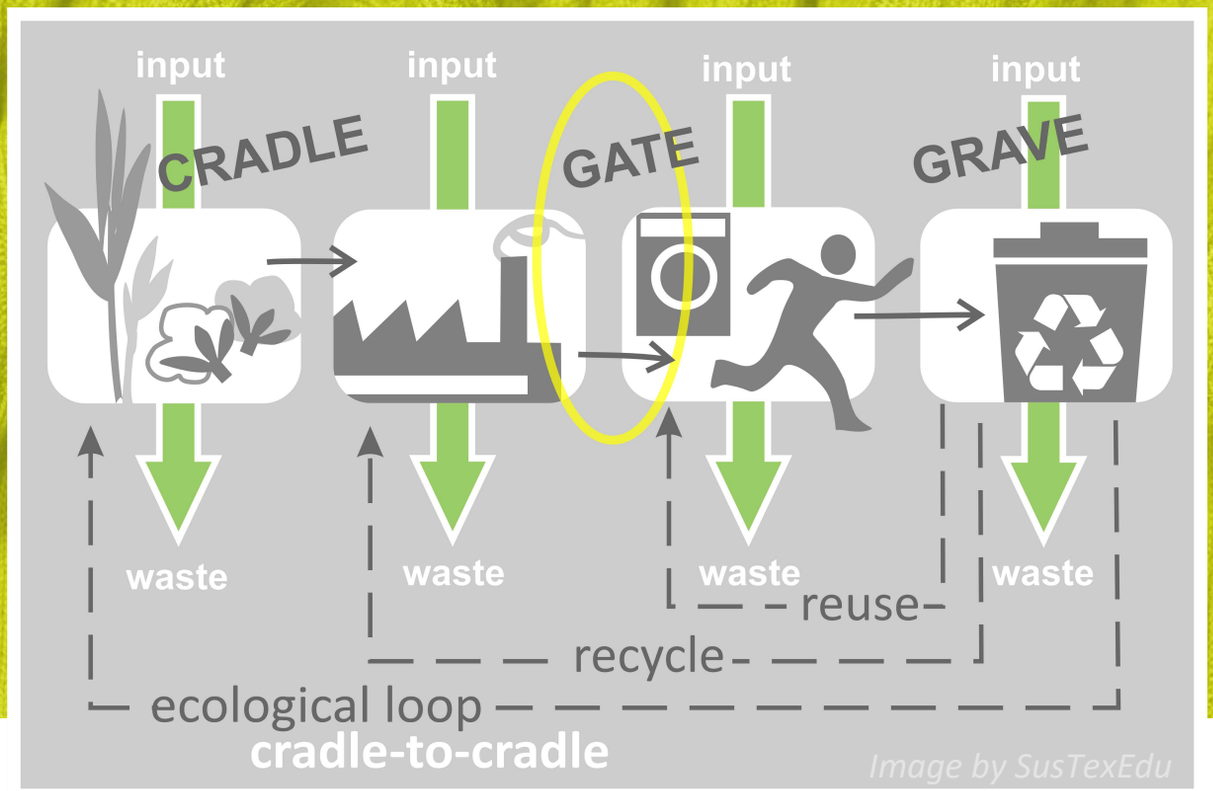

Photo by Essi Karell

This open educational resource has been developed by:

Karin Lindroos, TTK UAS
(Tallinna Tehnikakõrgkool)

5.7 Introduction of Life Cycle Assessment Tools

SusTexEdu

Funded by the Erasmus+ Programme of the European Union

SusTexEdu | Erasmus+

The objectives of the project concern Textile and Clothing (TC) sector, focusing on textile and clothing materials, sustainability and circular economy (CE). The project will create an open platform with study material and recommendations for developing an integrated formal and informal education which concerns the subjects mentioned.
https://www.metropolia.fi/en/rdi/rdi-projects/sustexedu-erasmus

The Coordinator: Metropolia UAS
The partners: Hogent (BE), Mome (HU), Omnia (FI), TTHK (EE), TTK UAS (EE), University of Borås (SE)
Funding: Erasmus +
Duration: 2022–2024

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About the use of study material:

This educational material forms a learning package that will be tested in the project's partner organizations in the fall of 2023.

As this study material is still in the testing phase, it should not be distributed to people outside the course.

Students are asked for feedback about the study unit with an electronic survey, the answer to which is optional.

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Organizational aspects of learning …

CONTENT

- Environmental management tools related to an environmentally friendly product
- Product life cycle assessment
- Life cycle assessment standard ISO14044
- Introduction of OpenLCA tool, sample model and its interpretation (cotton sweater with hood and zipper).

LEARNING OUTCOMES

After completing the course, the student will be able to:

- explain the principles and necessity of life cycle assessment
- describe the different stages of life cycle assessment, while understanding the importance of a holistic approach.
- use the life cycle assessment tool OpenLCA at the initial level.

WORKLOAD

At TTK, the study module corresponds to one (1) credit, i.e. xx hours:

- Lectures, 2 x 2 hours
- learning activities, 2x2.5 hours
- Independent reading assignment, 6 hours
- Electronic mini-exam, 12 hours

Contents

Life Cycle assessment

Life cycle Assessment tools

Environmental performance improvement tool

LCA standardization

Product oriented aspects and LCA

Cradle to cradle concept

Goal and Scope

Inventory analysis

Linear model with Open LCA

Centralized model with Open LCA

LCA Interpretation

LCA Application

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Environmental performance improvement tools

- Process-oriented tools
- Product oriented tools
- Life cycle/whole supply chain oriented approach
- Environmental awareness management tools
- Other initiatives, e.g. oriented towards affiliated groups, etc

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Product oriented environmental management tools

- Life Cycle Assessment
- Ecolabels (requiring verification) and environmental declarations.
- Environmentally friendly product development - eco-design
- A life-cycle approach is an action aimed at reducing the environmental impact of the life cycle of a product or service and closing the circle.
- The life cycle-based approach is used, for example, in environmental management, eco-labeling, environmentally friendly product development and comprehensive product policy.

LCA standardization

ISO 14044

The International Organization for Standardization (ISO) has issued several guidelines for conducting life cycle assessment.

Principles and requirements of the life cycle assessment process
ISO 14044:2006 Life cycle assessment. Requirements and instructions for use (the standard is reviewed every 5 years)

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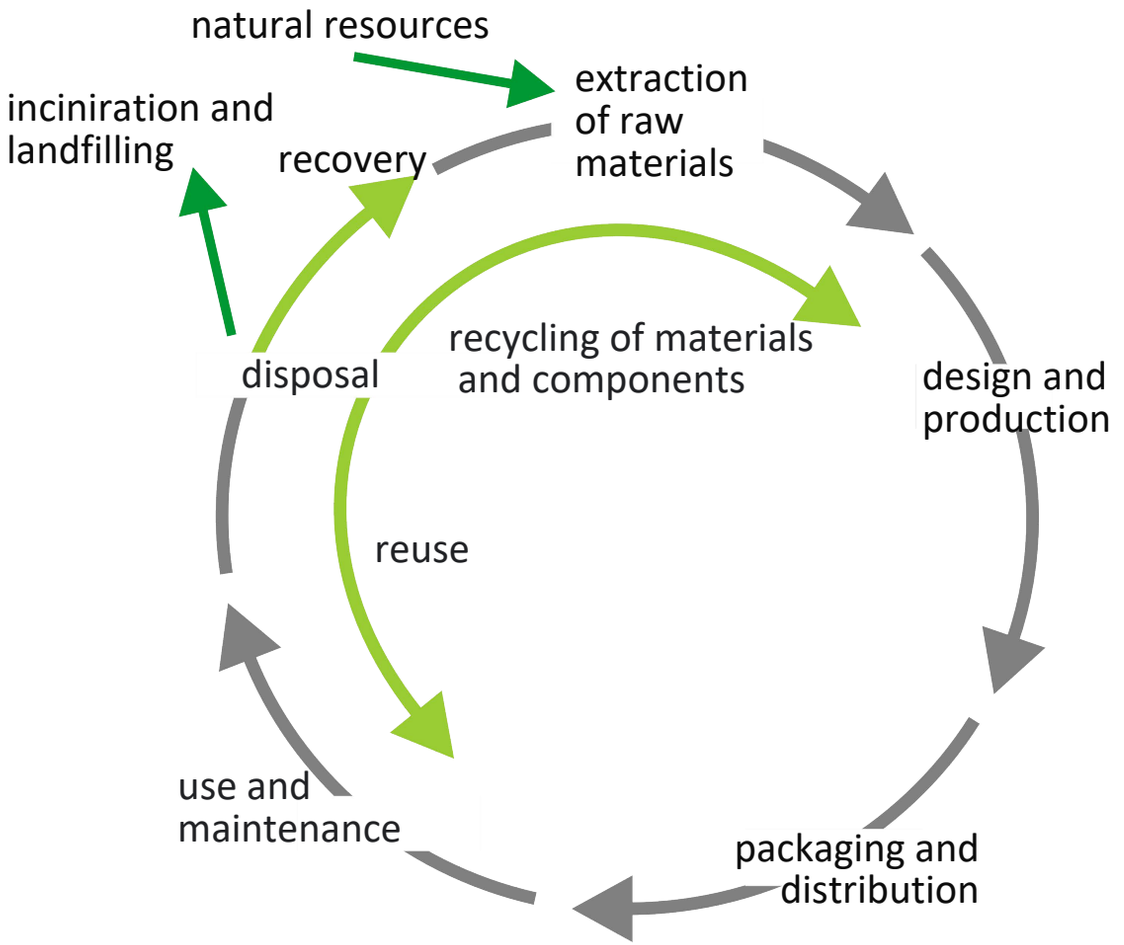
Life Cycle assessment

Life cycle assessment or LCA is a methodology for assessing the environmental impacts of a particular product or process throughout its life cycle.



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... Life Cycle Assessment

Typical life cycle is as follows:

Procurement of raw materials
→ **manufacturing,** pre-processing, development and design, processing/production (production of components, assembly of the product, completion of the final product)
→ (packaging), distribution
→ use, reuse
→ removal from use
→ diverting waste to a new cycle (secondary raw material).

Input/output analysis, material efficiency (material flows) and energy efficiency analysis.

In order to implement the entire "green" innovation process, we need a life-cycle (life cycle-based) approach - LCA (LC assessment) methodology + adding a social dimension to it.

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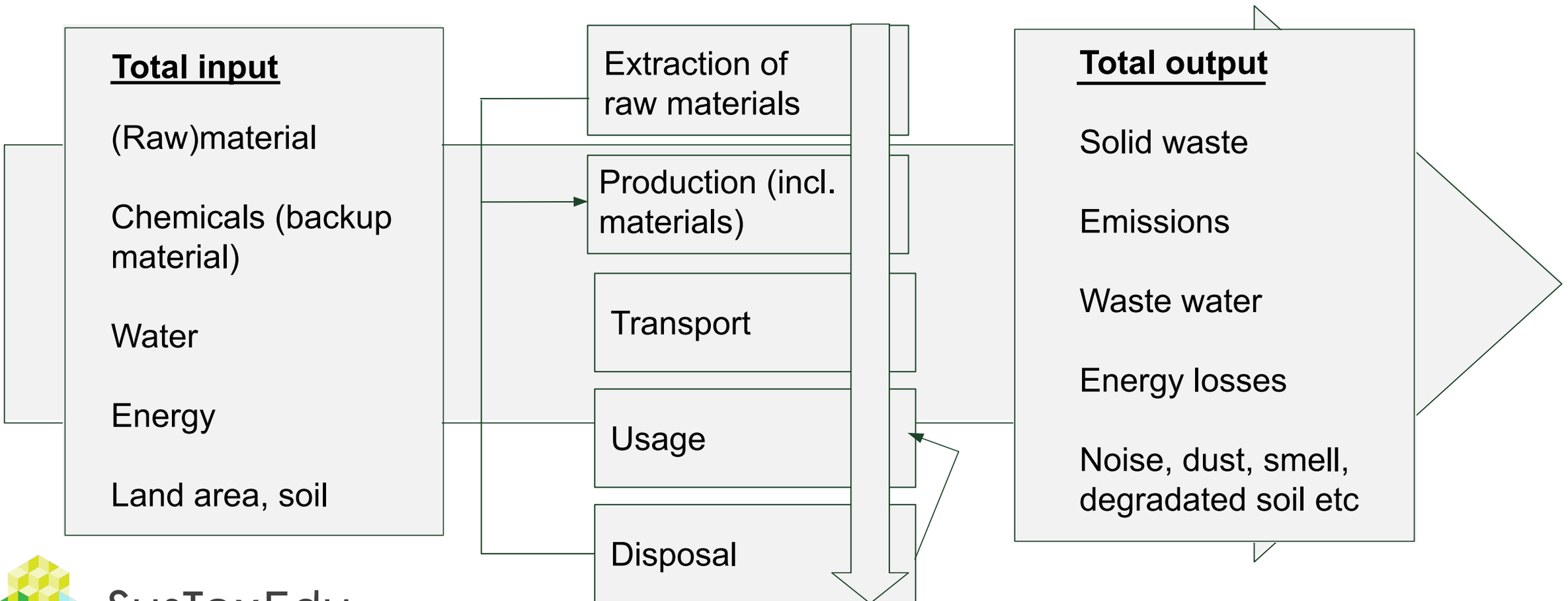
Product oriented aspects and LCA



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... Life Cycle assessment

The life cycle is a chain of successive and interconnected stages of a product/service "cradle to cradle" or "cradle to grave".

A life-cycle approach is an action aimed at reducing the environmental impact of the life cycle of a product or service and closing the circle (closed loop, circular economy).

- The description of the product's life cycle begins with the selection of materials during the manufacture of the product, the consumption and production of energy resources to the use of the product, waste management and final disposal. Including product packaging and transportation throughout the entire life cycle.
- The life cycle-based approach is used in environmental management, ecolabeling, environmentally friendly product development and comprehensive product policy.

... Life Cycle Assessment

- Life Cycle Assessment (LCA) is an approach that assesses the full environmental impact of a product throughout its life cycle.
- Life cycle assessment (LCA) is an environmental management tool that assesses the full environmental impact of a product or service throughout its life cycle.
- To assess the life cycle, the following must be added up:
  - inputs (material consumption and energy)
  - outputs (waste water, waste gas, waste) throughout the life cycle of the product or service
  - the environmental impact of full-cycle transport
- The impact of all inputs and outputs is assessed. For this purpose, the resource and energy consumption and the impact on the environment are summed up, from the acquisition of the raw materials necessary for the production to the disposal of the product after use.
- NB! Attention is to be paid on the reuse of the product.

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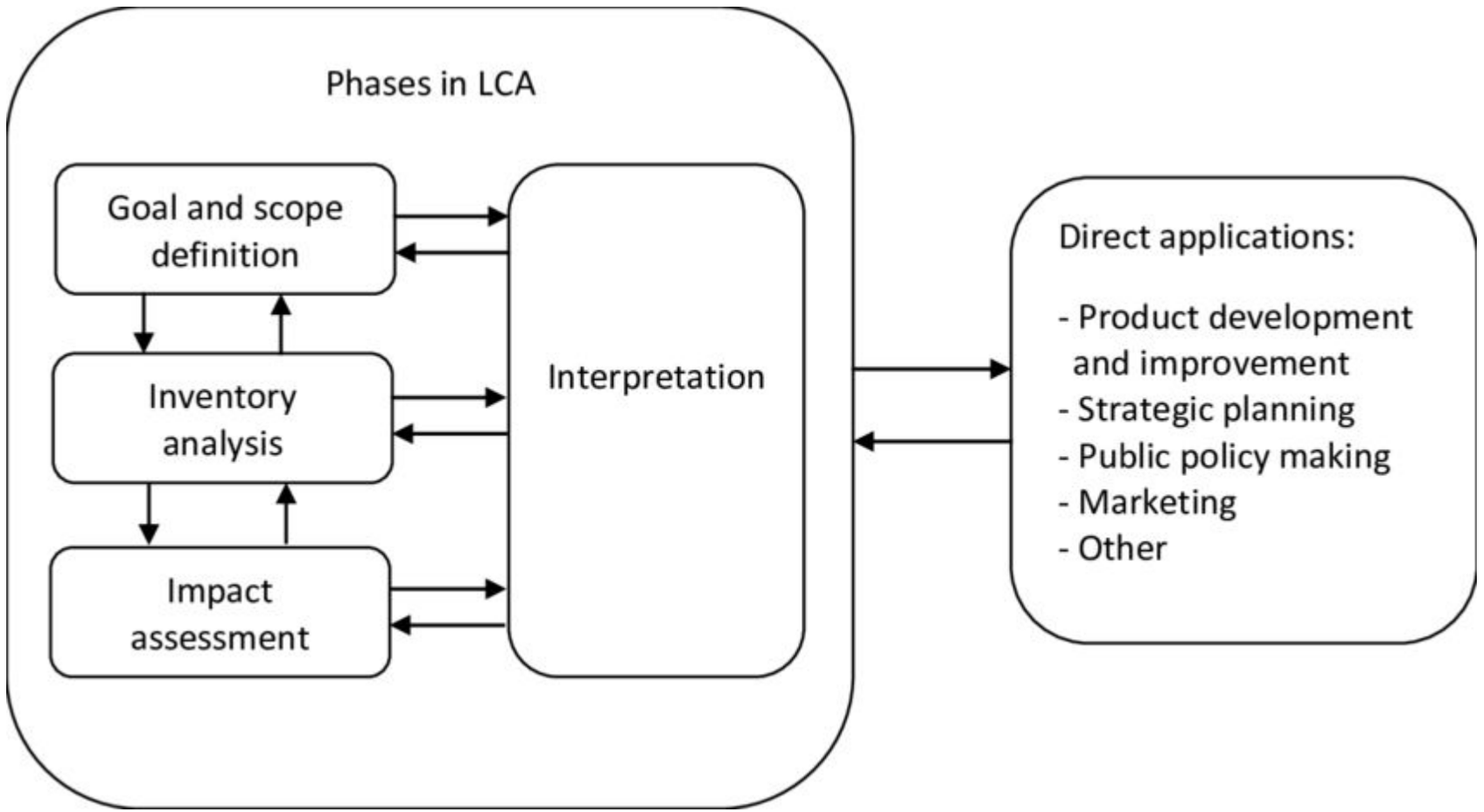
ISO14044. Life cycle (LC) assessment framework derived from ISO14044 (also includes previous standards)



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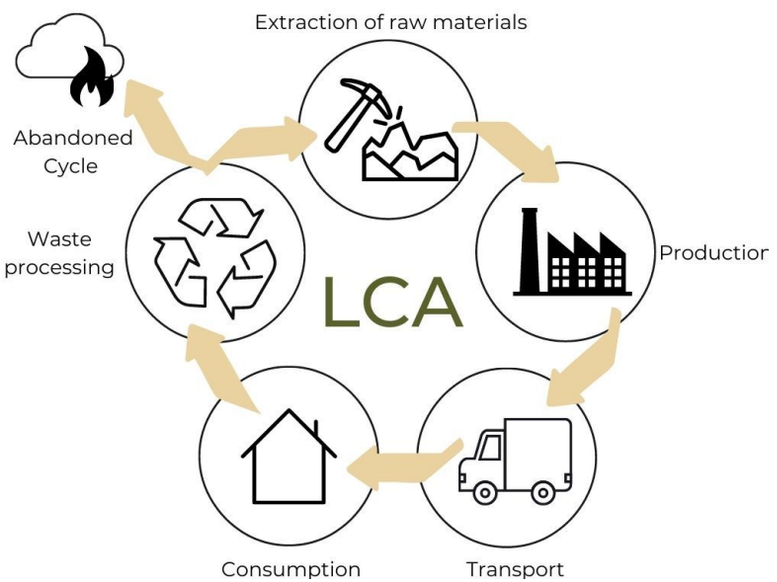
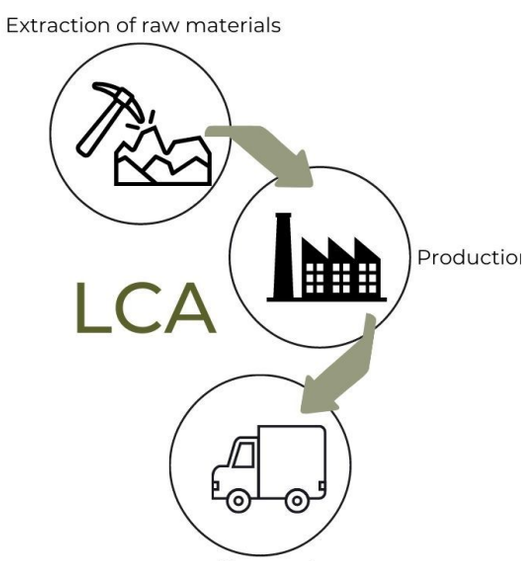
... Life Cycle assessment

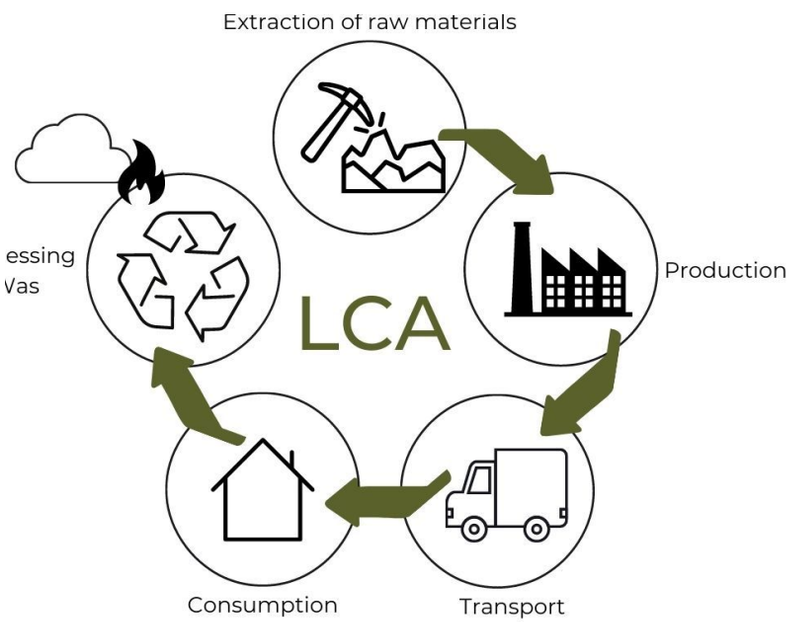
Cradle to cradle



Cradle to gate



Cradle to grave



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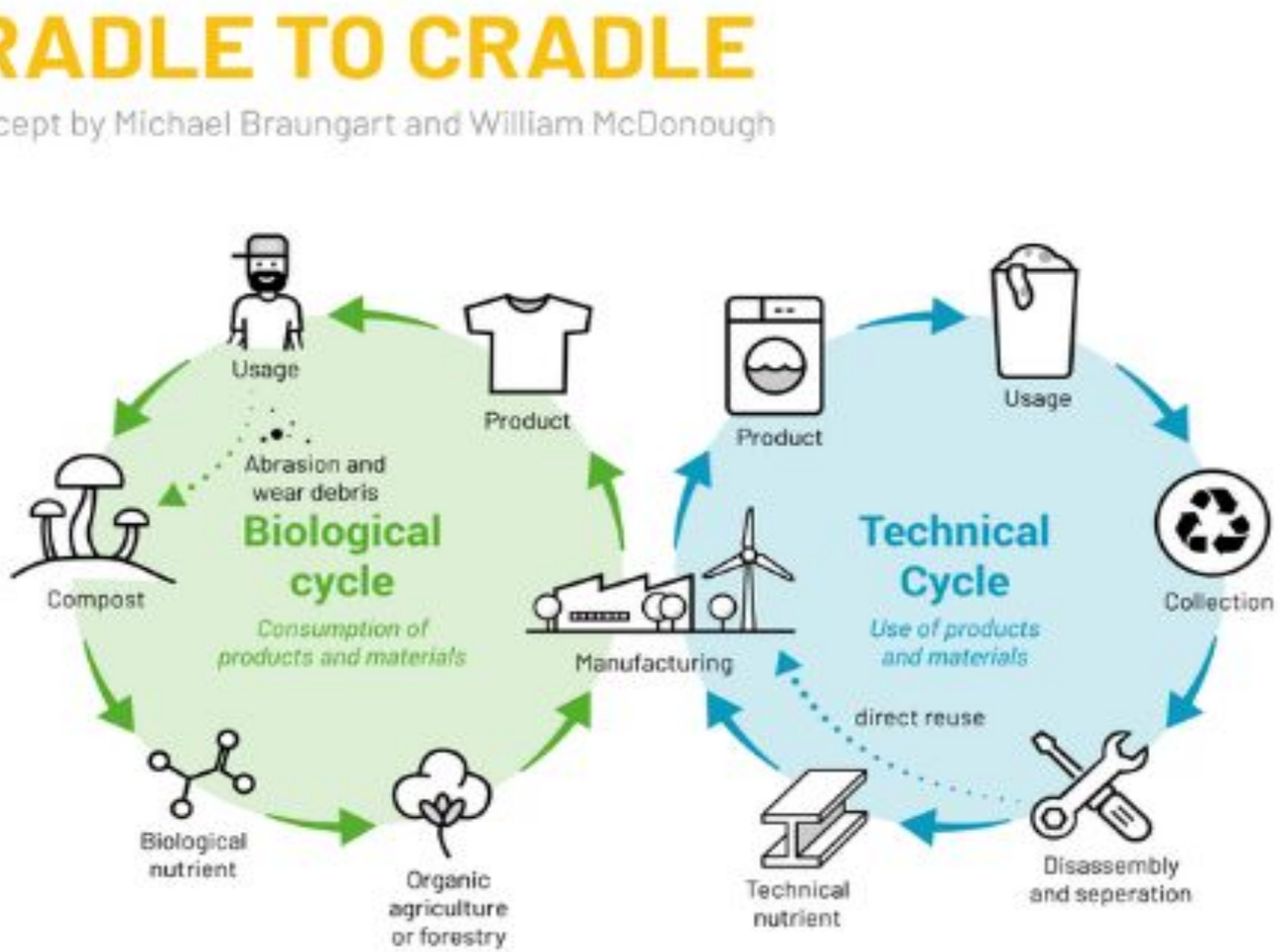
Cradle to cradle concept (M.Braungart, W.McDonough)



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LCA assessment

Creating the CONTEXT

Consumption - i.e Europe
Materials, fabrics - i.e cotton
Origin - va 50% cotton comes from India

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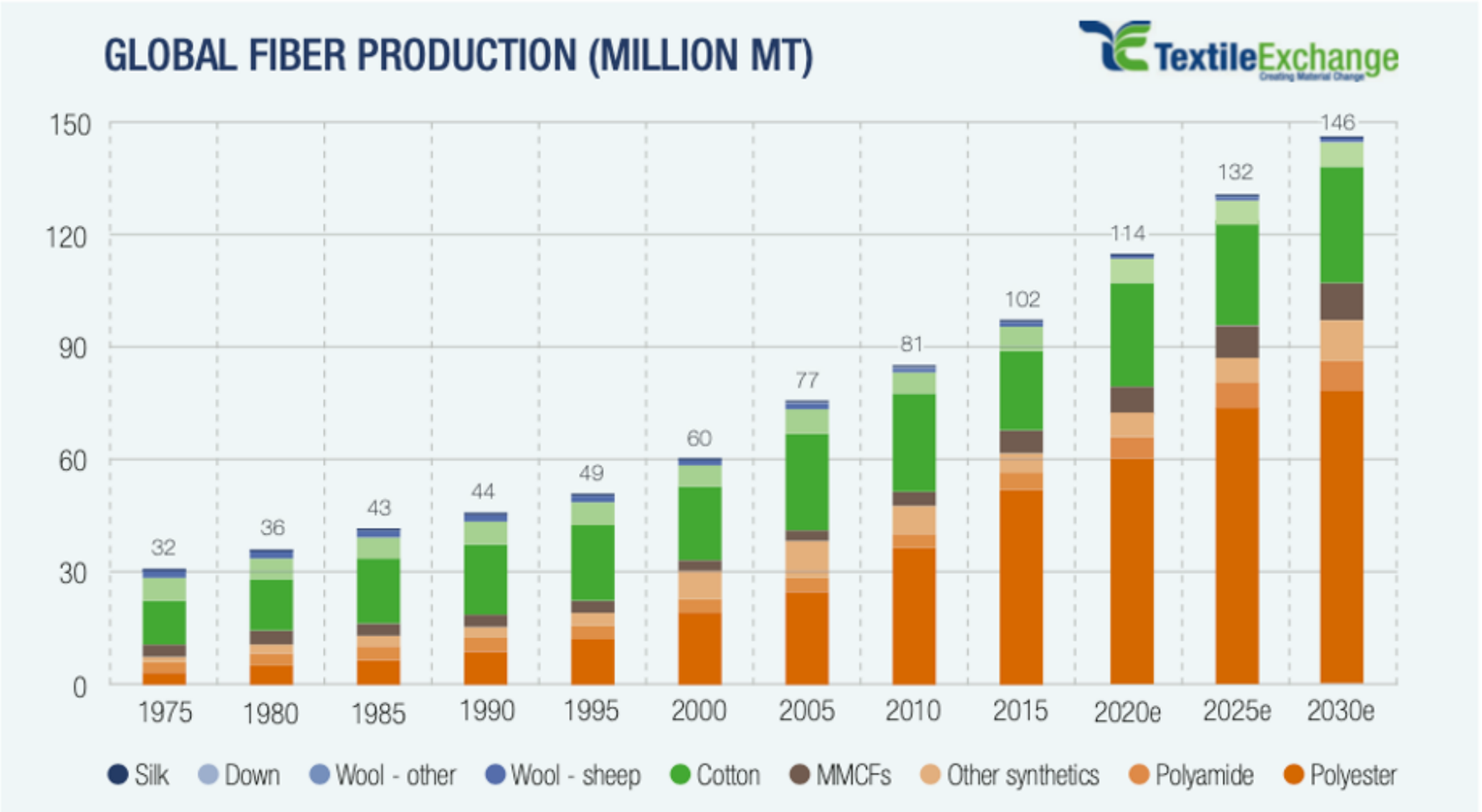
Fibre production



Global Fiber Production Projected to 2030. Source: Textile Exchange Preferred Fiber and Materials Market Report 2020.

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Environmentally friendly product life cycle assessment objective

GOAL setting

- Systematic integration of environmental considerations into the design of a product or service.
- The environmental impacts of a product or service throughout its life cycle are taken into account.
- Efforts are made to reduce the environmental impact of the product, from the procurement of raw materials required for the production of the product, the production process, packaging, distribution and use of the product to the abandonment of the product and the handling of the generated waste.

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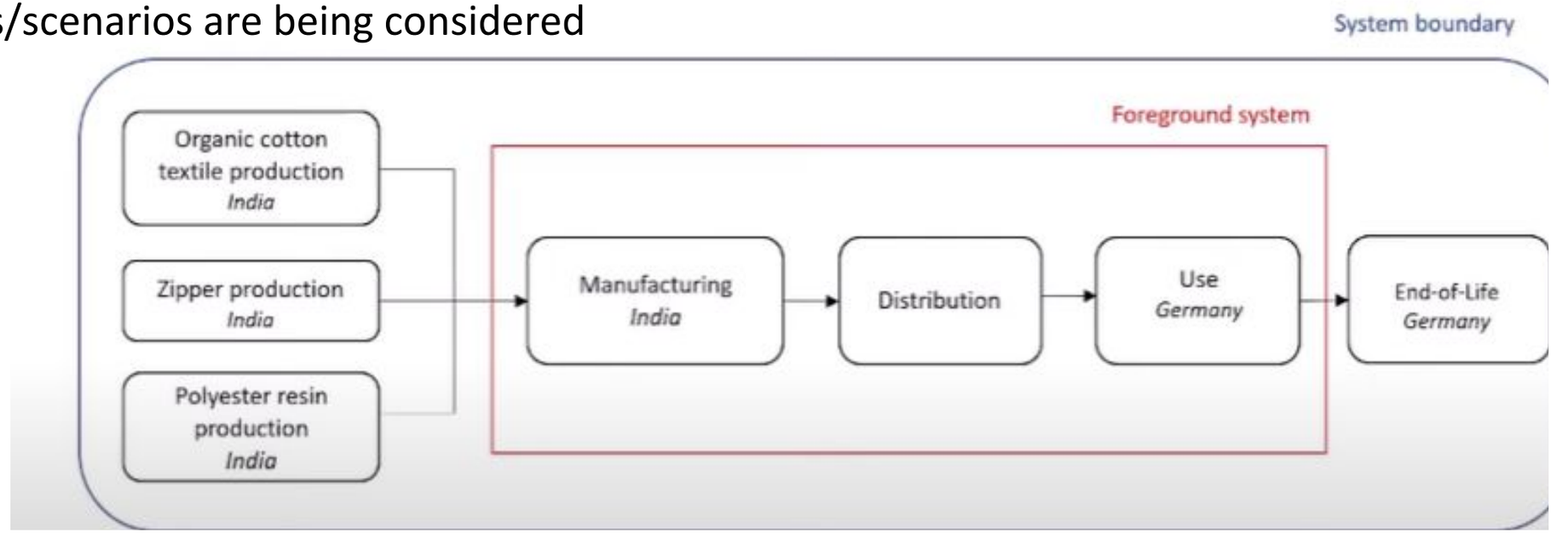
Goal and scope

- The entire supply chain or part of it
- Analysis of supply chain hot spots
- An analysis of the different effects associated with production and consumer behavior in different locations.
- Various options/scenarios are being considered



Source: OpenLCA

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... Goal and scope

Tools and methods

For example

Software: OpenLCA 1.11

Database: Ecoinvent 3.8, Cut off

LCA method: Environmental Footprint 3.0

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... Goal and scope

Assumptions

Life cycle stage	Assumption
Manufacturing	84% cotton, 10 % polyamide, 6% metal zippers and buttons
Use	Washing machine: type C, 6 kg max load User: 50 washing, 60 C, 3,5 kg load
End of life	100% municipal waste, no reuse, no recycling

Source: OpenLCA

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Inventory analysis LCI

(Raw) material

Quantities of different materials

Find out how much waste is generated when using different materials

Photo: Cotton field by David Nance / Wikipedia, Public Domain

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... Inventory analysis LCI

Manufacturing / production and distribution

Manufacturing

→11.8 % waste, own assumption based on literature

→ electricity consumption for cutting and sewing from literature

→ 50 km between cotton and garment factories

Distribution

Following PEF recommendation for manufacturer outside Europe:

→ 1000km truck

→ 11401 km sea, 13km inland waters (Sea Rates)

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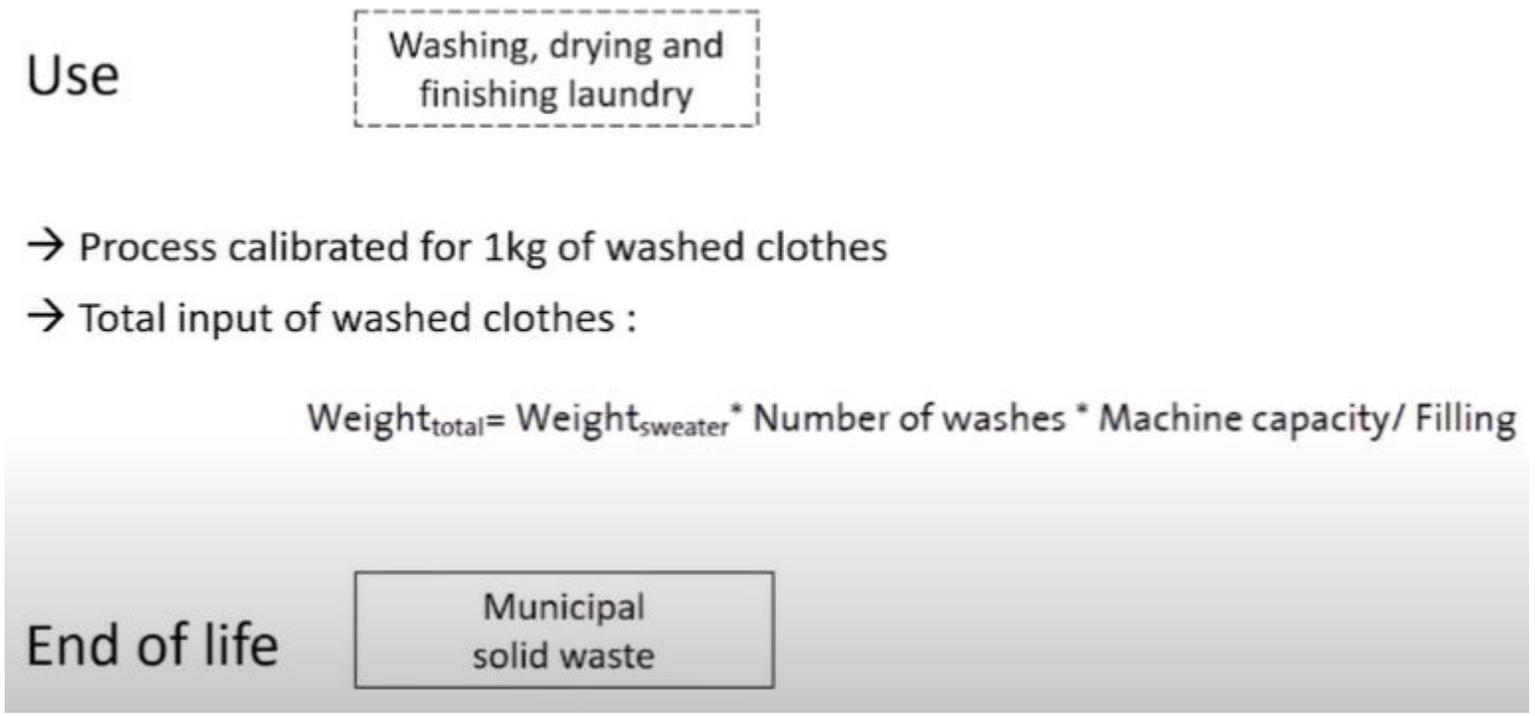
... Inventory analysis LCI

Usage and disposal (linear model)



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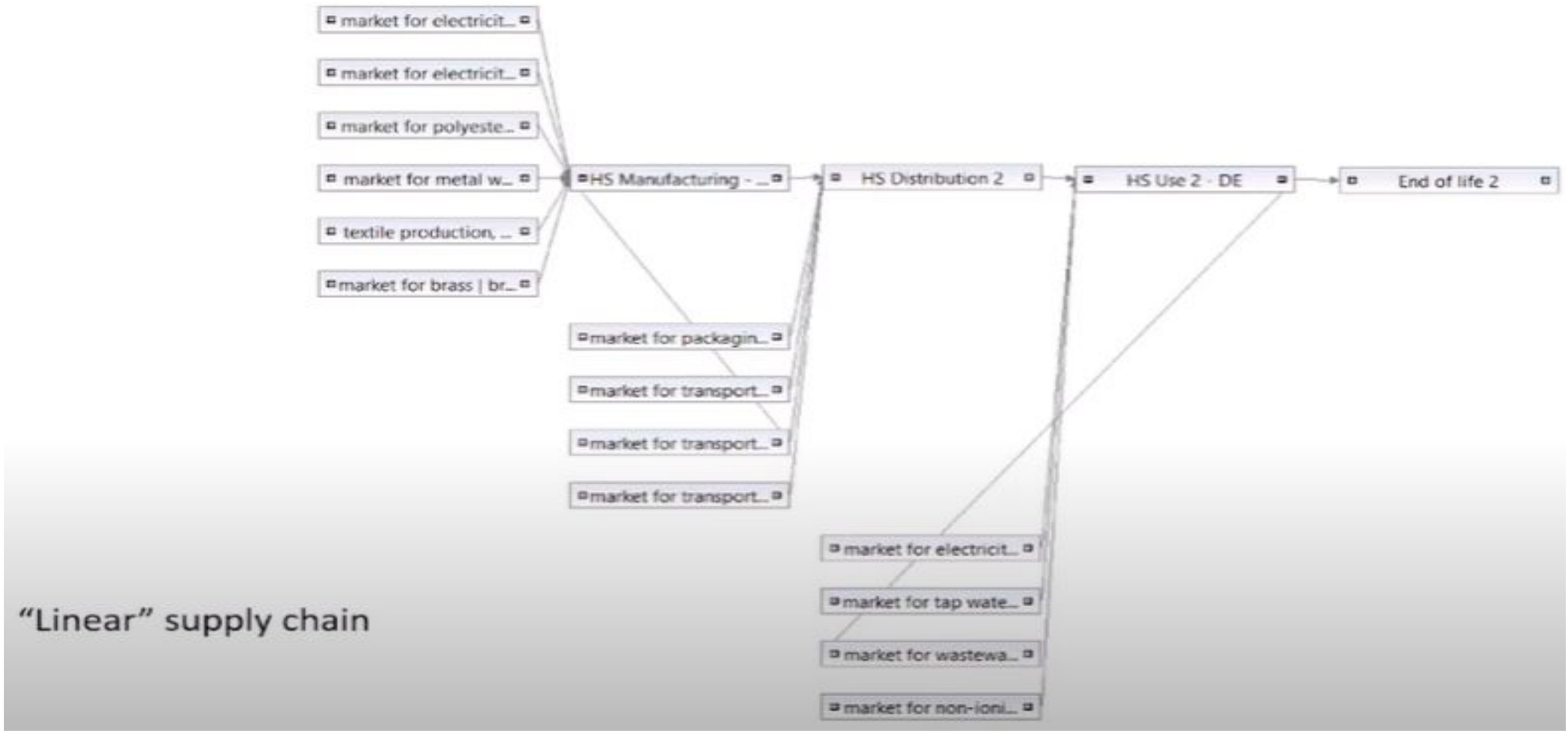
Linear model example with OpenLCA



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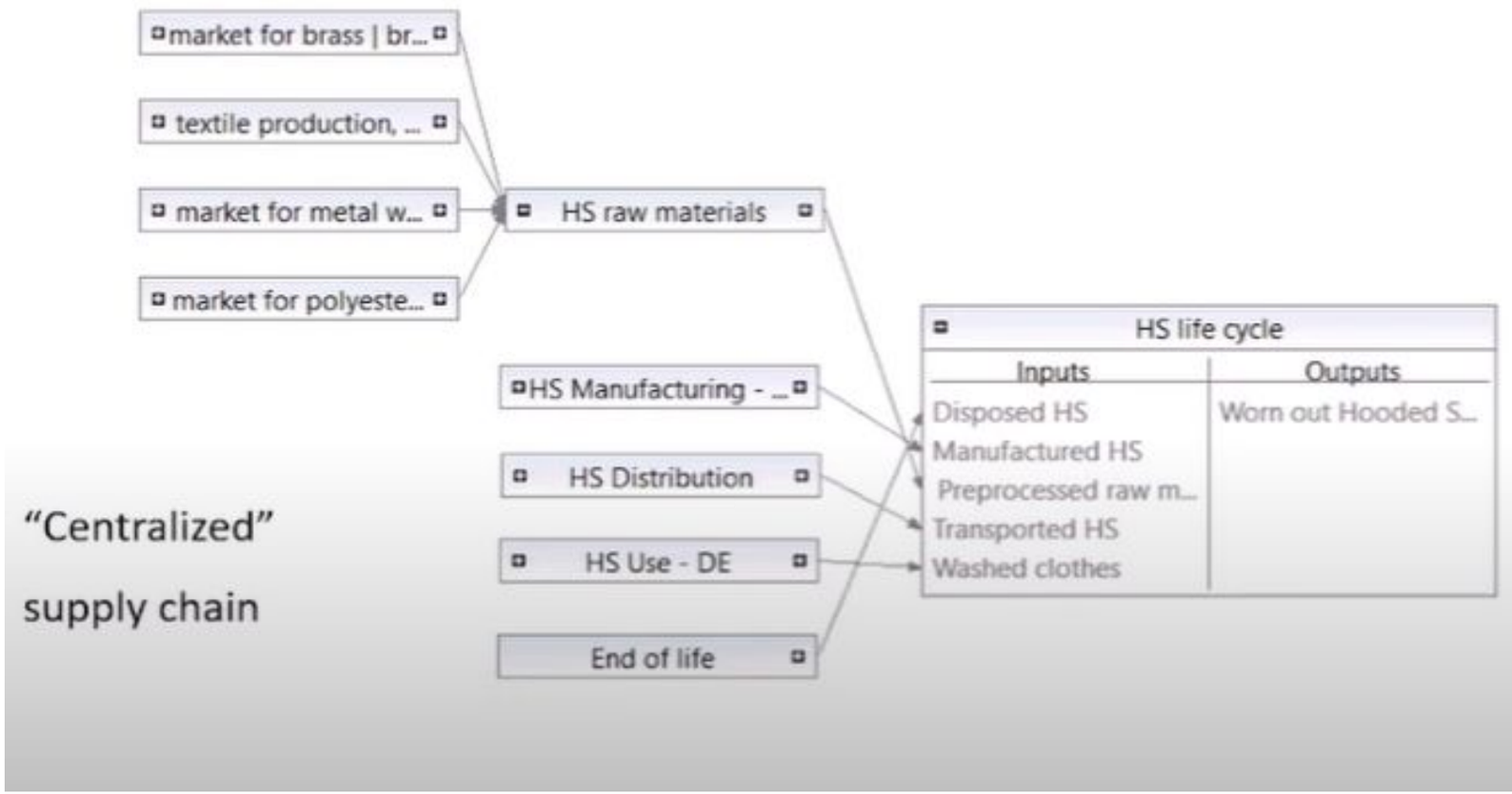
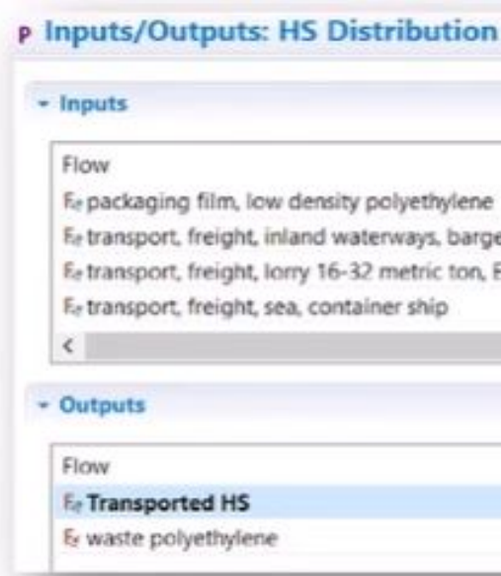
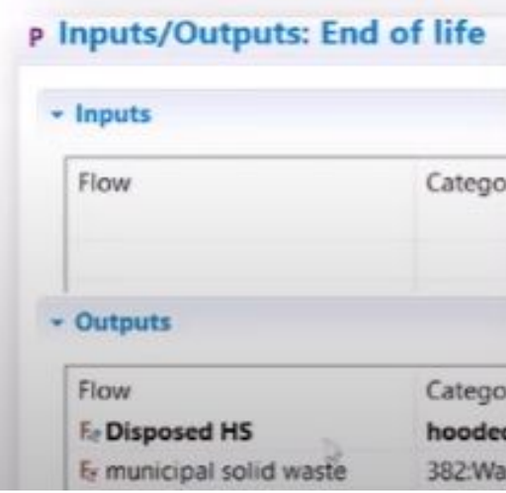
Centralized model with OpenLCA







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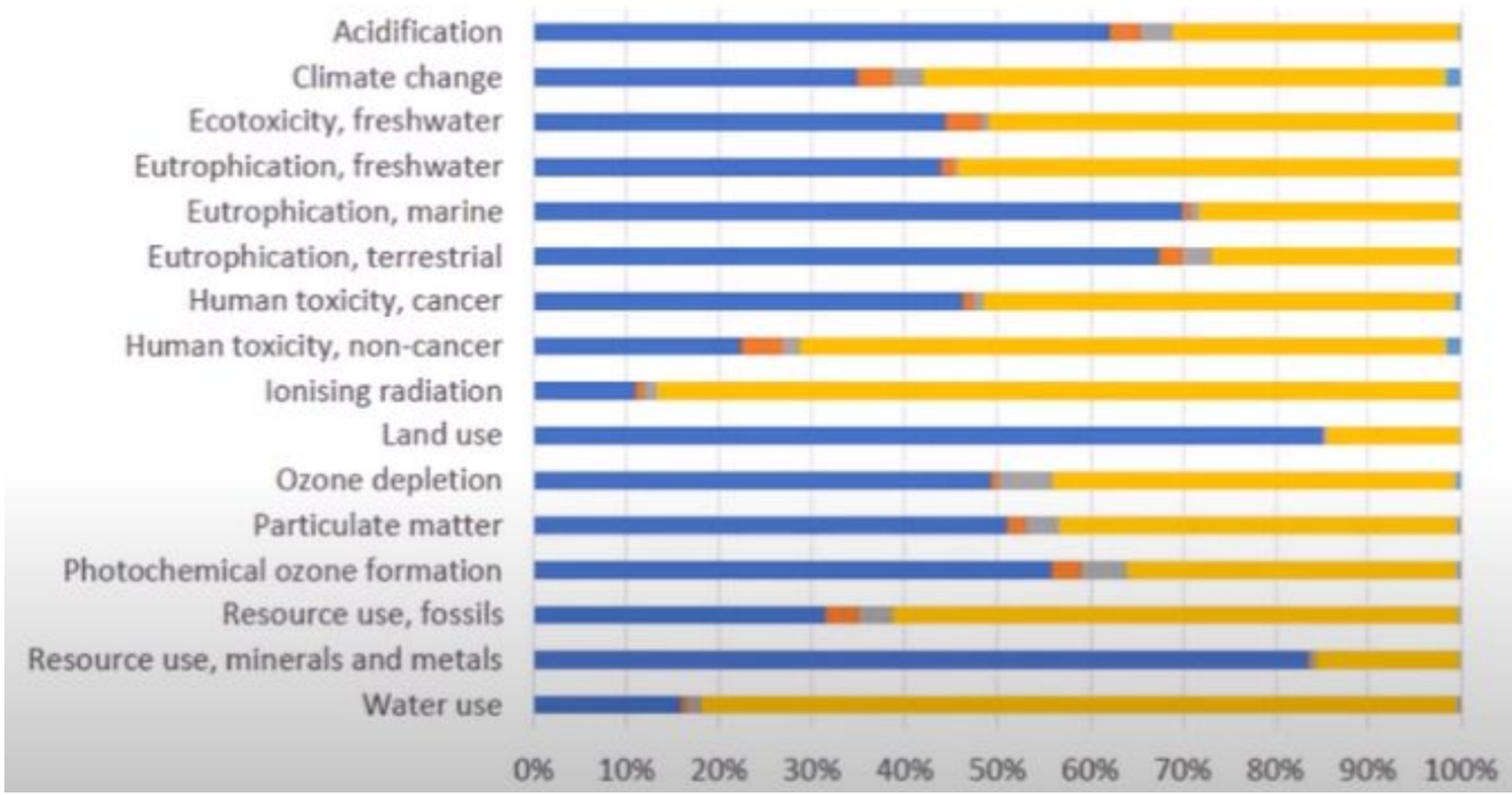
LCA Interpretation

Interpretation



Raw materials :
Cultivation of cotton, batch dyeing, brass

Use :
Electricity consumption, tap water

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Source: OpenLCA

... LCA Interpretation

	Impact assessment results	Unit	Normalized	Weighed (Pt)	Rank
Acidification	0.14179	mol H+ eq	2.55E-03	1.58E-04	7
Climate change	26.03615	kg CO2 eq	3.22E-03	6.77E-04	1
Ecotoxicity, freshwater	741.92648	CTUe	1.74E-02	3.34E-04	5
Eutrophication, freshwater	0.03371	kg P eq	2.10E-02	5.87E-04	2
Eutrophication, marine	0.11951	kg N eq	6.11E-03	1.81E-04	6
Eutrophication, terrestrial	0.40812	mol N eq	2.31E-03	8.57E-05	11
Human toxicity, cancer	2.05E-08	CTUh	1.21E-03	2.58E-05	14
Human toxicity, non-cancer	2.78E-07	CTUh	1.21E-03	2.22E-05	15
Ionising radiation	2.68006	kBq U-235 eq	6.35E-04	3.18E-05	13
Land use	702.27444	Pt	8.57E-04	6.80E-05	12
Ozone depletion	9.37E-07	kg CFC11 eq	1.75E-05	1.10E-06	16
Particulate matter	6.58E-07	disease inc.	1.10E-03	9.90E-05	9
Photochemical ozone formation	0.08147	kg NMVOC eq	2.01E-03	9.59E-05	10
Resource use, fossils	331.14724	MJ	5.09E-03	4.24E-04	4
Resource use, minerals and metals	0.00036	kg Sb eq	5.65E-03	4.27E-04	3
Water use	15.91969	m3 depriv.	1.39E-03	1.18E-04	8

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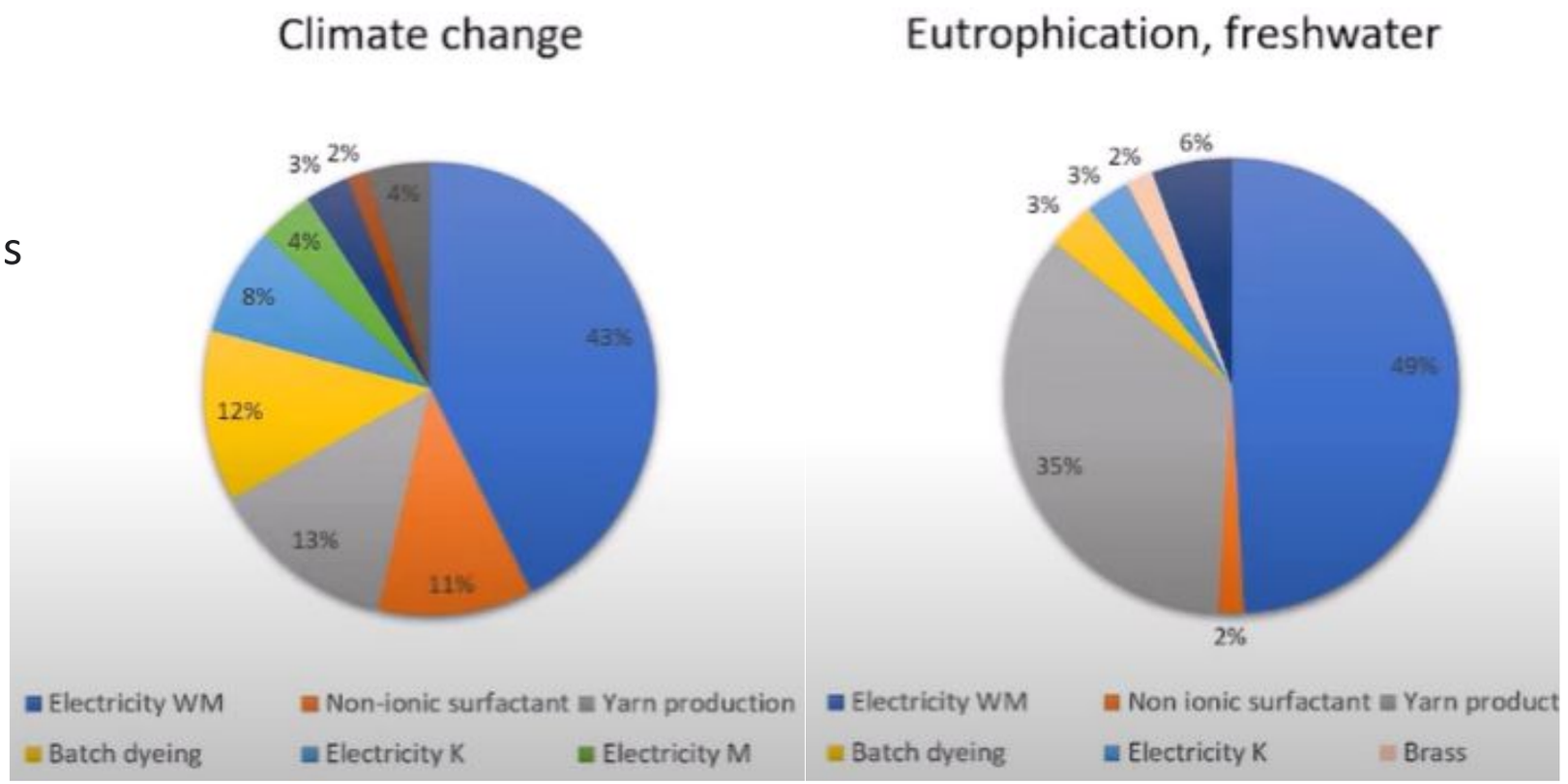
Source: OpenLCA

... LCA Interpretation

Hotspots analysis

Consideration of different scenarios is also done at this stage.



Source: OpenLCA

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LCA application (design)

Product planning, development and design

- Reduction of material consumption and quantity in the product, i.e. dematerialization
- Use of more environmentally friendly (i.e. safer, recyclable or reusable) material and raw materials in the product

Manufacturing/Production processes

- Optimization of production technologies
- Reducing the use of materials in the production process, using safer materials, saving energy, reducing waste and emissions

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... LCA application

Product packaging

- Reducing packaging usage and quantity
- Use of reusable and reusable packaging
- Use of homogeneous materials

Transport

- Choosing environmentally friendly transport
- Optimizing logistics

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... LCA application

Product usage/consumption

- Reducing the environmental impact during product use (less and more environmentally friendly consumption of energy and consumables)
- Extending and optimizing the (primary) life of the product (improving quality and durability, easier maintenance, possibility of maintenance, repair and upgradeability, increasing the functionality of the product).

Accessibility and durability strategies:

- more users
- secondary markets

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... LCA application

Product disposal

- Reuse and reuse of the product or its components and materials
- Product disassembly and reprocessing
- Use of homogeneous (similar properties) materials
- Safe disposal of product waste
- Use of biodegradable materials

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Application - LCA design

In conclusion

- The transition to a circular economy requires changes in the entire product value chain, from product design to new business models and consumption habits. For new and existing products, the main focus is on whole life cycle design.
- Focusing on sustainable material selection, quality (long product life, repairability), optimization of the supply chain and reuse and recycling (universality, possibility to separate components) or using bio-based materials that break down easily in nature.

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Let´s remember …

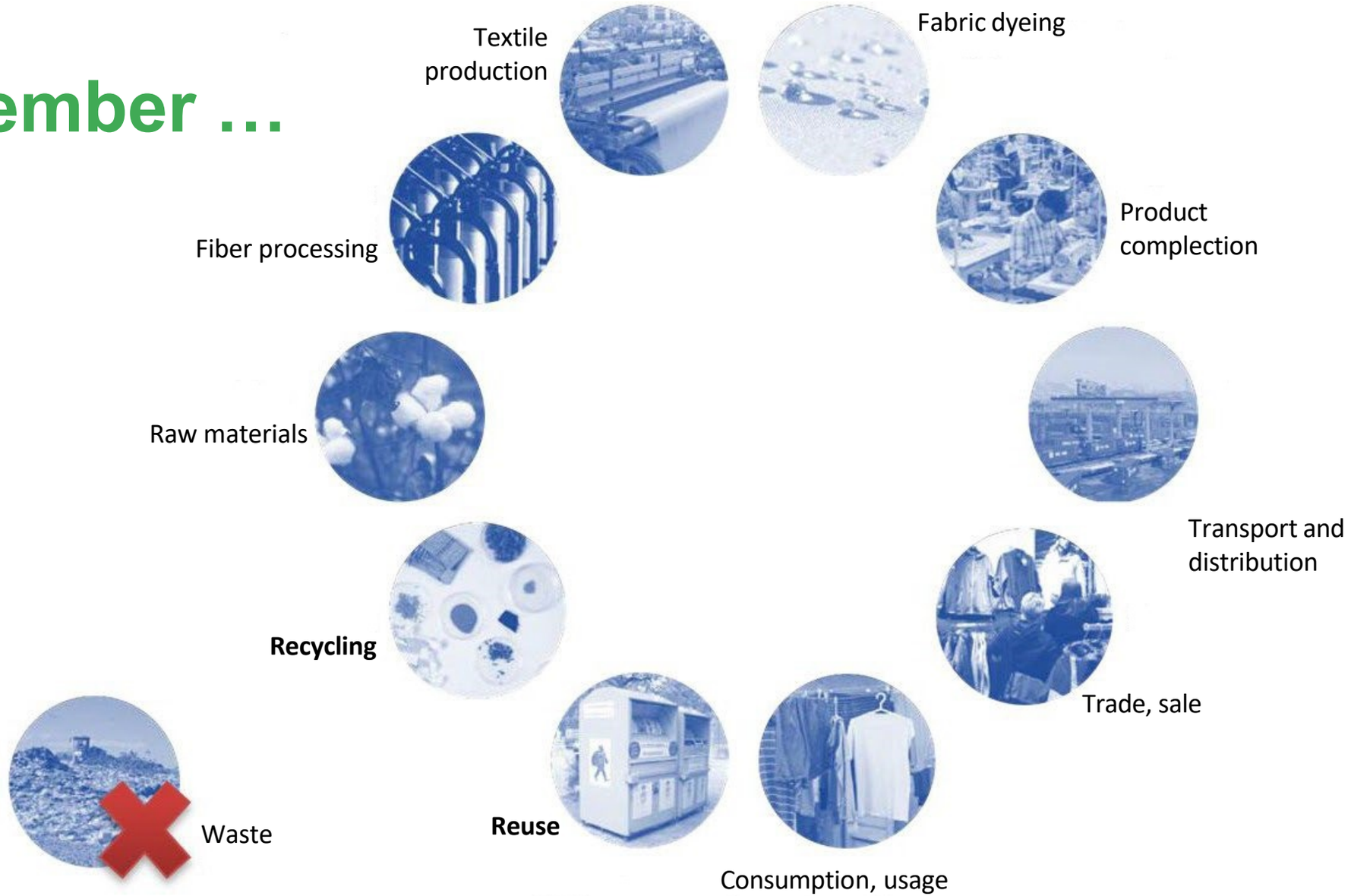

Image: Essi Karell

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LCA tool - OpenLCA

openLCA is an open source and free software for Sustainability and Life Cycle Assessments

Webpage of the progam
https://www.openlca.org/

Tutorial **VIDEOS** to be found with keywords: openLCA

Lesson activity

pair/group of 3

Try to use OpenLCA for product life cycle analysis and environmental impact assessment.

E.g with EcoInvent or Agribalyse databases.

60 min

SusTexEdu

SusTexEdu project (Education Partnership of Textile and Clothing Sector Materials & Sustainability, Agreement number 2021-1-FI01-KA220-HED-000023002) was funded by the Erasmus+ programme of the European Union.

Visit the project website to see all the intellectual outputs of the project.

Photo by Essi Karell

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