Photo by Essi Karell

This open educational resource has been developed by:

Essi Karell, Metropolia UAS

6.2 Principles of Textile Waste Management

SusTexEdu

Funded by the Erasmus+ Programme of the European Union

SusTexEdu | Erasmus+

This educational material was developed within Erasmus+ funded project Education Partnership of Textile and Clothing Sector Materials & Sustainability (SusTexEdu).

The aim of the project was to research and develop education related to the textile and clothing industry and textile materials, sustainable development and the circular economy.

Project coordinator: Metropolia UAS
Partners: Hogent (BE), Mome (HU), Omnia (FI), TTHK (EE), TTK UAS (EE), University of Borås (SE)
Funding: Erasmus+
Duration: 2022-2024

SusTexEdu

SusTexEdu | Erasmus+

About this learning material:

This learning material was piloted with second year students of Fashion and Clothing bachelor's degree programme at Metropolia UAS (level 6) on the course Circular Economy and Standards in Fashion and Clothing(5 cr). The theoretical course was held on-site.

This learning material is targeted for students that require basic knowledge about sources of textile wastes and their management.

Before studying this learning unit, the students should have some basic understanding of different sustainability aspects in the textile and clothing sector.

SusTexEdu

Oppimiskokonaisuudesta

CONTENT

- EU strategy for sustainable and circular textiles
- European Commission's waste framework directive
- Generation and reduction of waste in the textile industry
- Overview of collection, sorting, reuse and recycling practices
- Processing of textile waste as raw material

COMPETENCE OBJECTIVES

After completing the unit, the student is able to:

- understand the European Commission's waste framework directive
- describe the different origins of textile wastes
- identify practices and processes related to textile waste minimisation and treatment
- to understand the connection of these practices to EU strategy for circular textiles
- to name actors who use textile wastes as raw material.

WORKLOAD

The learning unit corresponds to one (1) ECTS, approximately 27 hours.

- Lectures, 3h
- Learning activities, 2h
- Independent assignment, 22h

SusTexEdu

Today…

- ...we identify at which stages in the textile supply chain textile waste is generated.
- ...we will go through several concepts that are essential in terms of textile waste management.
- ...we begin to understand the practices and processes related to textile waste management.

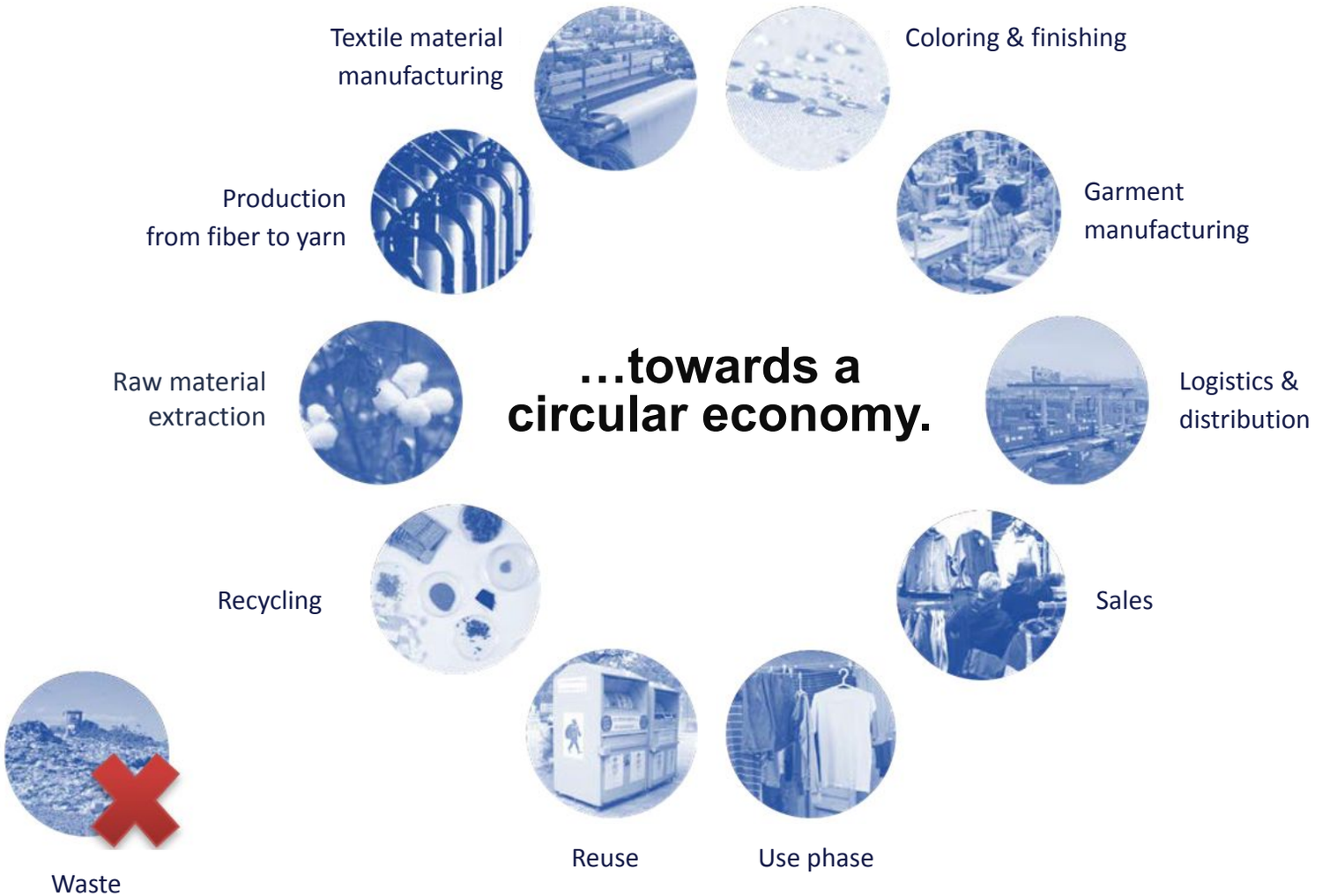
SusTexEdu

Striving for zero waste

One of the top goals of the circular economy is to close the material, energy and nutrient cycles, so that waste and wastage is as little as possible.

→ **Waste = resource / raw material**

The circular economy can be thought of as the basis of zero emissions.


Textile material manufacturing
Coloring & finishing
Production from fiber to yarn
Garment manufacturing
Raw material extraction
…towards a circular economy.
Logistics & distribution
Recycling
Sales
Waste
Reuse
Use phase

SusTexEdu

Learning activity 1.

What is meant by textile waste?

In groups of 2-3 people:

Discuss what kind of idea you have about textile waste.

What is textile waste and how/where is it generated? Write it down.

5 min

SusTexEdu

Terminology

TEXTILE WASTE

Textile waste is generated in different stages of the textile manufacturing process, such as yarn spinning, fabric weaving, clothing manufacturing and the use phase.

There are generally two types of textile waste:

1) textile waste generated in production (pre-consumer textile waste)
2) textile waste from consumers/users (post-consumer textile waste)

Terminology

Textile waste generated in production (pre-consumer textile waste)

Can also be called production waste. This includes fabric waste generated during the fiber, yarn and cutting stages. On average, about 15 percent of the material used in the manufacture of clothes is wasted, but estimates vary from 10 to 30 percent, depending on, for example, the type of product.

Unused surplus stock (deadstock), i.e. unsold and returned clothes can also be considered pre-consumer textile waste.

Source: Niinimäki ym. (2020)

SusTexEdu

Terminology

Textile waste from consumers/users(post-consumer textile waste)

This textile waste is discarded textile that is not suitable for reuse as such, i.e. it is, for example, broken or dirty. This type of textile currently belongs to the separate collection of waste textiles in Finland (and thus to recycling) or to mixed waste (from which it is diverted mainly to be used as energy).

Source: HSY 2023

Why is there so much fuss about textile waste? Why is that a problem?

SusTexEdu

Textile waste is a problem

Currently, only a fraction of textile waste is reused as a raw material for new materials or products. A large amount of waste ends up in landfills and incineration - often completely unused.

→ **A great wasted resource**

SusTexEdu

Textile waste is a problem

With fast fashion, clothes are made and thrown away at an increasing rate. Europeans consume almost 26 kilos and throw away about 11 kilos of textiles every year. Used clothes can be exported outside the EU, but most (87%) are burned or taken to a landfill. Source: European parliament, 2023

Approximately seven million tons of end-of-life textiles are produced in Europe annually, of which 85% consists of textiles removed from consumer use, such as clothes and home textiles. Only 30–35% of this amount can be collected. By 2035, nearly nine million tons of disposable textiles will be produced in the EU.
Source: McKinsey, 2022

SusTexEdu

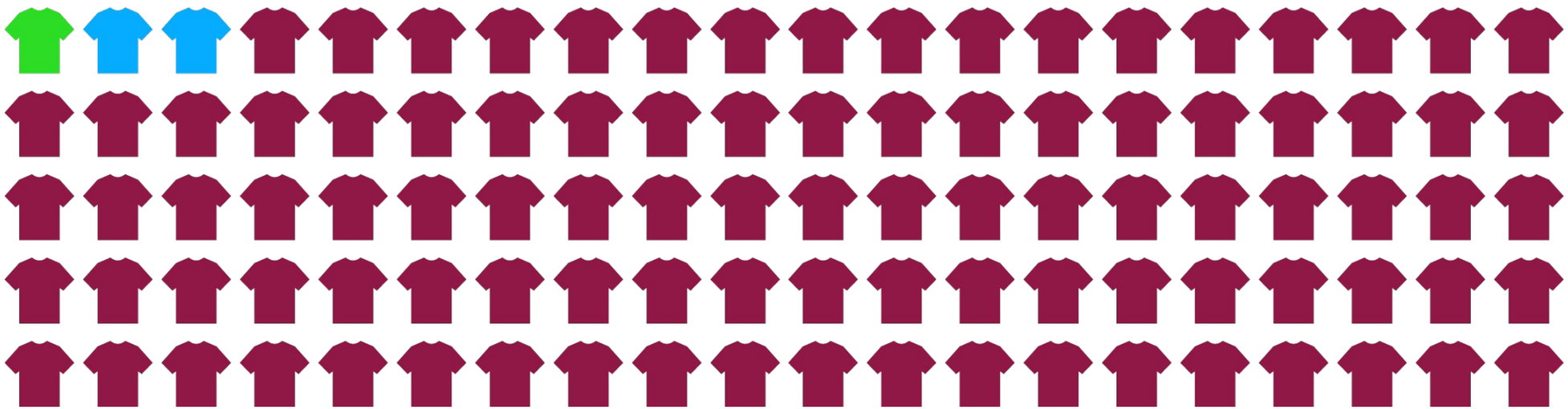
Textile waste is a problem

Textile waste causes pollution

In landfills, it takes hundreds of years before textile materials settle down and end up as part of nature's cycle. Secondly, textiles are often a mixture of many materials and chemicals that cause soil and groundwater pollution and thus negatively affect the functioning of natural ecosystems.

Global material flows

The origin of clothing materials in 2015



1% recycled textile fiber

2% recycled raw material from other industries

97% virgin raw material

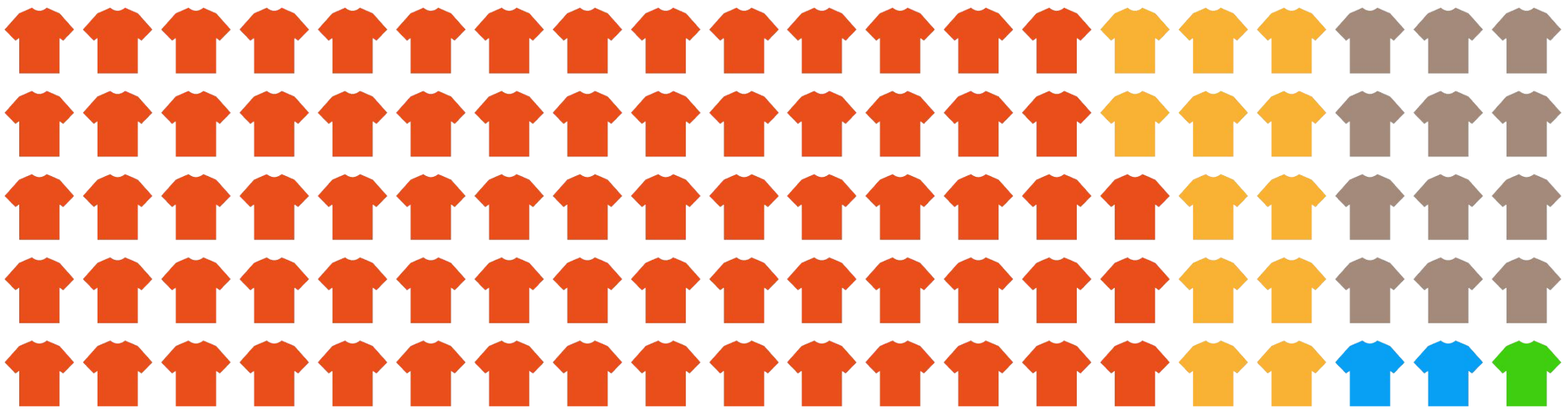
Source: EMF 2017

Picture: Essi Karell

SusTexEdu

Global material flows

Endpoint of clothing materials in 2015



73% landfill or incineration

12% production waste

12% recycling for other industries

2% waste generated in the sorting and processing of discarded textiles

1% recycling into high-quality textile fiber

Source: EMF 2017

Picture: Essi Karell

SusTexEdu

Local material flows

See for example Textile flows in Finland in 2019 report by Dahlbo et al. (2021).

[Add a diagram]

SusTexEdu

Terminology

END-OF-LIFE TEXTILES

End-of-life textiles are textiles that are unnecessary for their owner, which includes both usable, reusable textiles and textile waste, i.e. discarded textiles.

Source: Telaketju project, 2022

Learning activity 2.

Practices to reduce textile waste

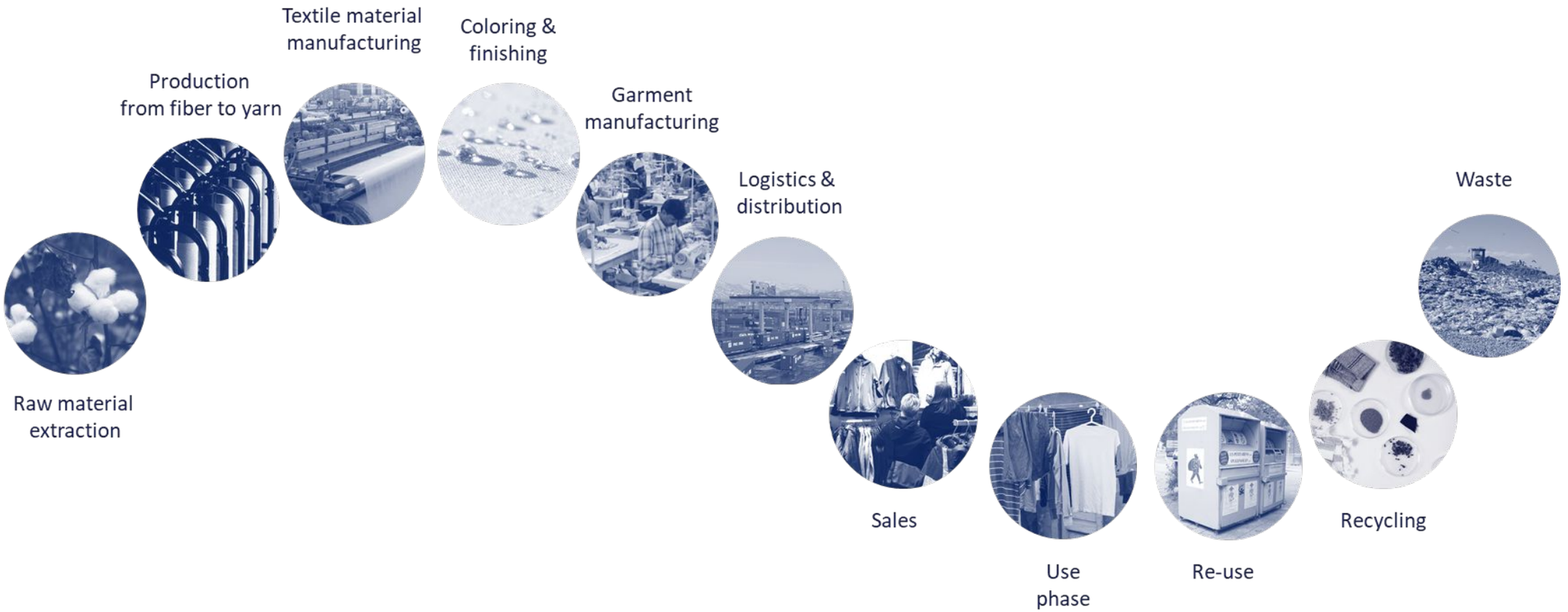
In groups of 2-3 people:

Discuss what methods or practices we could use to reduce/prevent the generation of textile waste.

Take into account the different stages of the garment's life cycle from production to consumption. You can use the illustration of the linear model of production and consumption (on the next page).

10 min

Linear model of production and consumption



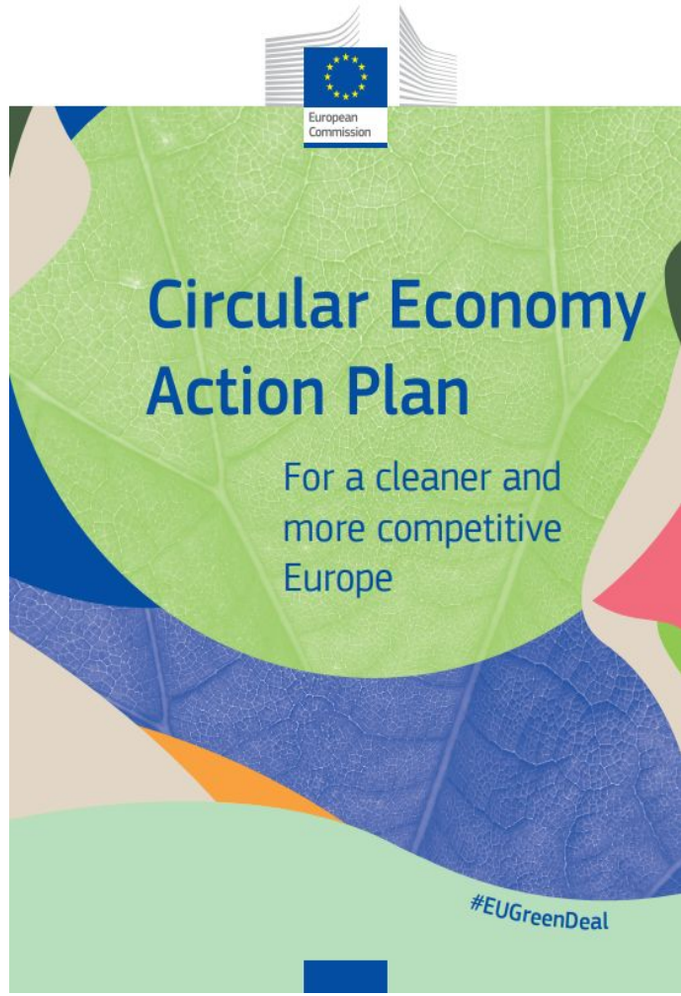
SusTexEdu

Practices on the EU level

The regulatory environment in the European Union is rapidly changing. The goal is to encourage companies to invest in the circular economy.

The EU published its new circular economy action plan, the New Circular Economy Action Plan, in March 2020 to ensure that products have a long life cycle in the future and that they can be repaired or recycled.

The European Union's textile strategy was completed at the beginning of 2022. The goal of the strategy is to promote the sustainability of the industry and create conditions for circular economy solutions.



SusTexEdu

European Commission, Directorate-General for Environment, Sustainable and circular textiles by 2030, Publications Office of the European Union, 2022 https://data.europa.eu/doi/10.2779/122408

SusTexEdu

[Zoom e.g. to the Commission’s 2030 Vision for Textiles]

SusTexEdu

[Zoom e.g. to the Key actions in the Textiles Strategy]

SusTexEdu

Practices on the EU level

EU's **Proposal for Ecodesign for Sustainable Products Regulation (ESPR)** also affects textiles.

Among other things, the regulation proposes:

- eco-design requirements (durability, repairability, recyclability, etc.)
- recycled fiber obligations
- introduction of the digital product passport
- ban on disposal of unsold products

Source: European Commission (n.d.)

SusTexEdu

Practices on the EU level

The EU waste legislation established in 2018 requires member states to start **separate collection of textile waste** by 2025 (European Commission, 2023).

In Finland, municipalities have been obliged to organize the collection of textile waste regionally since 2023.

Practices on the EU level

The digital product passport is part of the EU's sustainable products initiative.

A digital product passport would contain information about the composition of goods on the European market, which would increase their chances of being reused and recycled.

The idea is to identify the most important information about the composition of each product so that users throughout the supply chain can reuse them or treat them correctly in waste management facilities.

The information could also be used to combat greenwashing.

Source: European Commission (n.d.)

SusTexEdu

Practices on the EU level

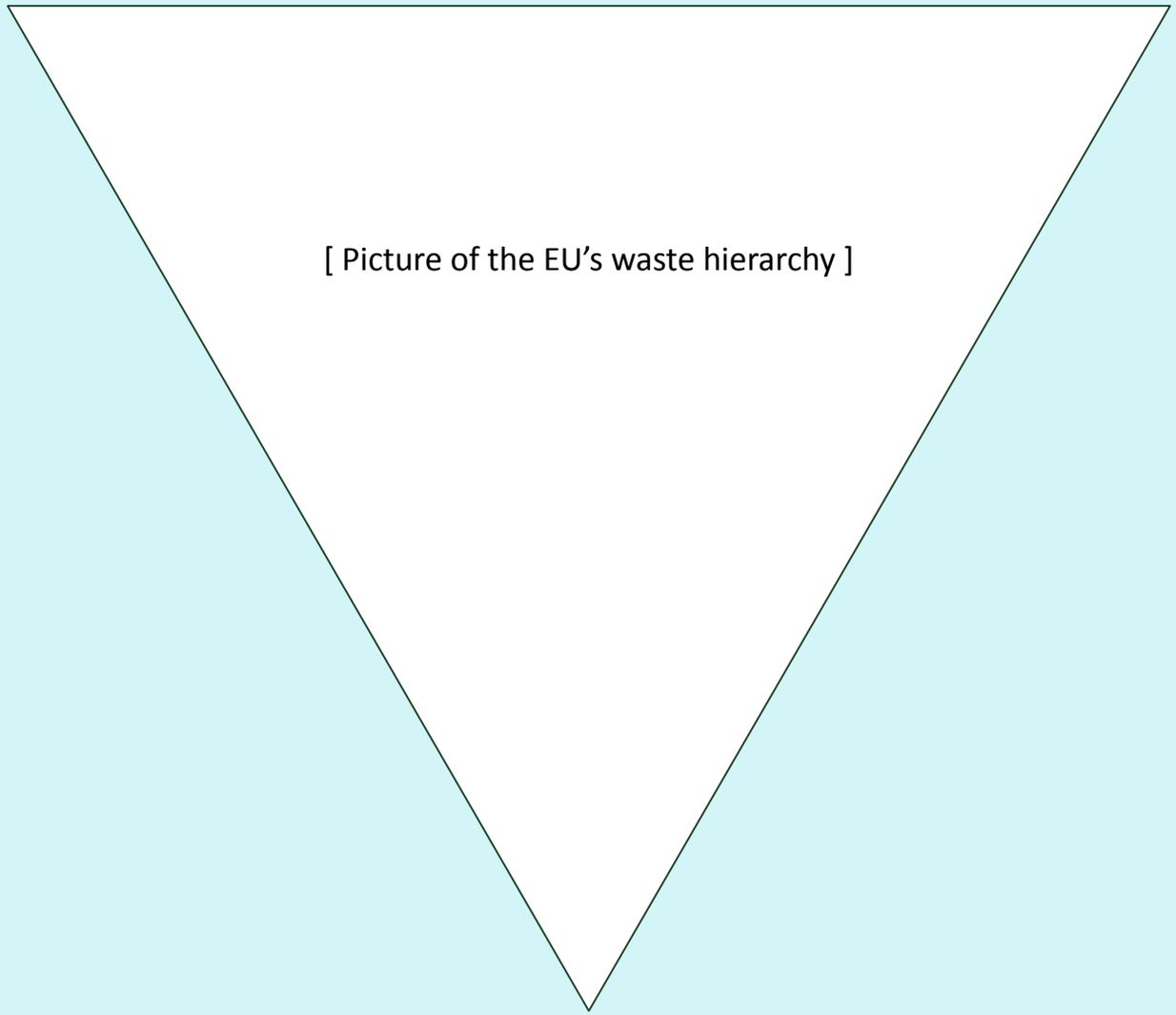
The European Commission has proposed that EU member states introduce uniform **Extended Producer Responsibility (EPR)** criteria for textiles.

This would mean that producers will be responsible for the costs of textile waste management in the future, which encourages them to design their products from the beginning in a way that reduces waste and increases the circulation of textile products.

Source: European Commission (2023)

WASTE HIERARCHY

The priority order of waste management operations. The waste hierarchy is defined in the EU waste directive.



SusTexEdu

Terminology

REUSE

is the reuse of a product, such as a textile, or a part of it, for the same purpose for which it was originally designed.

For consumers, the sale and purchase of used goods is made possible for example through various online platforms and flea markets.

Terminology

TEXTILE RECYCLING

is an activity in which textile waste is made into a product, material or substance either for the original purpose or for another purpose.

Textiles can be recycled using either a mechanical, chemical or thermal methods. Utilization of textile waste or material as energy, nor flea markets or recycling centers, does not count as recycling.

Sources: SYKE (2020), STJM (n.d.)

Textile recycling

Recycling plays a big role in textile waste management. However, it must be remembered that recycling is not a goal in itself. It is more of a means by which the use of natural resources can be better managed (Worrell & Reuter 2014).

By recycling, it is possible to reduce e.g.

- the use of virgin raw materials
- use of water, chemicals and energy
- greenhouse emissions
- environmental pollution
- the amount of waste that ends up in the landfill.

Textile recycling process

MAIN STAGES

[picture]

Collection

Mostly by charity organizations, recycling companies, etc.

[picture]

Sorting

Clothes are mainly sorted by hand, automation is being developed

[picture]

Pre-processing & recycling

There are several recycling methods; mechanical, thermal, chemical recycling

SusTexEdu

Collection

Example:
Helsinki Region Environmental Services HSY & LSJH Lounais-Suomen Jätehuolto Oy

Starting in 2021, a collection pilot for disposable textiles has been in operation.

See Clothes and textiles website by HSY (n.d.), which explains what can and cannot be put in the collection of disposable textiles.

Photo by Essi Karell

SusTexEdu

[E.g. the diagram by LSJH that illustrates
the circularity of end-of-life textiles in Finland]

SusTexEdu

Textile sorting

In recent years, textile sorting has been developed with the help of new technologies. The goal is to automate (at least part of) textile sorting.

However, the sorting of textiles is still mainly done by hand. When sorting by hand, it is even possible to identify textiles with a better sales value than with a machine, and materials can also be identified based on the identifier and product type.

If aiming to improve the recycling rate, the (collection and) sorting of textiles is key. How well the material composition of textiles can be identified during the sorting phase affects the functionality and profitability of the entire recycling system (Karell, 2021).

Manual textile sorting

+ An experienced employee can identify products suitable for sale better than a machine.

+ An experienced sorter can manually identify the fraction suitable for mechanical recycling.

+ Also suitable as a pre-sorting method, where textiles that are unsuitable for machine sorting and potentially dangerous are removed from the output textile stream.

- Labor intensive, slow and expensive.

- The care labels may be worn or cut off or have incorrect information (they are rarely even checked).

Source: Wedin yms. 2017

SusTexEdu

SusTexEdu

Automated textile sorting

The most promising method so far is the near-infrared (NIR) i.e. infrared spectroscopic analysis method, where the detection of the fiber content is done with the help of infrared light.

+ Automated, efficient and fast

+ Doesn't destroy the material, doesn't even require contact

- Textile fractions that cause error detection are e.g. coated textiles (raincoat, shower curtain), multilayer structures (top coat, blanket), coated fabrics or products with different fiber content in different areas, as the device does not scan the entire textile but only a small part of it.

- Transparent and thin fabrics are difficult to identify.

- Can't find very small percentages of fiber. This is especially a problem with elastane.

SusTexEdu

Textile recycling methods

1) **Mechanical recycling:**
   Shredding & re-using the fibres; suitable for almost any type of fibres.

2) **Thermo-mechanical recycling:**
   Melting the material & making new fibres; suitable for thermo-plastics.

3) **Chemical recycling:**
   Dissolving the material & re-building polymer chains; suitable for ”anything that can be dissolved/depolymerized”.

Mechanical recycling

Mechanical recycling is a more than 200-year-old method in which the fibers in the product/fabric/yarn are separated by tearing and reused as fiber. This is a fairly simple and effective process that is suitable for almost all fibers, especially the cutting waste from textile production, which is usually of a very uniform quality.

Tearing treatment damages the structure of the fiber and lowers its quality every time it is recycled, and therefore mechanically recycled fiber can be difficult to recycle again.

Mechanically recycled fibers can be used e.g. in composites; can be needle or heat fixed into non-woven fabric; or the fibers can be respun into yarn.

Examples of mechanical recycling

Oil-absorbing non-woven carpets are examples of *downcycling / open-loop recycling.*

+ enables the use of mixed, low-quality post-consumer textile waste
+ relatively simple and efficient
- cannot be recycled again

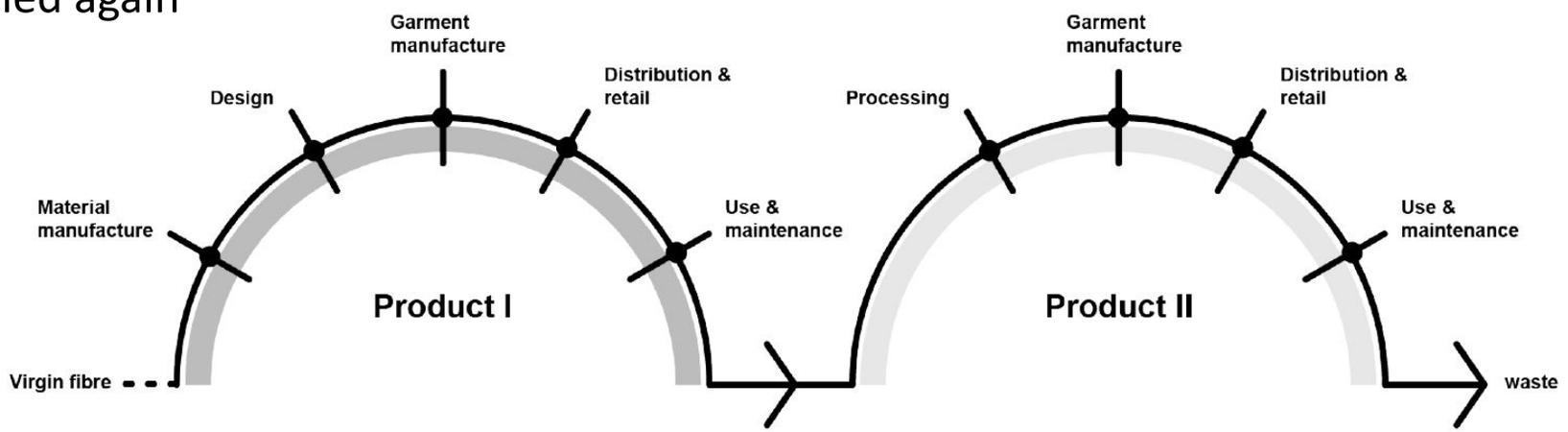


Illustration of open-loop recycling by Karell (2021, adapted from Payne, 2015)

SusTexEdu

Examples of mechanical recycling

A company **Pure Waste** utilises fabric off-cuts from sewing factories and recycles them into high-value products. This can be considered also *upcycling*.

+ enables garment level quality
+ appropriate use of pre-consumer waste
- not easy to set up a similar system
- loss of quality, cannot be recycled ‘forever’

Can you think of other companies that utilize mechanical recycling?

Thermo-mechanical recycling

Thermo-mechanical recycling is a recycling method suitable for synthetic fibers (at the polymer level). The fibers are heated and melted, which weakens the chemical structure of the fiber to the extent that it weakens.

Examples include **several swimwear brands** that utilise ocean plastics as raw materials for the swimsuits.

+ using actual waste
+ enables high value products
- cannot be recycled several loops without adding virgin material.

Can you think of other companies that utilize thermo-mechanical recycling?

SusTexEdu

Chemical recycling

In chemical recycling, textile fibers are separated from each other using chemical reactions. The technologies enable the recycling of cellulose-based and artificial fibers. Also suitable for recycling certain mixed materials. The result is new man-made fiber whose quality corresponds to the type of fiber (e.g. viscose recycled from cotton is of new quality viscose).

+ Enables even worn fibers to be recycled several times
+ Recycled fibers are suitable for making new high-quality textile products, can thus be considered *upcycling / closed-loop recycling*
- Takes a lot of energy
- Expensive
- Strict criteria for the raw material

SusTexEdu

Can you think of companies that utilize chemical recycling?

Recycling challenges

Product design

- Products of today are not designed with recycling in mind
- Clothes are complex products (mixtures of different materials, chemicals, multi-layering)
- "Clean" material cycles are missing

Market perspective

- Insufficient/inefficient collection of products
- The recycling process as a whole is expensive - is it profitable?
- Willingness to use recycled materials

Recycling challenges

Technology

- Various technologies under development; each has its own limitations and level of technological readiness
- Sorting is still mostly done by hand, which is expensive and insufficient

Lack of information and transparency

- Little understanding of sustainable design practices
- Material content of the product → information in the digital product passport in the future?
- Restrictions on sorting and recycling?

SusTexEdu

Aspects to consider (at design stage)

Monomateriality

- Limited material options
- Elastane, finishes, laminations and prints make recycling difficult

Modularity

- Separability of different material components, e.g. in multi-layered products
- Simplicity is a plus

Information

- Accuracy of materials
- How? What kind of system are we designing for?

Communication

- Understanding the limitations of sorting and different recycling processes
- Understanding the differences between mechanical, thermal & chemical recycling

SusTexEdu

Returning to Learning activity 2.

SusTexEdu

Summary of learning activity 2.

Practices to prevent textile waste

- [List here all the ideas generated by the students.]
- …
- …

SusTexEdu

Independent research based assignment

Recycling instructions

Imagine the following situation. Your friends who lived abroad have just moved to [your country] and right next door to you. They would like to know what should be done with old home textiles and clothes. How would you advise them?

Create an A4-sized document in which you summarize the following things for your friends:

- What can be done with unusable and usable home textiles and clothes in your local area?
- What can you generally tell your friend about the steps in the textile recycling process?
- How does waste textiles from consumers differ from textile waste generated during textile production?

SusTexEdu

References

Dahlbo, H., Rautiainen, A., Savolainen, H., Oksanen, P., Nurmi, P., Virta, M., & Pokela, O. (2021). Textile flows in Finland in 2019. Turku University of Applied Sciences. [PDF]

Ellen MacArthur Foundation (2017). A New Textiles Economy: Redesigning Fashion's Future. [PDF available in English]

European Commission (n.d.) Ecodesign for Sustainable Products Regulation.

European Commission (2020). A new Circular Economy Action Plan: For a Cleaner and More Competitive Europe.

European Commission (2023). Circular economy for textiles: taking responsibility to reduce, reuse and recycle textile waste and boosting markets for used textiles.

Karell, E. (2021). Closing the Loop through Clothing Design: Wishful Thinking or Achievable Practice? Doctoral Dissertation. Aalto University.

References

Niinimäki, K., Peters, G., Dahlbo, H., Perry, P., Rissanen, T., & Gwilt, A. (2020). The environmental price of fast fashion. Nature Reviews Earth & Environment 1, 189–200.

STJM (n.d.). Kiertotalouden termit tutuiksi. [Website only in Finnish.]

SYKE (2020). Circular economy term bank. [Website only in Finnish.]

Worrell, E., & Reuter, M. (2014). Definitions and Terminology. In E. Worrell & M. Reuter (Eds.), Handbook of Recycling: State-of-the-art for Practitioners, Analysts, and Scientists (pp. 9–16). Elsevier Inc.

Wedin, H., Gupta, C., Mzikian, P., Englund, F., Hornbuckle, R., Troppenz, V., Kobal, L., Krečič, M., Costi, M., Ellams, D., & Olsson, S. (2017). *Can automated NIR technology be a way to improve the sorting quality of textile waste?* Trash-2-Cash project report.

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

SusTexEdu

Funded by the Erasmus+ Programme of the European Union