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Circular economy perspectives in the EU Textile sector

Final report

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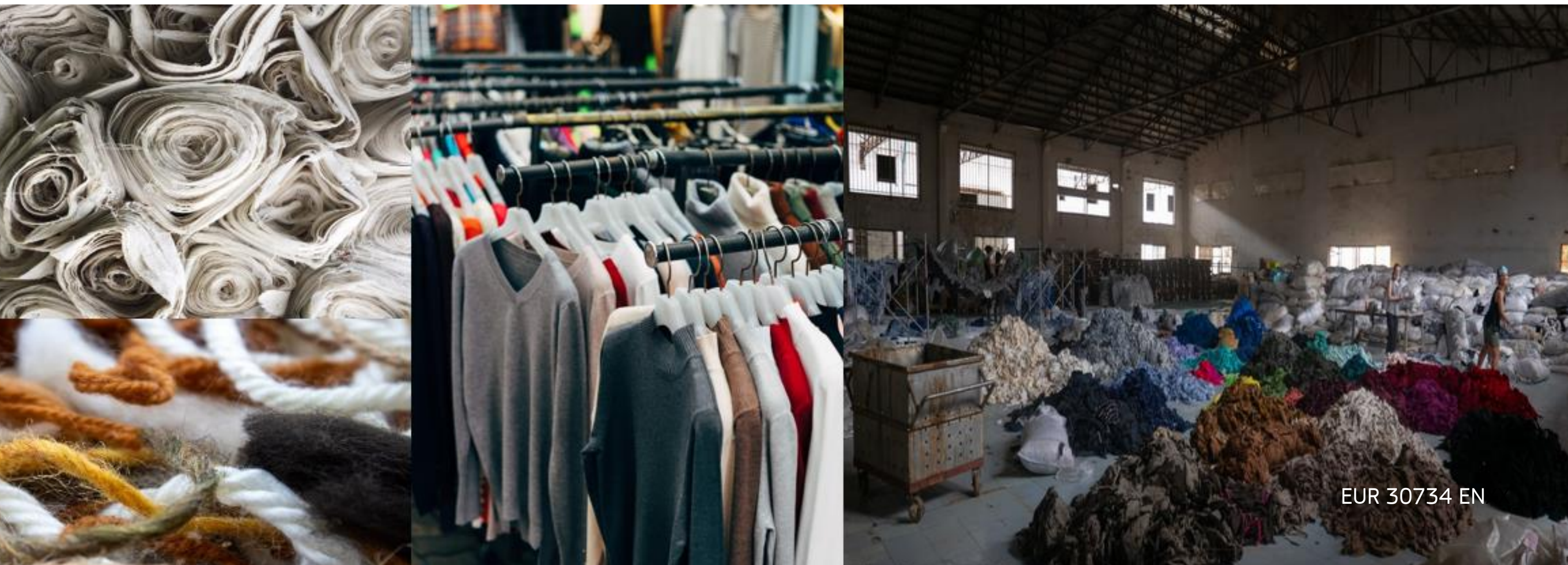

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Contents

Abstract

This study aims to provide information about circular economy perspectives in the management of textile products and textile waste in the European Union (EU). The report improves the understanding of current value chains in the manufacturing and retailing of apparel products in the EU and provides a detailed picture of material flows in the EU textile sector in a global context. This includes an overview of the size of the textile processing industry in the EU in terms of turnover, employment, number and size of companies, and the EU's share of the global industry. Then, an accurate picture is drawn of the volume (tonnes) and value (Euros) of new fibres, yarns, fabrics and textile products (apparel and household textiles) produced in the EU and traded with the rest of the world. This is complemented by a detailed look at the volumes of post-consumer textiles available for collection, reuse and recycling in EU countries, based on available data. This mapping serves as a preview of the upcoming challenges associated with the increased collection and processing of post-consumer textiles, foreseen as a result of mandatory obligations for the separate collection of textile waste in 2025. Furthermore, it identifies needs for planning the new fibre-to-fibre recycling capacity.

This study also provides information on current industrial practice in the EU for the collection, sorting and preparation of post-consumer textiles for reuse and recycling. Both currently installed and emerging technologies for the recycling of textile fabrics and apparel are mapped in order to provide a snapshot of the state of the art of available technologies that are expected to cope with the increased amount of textile waste towards 2025. The study details existing capacities for the collection and sorting of old textiles in Europe, and describes recycling technologies that are at a relatively high technological maturity level in order to estimate future sorting and recycling capacities. In order to minimise overlaps with an ongoing study commissioned by DG GROW about textile recycling technologies, the review of recycling technologies in this study mainly focuses on the core principles of each technology type and provides examples of that technology type in operation. On this basis, the challenges that exist with regard to the sorting and recycling technologies in terms of achieving a more circular economy will be addressed.

With regard to the perspectives of the circular economy in the textile sector, the study collects and examines established and newly emerging circular business models that have the potential to make the value chain for the European textile and clothing market and the post-consumer textiles sector more circular. Knowledge on existing and emerging practices of repair, reuse and recycling of textile products is presented and analysed with a view to ascertaining how these activities can contribute to increasing the circular economy in the EU. This provides a basis for identifying which options show the greatest potential, and for understanding which policy interventions, if any, could help shift the textile sector towards increased circularity.

The study concludes with an analysis of the strengths, weaknesses, opportunities and threats (SWOT) of the textiles production and consumption system in two scenarios: 1) the prevalence of a linear economy model and 2) a projected circular economy scenario. On this basis, the opportunities for and threats to the current textile sector, including the post-consumer textile collection, sorting, reuse and recycling industries, are examined in their entirety. Existing and emerging circular economy models are analysed in the same way.

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Executive summary

Textiles – an economically important sector with a major impact on the environment

In 2018, the textile industry in the EU employed 1.66 million people, representing 2 % of value added in the EU's manufacturing sector, 5 % of employment and 9 % of all manufacturing companies.

At the same time, the industry has a high impact on the environment. Around 4-6 % of the EU's environmental footprint across a range of impact categories is caused by the consumption of textiles. 85 % of the primary raw materials used, 92 % of the water used, 93 % of the land used and 76 % of the greenhouse gas emissions caused by the production of textiles for European consumption occur elsewhere in the world. The environmental impacts are a direct result of the global mass production and rapid consumption of textile products.

The European Commission is aiming for a circular textile economy

Along with cleaner production and the use of more sustainable fibre types, a transition to a circular economy has the potential to significantly reduce the impacts of textiles produced and consumed in Europe. In a vision for a circular economy, textiles placed on the market would be durable, their lifetime would be extended through repair and recirculation to new users so that they are in active use for as long as possible, and at the end of life cycle the materials they contain would be recycled into new high-quality products.

The European Commission's strategy on Sustainable Products in a Circular Economy has flagged textiles as a sector with a high potential for circularity. The implementation measures of the Action Plan for the Circular Economy address textiles in the field of consumption and waste management. The Commission is currently leveraging the Ecodesign policy to incorporate material efficiency aspects in the design of energy-related products and potentially in the future to other types of products (including textiles). More actions aim at the dissemination of good practices related to separate collection of post-consumer textiles in order to reduce waste and promote the repair and reuse of textiles.

Providing knowledge to assist the Commission with the EU Strategy for Sustainable Textiles

The objective of this project was to help prepare a knowledge base that could be useful in the development and implementation of the EU Strategy for Sustainable Textiles, through:

- Providing a detailed picture of the material flows in the EU textile sector and the textile product value chains, including flows and treatment of post-consumer textiles.
- Compiling knowledge on the state-of-the-art in existing and emerging post-consumer textile sorting and recycling practices.
- The compilation of good practice examples for circular business models in the textile industry.
- The analysis of strengths, weaknesses, opportunities and threats for existing and emerging circular business models in the EU textile and apparel market.

Value chains for new clothing and textiles are global

The value chain for a typical piece of clothing passes through several countries and even continents. For example, the cotton for a shirt may have been grown in Greece, spun into yarn in Turkey, woven into fabric in India, sewn in Bangladesh and purchased from a retailer in Germany.

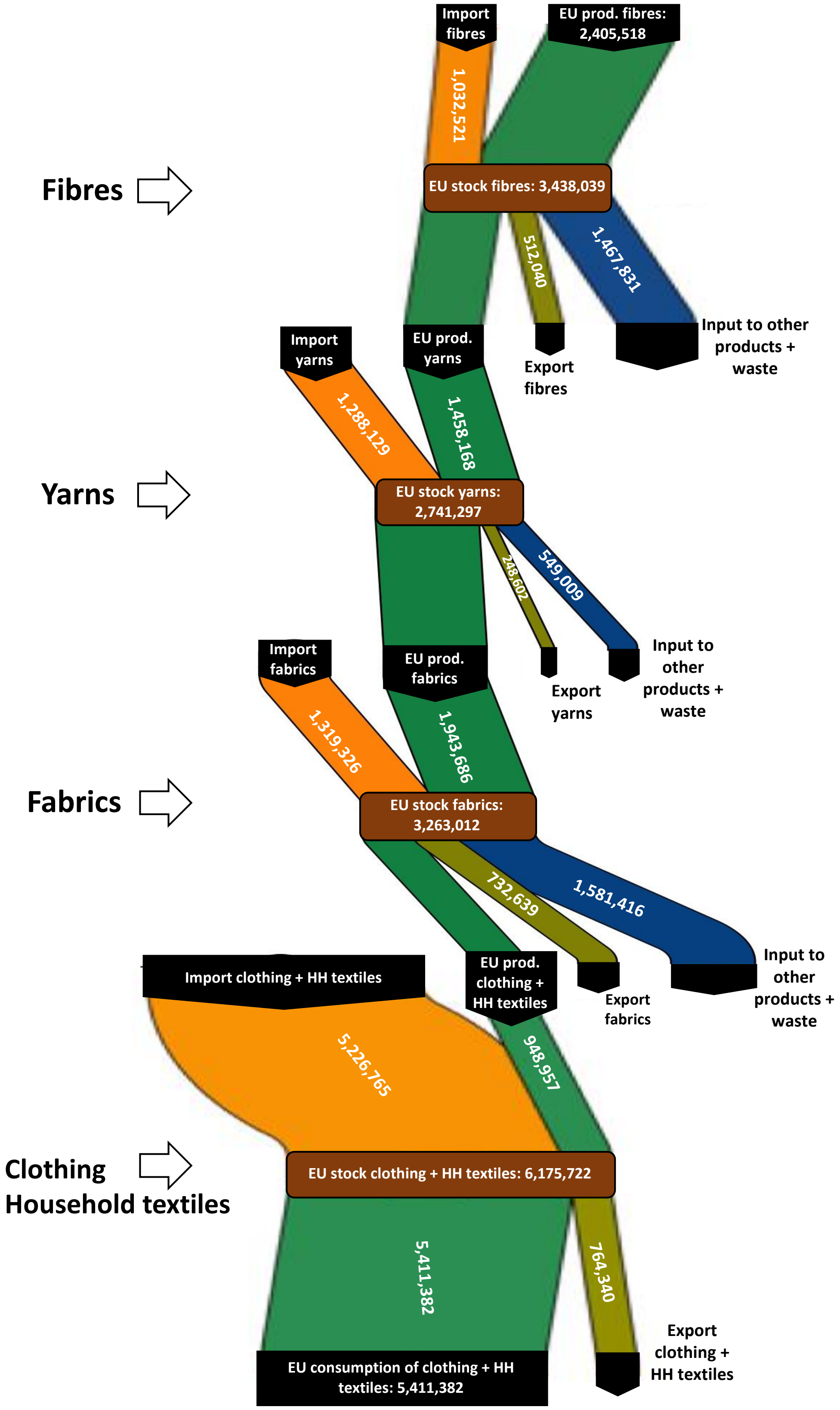
The EU is the world's second largest global importer of textiles (including fibres and fabrics) and clothing after the US with a combined value of 125 billion dollars, which is almost doubling when intra-EU trade is included. It is also the second largest exporter of textiles and clothing after China. Exports of clothing from the EU have increased by 6 % per year on average since 2010.

European consumption of new clothing and household textiles is gradually growing

Private households are the dominant consumers of clothing and household textiles. In 2018, the average European spent 591 Euro on clothing and 67 Euro on household textiles. Household expenditure on clothing and household textiles increased by 14 % and 17 %, respectively, between 2000 and 2018, although this includes a dip in consumption in the years following the 2008 financial crisis.

In terms of weight, this corresponds to 5.4 million tonnes in 2018 of which 4.4 million tonnes (81 %) comprised clothing and just over 1 million tonnes (19 %) comprised household textiles. The average per capita apparent consumption in EU-27_{2020} lay at 12.3 kg/capita in 2018, which is an increase of 20 % compared to the 10.1 kg/capita in 2003.

Mass flows of materials in the EU across the textile value chain



The material flows illustrated above (data for clothing and household textiles in $EU\text{-}27_{2020}$ economy in 2018, in tonnes) clearly show that final products represent the biggest share of material flows on the European markets.

Most of the final clothing and household textiles consumed in Europe are imported. EU production of clothing and home textiles declined by 44 % in terms of weight between 2003 and 2018 and by 2018 comprised just under 1 million tonnes (less than 20 % of EU consumption). Exports of clothing and home textiles from the EU-27 showed a similar trend.

Imports of clothing and household textiles for final use represent the largest share of material flows throughout the European value chain. Nevertheless, the EU is a significant producer, exporter and importer of semi-manufactured products along the value chain of textiles: fibres, yarns and fabrics. The EU produced 2.4 million tonnes of fibres, 1.4 million tonnes of yarns and just under 1 million tonnes of fabrics in 2018 for domestic and foreign markets.

Although European production and exports of fibres have increased steadily over the last decade, production of yarns and fabrics have been in decline, while imports have grown rapidly. Almost the entire reduction in EU production has been observed in cotton-based yarns and fabrics. Synthetics have remained relatively stable or have grown to dominate fibre, yarn and fabric production. Wool, meanwhile, is the only fibre type for which imports exceed EU production, with a significant share of imported wool processed in the EU into yarn for the export market.

Reporting on separate collection of post-consumer textiles is not yet standardised

The revised Waste Framework Directive requires Member States to establish systems for the separate collection of textile waste by 1st January 2025. Since there are (as yet) no targets for collection, Member States are not obliged to report on separate collection quantities as part of this obligation, although they may report voluntarily.

Some mapping and/or reporting of quantities and fate of separately collected post-consumer textiles occurs in 13 EU countries. Of these, only four countries/regions (Austria, France, Flanders (BE) and Italy) report annually on post-consumer textile collection. In the remaining countries, post-consumer textiles have been mapped once or twice over the course of the past decade, and often by non-governmental bodies. The scope and methodology used for the mapping of textile collection and of new textiles placed on the market varies from country to country; therefore, results are not immediately comparable.

Responsibility and implementation of collection of post-consumer textiles

France and Estonia are the only countries that already have legal requirements on the separate collection of textile waste. In France, producers of clothing, textiles and shoes are held responsible under EPR regulations. Sweden and the Netherlands also plan to adopt EPR regulations. Denmark, Italy and Spain meanwhile have allocated responsibility to municipalities who will begin separate collection of textile waste before the obligation in 2025.

Despite a lack of legal requirements, used textile collection has been widely applied for decades in many Member States, principally carried out by charitable and commercial collectors. Municipalities and their waste companies have also begun collection in recent years, although still on a small scale. Collection systems are dominated by bring banks, with over-the-counter collection in retailers, second-hand shops and socio-economic reuse organisations also prevalent, albeit at a smaller scale. A number of guidance documents on good practices in the collection and processing of used textiles have been produced.

Charitable and commercial collectors are principally interested in reusable textiles

Charitable and private collectors engage in used textile collection as an economic activity. Since there is currently no value in the recycling of textiles, these collectors tend to communicate that they only wish to receive clean and re-wearable textiles (and footwear) that they can sell on global reuse markets. The best 10 % (by weight) in quality of re-wearable textiles provides over half of the economic value of a typical bag of donated textiles.

The economic conditions for charitable and commercial collectors have become considerably less favourable over recent years as increasing supplies of separately collected re-wearable textiles have saturated global second-hand markets. Conditions have been made worse due to the reduced quality of the textiles donated by citizens. The combined result was a by 30 % drop in the price per kg for collected textiles between 2016 and 2019.

The Waste Framework Directive's obligation on the separate collection of textile waste by 2025 may critically change the rules of the game for the used textile sector: Textile waste with zero reuse value will now also need to be collected.

If parallel systems are set up where charitable and commercial collectors continue to focus on the reusable fraction while municipalities focus on collecting the non-reusable waste, the business model of traditional collectors may still be viable.

If, on the other hand, commercial and charitable collectors are expected by national or local government to collect the non-reusable waste along with the reusable textiles, then they, and/or the respective sorting companies, will need economic compensation from state governments, producers (via EPR legislation) or local government in order to survive economically.

Current and future collection quantities

Collection quantities per capita vary widely between Member States from just 0.3 kg/capita in Latvia to 8.3 kg/capita in the Flanders region. Across the countries with available data, no less than 38 % of new textiles placed on the market are eventually collected separately for reuse or recycling. It is estimated that between 1.7 and 2.1 million tonnes of used textiles are collected annually throughout the EU. The majority of the remaining 3.3 to 3.7 million tonnes are thought to be discarded in mixed household waste, with a much smaller amount being stored in increasing stockpiles in households.

To give an indication of growth in collection volumes across Europe, exports of used textiles from the EU-27 to other parts of the world grew from just under 400 000 tonnes in 2003 to 1.3 million tonnes by 2019. Collection volumes are expected to grow even more rapidly towards 2025, as countries begin to establish a system for the separate collection of textile waste to fulfil the obligations of the revised Waste Framework Directive.

Based on historical year-on-year improvements in countries/regions that have made strong efforts to increase collection rates through target setting, communication and an emphasis on collection of the non-reusable collection waste (France, Flanders and Netherlands), we estimate that annual collection will *increase* by a further 65 000 to 90 000 tonnes annually in coming years as Member States begin to roll out new/adjusted collection systems to implement the Directive.

Treatment of separately collected textiles

Textiles collected by *charities and professional collectors* tend to be treated as follows: a proportion of collected textiles may be pre-sorted to skim off the best quality textiles for sale in their own second-hand retail stores, provided they have such stores. The remainder is sold to wholesalers for detailed sorting and sale on global markets. Some collectors have their own detailed sorting facilities. Textiles may often be exported to other countries (mostly within the EU) for sorting. Both the Netherlands and Poland imported over 200 000 tonnes of used textiles in 2018, principally to feed the large wholesale and sorting sector in these countries.

The wholesalers manually sort the textiles they receive into between 100 and 300 different fractions according to garment type, style, size, season etc. for sale on global reuse markets. Textiles that are not suitable for global reuse markets are sent for recycling (normally as industry wipes or downcycling into lower quality products) where possible and otherwise to landfill/incineration.

Reuse shares typically range between 50 % and 75 % depending on the country where the textiles were collected and how the collection was carried out.

Wholesalers do not always have a clear idea of what happens to the textiles that they export for reuse elsewhere in the world. An increasing number of collectors have adopted codes of conduct for their buyers to ensure that they adhere to environmental and social criteria and to increase transparency in the eventual fate of used textiles, but there is a need for more widespread adoption of such codes of conduct.

Where textiles have been collected by *municipal waste companies* who focus on non-reusable textiles and which have limited access to global reuse and recycling markets, it is not unusual for almost all of these textiles to be incinerated or landfilled due to a lack of other options.

Dealing with the textiles diverted from mixed waste

A large part of the 65 000 to 90 000 tonnes year-on-year growth in textiles diverted from mixed waste to separate collection each year are likely to be non-rewearable or at least to have no value on second-hand markets. Whoever ends up collecting these will face a significant challenge in finding circular solutions. Prices for these textiles on existing recycling markets are at rock-bottom and recycling capacity is limited, meaning that a large share thereof must already be incinerated or landfilled at high cost to sorters. Current recycling markets comprise cutting (of cotton-rich) textiles into industry wipes or various downcycling options such as use in insulation, upholstery padding or other low-grade products.

If the textile waste is to be recycled and is to be of any economic value to the collecting organisations, new recycling technologies need to be developed along with sorting technologies to sort textiles waste by fibre type and colour.

Manual sorting: an essential first step for post-consumer textiles

Manual sorting is the most widespread textile sorting approach used in Europe with facilities sorting hundreds of thousands of tonnes of used textiles each year. Manual sorting is focused on selecting and sorting rewearable items for global second-hand markets with 1.3 million tonnes of textiles exported from the EU-27 in 2019 for global second-hand markets.

Manual sorting is likely to remain an essential first step for the processing of separately collected textiles in the future circular textile economy. Reuse delivers much greater economic and environmental benefits than recycling, and it will not be possible in the foreseeable future to train a machine to sort by quality and product type for reuse markets. Moreover, any post-consumer textile collection system will receive rewearable textiles, regardless of what the collection organisation requests in its communication with households.

The current manual sorting capacity will need to be expanded by a *further* 65 000 to 90 000 tonnes of capacity each year, towards and beyond 2025.

Automated or semi-automated sorting for the non-rewearable fraction

Automated or semi-automated sorting is likely to be the preferred process for the non-rewearable outputs of the manual sorting process or for the processing of other textile waste (e.g. pre-consumer factory waste) that has no rewearable content. Automated sorting can efficiently and accurately sort most textile wastes by colour and fibre type ready for input into high-quality mechanical or chemical recycling. While personnel in charge of manual sorting can sort between 100 to 150 kilos of textiles per hour, advanced facilities for automated sorting are suited to sort between 900-1500 kg per staff member each hour. This higher efficiency is necessary since the output of the automated sorting process delivers a much lower economic value than the rewearable output of the manual sorting process.

Automated sorting technologies have only recently become ready for upscaling to industrial scale, and capacity across Europe is currently just a few thousand tonnes per year. Significant investments will be needed over the next few years to sort the hundreds of thousands of tonnes of non-re-wearable textiles that are expected to be collected each year towards and beyond 2025.

Due to the low economic value of the non-reusable waste textiles from manual sorting plants, it may be both economically and environmentally advantageous to locate automated sorting facilities close to manual sorting facilities or to integrate them directly into these facilities. The same could also be true for recycling facilities.

Mechanical recycling dominant, but chemical recycling processes are scaling up

Approximately 20 % of the used textiles that are separately collected in Europe each year are used as industry wipes or for other recycling purposes on European and global markets. Mechanical recycling technologies, where the waste textile is physically manipulated to recover materials, fibres or fabrics, are currently the most prevalent. Typical products from mechanical recycling include industry wipes, padding and filling for the car industry, acoustic and thermal insulation at well as non-woven mats.

Other fibre-to-fibre recycling processes rely on chemical recycling technologies. These technologies reduce textiles to their base components, which can then be re-spun into new fibres, yarns and textiles. The chemical process is often preceded by a mechanical process. Chemical recycling for non-plastic fibres such as wool or cotton is not currently at the same technological readiness level as polyester recycling. Although many of the more promising chemical technologies are still not operating at industrial scale, some are expected to expand in capacity substantially over the next few years. It is hoped that increased fibre-to-fibre recycling will be driven in part by an increased demand for recycled textile fibres from producers and brands.

Fibre-to-fibre recycling still faces a range of barriers

A range of stakeholders, including fashion companies and other textile companies, collectors and recyclers, have an interest in increasing fibre-to-fibre recycling of textiles but face challenges in doing so. Some of these challenges are of a technical nature including shortening of fibre lengths, separation of fibre types in products with fibre mixes and the presence of persistent chemicals in some specialised products. Others are system problems related to the gathering and sorting of sufficient quantities of recyclable used textiles, while at the same time not closing off environmentally preferable reuse pathways. Finally, there are substantial economic and market-based challenges. Recycled-content yarns and fibres remain more expensive than their virgin content counterparts, and the fact that the range of recycled-content yarns and fabrics available are much more limited presents challenges for designers.

Eco-design of products can partially assist developers in some of the technical challenges by designing new products that can more easily be dissembled and recycled. However, it is vital that design for recyclability does not undermine product durability, since the extension of lifetime offers significantly greater benefits than recycling. Public and private investments in recycling technology can speed up development and reduce prices, but there is a strong need to increase the demand for recycled-content fibres in the industry and to develop policy instruments that will reduce the price differential between more expensive recycled and cheaper virgin-content yarns and fabrics of a given fibre type and composition.

Finally, there is a clear need for increased coordination and exchange of information between actors; in particular between designers/brands/producers and sorters/recycling companies and technicians developing new recycling technologies.

The circular economy inspires innovation in business models that benefit from reducing textile waste

The European Commission's Circular Economy Action Plan has promised an EU Strategy for sustainable textiles that will boost the EU market for sustainable and circular textiles. This includes the development of a market for textile reuse, addressing fast fashion-related challenges and new business models.

Circular business models (CBM) create value during the use phase and the end-of-life phase of textiles by extending the service life of products and returning textile waste to economic cycles. Examples of CBM mapped in this study include durable garment design, sharing/leasing services, repair and refurbishment, and the take-back, sorting and redistribution of second-hand clothing.

The closing of loops in the life cycle of textile products opens up opportunities for better value creation from the material resources from which the clothing is made. This lowers the demand on virgin textile raw materials and thus relieves the environment of negative impacts during fibre production, such as greenhouse gas emissions, water demand and pesticide use in cotton production.

While the environmental and social costs of these impacts are not fully accounted for in the existing linear economic system, the circular economy holds opportunities to generate revenue from reducing these environmental burdens. For companies that wish to innovate in CBM in textiles, decoupling profit generation from raw material consumption and product sales in a highly competitive market is a crucial motivating factor. Circularity-oriented service offerings can leverage competitive advantages in an otherwise extremely saturated apparel market.

Unique value propositions of circular business models

CBMs differ in terms of value creation from linear counterparts in the traditional apparel industry that relies on fast fashion trends and mass consumption. Value creation in CBMs is often based on service offerings, such as leasing and repair, rather than on sales of products. Circular businesses are often implemented by communities of entrepreneurs and customers, both of which are highly committed to the idea of sustainable and resource-efficient fashion.

A sustainability-oriented community constitutes a crucial success factor for circular textile businesses to thrive. The market segment of sustainability-conscious consumers represents a niche, while the traditional market for second-hand clothing coexists in a budget economy target group.

However, the availability of social media technologies and virtual platforms are removing the traditional dependence of small businesses on the physical proximity of businesses and consumers. Thus, emerging circular businesses are also pioneering with regard to an increased uptake of durable and sustainable clothing and repair and reuse in broader consumer segments. At the same time, CBMs often include certain sustainability standards and ecological or fair-trade offers. That explains why business models are directed towards informed customers interested in sustainability, who are aware of the negative effects of fast fashion. As public awareness and policy frameworks increasingly draw attention to these aspects, there is an opportunity for CBMs to grow out of their market niche.

Strengths, weaknesses, opportunities and threats of circular business models

A SWOT analysis was conducted to evaluate the viability of existing and emerging CBM against the background of two economic model scenarios: 1) The current linear economic approach in the textile sector, representing the business-as-usual scenario. 2) A circular economy scenario that anticipates a possible future in which the goals of the EU's Circular Economy Action Plan are fully implemented and where CBMs become well-established in the textile sector.

The findings suggest that the success of circular businesses in the textile sector is currently limited to a market niche populated by environmentally and socially conscious consumers and social actors committed to sustainable consumption. As long as the economic framework favours a linear growth model, circular enterprises are restrained from gaining traction in the textile market. One of the reasons for this is that, in a linear economy, environmental and social costs are usually externalised – this allows for low-cost and short-lived clothing to be offered on the mass market.

CBMs tend to have a higher degree of cost internalisation (e.g. domestic labour costs). This aspect puts circular businesses at a competitive disadvantage, but at the same time offers them a unique value proposition, such as providing consumers with more sustainable and socially benign clothing.

Another important finding is the high dependence of the current post-consumer textile value chain on the abundant source material (i.e. post-consumer clothing) from the linear primary apparel market. This is both a curse and a blessing because their current business models rely on a mass-consumption driven paradigm. A transition to a circular economy might deprive this sector of the availability of cheap feedstock, but on the other hand may boost demand for second-hand, remade and recycled-content textiles.

Service-oriented CBM can benefit from the growing market demand for textile care and repair as well as from sharing offers. On the other hand, the transition to the mainstream in a circular economy is likely to be accompanied by a loss of their uniqueness and trendsetter role in terms of sustainable textile consumption. Growing out of its current market niche therefore challenges CBMs to evolve into a less idealistic consumer segment without losing touch with their base of committed clients and supporters.

1 Background

1.1 Impacts of textiles production and waste & approaches towards impact reduction

Clothing is of great importance in everyday life. Over 75 million people are employed in the textile industry globally (UNECE, 2018). Indirectly, the sector creates additional jobs in upstream or downstream industries such as mechanical engineering, design and logistics. With a worldwide annual turnover of 1.13 trillion Euros, the garment industry is a significant sector in the global economy (EMF, 2017). In the last 15 years, global production of apparel has approximately doubled and demand for textile fibres is projected to increase from 62 million tonnes in 2017 to 102 million tonnes in 2030 (BCG & GFA, 2017).

In recent years, the clothing industry has been characterised by increasing numbers of collections issued each year, with associated rapid obsolescence. Fashion brands compete on the speed of fashion cycles and the production of short-lived consumer goods. The two largest European clothing brands roll-out 24 and 16 collections per year, respectively (BVSE, 2020). The time span between design, production and sale is about one month (Bhardwaj & Fairhurst, 2010). The predominantly linear business model based on selling high volumes of short-lived clothing has led to a high per capita consumption of material resources and associated waste generation. Instead of reusing clothing and recycling the materials that it contains, it is estimated that 87 % of the total fibre input at global level is landfilled or incinerated following first use (EMF, 2017). This results in an annual loss of value estimated at more than USD 100 billion.

The textiles industry has a high impact on the environment (e.g. global warming, water consumption, conversion of ecosystems to agricultural land, use of chemicals, microplastics emissions). The Ellen MacArthur Foundation (2017) estimated that the global greenhouse gas (GHG) emissions from textile production totalled 1.2 billion tonnes of CO_2 equivalents in 2015. Environmental impacts are caused along the full lifecycle of textile products, from the extraction of raw resources through production, transport and use. Either the production phase or use phase dominates the overall impacts depending on the impact category. Regarding human, freshwater and marine toxicity for example, it is the use phase (e.g. laundry of garments) that dominates; regarding land use and eutrophication and, to a lesser extent, regarding greenhouse gas emissions, the production phase is dominant (JRC, 2014).

Since a large part of textiles consumed in the EU are produced outside the EU, impacts associated with resource extraction, production and GHG emissions also occur elsewhere in the world. Around 85 % of the primary raw materials used, 92 % of the water used, 93 % of the land used and 76 % of the greenhouse gases emitted for the production of clothing, footwear and household textiles consumed in the EU occur in non-EU countries (Manshoven et al, 2019). The global warming impact of textiles imported into the EU is substantial. In a life cycle assessment of the French textile sector, Payet (2021) estimated the carbon footprint for the sector at 442 kg CO_2equivalents per person per year. Assuming similar consumption patterns in other EU member states, the overall annual global warming potential of textiles placed on the EU27 market can be extrapolated to 198 million metric tonnes CO_2equivalents (compare Eurostat, 2020).

Around 4-6 % of the EU's environmental footprint across a range of impact categories is caused by the consumption of textiles. As a consumption category, the footprint for clothing, footwear and household textiles ranks fourth, directly behind the three main consumption areas of housing, mobility, and food (Manshoven et al, 2019).

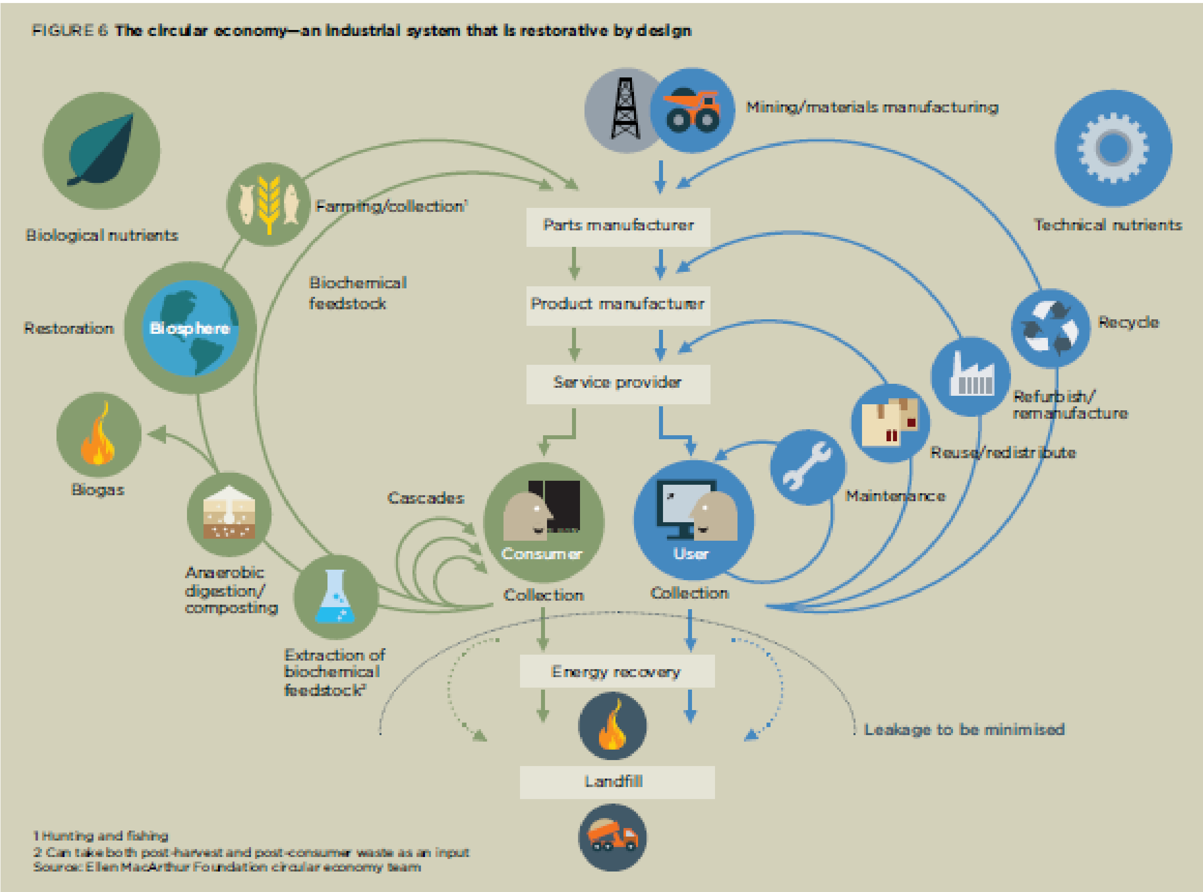
These environmental impacts are a direct result of the global mass production and consumption of textile products, which are often very short-lived, especially in the case of clothing. While several approaches have been implemented to reduce environmental pressure during the textile supply chain, such as cleaner production and use of more sustainable fibre types, these measures have been outweighed by the ever-increasing amounts of textiles placed on the market. To reverse the trend, the challenge is therefore to promote sustainable consumer behaviour aimed at reducing the use of short-lived clothing. The circular economy framework could provide an additional significant impact reduction potential, where high quality, durable products are repaired and recirculated so that they are in active use for as long and as much as possible, and at end of life the materials they contain are recycled into new (possibly textile) products.

The transition from the current linear economy-oriented textiles production and consumption system towards a circular one is a process to which all stakeholders along the value chain can contribute. Contributions would include changing how textiles are designed, produced, sold, used, collected and treated at the end of life. Circularity in the textile industry can be achieved through circular business models, developing and promoting recycling technologies, political measures and changes in consumer behaviour. The EEA (2021) states that “there are four main circular business model types, each supporting the shift towards circularity: (1) ensuring products` longevity and durability; (2) access-based models (renting and leasing); (3) textile collection and resale; and (4) recycling and reusing materials”.

1.2 Linear versus circular economy

A circular economy differs from a linear economy mainly in that the value of materials and resources is preserved as long as possible in form of functional products. In a linear economy, the value chain starts from the production of raw materials (such as cotton) to the point of sale where the product is sold to the consumer. After purchase, the product offers its user a function until it breaks down or the owner does not want it anymore for various reasons. Then, the user buys a new product and discards the old one which is then disposed of.

Figure 1: The circular economy model by Ellen McArthur Foundation (EMF), i.e. the “butterfly diagram”



Source: EMF (2012)

A circular economy, on the other hand (see Figure 1), is characterised by a value chain that extends over the entire product life cycle and also includes the so-called reverse value chain which creates value by reintegrating used products and materials into the economic cycle. In a circular economy, the active lifetime of a product is extended as far as possible through design for durability, through repair, and through sharing with or passing on to other users when the first user no longer needs it. When the product has reached its end of life, the materials it contains become a resource for the production of new products through recycling. Circular textiles and fashion products (including apparel, footwear, and accessories) are thus designed in order to be used for a longer time. Returning products that have reached the end of their useful life and reintegrating them into the value chain helps not only to minimise the generation of waste but can also be a means of value creation through new jobs (European Commission, 2020). Circular textiles are often made from recycled or renewable raw materials. The fewer raw materials are needed to produce new clothing, the less natural capital is consumed in the process and the lower the impacts on the environment will tend to be (Manshoven et al, 2019), (Eurostat, 2020a).

Figure 1 presents a visualisation of the circular economy as a "butterfly" to which later chapters of this report will refer. It features a generic product value chain, displayed at the centre of the figure. The right side of the figure (the technical cycles), shows that after completion of its primary use phase, the end-of-life product is not disposed of, but instead collected in order to be reintroduced into a new value chain. The model eliminates the generation of waste at the end-of-life stage. It then follows one of the cyclical "arrows" into the technical recovery processes. The different radii of the cycles symbolize the value level of the recovery step: the smaller the cycle, the higher the value retention and the shorter is the reverse value chain.

Only the technical cycles (right side of Figure 1) are considered as relevant for this report (the left side shows the biological cycles instead). The technical cycles from inside to outside are as follows: Maintenance – Reuse – Refurbishment – Recycling. The bigger the cycle, the further back the measure brings the product to the beginning of the value chain and the higher the energy required to create a new product.

1.3 Textiles and the European Circular Economy Action Plan

The transition to a circular economy is a main policy priority for the European Commission. The shift to a circular economy is regarded as an opportunity to establish new job-intensive activities within Europe's industry and bring more manufacturing back to the EU in some sectors, while minimizing environmental and climate impacts. The EU Circular Economy Action Plan 1.0 from 2015[1] required changes to EU legislation to encourage a more circular economy. Amongst other things, the subsequent revision of the EU Waste Framework Directive in May 2018 (Official Journal of the European Union 2018), Article 11(1) requires EU Member States to establish systems for the separate collection of textile waste by 1 January 2025. Moreover, Article 11(6) of the revised EU Waste Framework Directive states that the European Commission must consider by December 31, 2024, to set targets for (preparing for) reuse and for recycling of separately collected textiles (ibid), Article 9(1) of the Directive was amended as to encourage the reuse of textile products and the setting up of systems that promote repair and reuse activities for textiles.

More recently, the European Commission introduced a new Circular Economy Action Plan[2] as one of the main blocks of the European Green Deal.[3] The aim of the Circular Economy Action Plan is to reduce the EU's consumption footprint and double the EU's circular material use rate in the coming decade, while boosting economic growth. As part of this plan, a comprehensive EU Strategy for sustainable textiles will be proposed that aims to boost the EU market for sustainable and circular textiles, including the development of a market for textile reuse, addressing fast fashion-related challenges and new business models as well as promoting innovative approaches for improving design for sustainability under the Sustainable Products Initiative (see section 3.1). The strategy will aim to boost the sorting, reuse and recycling of textiles through innovative technologies, and encourage industrial applications and regulatory measures such as extended producer responsibility (EPR).

There is a long history of collection of reusable textiles in many countries, primarily carried out by charitable organisations in order to fund their activities, or by commercial actors, since there has been profit to be created from the sale of better quality second–hand clothing (Watson et al, 2018). However, these actors have not been interested in the non-reusable fraction of clothing and textiles due to a lack of economically viable recycling markets (ibid). It is principally the non-reusable textile waste that the WFD's separate collection requirement for 2025 is focused on. Many EU Member States are working on options for meeting the 2025 collection requirement and are considering placing responsibility on municipalities (e.g. Denmark, Finland, Germany) or on producers via EPR regulations (e.g. France, Sweden, Netherlands) (Watson et al, 2020a).

However, the collection of textiles waste in itself will not ensure that these textiles are subsequently reused and/or recycled. The current recycling of textiles is almost entirely limited to downcycling solutions such as use as industry wipes and use in insulation, upholstery fill and low-grade non-woven textiles. Significant investments in the development and establishment of automated sorting and fibre-to-fibre recycling

[1] COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Closing the loop - An EU action plan for the Circular Economy

[2] Communication from the Commission to the European parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, A new Circular Economy Action Plan, For a cleaner and more competitive Europe. Brussels, 11.3.2020 (COM 2020) 98 final)

[3] Communication from the Commission to the European parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions. The European Green Deal. Brussels, 11.12.2019 (COM(2019) 640 final)

technologies are needed for the non-reusable textile wastes (Watson et al, 2020a). Moreover, even global markets for reusable second-hand textiles are showing signs of saturation as supply increases but demand stagnates (Ljungkvist et al, 2018). The coming EU Strategy for Sustainable Textiles will need to address these issues if a significant circular economy for textiles is to be established.

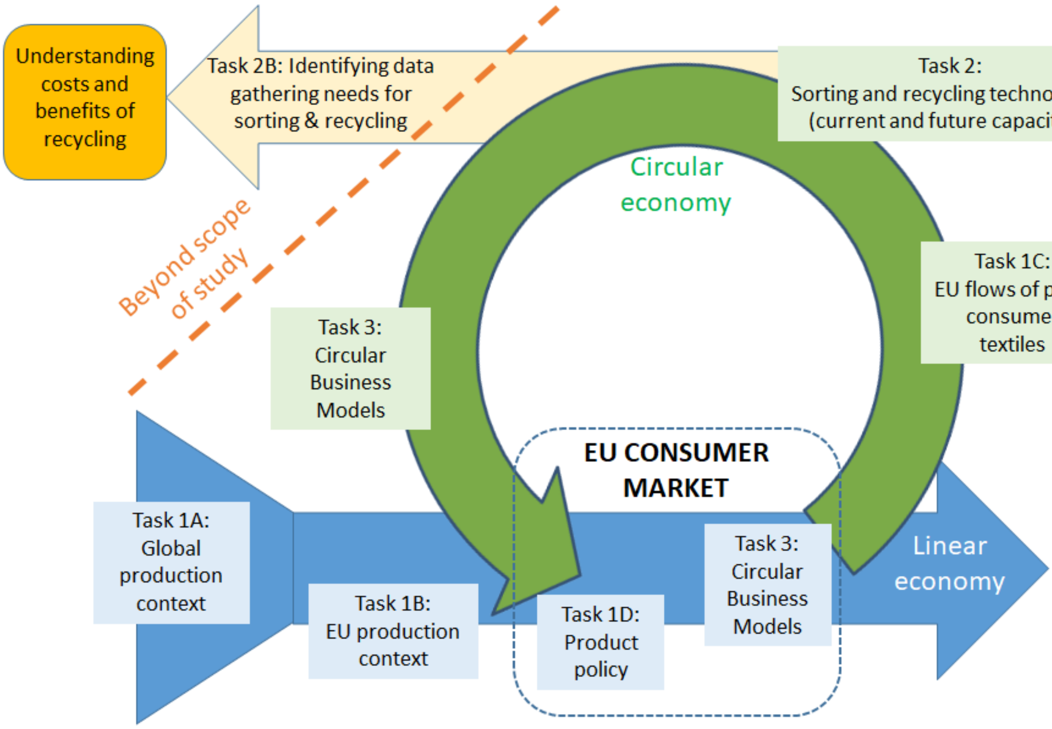
2 This project

2.1 Goal of the project

The key goal of this project is to provide a knowledge basis to equip the Joint Research Centre with information to assist the European Commission in developing and implementing the coming EU Strategy for Sustainable Textiles. It will achieve this through:

- Providing a detailed picture of the material flows in the EU textile sector and a good understanding of textile product value chains in particular flows and treatment of post-consumer textiles (**task 1**).
- Compiling knowledge on the state-of-the-art and best practices existing and emerging post-consumer textile sorting and recycling practices (**task 2**).
- Providing the basis for quantifying the potential benefits of increasing circularity in the EU textile and clothing market, identifying which options show greatest potential and understanding which policy interventions, if any, could help shift the textile sector towards increased circularity (**task 3**).
- Providing an analysis of the strengths, weaknesses, opportunities and threats (SWOT) of the current textile sector (**task 4**), both in a scenario where the business as usual linear economy model continues (blue arrow) and in another scenario where circularity is greatly increased in the sector (green arrow).

Figure 2: Inter-relations of tasks in this project



Source: Own representation

3 Task 1: Analysis of the material flows, value chains and waste generation data associated with the EU textile and clothing market

3.1 Overview

The objective of **Task 1** is to provide the Joint Research Center (JRC) with a detailed picture of the material flows and value chains of textile products, and the subsequent flows and treatment of post-consumer textiles. This picture can then be integrated together with those provided under Task 2 and Task 3, so that a useful knowledge base can be built that can contribute to the development and implementation of the EU strategy for sustainable textiles and Europe's transition to a circular economy.

The following key themes are covered under Task 1:

- The European textile industry in a global context (**Theme 1A**): a brief overview of the size of the textiles manufacturing industry in the EU in terms of turnover, employment, number and size of companies, the EU's share of the global industry as well as trade between the EU and rest of world. This provides the context for the entire report.
- New textile products and semi-manufactures – EU production, consumption and trade (**Theme 1B**): a detailed mapping of volume (tonnes) and value (Euro) of fibres, yarns, fabrics and final products (clothing and household textiles) produced in the EU and traded with the rest of the world. This provides an overview of the metabolism of the industry, the tonnage of fibres and textiles that are produced and processed and an upper limit of the quantity of consumed products for which circular solutions will be needed.
- Flows of post-consumer textiles - separate collection, processing and treatment (**Theme 1C**): a detailed view of the collection, reuse and recycling of post-consumer textiles in EU countries with available data, the current level of circularity and upcoming challenges associated with increased collection and processing capacities needed moving towards 2025, including the need for new fibre-to-fibre recycling capacity.
- Product policy for textiles (**Theme 1D**): a brief overview of the availability and use of different product policies for clothing and textiles and how these could potentially contribute to an increased circularity for these products.

Section 3.2 outlines the scope for the product types and categories covered as well as the geographical scope. The research structure and methodology for the compilation of data is explained for each theme (1A, 1B, 1C and 1D). In Section 3.3, the results are presented for each theme.

3.2 Methodology

3.2.1 Scope: Product types and categories

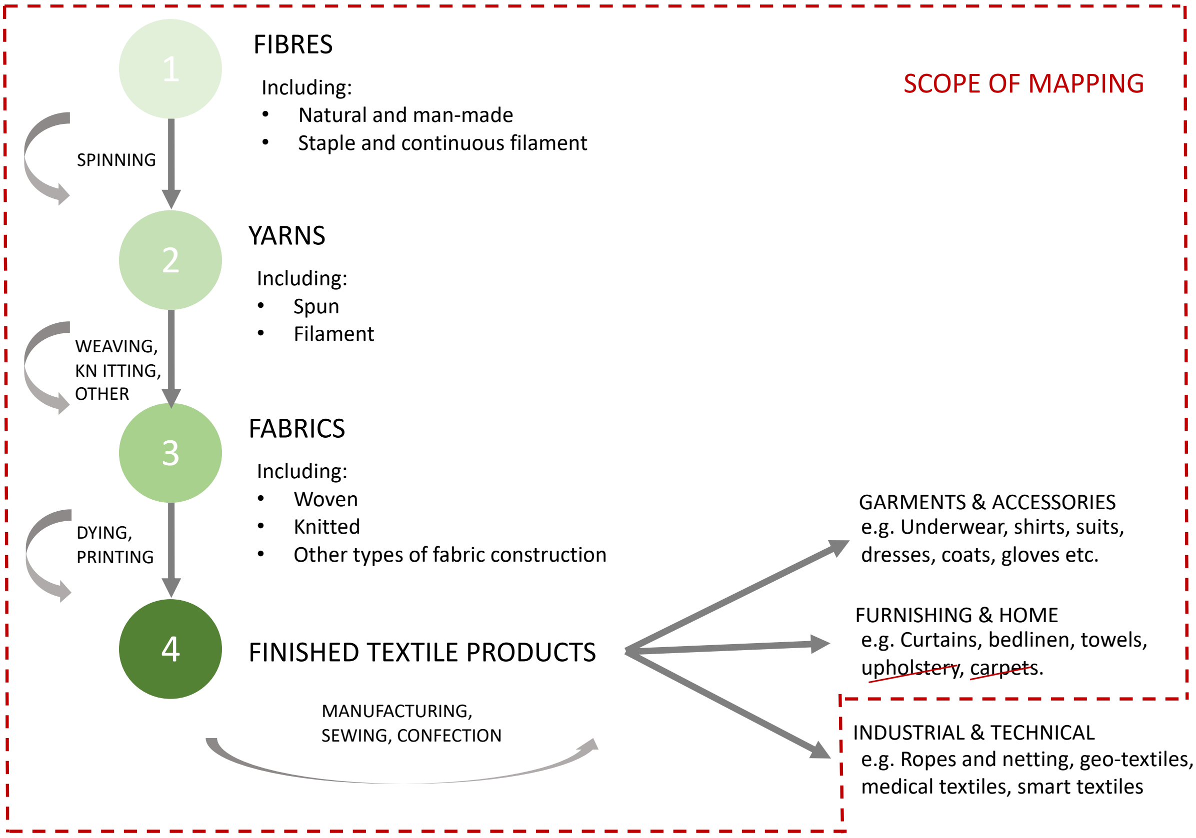
Box 1: Definition of 'textiles'

Textile products are defined by the European Parliament and the Council (2011) as "any raw, semi-worked, worked, semi-manufactured, manufactured, semi-made-up or made-up product, which is exclusively composed of textile fibres, regardless of the mixing or assembly process employed". Products 'containing at least 80 % by weight of textile fibres' are also referred to as textile products.

The overall term 'textiles' (see Box 1) is rather broad and covers a large range of final and semi-manufactured products for a wide range of uses.

Task 1 (particularly themes 1B and 1C) focus on clothing and home textiles (e.g. bedlinen, towels, tablecloths, curtains etc.), however, excluding products for which textiles are not the dominant component (e.g. upholstery textiles, carpets, duvets, pillows). We focus on clothing and home textiles consumed by households, and similar products consumed by government and business (e.g. uniforms and workwear used by all public and private sectors, bedlinen and towels etc. consumed by hotels, restaurants, healthcare services etc.). Related semi-manufactures that are produced, imported and exported along the value chain of clothing and home textiles are also mapped. Textiles that are not normally consumed by households, such as technical textiles[4], are excluded. Shoes are also excluded regardless of their composition. See Figure 3 for an overview of the scope of the mapping under Theme 1B. It should be noted that this scope is somewhat narrower than the scope of the upcoming EU Strategy for Sustainable Textiles which includes apparel, footwear, technical textiles and home textiles.

Figure 3: Scope of semi-manufactures and final products mapped in Theme 1B



Source: Adapted from Euratex (2020)

3.2.2 Scope: countries

The European Union is the primary focus area for Task 1. Unless otherwise stated, the EU is taken to exclude the United Kingdom (denoted EU-27_{2020}), irrespective of the year for which data were available. Similarly, under Theme 1C, data has only been included for post-consumer textiles in selected EU-27_{2020} countries as named in the respective section of the report.

3.2.3 Data sources for Theme 1A: The European textile industry in a global context: a brief overview

Data, information and statistics on the European textile industry and its global context presented in this report are based on available literature. Key sources of data were regular bulletins from the European branch organisation for the textile industry (Euratex), and reports from the Directorate General for Internal Market, Industry, Entrepreneurship and SMEs (DG GROW).

3.2.4 Methodology for Theme 1B: New textiles and semi-manufactures

Theme 1B comprises developing snapshots of domestic production, consumption and trade of clothing, home textiles and semi-manufactures along their value chains.

[4] Textiles manufactured for non-aesthetic purposes, where function is the primary criterion. Technical textiles can include automotive applications, medical textiles (e.g., implants), geotextiles (reinforcement of embankments, drainage, protection, filtering), agricultural textiles (for crop protection), and special protective clothing

The value chain for textile products is complex, consists of many production stages and involves a vast number of companies at each stage of production, which are spread out across the globe. It is beyond the scope of this study to illustrate the entire flow of semi-manufactures and final products between different regions of the globe on their way to and from and through the EU. Instead, 'slices' have been taken at four different points in the value chain in order to provide an impression of overall trends and volumes in materials flows and values. These 'slices' are:

- Raw fibres
- Yarns
- Fabrics
- Final products

Box 2: ProdCom database

Eurostat's ProdCom database (Eurostat, 2021a) comprises statistics on manufactured goods and services together with trade data for the same products. At the 8-digit disaggregation level, the database includes app. 3900 distinct product types defined using a ProdCom code which is derived from 6-digit CPA headings and 4-digit NACE codes.

Broadly speaking, the Prodcom data includes for each product category:

— the volume of production (sold and/or produced) given in a physical unit selected according to the product type (pieces, kg, m2 etc.)

— the physical volume of the product exported and imported in the same physical unit

— the value of production sold in Euros

— the value of imports and exports

In each reporting country, the National Statistics Institute carries out a survey of industrial production in that country, collates the results and transmits them to Eurostat. Eurostat calculates EU totals and publishes the national and EU data together with the related external trade data. Individual EU and EEA countries can be selected as reporting countries or groupings of countries including the grouping EU-27_2020.

Link: https://ec.europa.eu/eurostat/web/prodcom/data/database

Raw fibres, yarns and fabrics

Data was gathered, collected and presented for the domestic production (in EU-27 as a whole), with imports and exports broken down, as far as possible, by main fibre type. Data was drawn from Eurostat's ProdCom dataset (see Box 2), and supplemented where necessary by the Eurostat Comext database (Eurostat, 2021b).

ProdCom codes in the aggregated product group "13 Manufacturing of textiles" were selected and downloaded for $EU27_{2020}$ as the reporting 'country' and for the years 2003 to 2018 for which data were available. The following 4-digit codes were relevant: *1310 Preparation and spinning of textile fibres; 1320 Weaving of textiles; and 1391 Manufacture of knitted and crocheted fabrics*. In addition, the 4-digit product code *20.60 Manufacture of man-made fibres* under the 2-digit code *20 Manufacture of chemicals and chemical products* was also relevant.[5]

The 8-digit product codes under each of the 4-digit groups were carefully filtered to remove all product types that were not considered to be a semi-manufactured product that would eventually find its way into a garment or home textile product (e.g. 13.20.4600 woven fabrics of glass fibre). The final result after filtering comprised 102 relevant 8-digit product codes.

These product categories were further divided into three main groupings of *Fibres, Yarns & sewing threads and Fabrics*. All relevant 8-digit product codes were each assigned to a fibre-type sub-group from one of the following: *Cotton, Wool, Other natural fibres (silk, hemp, flax etc.), Synthetic, Cotton/synthetic blend; Wool/synthetic blend and Unknown*. This assignation was made according to the product code name/label. These groupings were largely determined by the level of aggregation in 8-digit product codes. For example, while 8-digit codes under the 4-digit group 20.60 do often identify the specific polymer, 8-digit codes under 1310, 1320 and 1391 group them all under the single name of 'synthetics'. Consequently, it was not possible

[5] A full list of codes can be found here: https://www.ine.es/en/daco/daco42/encindpr/lista_prodcom_en.pdf

to further split *synthetics* into sub-components such as polyester, polyamide etc. This filtering, grouping and assignation resulted in a large spreadsheet which was analysed in relation to gaps.

A number of gaps were found in the ProdCom data which were filled as follows:

- 2005 trade data was missing for all products[6]: This was filled in by taking an average of 2004 and 2006 values.
- Half a dozen outlying data points were found for physical quantities for individual products and years that had a large impact on overall trends: These were replaced by quantities estimated by multiplying the value in Euros with the average Euro/kg conversion factors of the two years immediately adjacent to the outlying year.
- Trade data was missing in ProdCom for all years for some types of cotton yarn and cotton fabric products: The missing trade data was replaced with Comext trade data for cotton yarns and cotton fabrics.

With respect to the latter point, the following relevant Common Nomenclature (CN) 4-digit codes (European Commission 2021) were identified in Comext data: 5204 to 5207 cotton yarns and threads and 5208 to 5212 cotton fabrics. The extra-$EU27_{2020}$ imports and exports for these product codes were extracted from the Comext database[7] for the same years as the ProdCom data and aggregated to give import and export data by weight and value for cotton fabrics and cotton yarns. These were used to replace cotton yarn and cotton fabric trade data from ProdCom wholesale, including those product codes for which data existed. This was necessary because the relationship between CN 8-digit and ProdCom 8-digit codes was found to be 'many-to-many' (i.e. each CN code could correspond to more than one ProdCom code and each ProdCom code could correspond to more than one CN code).

After the gap-filling exercise, graphs were produced showing trends in the value and volume (tonnes) of production, imports and exports of yarns and raw fibres, split by material type.

Fabrics (further data work)

Some further processing was needed before similar graphs could be made for fabrics. While the physical unit for Fibres and Yarns in the ProdCom database is kilograms, the physical unit for fabrics since 2005 has been m^2. The Comext database, on the other hand, contains physical trade data in kg for all years. However, the relationship between CN codes and ProdCom codes for fabrics is many-to-many and does not readily allow value-to-weight conversions, as was possible with garments and home textiles (see later). As a result, an alternative rougher conversion solution was used as follows:

ProdCom data for fabrics for 2003 and 2004 includes kg as the physical unit. This was replaced by m^2 in subsequent years. Thus, the years 2004 to 2005 gave an opportunity for estimating kg/m^2 conversion factors for each ProdCom code. Conversion factors were calculated using the following equation:

$$\text{Conversion factor for Fabric A} = \text{Total kg}_{2004}/\text{Total m}^2_{2005} \times (\text{value}_{2005} - \text{value}_{2004})/(\text{\% price change 2004 to 2005}) \quad (1)$$

The % price change between 2004 and 2005 was estimated to be the same as the price change per kg for yarn of the same material type (e.g. cotton, wool etc.) as the fabric product.

The kg/m^2 conversion factors were then used to estimate total production, import and export volume (tonnes) for all years subsequent to 2005. This method contains potential sources of errors. The first is that the price change between 2004 and 2005 for fabrics may differ significantly from yarns if the material inputs are not the largest cost factor for fabric production. Secondly, the method assumes that a ProdCom 8-digit product group comprises a constant basket of sub-products from 2005 to 2018.

The following rough quality check of the conversions was carried out: ProdCom codes for fabrics sometimes differentiate between fabrics > 200 g/m^2 and the same fabric type < 200 g/m^2. When conversion estimates were compared to these figures they were, with one exception, in agreement with these limits. Conversion estimates were also sent to Euratex for their comment/input.

In a similar manner to yarns and raw fibres, graphs were produced showing trends between 2003 and 2018 of the value and volume (tonnes) of production, imports and exports of fabrics, split by material type.

[6] The reason for this 2005 gap in trade data has not been identified

[7] Eurostat database DS-016890

Finished garments and home textiles

In addition to *domestic production* and *trade*, a further dimension is of high interest for finished garments and home textile products, namely *consumption*.

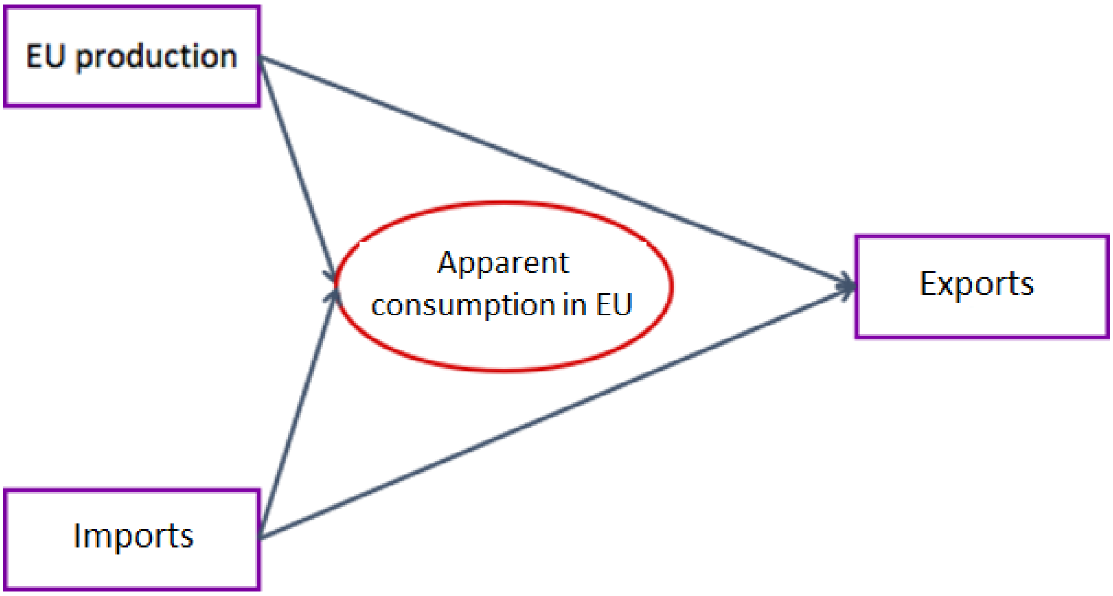
The volume (e.g. weight) of consumption of new textiles is highly relevant to the achievement of a circular economy for several reasons. Firstly, this is the volume of textiles that will eventually become waste in the EU and for which circular solutions must be found. Moreover, the volume of consumption is the most important variable in determining the environmental footprint of textiles. Reduction of the overall consumption of new textiles will reduce the total environmental footprint.

The consumption of clothing and home textiles is normally assumed to be equivalent to the **supply**, e.g. the volume of textiles placed on the market. Textiles placed on the market originate from domestic production or imports. However, when trying to estimate the supply (also known as **apparent consumption**) in the same market, it is important to subtract exports. Exports could originate from domestic production or via intermediaries who both import and export fibres, fabrics, semi-finished and final products but do not necessarily produce anything (hence the arrow in Figure 4 going directly from imports to exports). Supply/apparent consumption is guided by the simple equation (see also

Figure **4**):

$$\text{Supply} = \text{Domestic production} + \text{Import} - \text{Export} \qquad (2)$$

Figure 4: Schematic representation of textiles supply (apparent consumption) in the EU



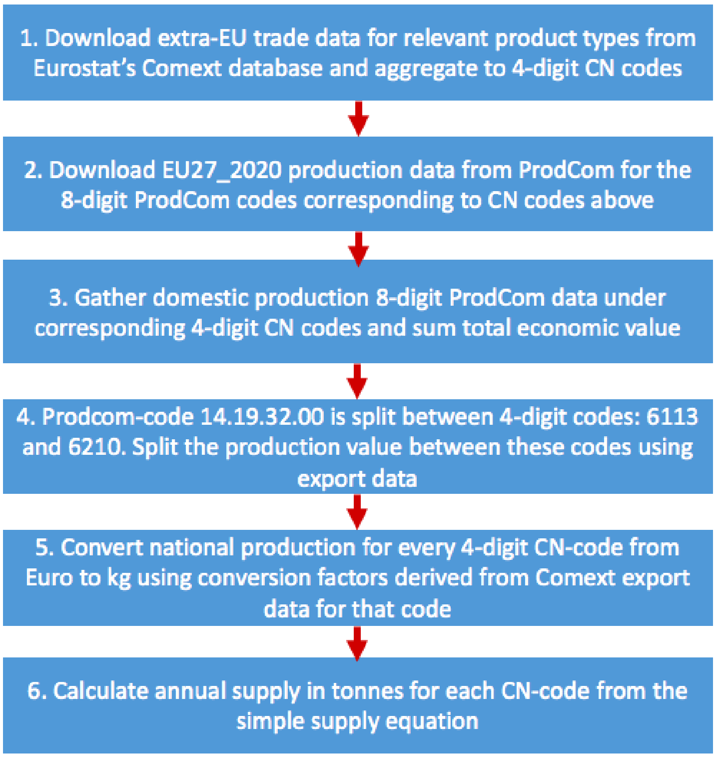
Source: own representation

The weight of apparent consumption can be calculated for any product for which there is compatible import, export and production data and for which the physical unit is a weight.

EU Comext data includes imports and exports to and from the EU both by value (Euro) and by weight (100 kg). Domestic production data for finished garments and home textiles is available from ProdCom in Euro, but the physical unit is not a weight but normally provided in ‘pieces’ or m^2. Moreover, ProdCom codes and the CN8 codes given in the Comext database are not immediately compatible. However, fortunately, there is a *many-to-one* relationship between ProdCom 8-digit and CN4 4-digit codes in Comext. This allowed for estimating weights of production for each 4-digit CN code by using a Euro/kg conversion factor derived from the Comext trade data.

It should be noted that using a Euro/kg conversion factor derived from exports to apply to the value of production for a given product group is associated with some error, since the value of exports are evaluated at the time the goods cross the border and may differ from the price of goods as they leave the factory (Europroms, 2008). The calculation process is presented in Figure 5.

Figure 5: Method used for calculating total supply of new clothing and home textiles to European final users



Source: Developed by PlanMiljø for this project

The apparent consumption calculation method does not take account of the following material flows:

- Purchases while abroad on vacation or other travel – however, since we are considering consumption for the EU as a whole and since the majority of holidays taken by EU citizens is spent in other EU Member States – the underestimate caused by this should be minimal
- Online purchases from businesses in other countries – again because of the EU scope this is seen as a small underestimate. It is assumed that, due to shipping costs, most internet sales will be internal within the EU.
- Hidden production – production data in ProdCom is not always accessible for commercial confidentiality reasons. This is the case, for example, if a single company dominates the production of a particular product type. While this is not unusual for a small economy, at EU level it is very rare.
- Illicit imports/exports/sales – purchases on grey markets/black markets can represent a significant part of total consumption in some EU regions. A study in six EU countries (Estonia, Czech Republic, Latvia, Lithuania and Sweden) estimated that between 10 % and 14 % of clothing consumption is via illicit sources (Oxford Economics, 2018).

The relevant 4-digit CN codes for which consumption (supply) was calculated are provided in Table 1. This comprises garments and home textiles, excluding products where textiles are not the dominant weight (e.g. upholstery textiles, carpets, duvets, pillows).

EU consumption of each of these product groups was estimated for each year and the results for year 2018 are presented later. In addition, trends in production, consumption and extra-EU trade in garments and home textiles between 2003 and 2018 are presented.

Table 1: CN 4-digit codes for garments and home textiles

4-digit code	Product group
6101 + 6102 + 6201 + 6202	Overcoats, car coats, capes, cloaks, anoraks, incl. ski jackets etc.
6103 + 6104 + 6203 + 6204	Suits, ensembles, jackets, blazers, trousers, bib and brace overalls,
6105 + 6106 + 6205 + 6206	Shirts and blouses
6107 + 6108 + 6207 + 6208 + 6212	Underwear, nightshirts, pyjamas, bathrobes, dressing gowns plus bras, corsets etc.
6109	T-shirts, singlets and other vests
6110	Sweaters, cardigans, waistcoats
6111 + 6209	Baby clothing
6112 + 6211	Tracksuits, skisuits and swimwear
6113	Garments covered or impregnated with plastics
6115	Pantyhose, tights, stockings and socks
6114 + 6116 + 6117 + 6213 + 6214 + 6215 + 6216 + 6217	Handkerchiefs, ties, scarves, gloves and other
6210	Non-woven garments
6301	Blankets and travelling rugs
6302	Bed linen, towels and tablecloths
6303 + 6304	Curtains and drapes and other interior furnishings

3.2.5 Methodology for Theme 1C: Post-consumer textiles

The aim of this task was to develop a picture of the degree to which recirculation of used textiles is already occurring in Europe and how this takes place. More specifically, the aim was to find answers to the following questions:

- What share of post-consumer textiles is separately collected (and what share of this ends up in mixed waste)?
- Who separately collects post-consumer textiles and how?
- How are separately collected textiles processed and treated? What share is reused, recycled and incinerated and where?
- Is there a large internal EU trade in used textiles and who are the biggest receivers?
- What share of total consumption of garments and household textiles is comprised of second-hand products?

To answer these questions, we used existing mapping studies of post-consumer clothing and household textiles as far as possible. Mapping studies were gathered using the team's extensive knowledge of the topic from previous studies (e.g. Watson et al, 2018a) and through responses from members of the project stakeholder group. The countries with available data are presented in Section 3.3.3.

Mapping reports were studied, and contact was made with the authors where methodologies were unclear and needed further clarification. Where a study did not cover one of the issues of interest, attempts were made, with the authors of the study as first contact point, to find the missing information.

The studies from different countries differ significantly with respect to scope, year for which data are available and methodology. These differences could not necessarily be resolved but it is important to highlight them in this report and to warn against making direct comparisons. A rough interpolation of the results from the countries with data to the EU as a whole was carried out, but care must be taken when using the results since:

- Data years for mapping studies differ and since the sector is under strong development, earlier mapping studies could skew EU averages downwards.
- Methodologies differ, so figures such as used textile collection rates are not necessarily comparable between countries.

The countries for which mapping studies have been carried out may be those where there is most political interest in circularity in textiles and may therefore not be representative of other EU countries.

3.3 Results

3.3.1 Theme 1A: The global context of the EU textile and clothing market

The textile industry is global. The value chain for a typical piece of clothing passes through several countries and even continents. For example, the cotton for a shirt may have been grown in Greece, spun into yarn in Turkey, woven into fabric in India, sewn in Bangladesh and purchased from a retailer in Germany (see e.g. Rivoli, 2008).

The global textile industry is worth US$ 3 trillion, accounts for about 2 % of the world's GDP and employs about 60 million people (Migiro, 2020).

The EU plays an important global role in the industry, both as an importer and consumer and as a producer and exporter of final products and semi-manufactures. In 2019, the EU-28 including the UK (separate figures not available for EU-27_{2020} from EURATEX) was the second largest global importer of textiles and clothing, with a combined value of USD 125 billion, only slightly less than US imports at USD 136 billion (WTO, 2020). When intra-EU trade is included, the value of trade is nearly doubled to USD 247 billion (see Table 2 and Table 3). Note that the scope of 'textiles' as used by WTO and Euratex in these statistics is wider than our focus in this report (see Box 3).

Box 3: What is meant by 'clothing' and 'textiles' in WTO and Euratex statistics?

Both WTO and Euratex distinguish between 'clothing' and 'textiles'. The scope of 'clothing' includes all products under Harmonised System Section XI codes 61 and 62. HS codes are more or less the same as CN codes (see Figure 5 and Table 1 earlier). Thus 'clothing', when included in WTO and Euratex data, has the same scope as we use in this report (see 3.2.4 and 2).

'Textiles', when included in Euratex and WTO statistics, include all products under HS codes 50 to 60 and 63. This includes semi-manufactures (fibres, yarns, fabrics) as well as all final textile products other than clothing – including household textiles, carpets, impregnated textiles and technical textiles (code 5911). Thus, their scope is somewhat larger than the scope we have included under Theme 1B.

The EU-28 was also the second largest exporter (excluding intra-EU trade) of both textiles and clothing with a combined value of USD 67 billion, although this value is dwarfed by China in first place at USD 272 billion. China's exports had already exceeded the EU-28's prior to 2000 and China's textiles and clothing exports have been growing at an average of 5 % and 2 % per year respectively since 2010.

Interestingly, while the EU-28's exports of 'textiles' (see Box 3 for definition) have remained relatively stable over the same period, exports of clothing from the EU have increased by 6 % per year on average since 2010 (see Table 3).

Table 2: Top ten global importers and exporters of textiles in US$ billion and percentages

	Value	Share in world exports/imports				Annual percentage change			
	2019	2000	2005	2010	2019	2010-19	2017	2018	2019
Exporters									
China (1)	120	10.3	20.2	30.4	39.2	5	5	8	1
European Union	66	33.4	32.5	25.3	21.7	0	5	7	-6
Extra-EU Exports	24	11.5	11.3	9.0	7.9	1	5	8	-5
India	17	3.6	4.1	5.1	5.6	3	6	6	-5
United States of America	13	7.0	6.1	4.8	4.4	1	3	1	-3
Turkey	12	2.4	3.5	3.5	3.9	3	5	4	-1
Korea, Republic of	9	8.1	5.1	4.3	3.0	-2	-2	0	-7
Viet Nam (2)	9	0.2	0.4	1.2	2.9	12	18	13	8
Chinese Taipei	9	7.6	4.8	3.8	2.8	-1	3	0	-8
Pakistan	7	2.9	3.5	3.1	2.3	-1	2	2	-11
Hong Kong, China	6	...	...	...	...	-6	-4	-3	-13
Domestic exports	0	0.8	0.3	0.1	0.0	-11	7	3	11
Re-exports	6	...	...	...	...	-6	-4	-3	-14
Above 10	**262**	**76.2**	**80.4**	**81.8**	**85.8**	-	-	-	-
Importers									
European Union	67	29.7	29.2	23.8	21.3	1	5	5	-5
Extra-EU Imports	30	9.6	9.8	9.6	9.5	2	5	6	-4
United States of America	31	9.7	10.5	8.7	10.0	3	3	8	-2
Viet Nam (2)	16	0.8	1.6	2.6	5.2	10	9	11	1
China (1)	16	7.8	7.2	6.6	5.0	-1	4	3	-12
Bangladesh (2)	10	0.8	1.1	1.7	3.1	9	6	17	-6
Japan	9	3.0	2.7	2.7	2.8	2	3	6	-1
United Kingdom	7	4.4	3.5	2.7	2.3	0	1	1	-2
Indonesia	7	0.8	0.4	1.6	2.1	5	4	12	-2
Hong Kong, China	6	...	...	...	...	-7	-4	-3	-15
Retained imports (2)	1	0.9	0.3	0.1	0.2	...	-13	0	-29
Mexico (1),(3)	6	3.5	2.8	1.9	1.8	1	1	4	-13
Above 10	**169**	**61.3**	**59.3**	**52.4**	**53.8**	-	-	-	-

(1) Includes significant shipments through processing zones
(2) Secretariat estimates
(3) Imports are valued f.o.b.

Note: EU in this table refers to EU-28 including UK.
Source: WTO (2020)

Table 3: Top 10 global importers and exporters of clothing in US$ billion and percentages

	Value	Share in world exports/imports				Annual percentage change			
	2019	2000	2005	2010	2019	2010-19	2017	2018	2019
Exporters									
China (1)	152	18.2	26.6	36.6	30.8	2	0	0	-4
European Union	136	26.4	29.3	26.9	27.6	4	10	11	0
Extra-EU Exports	43	8.1	8.6	7.5	8.8	6	12	10	2
Bangladesh (2)	34	2.6	2.5	4.2	6.8	10	2	13	2
Viet Nam (2)	31	0.9	1.7	2.9	6.2	13	9	13	8
India	17	3.0	3.1	3.2	3.5	5	2	-10	4
Turkey	16	3.3	4.2	3.6	3.2	2	0	4	1
Hong Kong, China	12	...	...	...	...	-7	-8	-4	-11
Domestic exports	0	5.0	2.6	0.1	0.0	-24	-40	-10	-9
Re-exports	12	...	...	...	...	-7	-8	-4	-11
United Kingdom	9	2.1	1.8	1.6	1.8	6	2	5	1
Indonesia	9	2.4	1.8	1.9	1.7	3	10	9	-4
Cambodia (2)	9	0.5	0.8	0.9	1.7	12	8	13	4
Above 10	**411**	**64.4**	**74.4**	**81.8**	**83.5**	-	-	-	-
Importers									
European Union	180	32.7	37.4	37.6	34.2	3	6	9	-1
Extra-EU Imports	95	16.4	19.4	21.2	18.1	2	5	8	-1
United States of America	95	33.1	28.7	22.1	18.2	2	0	4	0
Japan	30	9.7	8.1	7.2	5.7	1	1	8	-2
United Kingdom	26	7.5	8.7	7.1	5.0	0	-1	3	0
Hong Kong, China	11	...	...	...	...	-4	-6	2	-11
Retained imports (2)	1	0.9	...	...	0.2	...	...	557	-12
Canada (3)	11	1.8	2.1	2.2	2.1	3	5	5	4
Korea, Republic of	11	0.6	1.0	1.2	2.1	11	8	16	2
China (1)	9	0.6	0.6	0.7	1.7	15	13	14	8
Russian Federation (3)	8	0.1	0.3	2.0	1.5	1	26	7	4
Switzerland	8	1.6	1.6	1.4	1.5	4	12	13	2
Above 10	**379**	**88.5**	**88.5**	**81.6**	**72.1**	-	-	-	-

(1) Includes significant shipments through processing zones
(2) Secretariat estimates
(3) Imports are valued f.o.b.

Note: EU in this table refers to EU-28 including UK.
Source: WTO (2020)

According to Euratex (2020), the European textile industry covers the full range of textile manufacturing from production of fibres to manufacturing and finishing of final products, including clothing, household textiles and technical textiles. In 2018, the industry in EU-28 employed 1.66 million people – down from 2.03 million employed in 2010. The industry is dominated by micro-companies and SME's with only 0.2 % of textile companies with more than 250 employees. Some 67 % of companies in the sector are concerned with the production of clothing and the remaining 33 % with the production of other textiles and semi-manufactures (Euratex, 2020).

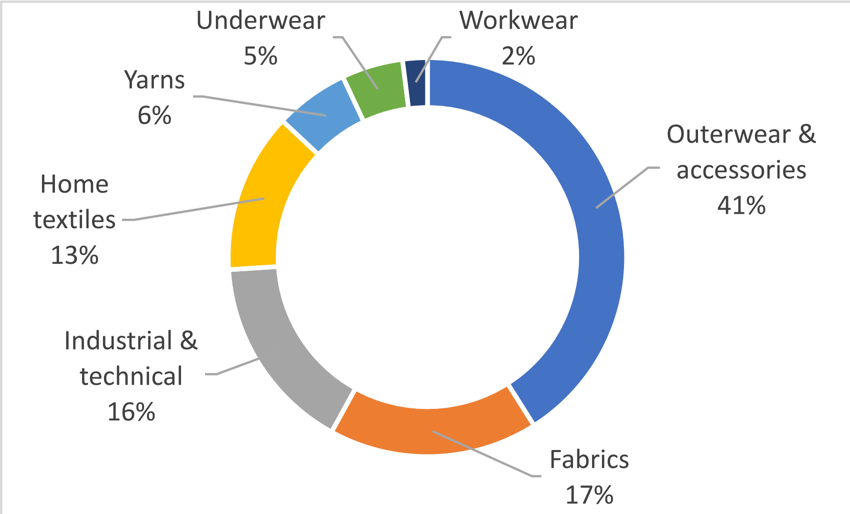
The industry represents a small, but not insignificant part of the European manufacturing sector as a whole. It represents 2 % of key economic indicators in EU-28 (turnover, production value and value-added) but 5 % of employment and, due to the predominance of small industries, 9 % of all companies in the manufacturing sector. Around 31 % of all production (by value) in 2019 of the industry in EU-28 was for export markets (Euratex, 2020).

The breakdown of production by the European (EU-28) textile industry is shown in Figure 6. Clothing (outerwear plus accessories plus underwear plus workwear) comprises 48 % of all production, and home textiles 13 %, while fabrics and yarns represent 17 % and 5 % respectively.

Technical textiles represent 16 % of production and comprise ropes and netting, geotextiles, medical textiles, smart textiles and other specialist textiles. Technical textiles represent an increasing area of specialisation and dominance in European manufacturing: as other production areas such as clothing, home textiles and fabrics have gradually migrated to Asia, technical textile production has expanded in Europe (Euratex, 2020). Technical textiles are, however, not within the scope of this study.

The European industry has been hit hard by the response to Covid-19 pandemic, with 96 % of Euratex' members reporting a decrease in sales and 65 % identifying significant complications and obstacles in supply chains. It is of relevance to this study to note that sustainable supply chains and recycling hubs are two key elements of the Euratex recovery strategy for the industry after the impacts of Covid-19 (Euratex, 2020).

Figure 6: Breakdown of European production by broad product type



Source: derived from Euratex (2020)

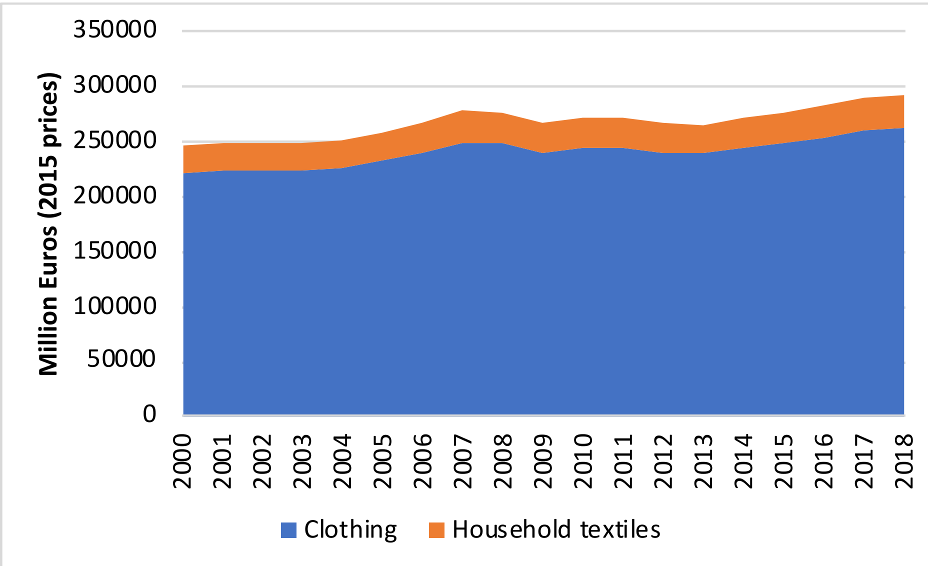
3.3.2 Theme 1B: EU production, trade and consumption in clothing, household textiles, fabrics, yarns and fibres

3.3.2.1 Final products

3.3.2.1.1 Consumption expenditure

Private households are the dominant consumers of clothing and household textiles. Household expenditure on clothing and household textiles respectively increased by 14 % and 17 % in real terms between 2000 and 2018, or less than 1 % per annum on average. However, both consumption areas were affected by the 2008 recession and first surpassed the 2007 pre-recession peak in 2015 (see Figure 7).

Figure 7: Average household expenditure per capita in EU-27 (2015 prices), 2015



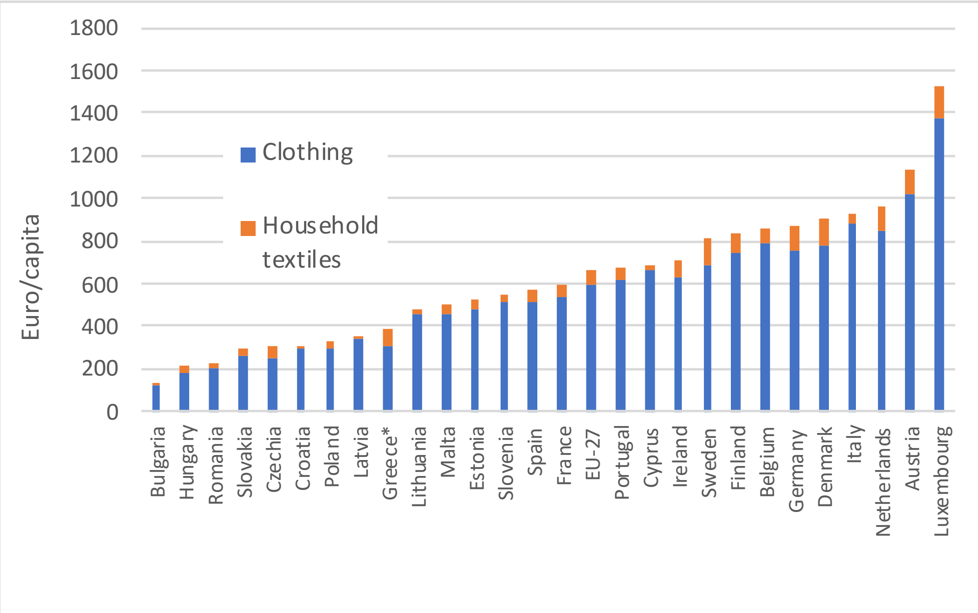
Data source: Eurostat table nama_10_co3_p3

In 2018, the average European spent 591 Euro on clothing and 67 Euro on household textiles. However, there are significant differences between countries: the average Luxembourger's expenditure was nearly 12 times higher than the average Bulgarian's (see Figure 8). This is largely due to differences in income, but the share of total expenditure used on clothing and textiles also varies between countries (see Figure 9).

In general, there is a reasonably linear relationship between household income and household expenditure on clothing and household textiles (see Figure 10). This suggests that textiles are not perceived as basic goods, or at least the level at which textiles are consumed in Europe is far beyond consumption of basic textiles.

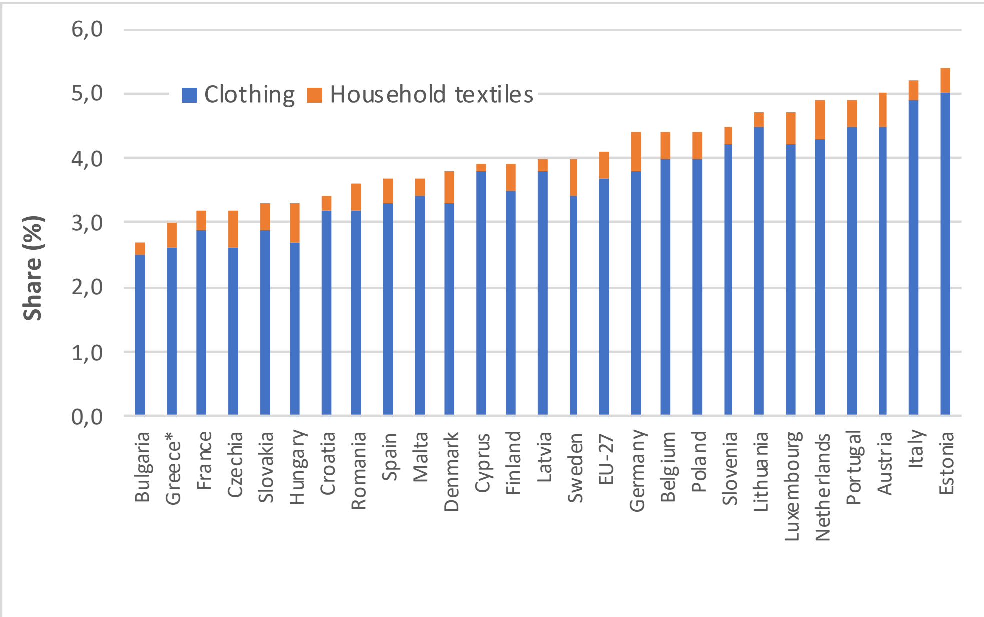
At each income range, there are countries where households spend much money on clothing and home textiles (e.g. Austria, Netherlands, Portugal, Italy, Estonia) and countries with a relatively low level of expenditure (Denmark, Ireland, France, Greece, Slovakia) compared to other similar income countries.

Figure 8: Average household expenditure per capita by country, 2018



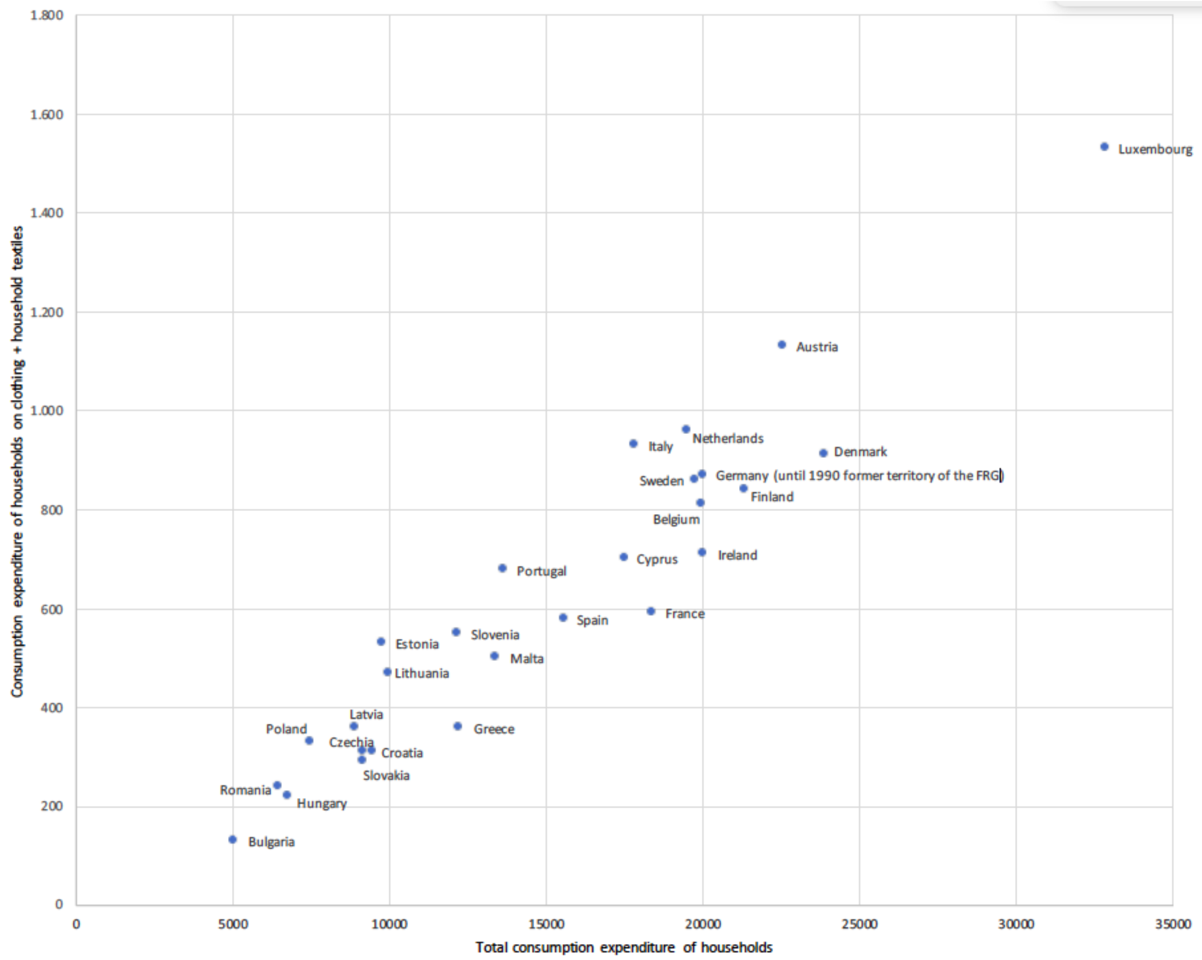
Data source: Eurostat table nama_10_co3_p3

Figure 9: Share of clothing and household textiles in household expenditure by country, 2018



Data source: Eurostat table nama_10_co3_p3

Figure 10: Household expenditure on clothing and textiles versus total household expenditure per capita by EU Member State, 2018



Data source: Eurostat table nama_10_co3_p3

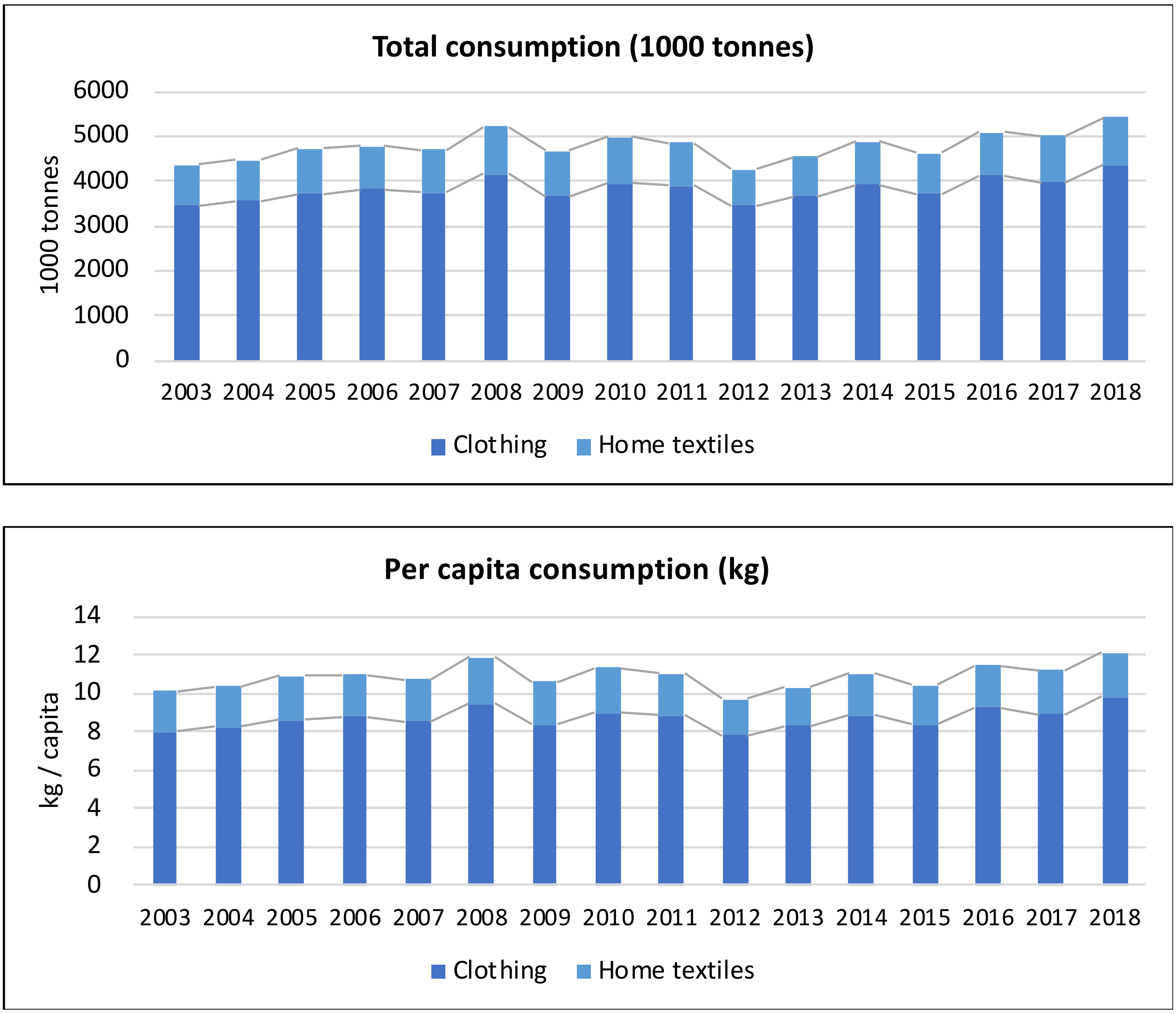
3.3.2.1.2 Imports, exports and supply of clothing and household textiles

Trends in the total supply (apparent consumption) of clothing and household textiles in EU-27_{2020}, as calculated on the basis of ProdCom and Comext data, are presented in Figure 11.

Apparent consumption amounted to 5.4 million tonnes in 2018 of which 4.4 million tonnes (81 %) comprised clothing and just over 1 million tonnes (19 %) comprised household textiles.

It should be noted that not the entire consumption is attributable to households. A share is also consumed by government and businesses for final use as workwear, uniforms for employees, bedlinen for hospitals and hotels, kitchen linen for restaurants etc. The split between these final consumers has, as far as we know, only been estimated for Denmark, where consumption by private households comprised 88 % of the total share and the remaining 12 % was split evenly between government and business (Watson et al, 2018b).

Figure 11: Trends in supply of new textiles to EU-27$_{2020}$: total volume and per capita

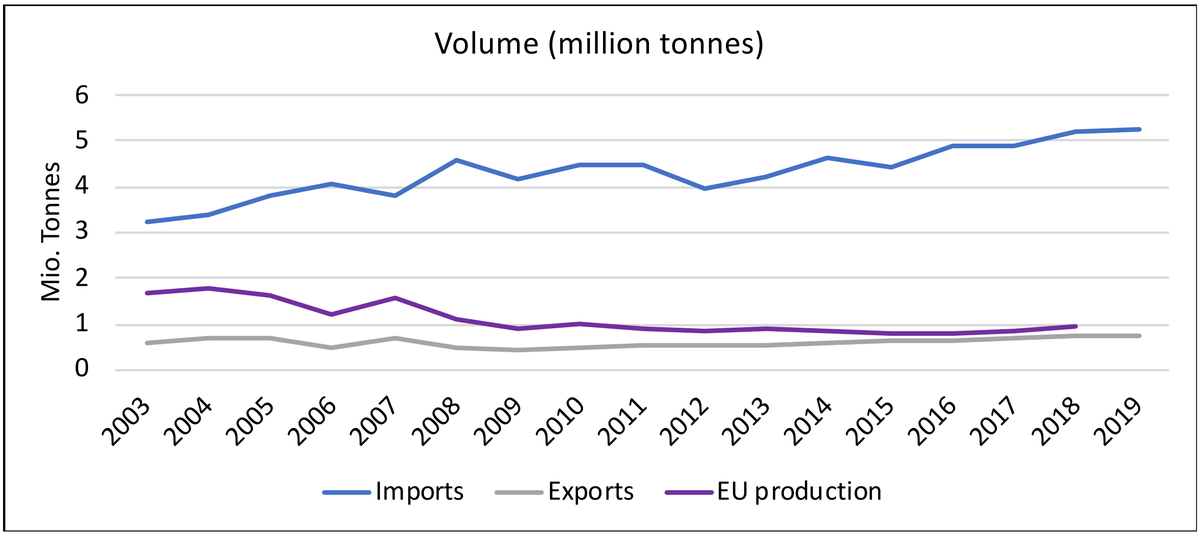


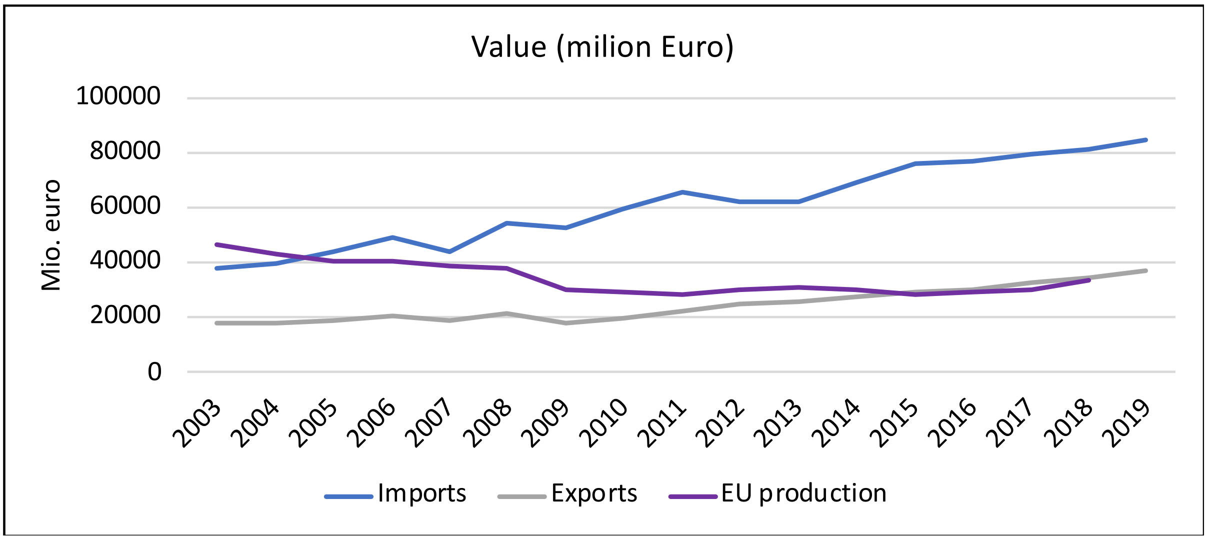
Source: Own calculations based on Eurostat ProdCom and Comext data

Average per capita apparent consumption in EU-27$_{2020}$ amounted to 12.3 kg/capita in 2018, up 20 % from 10.1 kg/capita in 2003. Consumption was significantly dampened by the last economic recession and only returned to pre-recession levels in 2018.

The consumption figures estimated here are significantly lower than consumption estimated by others. For example, Manshoven et al (2019) estimated average supply of new textiles to Europeans at 25.9 kg/capita in 2017, and JRC (2014) estimated supply at 19.1 kg/capita in 2007. This can at least partly be explained by a wider scope of products included in these studies. Both Manshoven et al's and JRC's consumption estimates include clothing and household products whose weight is dominated by non-textiles, such as floor carpets with heavy plastic/rubber backing and duvets, pillows, quilts etc. Manshoven et al (2019)'s consumption estimates, moreover, include footwear. This wider scope at least partly explains the higher consumption weights per capita estimated by these studies although some differences may also be caused by uncertainties in value-to-kg conversions.

Figure 12: Trends in domestic production, imports and exports of clothing and home textiles, EU-27$_{2020}$





Data source: own calculations from Eurostat ProdCom and Comext data

Trends in domestic production, imports and exports of clothing and home textiles are shown in Figure 12. EU production of clothing and home textiles declined by 44 % in weight between 2003 and 2018, and this shortfall was compensated for by increasing imports. Interestingly, exports of clothing and home textiles from EU *increased* by 36 % over the same period. By 2018, exports represented over 80 % of domestic production by weight. However, it should be noted that a share of these exports are simply re-exports of imported goods. When considered in terms of value (see lower graph in Figure 12) exports slightly exceeded the value of domestic production by 2018.

Table 4 breaks down consumption of clothing and home textiles in the EU-27$_{2020}$ by product type. Clothing and accessories comprise 81 % of total consumption, and home textiles the remaining 19 %. It might be interesting to analyse this table with respect to potential circularity.

Europeans purchase over 2.6 million tonnes of suits, jackets, coats, trousers, shirts and blouses each year, or over 6 kg per capita. These products offer a high potential for reuse and are thus typically found in second-hand shops across Europe. They represent 60 % of total consumption of clothing. Underwear, tights, stockings and socks typically have less potential for reuse, are more often used until the end of their technical life and are considerably more likely to end in mixed waste at their end of life. These garments comprise just under 800 000 tonnes a year or 1.3 kg/capita. These issues are considered in more detail under Theme 1C.

Table 4: Apparent consumption of clothing and household textiles in $EU27_{2020}$ by product type, 2018

CN 4-digit codes	Product grouping	1000 tonnes	kg/capita
6101 + 6102 + 6201 + 6202	Overcoats, car coats, capes, cloaks, anoraks, incl. ski jackets etc.	419	0.95
6103 + 6104 + 6203 + 6204	Suits, ensembles, jackets, blazers, trousers, bib and brace overalls,	1 408	3.19
6105 + 6106 + 6205 + 6206	Shirts and blouses	314	0.71
6107 + 6108 + 6207 + 6208 + 6212	Underwear, nightshirts, pyjamas, bathrobes, dressing gowns plus bras, corsets etc.	317	0.72
6109	T-shirts, singlets and other vests	526	1.19
6110	Sweaters, cardigans, waistcoats	571	1.30
6111 + 6209	Baby clothing	106	0.24
6112 + 6211	Tracksuits, ski-suits and swimwear	114	0.26
6113	Garments covered or impregnated with plastics	7	0.02
6115	Pantyhose, tights, stockings and socks	264	0.60
6114 + 6116 + 6117 + 6213 + 6214 + 6217 + 6215 + 6216	Handkerchiefs, ties, shawls, scarves, gloves and other	207	0.47
6210	Non-woven garments	119	0.27
	Total clothing	**4 371**	**9,92**
6301	Blankets and travelling rugs	117	0.27
6302	Bed linen, towels and tablecloths	635	1.44
6303 + 6304	Curtains and drapes and other interior furnishings	288	0.65
	Total home textiles	**1 040**	**2.36**
	Sum clothing and home textiles	**5 411**	**12.28**

Data source: own calculations from Eurostat ProdCom and Comext data

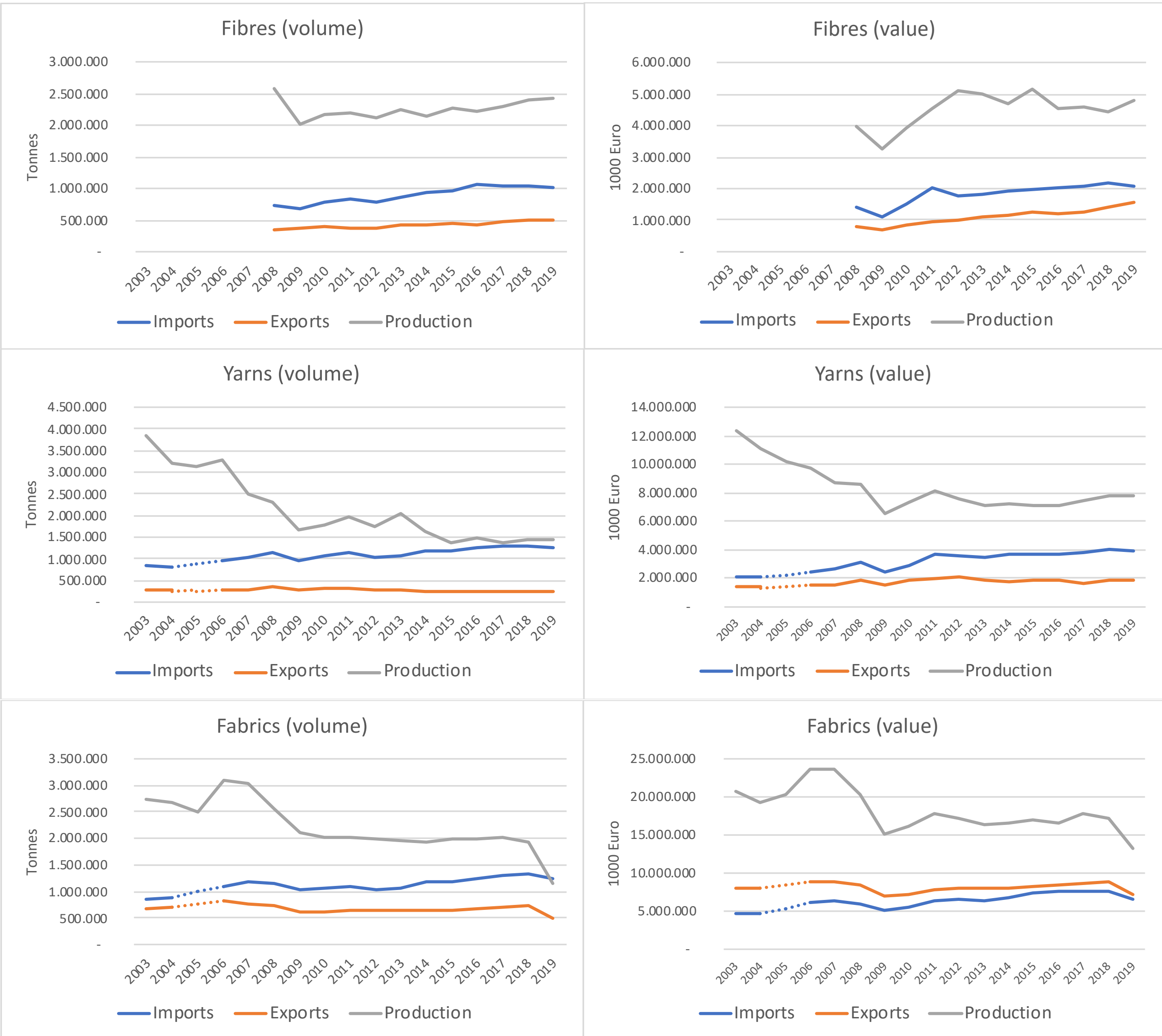
3.3.2.2 Fibres, yarns and fabrics

Trends in EU production and trade in fibres, yarn and fabrics are presented in Figure 13, by weight and value. Fibres are only presented after 2008, since prior to this year ProdCom data for fibres is incomplete, particularly with respect to synthetic filament fibres from polyester, nylon and viscose, which present large shares of the total volume of fibres.

Trends of interest are as follows:

- EU production and exports of fibres increased since around 2008. This may indicate an increasing global demand for fibres over this period.
- Increased EU production of fibres coincided with import and export quantity increases that balanced each other out, indicating an increasing EU demand for fibres for use in EU production of textiles. However, there seems to be a mismatch between this trend and the fall in yarn production in the EU over the same period. This suggests that the additional fibres may have been used for the production of semi-manufactures/final products other than yarn.
- EU yarn production fell rapidly particularly in the years from 2003 to 2009. This was not compensated for by increasing imports. This indicates a falling demand for yarns by textile manufacturers in the EU, a finding that is borne out by the falling EU production of fabrics over the same period.
- EU production and exports of fabrics stabilised after 2009, while imports increased. This would suggest increasing demand for fabrics in the EU for the manufacture of clothing and other textile-based final products. However, EU production of clothing and household textile products (see Figure 12) did not grow over the same period. This could potentially be explained by the growth in EU production of other fabric-based products such as technical textiles.

Figure 13: Trends in EU production, imports and exports of fibres, yarn and fabrics (by weight and value)



Data source: own calculations from Eurostat ProdCom and Comext data

Figure 14 presents the mass flows of fibres, yarns, fabrics and final products, including imports and exports, for a single year (2018). The figure implies a generally applicable production value chain where fibres form the main building blocks of yarn, whereas yarns are the basis for making fabrics and fabrics are the basis for clothing and household textiles. However, it must be noted that at each stage of the value chain, there are flows of these semi-manufactures in and out of the EU. Furthermore, there is not a one-to-one flow through the four main building blocks. For example, not all fibres are used to make yarns and not all yarns are made from fibres. Nylon and polyester yarns are generally produced by melting polymer chips or granules and then extruding them to produce very long fine filaments that are wound together to form the yarn. Many of the processes for producing viscose/rayon also involve extrusion of filaments for producing yarns.

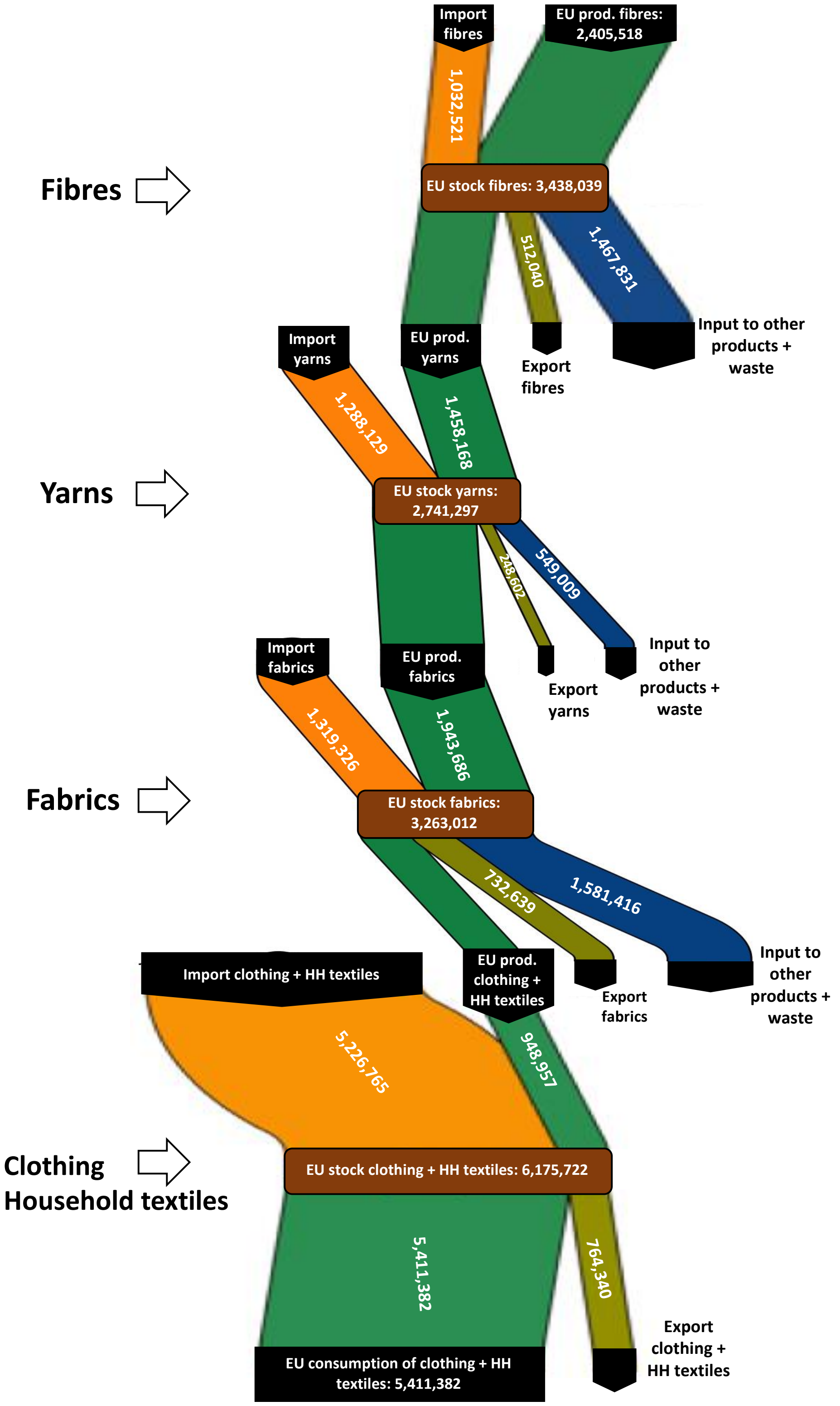
A further example is that clothing is often knitted directly from yarns without the intermediate production of fabrics. Vice versa, some fabrics are used to produce textile products other than clothing and household textiles. These volumes are shown in the blue flows leaving the EU stock at each stage.

The destination of EU stock at any particular stage of the production value chain is split into:

- The next stage of the textile value chain (green flows covered by ProdCom data).
- Export out of the EU (olive green flows covered by ProdCom data).
- Input to other value chains and waste (blue flows to ensure a mass balance).

The blue flows cover a large number of possible destinations and ProdCom does not have categories for all of these possibilities. On a similar note, the waste data comes from different sources and is incomplete. Consequently, it was decided to simply adjust the blue flows to ensure the mass balance between the other flows.

Figure 14: Mass flows of fibres, yarns, fabrics and final products of clothing and household textiles through the EU-27 2020 economy in 2018 (all figures in tonnes)



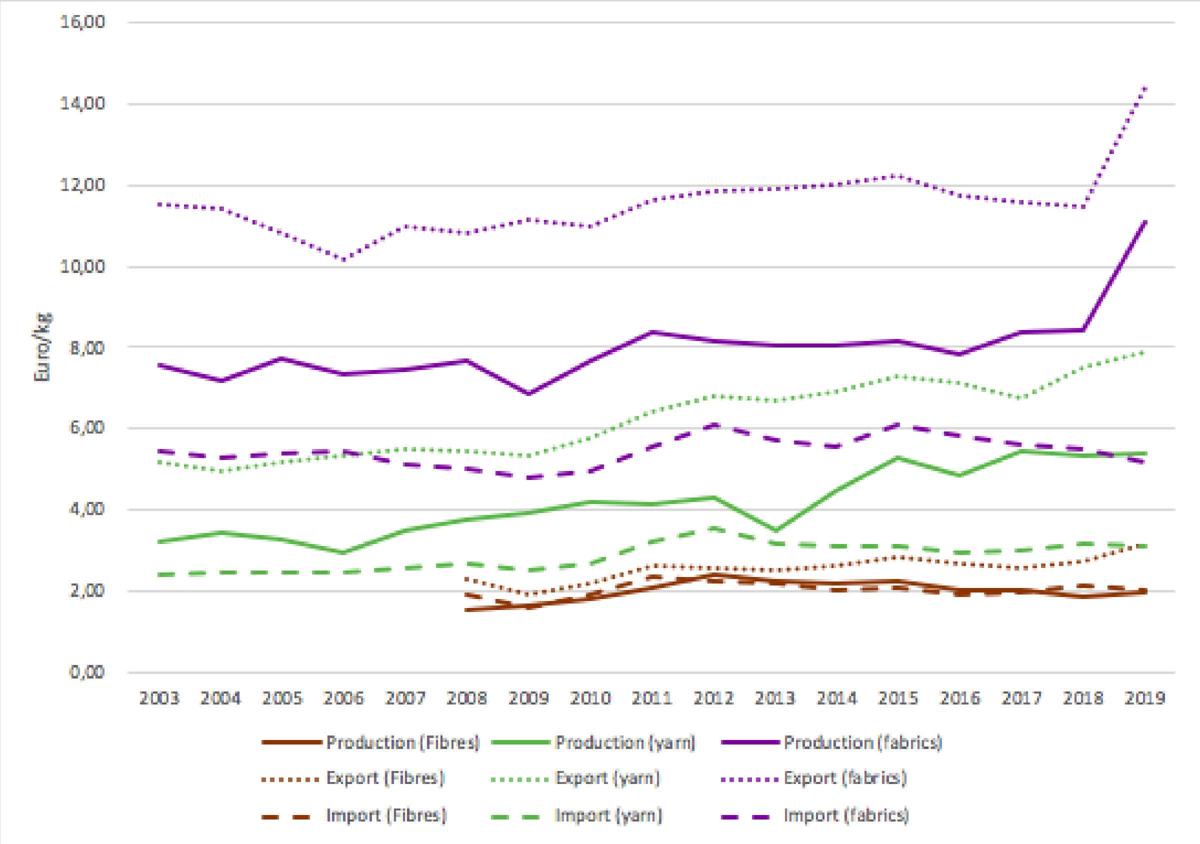
Source: calculations for this project by PlanMiljø using Eurostat ProdCom and Comext data

One striking result is the dominance of imports in the final step of the value chain, i.e. clothing and household textiles for consumption in the EU. EU production only contributes in a minor way to the stock of clothing and household textiles which are subsequently consumed within the EU or exported/re-exported.

Figure 15 presents trends in price per kg for fibres, yarns and fabrics from production import and export respectively. Some observations include:

- Unit prices for fabrics are higher than for yarns the prices of which are higher than for fibres. This is because each production stage – spinning and then weaving or knitting – requires extra work and adds value.
- For all three types of pre-manufactures – export prices are generally higher than production prices which are higher than import prices (except for fibres in some years). This could indicate both differences in production costs (cheaper for products produced outside the EU) and in the type and quality of textiles being imported, produced and exported. For example, exported fabrics might comprise a higher share of high-value technical textiles than in the entire EU production.
- EU production of fibres has for some periods been slightly cheaper than imports. It is not clear why this happens.

Figure 15: Trends in prices of fibres, yarn and fabrics, 2003-2019



Data source: own calculations from Eurostat ProdCom and Comext data

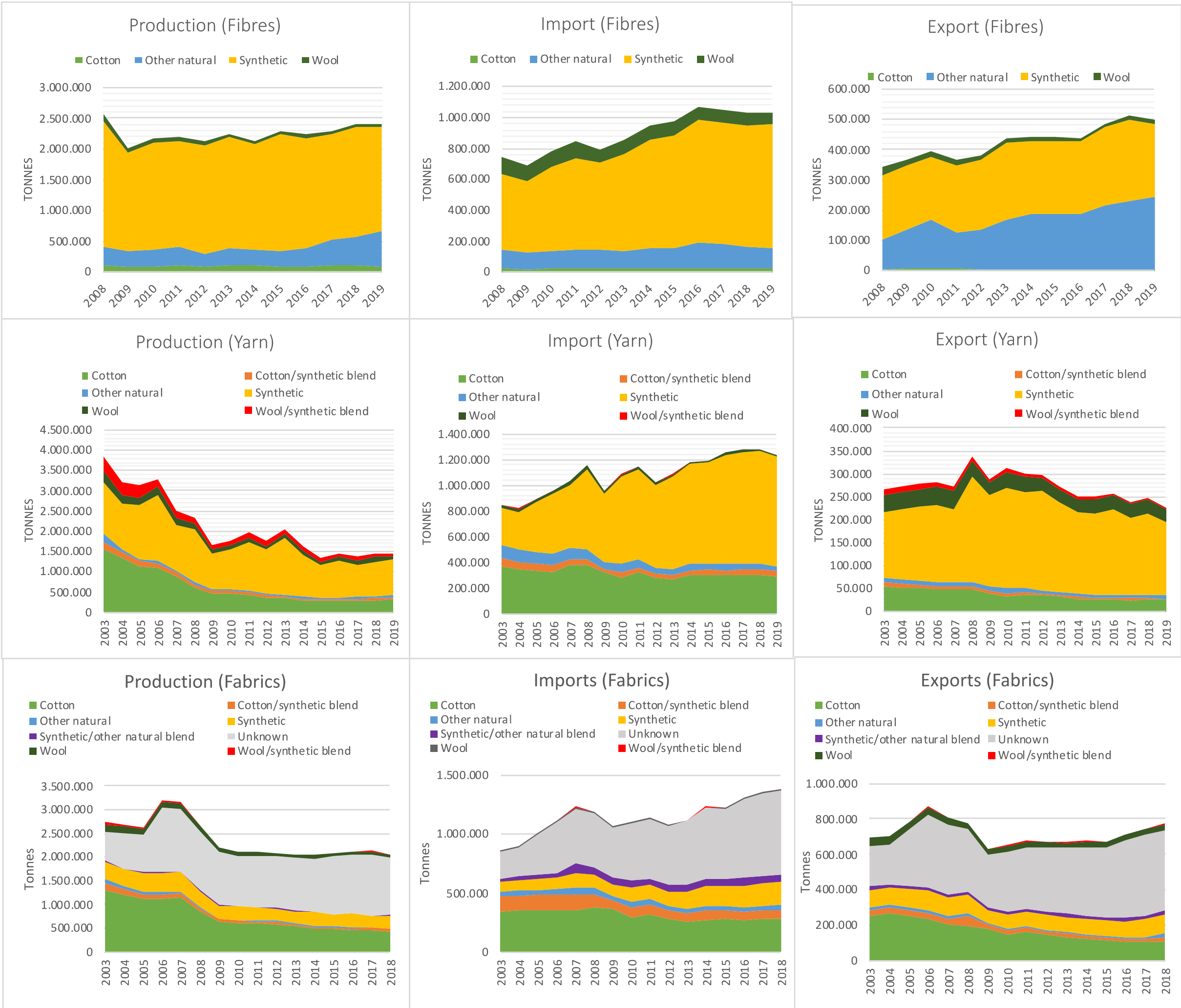
Each group of semi-manufactures comprises a large number of material types. For example, fibres can comprise cotton, wool, jute, hemp, polyester, nylon, viscose and so on. Yarns can be made of the same fibres in pure form or can be blends of two or more fibre types. The same is true of fabrics.

Figure 16 breaks down the volumes of EU production, import and export by material (fibre) type. Some observations include:

- The number of material types and mixes increases as we move from fibres through yarns to fabrics where there are several blends
- Synthetics fibres dominate production, imports and exports of fibres. Cotton fibres comprise a relatively small part of production, imports and exports of fibres.
- Wool is the only fibre type for which imports exceed EU production. A significant share of the imported wool is processed into yarn for the export market.

- The share of cotton in production, imports and exports of all three semi-manufactures – fibres, yarns and fabrics – is in decline. The share of synthetics has grown in the imports of yarn and imports of fabrics but not in production or exports of yarns or fabrics. More than 50 % of production, imports and exports of fabrics are undefined with respect to fibre composition

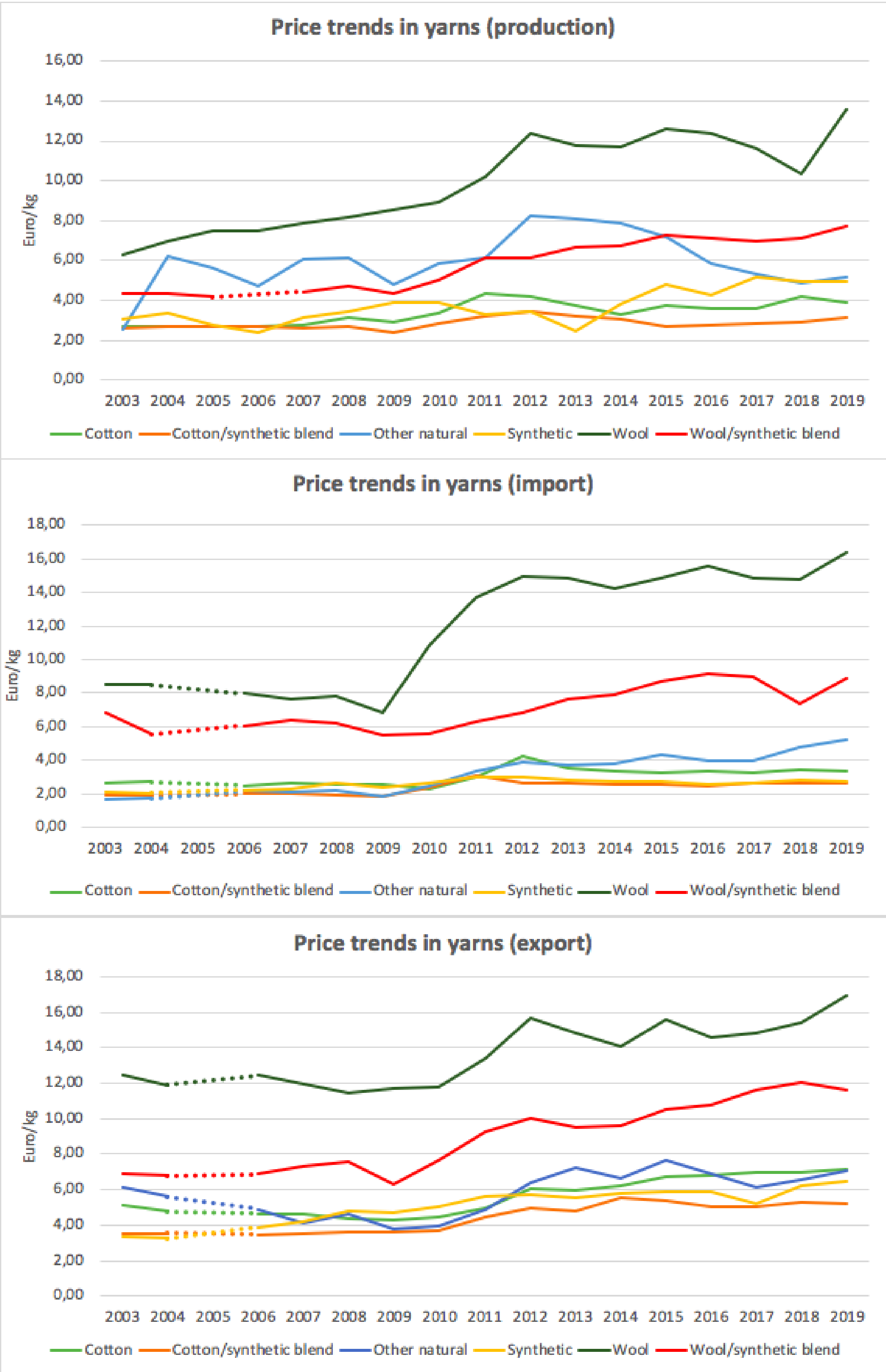
Figure 16: Trends in production, import and export of fibres (2008-2019), yarns (2003-2019) and fabrics (2003-2018), split by fibre composition



Data source: PlanMiljø'sown calculations from Eurostat ProdCom and Comext data

Figure 17 presents price trends in yarns of different fibre types. Wool is by far the most expensive yarn and is also the only yarn for which prices have been higher for imports than for yarn produced in the EU. This would explain the rise in imports of raw wool to the EU for yarn production. Unsurprisingly, wool/synthetic blends comprise the second most expensive yarn. Cotton and cotton blends are the cheapest yarns and prices thereof have stagnated since 2011/2012.

Figure 17: Trends in prices of yarns of different fibres compositions



Notes: 1) 2005 price data is missing for imports and exports: the dotted lines show interpolated trends between 2004 and 2006.
2) 2006 price data is missing for production of wool/synthetic blends: the dotted lines show interpolated trends between 2005 and 2007.
Data source: own calculations from Eurostat ProdCom and Comext data

3.3.3 Theme 1C: Post-consumer textiles

3.3.3.1 Reporting requirements, data availability and methodological differences

There is currently no requirement at EU level for reporting on the separate collection and treatment of all post-consumer textiles. The revised Waste Framework Directive requires Member States to establish systems for the separate collection of textiles by 1st January 2025 (see introduction) but since there are no targets for collection, Member States are not obliged to report on separate collection quantities as part of this obligation, although they may report voluntarily[8].

Box 4: Targets for collection and treatment of used textiles and Extended Producer Responsibility

Three EU Member States have so far developed concrete targets for the collection and treatment of used textiles: France, the Netherlands and Sweden. These countries have already established, or plan to establish, mandatory Extended Producer Responsibility (EPR) schemes for clothing and household textiles.

The French EPR for Clothing, Home textiles and Footwear purchased by households was issued in 2007 (Légifrance, 2021). Under the French regulations, producers can either organise their own collection, reuse and recycling system or contribute to an accredited Producer Responsibility Organization (PRO) who will carry out these activities on their behalf. Eco TLC is the only accredited PRO in the area of textiles and operates under a mandate negotiated with the government every 6 years. The mandate until the end of 2019 included targets of 50 % of textiles placed on the market to be diverted from landfill by 2019, with at least 95 % of any collected textiles going to reuse, recycling or energy recovery and no more than 2 % being landfilled (Eco-TLC, 2019). The new mandate only lasts for 3 years (Déchets infos, 2019) and includes regular updating of targets.

In the Netherlands, in a letter to the Dutch Parliament dated 14th April 2020, the Secretary of State for Infrastructure and Water Management proposed a Policy Programme for Circular Textile 2020-2025. The programme includes the concrete target that by 2025, 30 % of textile materials and products sold in the Netherlands are recycled after collection, if immediate reuse is no longer possible; this target will increase to 50 % by 2030. A further target included is that by 2025, new textile products should contain at least 25 % materials from recycled post-consumer textiles or other sustainable materials, increasing to 50 % by 2030. The programme also proposes the introduction of an EPR for textiles, with full proposals to be made by spring 2021[9].

In 2016, the Swedish EPA proposed targets for reducing textiles in household mixed waste by 60 % between 2015 and 2025, and a further target that 90 % of collected textiles should go to preparation for reuse or material recycling as of 2025 (Naturvårdsverket, 2016). These targets are still being considered by the Swedish parliament. Meanwhile, i.e. in 2019, the Swedish government committed itself to introduce an EPR for textiles in Sweden (Swedish Government, 2019). A commission was set up in December 2019 to investigate options for implementation and the results were published in late 2020 (Swedish Government, 2020). Some Member States already have their own reporting requirements that are relevant to the separate collection of textiles. With a single exception, these only concern the reporting of textile waste.

In countries such as Italy, Austria, Germany and the Netherlands, *all* collection of textiles via bring banks is classified as waste collection, regardless of the quality of the textiles or the intent of the deliverer. In other countries such as the Nordics, collection via bring banks is not classified as waste collection, provided that the collector clearly communicates that they only wish to receive reusable textiles (Watson et al, 2020a). There is no country where collection of reusable textiles over the counter in second-hand shops or other manned collection points is classified as waste collection (ibid).

Even when textile collection via bring banks is classified as waste collection and is covered by reporting obligations, collection data is often neither reported accurately nor consistently (Ibid).

[8] See under heading A need for standardised reporting and greater transparency at the end of this chapter
[9] Letter from THE STATE-SECRETARY OF INFRASTRUCTURE AND WATER MANAGEMENT to the Dutch Parliament 14th April 2020

Table 5: Data availability on post-consumer textiles in EU27$_{2020}$ Member States (with data year)

	AT[10]	CZ[11]	DK[12]	EE[13]	FI[14]	BE[15] (Fla)	FR[16]	DE[17]	IT[18]	LV[34]	LT[34]	NL[19]	SE[20]
Consumption of new textiles	No	Yes (2013)	Yes (2016)	Yes (2018)	Yes (2012)	No	Yes (2019)	Yes (2018)	Yes (2018)	Yes (2018)	Yes (2018)	Yes (2018)	Yes (2013)
Separate collection of used textiles	Yes (2018)	Yes (2013)	Yes (2016)	Yes (2018)	Yes (2012)	Yes (2019)	Yes (2019)	Partial (2018)	Partial (2018)	Yes (2018)	Yes (2018)	Yes (2018)	Yes (2016)
Fate of separately collected textiles	Partial (2018)	Partial (2013)	Yes (2016)	Yes (2018)	Partial (2012)	Partial (2019)	Yes (2019)	Partial (2018)	Partial (2018)	Partial (2018)	Yes (2018)	Yes (2018)	Yes (2016)
Consumption of 2nd hand	Partial (2018)	No	Yes (2016)	Yes (2018)	Yes (2012)	No	Partial (2019)	Partial (2018)	No	Yes (2018)	Yes (2018)	Partial (2018)	Partial (2016)
% of EU-272020 population	1,9	2,4	1,3	0,3	1,2	1,5	15.0	18,5	13,5	0,4	0,6	3,9	2,3

Data source: see footnotes

10 Austrian MoE (2020) provides data on separate collection of textile waste in 2018. Some treatment data is available from RepaNet (2018) on reuse via their members and Austrian Federal Environment Agency (2019) provides information on collection and processing by Humana People to People.
11 Ernst & Young (2015) plus Ministry of environment of the Czech Republic (2017)
12 Watson,et al (2018b)
13 Watson et al (2020b)
14 Dahlbo et al (2017)
15 Excel spreadsheet sent by Evelyn Lafond (OVAM) plus OVAM (2019) plus information from information from De Kringwinkel https://www.dekringwinkel.be/nieuws/339/Kringwinkels-populairder-dan-ooit.html
16 EcoTLC (2020)
17 BVSE (2020)
18 Mazzei (2020)
19 FFact (2020)
20 For latest separate collection mapping: SMED (2018) For latest consumption data: Elander et al (2014)

The only MS that currently has comprehensive reporting obligations for *all* used textile collection, including textiles that are **not** classified as waste, is France. These obligations are part of the country's extended producer responsibility (EPR) scheme for textiles (and footwear). France is also the only MS that currently has an EPR scheme that covers textiles, although Sweden committed itself at the beginning of 2019 to adopt an EPR (Swedish Government, 2019a) and the Dutch parliament is also considering a Circular Textile Policy Program 2020-2025 that includes the establishment of an EPR[21] (see also Box 4).

France has also been the only Member State with minimum targets for separate collection quantities and for the subsequent treatment of the collected textiles. The Swedish EPA has developed targets for collection and treatment, but they have yet to be adopted by the national government (Naturvårdsverket, 2016). The draft Netherlands Circular Textile Policy also includes proposals for targets for collection and treatment (see Box 4).

In order to assess progress against targets to be monitored, the French Producer Responsibility Organisation, EcoTLC, must report annually on all used textile collection and treatment. Comprehensive mapping of both used textiles and textiles waste has also been carried out in other Member States (e.g. the Netherlands, Flanders, the Nordic countries and the Baltic States) and partial mapping has taken place in other countries. In some of these countries, the mapping has been carried out more than once. In Flanders, Austria and Italy, collection is reported annually, but in the latter two this reporting does not cover textiles donated over the counter in second-hand/charity shops.

Table 5 gives an overview of data availability. The countries with at least some data account for 62 % of the EU-27 population.

The mapping of years, scope and methodologies differs widely from Member State to Member State due to a lack of any standard for mapping studies or reporting. There are several areas where data is only partially available or where scopes differ. Some examples of differences in methodologies and scopes are summarised below.

Consumption of new textiles:

- Calculation method: most mapping studies have used an apparent consumption calculation based on the simple equation Domestic Production plus Imports minus Exports. These studies have used ProdCom data at a detailed product level combined in some cases with Comext export data to produce conversion from Euro of production to weights (DK, EE, FI, LV, LT, SE). In other cases, conversion factors from industry were used to convert production data from pieces to kg (DE) or use was made of Interstat net mass conversion factors that are available from Eurostat for a wide range of CN 8-digit codes (Eurostat 2021c) (IT). In the Netherlands on the other hand, a mass-balance approach where outputs (separately collected used textiles and textiles found in mixed waste) are used to estimate inputs (consumption of new textiles) was applied in mapping. The Dutch mapping report notes that this approach may underestimate quantities of new textiles placed on the market.[22] Germany is the only country for which mapping studies have taken account of illegal exports of used textiles and direct imports by household via internet sales and purchases while on vacation.
- Product scope: Most MS have only included clothing and household textiles (DK, EE, FI, IT, LV, LT, SE) in consumption estimates. Others have included footwear (FR, NL) or footwear, bags and leatherware (DE).
- Scope of consumers: The consumption figures estimated by using production and trade data tend to be for an entire country, irrespective of the final user, e.g. final use by private households, government and private companies. The consumption figures for France on the other hand are for households only. The same is true for the Netherlands since the mass balance method only includes estimates of textiles in household waste. Denmark is the only country where the overall consumption has been split between households, government and business.

[21] Letter from THE STATE-SECRETARY OF INFRASTRUCTURE AND WATER MANAGEMENT to the Dutch Parliament 14th April 2020

[22] When assuming that new textiles placed on the market are equivalent to outputs of used textiles, the projections may underestimate actual consumption of new textiles for two reasons: 1) households may increase the stock of textiles that they store in their wardrobes year-on-year– no data is available on this storage 2) only separately collected textiles and textiles in household waste were included on the output side – textiles in waste collected from businesses were not included.

Separate collection of used textiles:

- Inclusion of collection actors: Many estimates of total separate collection of used textiles are based on surveys of (CZ, DK, EE, Flanders, LV, LT, NL) or reporting by (FR) collection organisations, which include municipal waste companies, charities and professional collectors. It is rare that all the collectors reply, but in most cases the share that does reply is statistically representative and is interpolated to the country as a whole. In Sweden and Finland only charities were surveyed, but municipal and private operator collection was thought to be very small at the time of the surveys. In Italy and Austria, only collection via bring banks has been recorded, not collection over the counter in second-hand shops[23].
- No survey data: The German mapping has taken a completely different approach. Some collectors were surveyed but they were not asked for the quantities of used textiles that they collect. Instead, collection was estimated by a process of subtraction. It is assumed that separate collection is equivalent to consumption, minus textiles disposed of in mixed waste minus textiles accumulating in households, minus lint loss in laundry. The latter two factors are estimated very roughly. The textiles disposed of in mixed waste is based on non-comprehensive waste picking data from 2006. Thus, the estimate for separate collection must be treated with great care and should be regarded as an upper limit of potential collection rather than actual collection that was achieved. As a comparison, if a similar approach had been used in Denmark, this would have overestimated collection by 10 000 tons and would have increased apparent collection rates from 43 % to 55 %.
- Product scope: Most mapping studies include footwear as part of the collection quantities reported by collection organisations, even if they have not been included in new consumption of textiles. This can lead to inconsistencies when comparing the two quantities and lead to overestimates of the share of products placed on the market that are eventually separately collected. Only the Danish study has removed shoes from final separate collection figures. Earlier French mapping studies have reported footwear, garments and household textiles separately, both for products placed on the market and in post-consumer collection. The 2020 report does not provide for such a split.

Treatment of separately collected textiles:

- Number of steps down the treatment path: Most mapping studies have used surveys of collectors to gain information on the treatment of the textiles that they collect. Some (DK, EE, FR, LT, LV, NL, SE) have also gone further downstream to survey wholesalers/sorters to find out what happens to the textiles that are sold to them for further sorting and further treatment. For the other studies (CZ, DE, IT), some broad assumptions have been applied for reuse, recycling and waste treatment without specifying whether these take place in the collection country or elsewhere.
- Only available for some fractions: For Austria and Flanders, *treatment* data is only available for textiles collected by the Repanet (Repanet**,** 2021) and Branchevereniging Kringloopbedrijven Nederland (BKN 2021) networks of social economy reuse organisations. No data is readily available for treatment of textiles and textiles waste collected by other organisations.

Consumption of second-hand clothing/textiles:

- Missing treatment data for used textiles: One of the key components of second-hand textiles consumption are the domestically collected used textiles that are subsequently sold or donated for reuse within the country. As described above some countries (AT, CZ, DE, Flanders, IT) do not have any detailed data on treatment shares or on the place where reuse took place.
- Missing data on the treatment of imports of used textiles: For countries with little or no sorting/wholesale sector, imports of used worn textiles (CN code 6309) can be assumed to be imported for immediate sale by second-hand retailers. This is the other key component of consumption of used textiles. However, several of the MS in Table 6 (CZ, DE, EE, Flanders, FR, IT, LT, LV, NL) have significant sorting/wholesale sectors that import unsorted textiles (under CN Code 6309 or 6310) for sorting and processing and subsequent sale on reuse and recycling markets only part of which are sold on domestic markets (see also Figure 22 later). The sorting/wholesaler's treatment of imported textiles have only been mapped out in sufficient detail in EE, LT, NL and LV to allow the share of imported textiles that are sold for domestic reuse to be estimated.

[23] For Italy; personal communication with Caterina Caterina Mazzei (CNA Federmoda). For Austria; personal communication with Dr. Emile Van Eygen, Austrian Umweltbundesamt.

3.3.3.2 Overall responsibility for collection of textiles

France and Estonia are the only countries (from those in Table 5) that currently have legal requirements on the separate collection of textiles waste. In Estonia, municipalities are required by law to provide bring banks for citizens to deliver textiles waste (Watson et al, 2020b). In France, producers (and importers) of clothing, textiles and shoes are held responsible under EPR regulations (Watson et al, 2020a).

The remaining countries differ on how they will allocate overall responsibility for the collection of textiles (waste) and what systems will be set up to meet the WFD's obligation on separate collection of municipal textile waste by 2025.

Sweden and the Netherlands plan to delegate overall responsibility to producers via EPR regulations (see Box 4).

Germany has developed a draft revision of the German waste legislation that places the re-responsibility for the collection of textile waste from households on municipalities, provided that the treatment of these waste quantities is technically and economically feasible. Danish (Watson et al, 2020a) and Italian (Gazzetta Ufficiale, 2020) municipalities will be required to carry out the separate collection of textile waste from the beginning of 2022, and Spanish[24] municipalities from 31st December 2024. It seems that Finland will also place the responsibility on municipalities (Watson et al, 2020a). The status in other Member States is unknown.

An absence of current legal obligations for the collection of used textiles does not mean that this collection does not happen. Clothing is one of the few products for which a thriving post-consumer collection and treatment sector has existed for decades, for one good reason: it is, or at least has been, an economically viable activity. This is described in more detail below and under Task 2.

3.3.3.3 Collection actors and activities

In all countries with mapping studies, the major share of used textile collection is currently carried out by charitable and commercial collectors. In Denmark, Finland, Latvia and Sweden, the collection is dominated by charitable organisations (ibid). In Lithuania, commercial collectors are responsible for 54 % of collection (Watson et al, 2020b). In France, Germany and the Netherlands, commercial collectors also have a reportedly high share of the market, though there are no concrete figures on how big this share is (Watson et al, 2020a).

Municipal waste companies also play an increasing role in used textile collection in many countries. In Estonia, due to legal obligations, municipalities carry out 37 % of all collection, and in Lithuania they have a 30 % share (Watson et al, 2020b).

Collection by municipal waste companies in Denmark, Netherlands and Sweden are thought to be lower. In Denmark for example municipalities had a share of 5 % in all collection in 2017, but this is increasing over time (Watson, et al, 2018b).

Collection via bring banks is reported to be the dominant form of used textile collection in all countries with data. Only France is known to have official figures on this where 83 % of collection is via bring banks, of which three quarters are placed on streets and other public ground, and the remainder on private ground (EcoTLC 2020). It is estimated that 88 % of collection in Germany is via bring banks[25]. In Italy, all *reported* collection is via bring banks, but this is because there is no reporting on textile collection via other means e.g. across counters in shops (Mazzei, 2020). Bring banks are in general placed in civic amenity centres, on streets and on private ground. In Finland, it is normal for bring banks to be placed at the same sites as packaging collection under the EPR system for packaging (Watson et al, 2020a).

Kerbside collection is significantly less prevalent, in part due to higher costs but also due to risk of theft (EcoTLC, 2019a). It comprises only 1.8 % of collection in France (ibid) and 3 % in Germany[26]. In Austria, kerbside collection via special textile waste bags is carried out by a handful of municipalities, but has become rarer in recent years[27].

[24] In Spain, the law approved in June 2020 (Anteproyecto de Ley de Residuos y Suelos Contaminados) indicates that municipalities should provide for separate textile waste collection before 31 December 2024; see https://www.garrigues.com/es_ES/noticia/anteproyecto-ley-residuos-suelos-contaminados-economia-circular-reduccion-plastico-nuevos

[25] GftZ estimate. Nicole Kosegi personal communication

[26] GftZ estimate. Nicole Kosegi personal communication

[27] Emile Van Eygen, Austrian Umweltbundesamt Personal communication 8th October 2020

Box 5: The European RREUSE network

RREUSE is an international non-profit network representing social enterprises active in the field of reuse, repair and recycling. In 2019, RREUSE (Rreuse Activity Report, 2019) had 27 members across 25 European countries and the USA.

RREUSE's mission is to ensure that policies, innovative partnerships and exchange of best practices promote and develop the role of social enterprises in the circular economy. RREUSE members' activities include:

— Advocacy at local, regional and national levels and sharing of best circular practices
— Awareness-raising campaigns, local and international projects and business support
— Collection, sorting and redistribution of used textiles and clothing
— Collection, repair and reuse of electronics, furniture and bulky items
— Reuse of other household items such as bric-a-brac, books, toys and paint
— Operating second-hand retail outlets

In December 2019, RREUSE published a vision (Rreuse, 2019) for Europe on how to achieve a more inclusive and circular textile sector that prioritises reuse and emphasises the role of social enterprises in the value chain as part of the solution. The paper provides a number of key recommendations as to what specific actions the Commission should address when developing policy initiatives for the sector.

A handful of municipal waste companies have begun kerbside collection of textiles waste in Denmark, the Netherlands and Sweden, generally through the use of bags that are sealed and placed with other dry recyclables (Watson et al, 2020a). Kerbside collection by charities and commercial collectors is very rare although some charities offer on-demand pick-up services, usually in return for a fee. There is no kerbside collection in the Baltic States (Watson et al, 2020b).

Indoor collection across the counter or via small bring banks in second-hand shops and retailers is more significant, comprising 13 % of total collection in France though only 4 % in Germany (ibid). In the Netherlands, Flanders and Austria, socio-economic reuse organisations under the HERWIN (previously Komosie) and RepaNet networks respectively specialise in receiving used goods including textiles across the counter for processing and repair in the shop (Watson et al, 2018a). These national networks are all part of the European RREUSE network (see Box 5). Collection across the counter is also widespread in the Baltic States and the Nordic countries although not thought to represent a significant share of total collection. New methods of collection such as using return logistics from clothing retailers, or collection in workplaces are being experimented with in many countries.

A number of guidance documents on good practices in the collection and processing of used textiles have been produced for private, municipal and charitable collectors (see Box 6 for more information).

Box 6: Guidance on good practice in the separate collection of used textiles

In 2020, the European Commission commissioned the development of a report providing guidance on the separate collection of a number of waste streams by municipalities (Dubois et al, 2020). Chapter 6 concerns the separate collection of textiles and includes good practice examples under the themes of Economic Incentives, Legal Enforcement, Customised Facilities and Communication with Citizens.

Dutch Rijkswaterstaat with assistance from PlanMiljø also developed guidance (ECAP, 2019) for collectors as part of the European Clothing Action Plan (ECAP) program, which was supported financially by the European Commission. The guidance provides a policy context, an overview of the value chain for textiles and recommendations for good textile collection. The 13 recommendations were drawn from an ECAP study on used textile collection in 7 European cities (Watson et al, 2018a).

In 2016, WRAP UK developed a guide for used textile collectors (WRAP UK, 2016). The aim was to help local authorities and textiles collectors to increase textile reuse and recycling. The guidance is very comprehensive, and while much of the legal context is only relevant for the UK, the more practical recommendations on how to set up effective kerbside and bring-bank collection and communication with citizens are highly relevant for collectors in the EU.

Also of relevance are guidelines developed by three federal states in Germany – the Länder Baden-Württemberg, North Rhine-Westphalia and Saxony[28]. These guidelines are essentially a manual for the collection, sorting and reuse of used textiles, containing relevant background knowledge on textile and used textile definitions, and specifying when used textiles should be classified as waste and non-waste. The guidelines concern all stages of treatment and processing of used textiles, with the aim of enabling reuse as far as possible and failing that, recycling. The guidelines also cover the legal conditions in connection with the collection of used textiles, including classification, reporting obligations, requirements for collectors, possible prohibition on collection, rules for bring banks, etc. Similarly to the WRAP UK guidelines, the German manual contains good advice on how to tackle illegal collection and how to transport, unload and sort collected textiles.

3.3.3.4 Approaches to reusable and non-reusable textiles collection

With the notable exception of France, charitable and private collectors in most countries tend to make it clear on their bring banks that they only wish to receive clean and reusable textiles (and footwear), often due to the negative impact that collecting non-reusable textiles have on their economies.

To illustrate this, Figure 18 presents shares by quantity and value of reusable and recyclable fractions in a typical tonne of textiles collected in Nordic countries in 2015. As can be seen, the non-reusable textiles represented 29 % of the weight of collected textiles but less than 4 % of the value. Prices for recyclable textiles have declined even further since 2015 (WRAP UK, 2017).

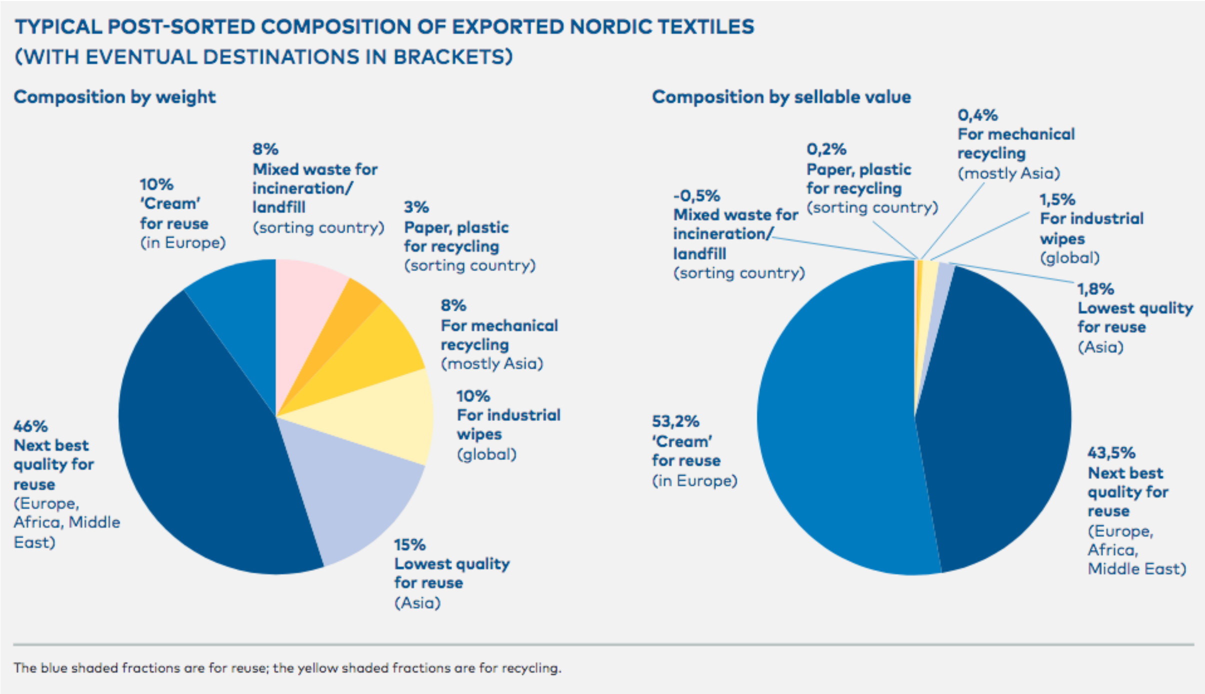
In the three Nordic countries, the strategy of making it clear on bring banks that collectors do not wish to receive non-reusable textiles also avoids claims that they are collecting waste and thus they avoid the need to register as waste collectors (Watson et al, 2020a). Many collectors also state that they do not wish to collect mattresses, duvets and pillows.

However, a few charitable and/or commercial collectors in all these countries do openly ask for non-reusable textiles. Some charities see the collection of non-reusable textiles as part of their wider environmental and social responsibility (ibid). In other cases, where they have competed under a tender process for collection services, the municipality may have required them to collect textile waste. This latter is perhaps most prevalent in Flanders and Netherlands (Watson et al, 2018a). However, tender processes are also used relatively often by municipal waste authorities in Germany which usually do not require of collectors that they ask for non-reusable textiles[29].

[28] See Case 6 in Watson et al (2020a)

[29] Nicole Kosegi, Personal Communication

Figure 18: Shares by quantity and value of reusable and recyclable fractions in a typical tonne of textiles



Source: Watson and Palm (2016)

The Dutch Green Deal for textiles 2012-2015 (greendeals, 2021) encouraged municipalities to include this requirement in tenders, and an increasing number of municipalities have adopted this principle[30]. In Flanders, the national waste agency OVAM has also encouraged used textile collectors to accept non-reusable textiles as part of a drive towards a more circular economy (OVAM, 2017). In France, all collectors accredited by EcoTLC must accept non-reusable textiles and footwear along with the reusable ones.

Regardless of whether collectors ask for non-reusable textiles or not, textiles received in unmanned containers or via kerbside collection almost always include a non-reusable fraction – typically 20- 30 % where only reusable is asked for, and perhaps 40-50 % where they also ask for non-reusables (Watson et al, 2020a). Where municipalities or municipal waste companies collect textiles themselves via bring banks in civic amenity centres or kerbside collection, they accept non-reusable textiles waste (ibid).

There are a few examples of where municipal waste companies communicate to citizens that they should *only* deliver non-reusable textile waste and donate the reusable fraction to charitable collectors. Despite this, a significant fraction of reusable textiles is delivered to these collection systems[31].

Second-hand shops that collect textiles over the counter tend to only accept reusable textiles, and often only textiles that are re-sellable in the collection country.

3.3.3.5 Total collection and collection rates of used textiles

Table 6 and Figure 19 present separate collection quantities alongside consumption quantities in countries with available data.

[30] Emile Bruls personal communication

[31] E.g. Vejen Municipality in Jutland in cooperation with Dansk Affald. Dansk Affald presentation to DAKOFA textile network, 1stMarch 2018. A further example is Argo in Zealand.

Table 6: Separate collection of used textiles as a share of new textiles placed on the market in the same year

Country code (data year)		AT (2018)	CZ (2013)	DE (2018)	DK (2016)	EE (2018)	FI (2012)	Fla. (2019)	FR (2019)	IT (2018)	LT (2018)	LV (2018)	NL (2018)	SE (2013)
Consumption of new textiles	K-tonnes	---	69	1715	85	16	72	----	648	1383	19	12	305	121
	Kg/ person	---	6.6	20.7	15.0	12.4	13.2	----	9.7	22.8	7.0	6.1	17.7	12.6
Separate collection of used textiles	K-tonnes	38	20	1271	37	4.8	16	55	249	146	2.1	0.5	136	23
	Kg/ person	4.3	1.9	15.3	6.4	3.7	3.0	8.3	3.7	2.4	0.8	0.3	7.9	2.4
Collection rate*	%	**---**	**30 %**	**---**	**43 %**	**30 %**	**23 %**	**----**	**38 %**	**11 %**	**11 %**	**4.5 %**	**45 %**	**19 %**

*The collection rate is defined as the total separate collection of used textiles divided by the total quantity of textiles placed on the market.
Note: the figures in this table are not immediately comparable between countries due to differences in methodologies and scope.
Data sources: see footnotes to Table 5

One key observation is that the apparent consumption of new clothing and textiles per capita varies by a factor of three between countries. These differences are not just a result of differing average income but also of cultural differences (there are also differences in calculation methodologies and data years although they are probably not responsible for the substantial differences existing). For example, France, with a similar GDP per capita to Italy, consumes less than half the textiles.

This suggests the potential for significant reductions in volume of consumption of new textiles through changing cultural norms, in part through raising awareness of the environmental impacts caused by the consumption of clothing and home textiles and providing information for consumers on how these impacts can be reduced (ECAP, 2021).

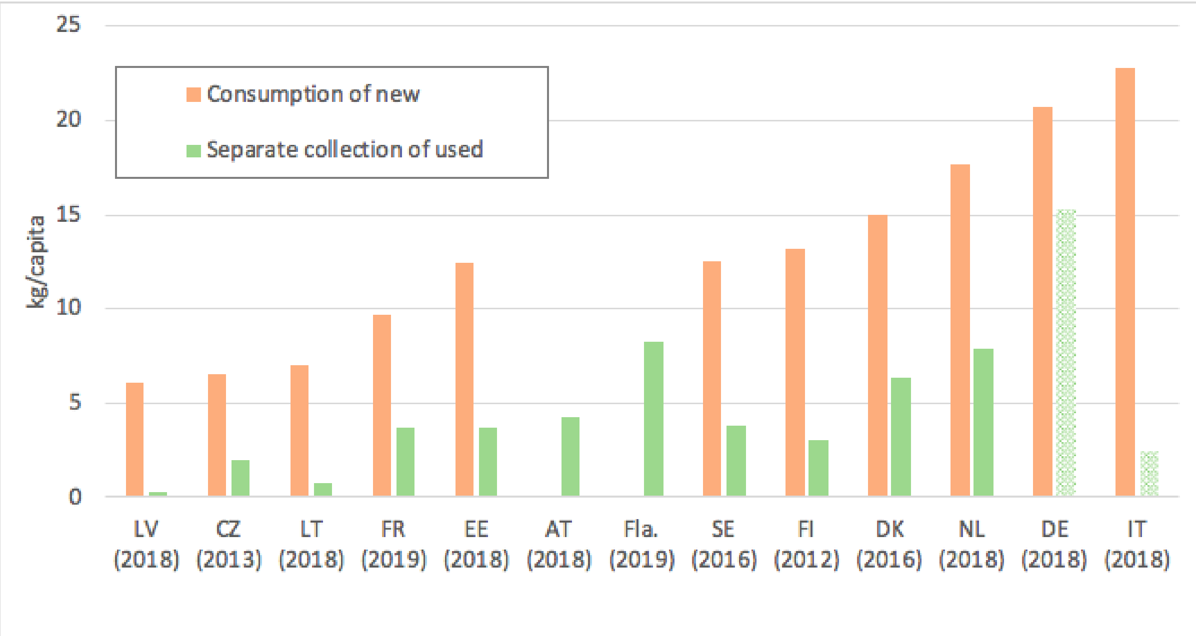
The collection of used textiles also varies significantly. Part of this difference is a result of variation in the quantities of new textiles placed on the market, but collection rates (separate collection as a share of new textiles placed on the market) also differ widely, ranging from just 4.5 % in Latvia to 45 % in the Netherlands.

Flanders is likely to have an even higher collection rate but, unfortunately, there is no consumption data available.

Germany may also have a higher collection rate than the Netherlands. However, Germany's reported collection quantity is built upon unsubstantiated assumptions and outdated waste picking data (see more detail in notes under Table 5) rather than surveys of collection organisations and is considered to be significantly overestimated which is why no collection rate has been provided in Table 6. Italy's and Austria's collection on the other hand is likely to be somewhat underestimated, since they do not include collection over the counter in retail stores and second-hand shops or collection via campaigns in the reporting.

Only four countries/regions are known to have annual reporting of separate collection of post-consumer textiles: France, Flanders, Austria and Italy. The latter two only cover collection via bring banks (textile waste), but not post-consumer textiles collected via other means (see above). Denmark, Sweden and the Netherlands have two years of data.

Figure 19: Separate collection of used textiles and new textiles placed on the market in the same year in kg/capita



Note: The figures in this graph are not immediately comparable between countries due to differences in methodologies and scope (see text under Table 5).

Source: Own representation with data from mapping reports/references (see Table 5 footnotes)

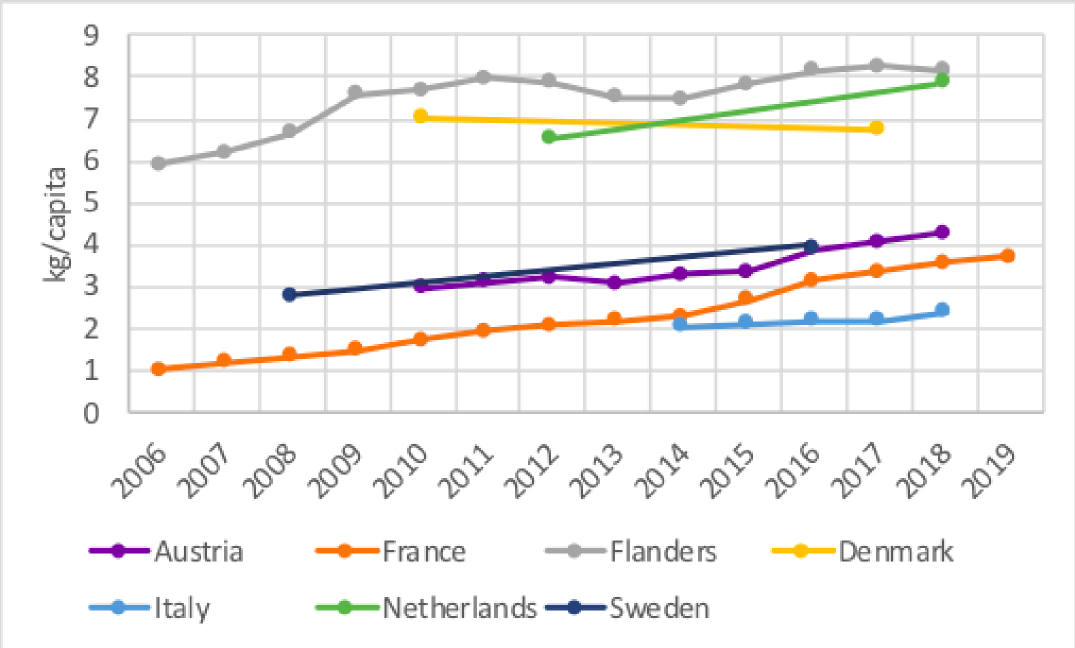
Total collection in France increased from 65 000 tonnes in 2006 [32], the year before the EPR regulations were adopted, to 249 000 tonnes in 2019 (EcoTLC, 2020), an increase of 380 %. This outstrips growth rates in other countries (see Figure 19). However, as is also clear from Figure 19, French collection rates have risen from an initially low level. Even now after a factor 3.8 increase, separate used textile collection represents only 38 % of new textiles placed on the market compared to 43 % and 45 % in Denmark and the Netherlands respectively.

The French EPR system has been effective at increasing collection rates through a combination of target setting and establishing systems and incentives to all actors to achieve these targets. Of particular importance has been the fact that targets set at national level have been translated to targets at municipal level (targets for density of collection points rather than targets for actual collection), which themselves are strengthened through economic incentives.

The producer responsibility organisation, EcoTLC, provides financial support to municipalities for communication to citizens on collection but only if the municipality has ensured that the collection point density (number of collection points per 1000 people) in their area meets the national density target. Moreover, financial support is also given to sorting facilities, which trickles up to collectors through payments of higher price per tonne of textiles delivered to sorting facilities. This financial support is dependent on both sorting companies, and the collectors that supply them, being officially registered within the EPR scheme and living up to reporting obligations (Watson et al, 2020a).

[32] See in Bukhari et al (2018)

Figure 20: Trends in separate collection quantities over time (in countries with more than one data point)



Data sources: Austria[33], Flanders[34], France[35], Denmark[36], Italy[37], Netherlands[38], Sweden[39]

3.3.3.6 *Tentative estimates of separate collection of textiles in the EU-27 as a whole*

Although the collection figures are for a range of years and methodologies differ, we can tentatively use the mapping to estimate a range of total separate collection of used textiles across the EU-27_{2020} as a whole. This is useful as input to Task 2. These countries represent 63 % of the total population of the EU-27.

Total reported separate collection in all 13 countries with mapping studies lies at just over 2 million tonnes per year (note though that for some countries this includes footwear). If a 60 % collection rate is assumed for Germany[40] instead of the 74 % estimated in the BVSE report, this would give an adjusted total of 1.8 million tonnes (again including footwear). Removing footwear (typically estimated by collectors at 5 % to 7.5 % of weight) might reduce this to approximately 1.7 million tonnes.

The weighted average collection rate for the 11 countries with both consumption and separate collection data, is 38 %, i.e. 38 % of textiles placed on the market are eventually collected separately. According to the results from Chapter 3.3.2, roughly 5.4 million tonnes of clothing and household textiles were placed on the market in 2019. If the remainder of the EU-27 had as high a collection rate per capita as the 11 countries with data, this would result in 2.1 million tonnes collection per year under current conditions.

Thus, the current separate collection of used textiles across the EU-27_{2020} is tentatively estimated to lie within the range 1.7 to 2.1 million tonnes.

These figures should be used with great care. They are based on mapping studies across Europe with widely different scopes, data years and data collection methodologies.

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33 Austrian Waste Management Inventory Status Reports 2012 to 2020 and Austrian Federal Waste Management Plans 2011 and 2017
34 See Figure 71 in OVAM (2020)
35 Figure 8 in Bukhari, et al (2018)
36 Watson, et al (2018b)
37 Mazzei (2020)
38 FFact (2020)
39 SMED (2018)
40 This 60 % assumption can be derived by adjusting the BVSE report results with newer data for textiles found in residual waste (4.5 % of residual waste rather than 2.5 %) and by looking only at clothing and household textiles and removing shoes and bags as proposed by Nicole Kosegi pers. comm.

3.3.3.7 Quantity and quality of textiles discarded in residual waste

It is of high interest to gain an overview of the quantity of used textiles currently discarded in residual waste for landfill and/or incineration. This quantity constitutes an upper limit of what could be diverted from residual waste to separate collection systems in the years leading up to and following the requirement for separate collection of textiles waste in 2025. It is similarly of high interest to gain an overview of the quality of textiles that are discarded in residual waste and the share thereof that could have been reused or recycled if they had been collected separately. Unfortunately, data in both these areas is very limited. The data that does exist is provided below.

Quantity

As described in the previous section, on average in the countries with data, approximately 38 % of textiles placed on the market are collected separately for reuse, recycling and other waste treatment. A minor proportion of the remainder is increasingly accumulated in wardrobes, or is lost from the system through lint loss to air or water, but the vast majority is eventually disposed of in mixed residual waste streams bound for incineration or landfill.

Using a mass-balance approach, taking the tentative figures for total separate collection given in the previous section along with estimates for new clothing and home textiles placed on the market (5.4 million tonnes in 2019), somewhere in the region of 3.3 to 3.7 million tonnes of clothing and household textiles are likely to be disposed of in mixed waste streams each year in EU-27. Increasing household stock could potentially decrease this by 10 % but is a largely unknown factor and deserves research focus.

Some countries/regions carry out regular monitoring and reporting on textiles found in residual waste, two of which are the Netherlands and the Belgian region of Flanders. In Flanders, textiles in mixed waste reduced between 1995/96 and 2000/01 from 5.5 kg/cap to 4.0 kg/cap as more and more textiles were separately collected from households (see Figure 19). However, as separate collection of textiles began to stagnate after 2008, the textiles found in mixed waste increased again and reached 7.09 kg/capita by 2013/14[41].

The Dutch data[42] is less useful in a direct manner as it provides the *share* of household residual waste that comprises textiles (and footwear) rather than absolute quantities in kg/capita. The share of textiles in residual waste is not only influenced by increases in separate collection of textiles, but also by increases in separate collection of other fractions, e.g. the more plastic, paper, cardboard, metal, glass and kitchen organic waste is separately collected, the larger the share of textiles will be, even if the absolute quantity of textiles has not increased. According to the data, textiles (including footwear) have steadily increased their share in residual waste from 1.8 % in 1980 to 5.9 % by 2018 (ibid).

Quality

Of more interest in the Netherlands is the analysis that Rijkswaterstaat carries out each year of the *quality* of textiles that are disposed of in household residual waste. This is based on an evaluation of the probable quality of the textiles *before* they were discarded. This gives an idea of the circularity potential. Over the past few years, approximately a quarter of the textiles would have been reusable, just under a third recyclable and the remaining 40-50 % non-reusable and non-recyclable waste (see Table 7).

41 See Figure 72 in OVAM (2020)
42 See Table 2.2 in Rijkswaterstaat (2020)

Table 7: Quality of textiles disposed of in residual household waste in the Netherlands

	2015	2016	2017	2018
Reusable	24 %	20 %	23 %	28 %
Recyclable	32 %	31 %	29 %	30 %
Waste (not reusable and not recyclable on current markets)	44 %	50 %	48 %	42 %
SUM	**100 %**	**100 %**	**100 %**	**100 %**

Data source: Table 3.8 in Rijkswaterstaat (2020)

There are only a few other examples of such studies. An evaluation of samples from household residual waste in seven Danish municipalities found that 23 % would have been reusable prior to discarding, 26 % recyclable under current markets, 38 % recyclable under future markets and the remaining 13 % waste (not reusable nor recyclable on current or future markets) (Watson et al, 2018b). These results are similar to those from the Netherlands.

A further Danish study, however, found that 65 % of textiles in residual household waste could have been reused, although this included clothing that could only be reused after a repair operation (Nørup, 2019). A Swedish study also evaluated that a high share (59 %) of the textiles discarded in residual waste could have been reusable prior to discarding (Hultén et al, 2016). Picking analyses in the UK (outside the geographic scope but still of interest), also estimated that 59 % of textiles discarded in mixed household waste in 2000 would have been reusable but this had fallen to 43 % by 2008 due in part to increasing separate collection of textiles.

The results of such picking studies and evaluations can be influenced by a wide range of factors: the quality of new textiles placed on the market; the intensity to which clothing is worn prior to being discarded, and the share of post-consumer textiles that are collected separately. Moreover, they are also dependent on the sampling and evaluation methodology. The studies discussed above have used somewhat different methodologies and cannot be immediately compared.

Therefore, it is hard to make general conclusions from these studies for Europe as a whole. One common finding though, is that at least half of the textiles discarded in mixed waste could have been reused or recycled, with higher shares likely in countries with low levels of separate collection.

In general, the higher the share of textiles that are already separately collected, the lower the average quality and value of textiles discarded in residual waste. This is partly because, households already make fairly reasonable decisions about what has significant value and should thus be donated/sold for reuse, and what has little reuse value. As an example, the 42 000 tonnes of textiles discarded in Danish residual waste for incineration in 2017 were estimated to have had a value of 12-15 million Euro prior to discarding whereas the 36 000 tonnes of separately collected textiles were sold on reuse markets for an estimated 65 million Euro, i.e. 4 to 5 times the value per tonne (Watson et al, 2018b).

The treatment and value of separately collected textiles under current systems is discussed below.

3.3.3.8 Current treatment of separately collected textiles

It is in the interests of all collectors of used textiles to maximise the economic profit that they can gain from the collected textiles. The degree to which they can do this is dependent on their experience, contacts and networks and most important of all, the quality of the textiles that they have collected.

At one extreme, there are municipal waste companies that collect textile waste with a specific focus on non-reusable textiles and have few contacts with global reuse and recycling markets. At the other end, there are charities and professional collectors that ask citizens to only deliver their good quality reusable clothing, footwear etc. and have their own retail shops and long-term agreements with wholesalers that have contacts on global markets.

In the former case, it is not unusual for much of the collected textiles to be incinerated or landfilled due to lack of other options for the waste company. In Estonia, 100 % of the 1 804 tonnes of textiles collected separately in 2018 were landfilled or incinerated (Watson et al, 2020b). The 3 702 tonnes of textile waste separately collected by municipal waste collectors in the Czech Republic in 2013 shared the same fate[43].

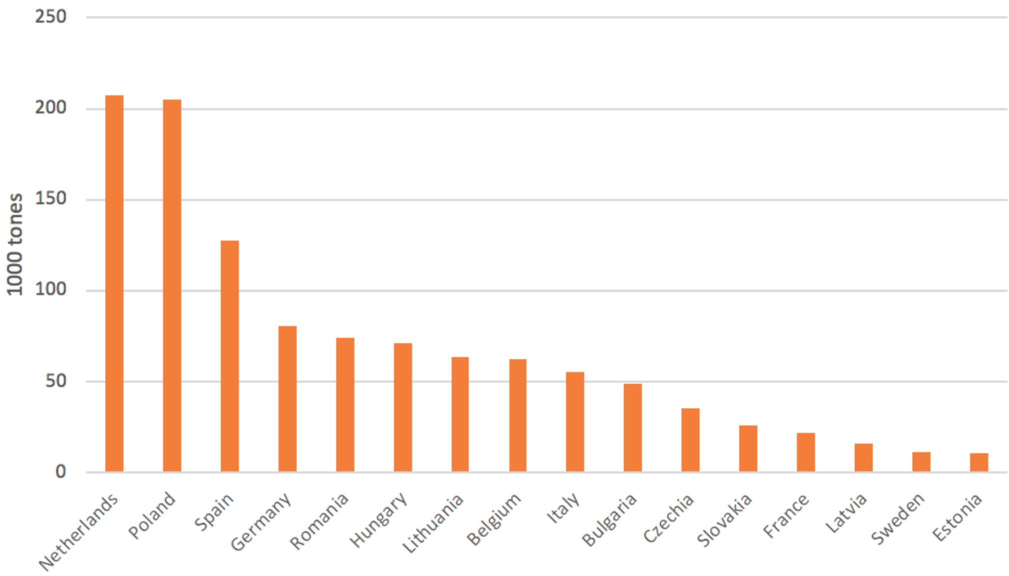
Textiles collected by charities and professional collectors tend to be treated as follows: for charities, at least part of the textiles they collect may be pre-sorted to skim off the best quality textiles for sale in their own second-hand retail stores, if they have such stores. The remainder is typically sold to wholesalers for detailed sorting and sale on global markets. Professional collectors may sell all they collect to wholesalers, or may themselves be wholesalers with full sorting facilities.

Textiles may often be exported to wholesalers in other countries. Figure 21 identifies the top EU importers of used textiles for sorting on the wholesale market. Both the Netherlands and Poland imported over 200 000 tonnes of used textiles in 2018, principally to feed the large wholesale and sorting sector in these countries.

The wholesalers manually sort the textiles they receive from collectors in sorting facilities into between 100 and 300 different fractions according to garment type, style, size, season etc. for sale on global reuse markets. Textiles that are not suitable for global reuse markets due to damage, wear etc. are sent to recycling (normally as industry wipes or downcycling into lower quality products) where possible and otherwise to landfill/incineration plants (Watson et al, 2016). This is described in more detail in Task 2.

Reuse shares typically range between 50 % and 75 % (see also Figure 22) depending on the country where the textiles were collected (the Nordic countries tend to have the highest quality of collected textiles) and how the collection was carried out.

Figure 21: Member States with imports of used textiles over 10 000 tonnes, 2018

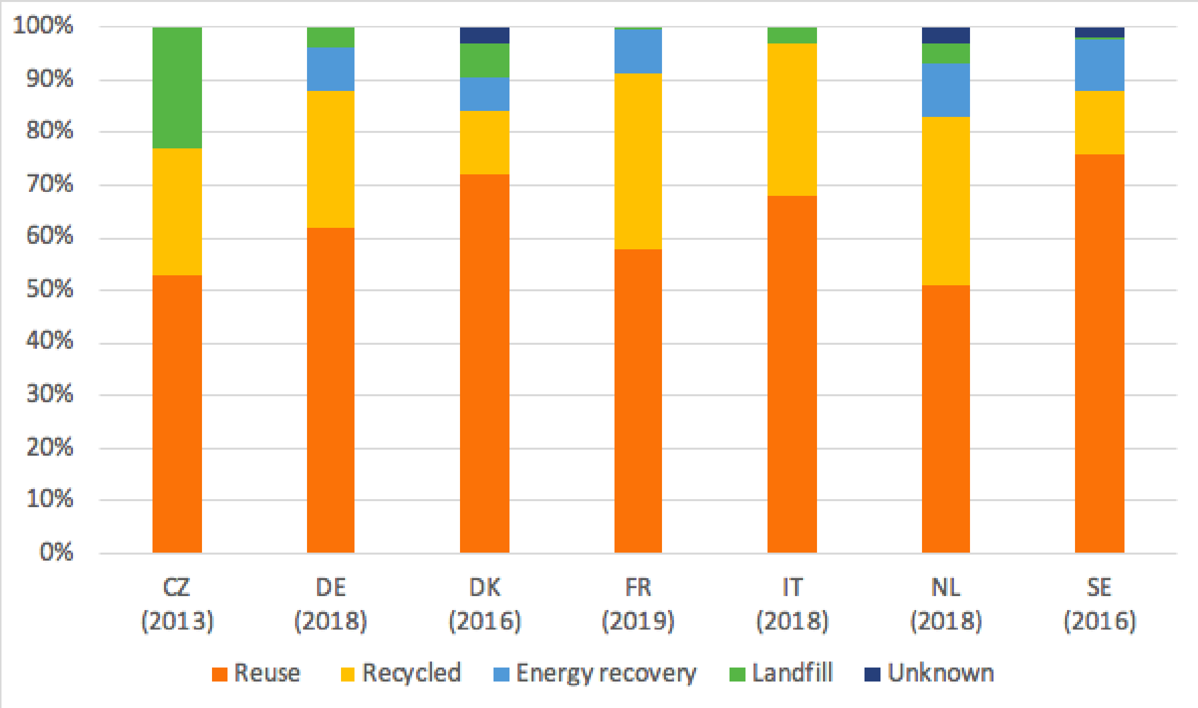


Source: Own representation from Comext trade data for CN codes 6309 and 6310

Figure 22 presents treatment shares for *all* separately collected textiles in countries with available data. The figures in the graph do not differentiate between treatment in the collection country and treatment abroad. For example, 58 % of textiles collected in France in 2019 were reused, but only a small part of this reuse actually took place in France; the remainder was sold for reuse on global markets.

43 Personal communication Olga Chybová, Inotex

Figure 22: Global treatment pathways* for separately collected post-consumer textiles in countries with available data



*Note that the treatment is global. For example, 71 % of all textiles collected separately in Denmark are reused either within Denmark or on global reuse markets.

Source: Own representation with data from mapping reports/references

It should be noted that data on reuse and recycling on global markets is usually provided by the wholesale companies that sort the collected textiles. Unless the sorted textiles were defined as textiles prior to sorting, and the sorting process is seen as a waste processing activity, there are no reporting obligations on these companies. Moreover, the companies may not always have a clear idea of what finally happens to the textiles that they export for reuse elsewhere in the world. There have been examples of textiles exported for reuse that have ended in landfill in the receiving country[44].

An increasing number of collectors have adopted codes of conduct for their buyers to ensure that they adhere to environmental and social criteria and to increase transparency in the eventual fate of used textiles (Watson et al, 2016), but there is a need for more widespread adoption of such codes of conduct. This is discussed more at the end of this chapter.

3.3.3.9 The consumption of second-hand textiles by European households

The previous sections have described the separate collection and treatment of used textiles in EU27 countries. The focus there has been on the *outputs* of households e.g. what happens to textiles once households no longer want them.

However, it is also of key interest for the circular economy of textiles to identify the extent to which the same households are willing to purchase second-hand textiles instead of new textiles. This is the other side of the circle.

Households can gain access to second-hand textiles in a number of ways:

- Informal passing on of clothing between family members or friends
- Formal C2C exchanges via physical flea-markets and online exchange platforms
- Purchases of second-hand products via second-hand retailers, either in physical shops or online that can either have been sourced from domestic collection of used textiles or imports of used textiles

Article 9(4) of the Revised Waste Framework Directive requires Member States to measure reuse according to a methodology developed by the Commission in 2019. It also requires the Commission, based on reporting by

[44] For example, the ITV News network in the UK identified mountains of imported used textiles in unregulated landfills in Ghana https://www.letsrecycle.com/news/latest-news/textiles-dumped-abroad-prompts-warning/

MS, to determine how reuse can be encouraged, which may include the adoption of targets for reuse. Textiles is one of the key product groups identified for reporting by Member States in draft reporting methodology (Oeko Institut & PlanMiljø, 2020). This methodology included options for reporting by second-hand retailers and operators of online C2C platforms, supplemented by household survey data that would also cover informal exchanges. The final methodology is yet to be agreed and Member States have yet to report on reuse.

Existing mapping of reuse of textiles is limited. Some national reuse networks under the RREUSE umbrella organisation report on reuse, but these do not show a full picture of reuse in a country, only reuse that is mediated by the organisation's members.

Some countries' textile mapping studies have either included estimates of domestic reuse as part of the study or include data that can be used to estimate reuse. Table 8 below shows data availability in various countries for calculating consumption of second-hand textiles.

Only two of the mapping studies (SE, DK) have attempted to estimate quantities of second-hand textile exchanges via formal C2C pathways (see the first row of Table 8).

Nine countries' mapping studies include estimates of the domestic reuse (via donation or resale) of used textiles that have been collected nationally by commercial, charitable or publicly owned collectors (see the second row of Table 8).

Five countries' mapping studies have estimated quantities of imported used textiles that are sold or donated for reuse within the country (see the final row of Table 8). For three countries (EE, LT and LV) this data was developed through interviews with the wholesale sector, who import textiles for detailed sorting and subsequent resale on domestic or foreign markets. In Sweden, the estimates were made through sales data from second-hand retailers of clothing. In Denmark, with no wholesale sector, it was assumed that all imports of used textiles under CN code 6309 were imported for direct second-hand retail.

Domestic reuse of imported used textiles can also be estimated for Finland and Netherlands:

- Finland: like Denmark, Finland does not have significant domestic wholesale/sorting capacity. Therefore, it can be reasonably assumed that all imports of used textiles under CN code 6309 in Eurostat's Comext database are for domestic retail.
- Netherlands: the Netherlands has a significant import of used clothing and other textiles for sorting in the large and active Dutch wholesale sector. The Dutch mapping report from 2020 estimates this quantity to have been 98.3 ktonnes in 2018. Although the report does not specifically map out the fate of these imported textiles for sorting, their fate can be assumed to be similar to the domestically collected textiles which is mapped in the report.

The other countries (AU, CZ, Flanders, FR, DE and IT) all have significant wholesale sectors that import used textiles for sorting, and no mapping has yet been carried out of the subsequent fate of these textiles after sorting (e.g. domestic reuse, recycling, incineration, landfill at home or reuse/recycling after re-export). This represents a major gap in knowledge on the fate of European used textiles.

Table 8: Detailed data availability for estimating consumption of second-hand textiles

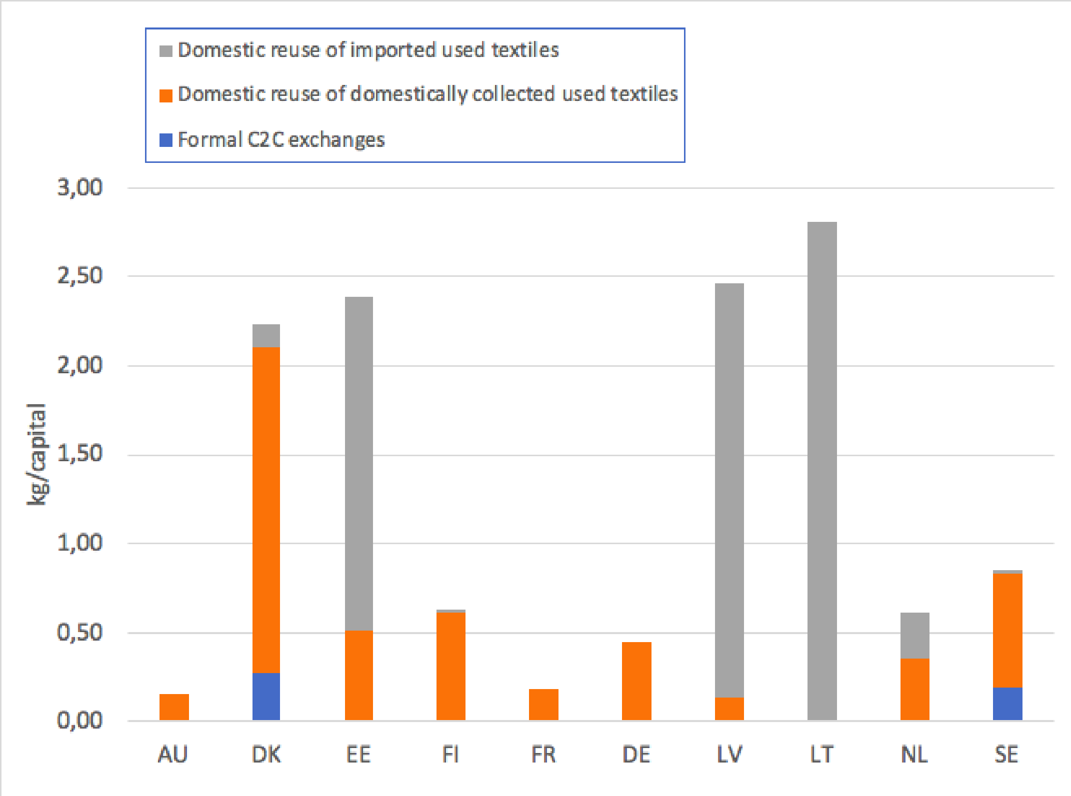
Country	AU	CZ	DK	EE	FI	BE (Fla.)	FR	DE	IT	LV	LT	NL	SE
Informal and formal C2C exchanges	No	No	Yes (2016)	No	No	No	No	No	No	No	No	No	Yes (2014)
Domestic reuse of domestically collected used textiles	Partial (2018)	No	Yes (2016)	Yes (2018)	Yes (2012)	No	Partial (2019)	Yes (2018)	No	Yes (2018)	Yes (2018)	Yes (2018)	Yes (2014)
Domestic reuse of imported used textiles	No	No	Yes (2016)	Yes (2018)	Can be estimated	No	No	No	No	Yes (2018)	Yes (2018)	Can be estimated	Yes (2014)

Data sources: same as in Table 5

Figure 23 presents the consumption of second-hand textiles from available sources. The consumption rate of second-hand is high in the Baltic countries (mostly of imported second-hand clothing from other parts of Europe) and in Denmark (mostly recirculated domestically collected textiles). In other Nordic countries, a higher share of collected used textiles are exported unsorted for detailed sorting elsewhere and domestic reuse is less prevalent. It is important to note that the data in the graph is incomplete as shown in Table 8.

Consumption of second-hand textiles accounts for a significant share of total consumption of clothing and home textiles in Latvia (29 %), Lithuania (29 %), Estonia (16 %) and Denmark (13 %).

Figure 23: Consumption of second-hand textiles in countries with available data



Notes: 1) Estimates of formal C2C exchanges are only available in Denmark and Sweden. 2) Estimates of domestic reuse of imported used textiles are not available in Austria, France or Germany. 3) The figure for domestic reuse of textiles collected in France only includes textiles that pass-through sorting facilities. A share of textiles collected by charities and professional collectors may be sold directly for reuse without entering a sorting facility. No data is available for this direct reuse.

Source: same as for Table 5

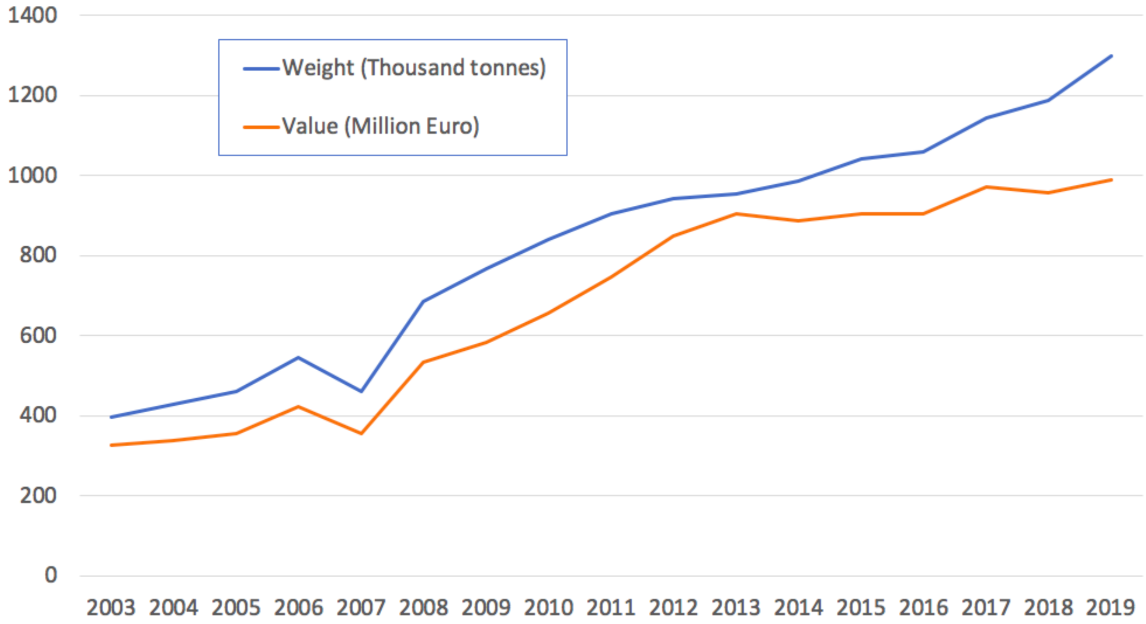
3.3.3.10 Developments in global markets for reuse and recycling

The circular economy for used textiles in Europe is highly dependent on global markets for reuse and recycling, since a large part of collected used textiles is eventually sold on global markets. Global markets have been affected in recent years by two developments:

- An increased supply of used textiles
- A stagnation in demand for used textiles both for reuse and recycling

Although time series data is generally not available across Europe, individual countries have shown increased collection volumes between consecutive mapping studies (see earlier). To give an indication of growth in collection volumes across Europe, exports of used textiles (CN/HS code 6309) from EU-27 to other parts of the world grew from just under 400 000 tonnes in 2003 to 1.3 million tonnes in 2019 (see Figure 24).

Figure 24: Growth in exports of used textiles from EU-27 by weight and value



Data source: Eurostat Comext database EU-27-extra exports for code CN 6309

Collection volumes are expected to grow even more rapidly towards 2025, as countries begin establishing separate collection of textiles waste to fulfil the obligations of the revised Waste Framework Directive.

Europe is not the only region that is increasing the collection and export of used textiles. Exports of used textiles from China increased from just 23 000 tonnes in 2010 to 294 000 tonnes in 2018 (Comtrade Database, 2021), a 13-fold increase. The value of USA's exports increased by 49 % over the same period, with 722 000 tonnes exported in 2010 (Ibid) increasing to perhaps over 1 million tonnes by 2018. Chinese exports have begun to flood many of the sub-Saharan African markets which had earlier been dominated by exports from Europe (Ljungvist et al, 2018).

There are no indications that the demand for reusable or recyclable textiles are following the latest swell in global supply. Indeed, an increasing number of countries are placing bans on or barriers to imports of second-hand textiles, citing that these undermine local production of new clothing and textiles (Watson et al, 2016). This is most notable in sub-Saharan Africa which is the biggest global market for used textiles. The COVID-19 pandemic has led to further standstill in imports of used textiles, for example, in Ghana (Recyclig International, 2020).

The changes in global supply and demand are particularly affecting, the lower grade reusable clothing. Global markets for these are becoming saturated, and clothing that was previously exported to Middle East, Africa and other global markets for reuse are now being downcycled instead (Ljungvist et al, 2018). This has negative environmental impacts since reuse is more environmentally beneficial than recycling (Schmidt et al, 2016). It also has negative impacts on collectors and sorters.

3.3.3.11 Economic conditions for collectors and sorters towards 2025

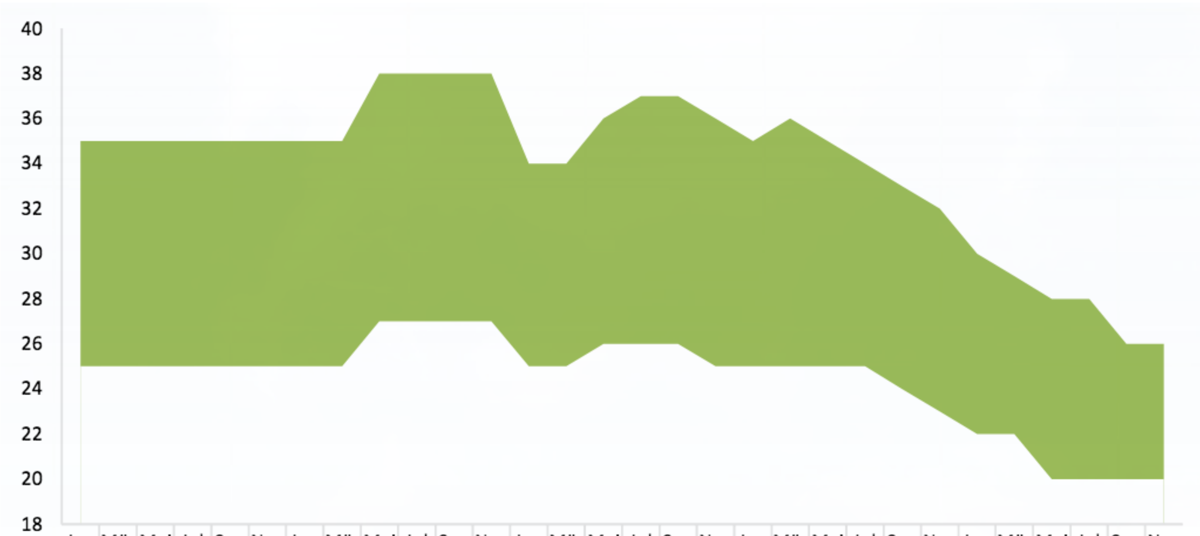
The result of an increasing supply chasing a stagnant or reduced demand for second-hand textiles is a reduction in price. Prices for extra-EU exports of used textiles (HS/CN code 6309) rose from 80 Eurocents/kg in 2003 to a peak of 95 Eurocents/kg in 2013, but have since been falling steadily again and by 2019 were down to 76 Eurocents/kg (see Figure 24 above). This is undermining the profitability of many collectors and wholesalers of used textiles.

For collectors, it is the price for 'original' that is of key importance. 'Original' is industry jargon for unsorted textiles as they were delivered to bring banks and includes reusable textiles, recyclable textiles and unusable textile waste. Original is often sold directly with only minimal removal of non-textile waste (without opening bags of textiles delivered to bring banks) to wholesalers for detailed sorting.

Figure 25 shows trends in price range for original collected in Germany between 2015 and 2019. It shows a significant fall over the past two years. This fall is not only a result of changes in global markets. Around

87 % of German collectors reported that the quality of what they receive from citizens has fallen (BVSE, 2020). The share of worn out and lower quality textiles has increased as has the share of textiles contaminated by water or other waste. Contaminated textiles have increased to over 10 % of the total (ibid). Some collectors in the Netherlands report even higher rates of contamination at 15 % or more (Watson et al, 2018a). Contamination by rainwater or wet waste often leads to mould and makes the textiles worthless for the collector, as the narrow economic margins do not allow for cleaning, washing or drying of received textiles.

Figure 25: Trends in the value of German original since 2015 (Eurocent/kg)



2015	Jan	Mär	Mai	Jul	Sep	Nov
Max.	35	35	35	35	35	35
Min	25	25	25	25	25	25

2016	Jan	Mär	Mai	Jul	Sep	Nov
Max.	35	35	38	38	38	38
Min	25	25	27	27	27	27

2017	Jan	Mär	Mai	Jul	Sep	Nov
Max.	34	34	36	37	37	36
Min	25	25	26	26	26	25

2018	Jan	Mär	Mai	Jul	Sep	Nov
Max.	35	36	35	34	33	32
Min	25	25	25	25	24	23

2019	Jan	Mär	Mai	Jul	Sep	Nov
Max.	30	29	28	28	26	26
Min	22	22	20	20	20	20

Source: BVSE (2020)

The increased share of lower quality textiles in original can have a number of explanations, which may be operating in combination (Ljungvist et al, 2018). Some collectors cite an increase in the market share of fast fashion (e.g. low price, lower quality clothing) as the chief reason (BVSE, 2020), while others note that consumers have begun to see their used clothes as having commodity value and sell the best quality themselves via C2C exchange platforms. This would be a positive trend with respect to the circular economy but has a negative effect on the economy of collectors of used clothing. A further explanation may be that campaigns in some countries have encouraged citizens to deliver their worn-out textile waste along with the reusable textiles to bring banks (Watson et al, 2018a).

A recent detailed survey of the quality of textiles collected in civic amenity centres in Denmark, Norway, Sweden and Germany found that the share of non-reusable textiles delivered varied dramatically from just 1.3 % to 46 % (Pihl, 2020). There was found to be a strong connection between the level and quality of information given to citizens and the quality of the textiles received. When the waste management companies ask for waste, they receive waste. When they ask for reusable textiles, they receive much better qualities (ibid).

The share of lower quality textiles is critical in defining the difference between a viable and non-viable economic model for collectors. This is clearly demonstrated earlier in Figure 17.

The Waste Framework Directive obligation on Member States to set up systems for the separate collection of textiles waste by 2025 may critically change the rules of the game for the used textile sector: textile waste with no reuse value will now also need to be collected.

If parallel systems are set up where charitable and commercial collectors continue to focus on the reusable fraction while municipalities focus on collecting the non-reusable waste, the business model of traditional collectors may still be viable. This seems to be the approach to be taken by Denmark. If, on the other hand, commercial and charitable collectors are expected by national or local government to collect the non-reusable waste along with the reusable textiles then they, and/or sorting companies, will need economic compensation from state governments, producers (via EPR legislation) or local government in order to survive economically

(Watson et al, 2020a; BVSE, 2020). This kind of support has already been provided in some countries/regions, notably in France and Flanders (Watson et al, 2018a).

Whoever ends up collecting the non-reusable textile waste will face a significant challenge in finding circular solutions for this. Prices for these textiles on existing recycling markets are at rock-bottom (Watson et al, 2020a) and recycling capacity is limited, meaning that a large share of these textiles must already be incinerated or landfilled at a high cost to sorters (ibid). Current recycling markets comprise cutting (of cotton-rich) textiles into industry wipes or various downcycling options such as use in insulation, upholstery padding or other low-grade products (ibid).

3.3.3.12 Increases in separate collection of textiles towards and beyond 2025

In Section 3.3.3.6, the separate collection of used textiles across the EU-27_{2020} in 2018 was tentatively estimated to lie within the range 1.7 to 2.1 million tonnes. Perhaps the most important question being asked by the used textile sector is 'what increases in separate collection can we expect over the coming years in response to the 2025 separate collection requirement?'

Answers to this question will guide investments in sorting capacity and capacity for new reuse and recycling solutions.

It is not a question that can be answered with any certainty and depends on a number of issues:

- When will Member States implement the requirement with roll-out before 1st January 2025?
- To what degree will the new systems differ from existing ones in terms of collection point density, introduction of new collection direct from households or continued reliance on household's delivery to collection points etc.?
- How much effort will be placed on communicating with and nudging citizens in separating textiles from mixed household waste?

The WFD leaves these issues up to Member States to decide for themselves, and with no imposed target for separate collection of textiles, the effectiveness of the systems and communication around them are likely to differ widely between MS, depending on the motivations and priorities of national governments and other stakeholders.

Under any circumstances, citizens will not change their behaviour overnight. The French Extended Producer Responsibility System for textiles (and footwear) has been in place since 2007 and registered collectors must collect all textiles, including the textile waste. Nevertheless, despite the imposition of collection targets, incentives to meet these targets by involved actors, and significant communication with citizens, and associated impressive growth rates in collection, the French system nevertheless had only collected 38 % of textiles placed on the market by 2019 (see Table 6 and Figure 20).

The best we can do is to consider the growth rates in collection achieved over the past decade in individual countries (see Figure 20) and assume that the best growth rates are mirrored across the EU as a whole in the years following 2025. In the years up to 2025 there will be some growth, but it can be expected that many Member States may wait to implement the WFD requirements until the last minute.

Table 9 provides an overview of average growth rates in the collection of textiles in the countries/regions with several years of data (as presented in Figure 20). Based on this historical data, and giving weight to those countries/regions that have made strong efforts to increase collection rates through target setting, communication and an emphasis on collection of the non-reusable collection waste as well as reusable textiles (France, Flanders and Netherlands), we might optimistically expect growth across the EU-27 as a whole in the range 150 to 200 g/capita/year.

Assuming a stable population this would give approximate increases of 65 000 to 90 000 tonnes per year in the years following 2025. Increases of perhaps half that might be expected in the years up to 2025 as Member States begin to roll out new/adjusted collection systems to implement the Directive.

Table 9: Historical growth rates for separate collection of textiles in countries/regions with more than one data year

	Period	Average growth rate (g/cap/year)
Austria	2010-2018	160
France	2006-2019	207
Flanders	2006-2018	186
Denmark	2010-2017	-37
Italy	2014-2018	93
Netherlands	2012-2018	223
Sweden	2008-2016	138

The second question of immediate interest is 'what share of this additional collection will comprise reusable textiles and what share will be non-reusable'? This question is even more difficult to answer and will depend upon many factors:

- Current collection rates in a country and the share of reusable textiles that are still discarded in mixed waste
- The future development of global reuse markets – it is one thing to be technically reusable but quite another if it can be sold for reuse
- Future developments in the quality of new clothing and textiles placed on the market
- The degree to which new circular business models including enhanced C2C exchanges will divert good quality reusable textiles from collection systems

All these factors will develop over time and the developments are difficult, if not impossible, to predict. Very roughly speaking, following a glance at Figure 22, at most half of the increased collection will be reusable in the first years and this is likely to fall off over time, as more marginal textiles are collected, consumers are encouraged to exchange between themselves and engage more actively in circular business models and global reuse markets become ever more saturated.

3.3.3.13 Need for new approaches and new recycling opportunities

As identified above, quantities of separately collected textiles are tentatively expected to increase by 65 000 to 90 000 tonnes per year across the EU-27 from 2025, with perhaps at least half this increase in the years up to 2025. At least half of these increases are likely to be non-reusable textile waste, with this share increasing over time.

If the textile waste is to be recycled and be of any economic value to the collecting organisations, new recycling technologies need to be developed along with sorting technologies to sort textiles waste by fibre type and colour. The status of development of such technologies is considered in Chapter 4. In addition, textiles need to be better designed for ease of recycling. This is considered further under Ecolabels in Theme 1D (Chapter 3.3.4).

The highest priority in the waste hierarchy is prevention. The sheer quantities of textile waste generated in Europe is likely to overwhelm sorting and recycling capacity after 2025. Effort is needed to reduce these quantities through ensuring that textile products remain in circulation as long as possible, and through promoting quality rather than quantity, in part through new circular business models for textiles. The aim of the Circular Economy Action Plan is to reduce the EU's consumption footprint and double the EU's circular material use rate in the coming decade, while boosting economic growth; and this will be implemented amongst other things by the Sustainable Products Initiative to be adopted by end 2021. Further actions for reducing the consumption footprint of textiles are likely to be provided in the coming EU Strategy for Sustainable Textiles.

Circular business models are considered further in Chapter 5.

3.3.3.14 A need for standardised reporting and greater transparency

The investigations under Theme 1C highlight that there is a lack of consistent data on the quantities and fate of used textiles and textile waste in Europe. Mapping studies that have been carried out in individual countries vary in the scope of products that are included, how data is gathered, and which separate collection and processing activities are included in the studies. Even mapping studies in the same country have not necessarily followed a consistent methodology. Only a few Member States carry out annual, consistent reporting on the collection of used textiles. The result is an incomplete picture of the flows of used textiles and textile waste within the EU and from the EU to the rest of the world.

The provision of consistent, robust and comparable data is a key element in developing and monitoring policies that aim at establishing a circular textiles economy in Europe.

It is not certain whether the requirement for establishing separate collection of textiles waste by 2025 under the revised Waste Framework Directive will lead to reporting requirements that fill this data gap.

Every three years, pursuant to Commission Implementing Decision of 24/10/1994[45], Member States must provide answers to a questionnaire on the implementation of the requirements of the Waste Framework Directive, which are then used to produce a Waste Directive implementation report.

Question 7 of the survey for the 2018 report concerned separate collection schemes. This requires Member States to describe the systems that have been set up to for the separate collection of various waste streams. However, unless a target has been set for collection, reuse or recycling of that waste stream, Member States are not expected to report on collected quantities nor the treatment that they received.

The collection and treatment of textile waste will be relevant to the recycling and preparation for reuse targets for municipal waste in general. Implementing Decision (EU) 2019/1004 lays down rules for the calculation, verification and reporting of data on waste including the preparation for reuse and recycling targets for municipal waste. Reporting on textile waste is included in these rules but only data on waste generation, recycling and energy recovery of textiles waste is obligatory; reporting on separate collection and preparation for reuse is voluntary (Implementing Decision 2019/1004).

Moreover, this reporting will not cover exchanges of used textiles that have never been defined as waste. As described earlier, in some countries, all unmanned collection of used textiles is considered as waste collection, while in others, collection that is primarily focused on reuse is not defined as waste collection.

In this context, Article 9(4) of the Waste Framework Directive (WFD) is of relevance. It stipulates that the European Commission should, by 31 March 2019, have adopted an implementing act to establish a common methodology to report on and monitor the reuse of products. The resulting implementing regulation[46] includes textile products as a key reporting theme for Member States who must report on annual reuse in tonnes. MS may, however, gather data from reuse operators or households but are not obliged to report separately on quantities of reuse via various channels.

A particular weakness in current mapping of the flows and fate of post-consumer textiles is the eventual fate of textiles exported to other parts of the world for reuse and recycling. As already described, wholesalers that receive and sort used textiles may not always have a clear idea of what finally happens to the textiles that they export for reuse elsewhere in the world.

An increasing number of collectors have adopted codes of conduct for their buyers to ensure that they adhere to environmental and social criteria and to increase transparency in the eventual fate of used textiles (Watson et al, 2016), but there is a need for more widespread adoption of such codes of conduct. The Nordic Reuse and Recycling Commitment (Fråne et al, 2017) developed by the Nordic Council of Ministers, is one example of a third party verified standard, which increases transparency on the fate of textiles downstream and ensures that the downstream actors adhere to environmental and social standards.

3.3.4 Theme 1D: Product policy for textiles

This section focuses on how environmental policies that target textile products could potentially influence the extent to which the sector could move to a more circular approach.

Ecolabel for textile products

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45 Commission Implementing Decision of 18.04.2012 establishing a questionnaire for Member States reports on the implementation of Directive 2008/98/EC of the European Parliament and of the Council on waste

46 Commission Implementing Decision (EU) 2021/19 of 18 December 2020 laying down a common methodology and a format for reporting on reuse in accordance with Directive 2008/98/EC of the European Parliament and of the Council

Ecolabels are voluntary marketing tools that aim to inform customers, in a simplified manner, that the ecolabelled product is associated with a good environmental performance. Behind any ecolabel are a number of criteria and conditions that the ecolabelled product must comply with. If the ecolabel is an example of an ISO 14024 Type I ecolabel, then the criteria should reflect a consideration of the whole life cycle of the product and be verifiable. Compliance of any product with ISO Type I ecolabel criteria must be assessed by an independent third party. ISO 14024 Type I ecolabels should not be confused with ISO 14021 self-declared environmental claims. These claims, for example on recycled content, can be much more specific and do not need to consider the whole life cycle and such claims are not covered by product policy or necessarily assessed by independent third parties.

Most ecolabels are not specifically aimed at promoting a circular economy or circular products but some of the criteria used by ecolabels have relevance for the circular economy. These can include (Ecolabel, 2021):

- Requirements for recycled content
- Quality and durability requirements
- Requirements for ease of dismantling and repair
- Requirements for optimum waste and resource handling
- Strict requirements on hazardous substances.

Hazardous substance restrictions are included in ecolabels to reduce human and ecotoxicity impacts of production processes as well as to protect the wearers of the labelled product. Restriction of hazardous chemicals can also have a positive impact on the circular economy: for example, persistent functional chemicals such as flame retardants, anti-bacterial or wrinkle resistant finishes can risk contamination of recovered fibres and subsequently, result in health risks with second generation recycled products (Swedish Government, 2015; Schmidt et al, 2016).

In addition to the EU Ecolabel, there is a wide range of "ecolabels" available for clothing and home textiles. *EcolabelIndex.com* identifies no fewer than 104 labels in use worldwide (Ecolabel Index, 2021). Only some of these are third-party verified and only some of those labels include some of the criteria types listed above that have relevance for the circular economy. Others focus on issues that are not directly relevant to the circular economy such as animal welfare, carbon neutrality, workers' rights and fair wages. Table 10 gives an overview of a small selection of the three most widely used ISO 14024 Type I ecolabels in Europe that have criteria for textiles and some textile-centric environmental certifications which include circular economy relevant criteria.

Table 10: Inclusion of circular economy relevant criteria for textiles in a selection of "ecolabels"

Circular economy relevant criteria	EU Ecolabel	Nordic Swan	Blue Angel	GOTS	Oekotex 100	Bluesign
Requirements/ points for recycled content	✓✓ (polyester and nylon)	✓ (wood inputs)	✓✓ (polyester and nylon)			
Quality and durability requirements	✓		✓	✓		
Requirements for ease of dismantling and repair						
Requirements for recycling of production waste		✓✓				
Restrictions on residual chemicals in product	✓	✓✓	✓✓	✓✓	✓	✓✓

Source: own representation using criteria standards[47]

[47] EU Ecolabel: COMMISSION DECISION 2014/350/EU of 5 June 2014 establishing the ecological criteria for the award of the EU Ecolabel for textile products. A consolidated file included subsequent amendments can be found here.
Nordic Swan: Nordic Ecolabelling for Textiles, hides/skins and leather: Version 4.13 • 12 December 2012 - 30 November 2022. The criteria document can be found online here.
Blue Angel: Textiles DE-UZ 154, Basic Award Criteria, Edition July 2017, Version 1.8. The criteria can be found here.

Looking at the Table above, it can be seen that even the most comprehensive ecolabels do not meet their full potential in encouraging a circular economy.

Key gaps/weaknesses are:

- Recycled content – only currently required or give points with respect to recycled content in polyester and nylon (EU Ecolabel and Blue Angel) or wood inputs to cellulose-based semi-synthetics like viscose/Lyocell (Nordic Swan). They could be expanded to include natural fibres like cotton and wool etc. Moreover, current requirements/points can be met by pre-consumer or post-consumer waste. Requiring a minimum level of post-consumer waste recycled content could accelerate recycling of post-consumer textiles which is currently low.
- Ease of dismantling and repair/recycling – there are no ecolabels whose current criteria consider this issue. However, the European Commission guidance on green procurement of textiles (JRC, 2020) does include such criteria.
- Recycling of production waste – only the Nordic Swan includes criteria in this area

While the EU Ecolabel, the Nordic Swan and the Blue Angel are official ISO 14024 Type I ecolabels, offering a full range of environmental criteria, GOTS (organic cotton and labour conditions) and Oekotex 100 (harmful substances in textile articles) have a narrower focus. However, these latter two, plus the Bluesign certification system, are well established at all the different stages of the textile supply chain – something that could be important in the future in efforts to promote, assess and verify recycled contents.

Along this same line, an important standard which is increasingly being used in this context, and which is also sometimes considered as an ecolabel in its own right, is the Global Recycled Standard (GRS). GRS is a third-party-verified standard for the share of recycled content in textile products but which also includes social and environmental criteria and chemical restrictions for recycling processes (Textile Exchange, 2021).

A revision of the Nordic Swan is currently underway. The criteria that were put out to public consultation during spring/summer 2020 include a number of new criteria which specifically aim at promoting the circular economy. These include:

- All synthetic fibres must be either based on recycled or bio-based material.
- Regenerated cellulose fibres must be recycled or certified as sustainable.
- Recycled fibres must document test requirements for harmful substances.
- Durability: New wear resistance requirement for selected textile products with differentiated requirement level; for example, for furnishing fabrics, professional work wear and outdoor wear in general
- Design for recycling of packaging: Design requirements for recycling of primary packaging
- Unsold textiles: New requirement for both brand owner and textile manufacturer that unsold textiles must not be sent for incineration or landfill

Possible role of PEF with EU Ecolabel for textile products

The current EU Ecolabel criteria for textiles and for footwear have been prolonged until the end of 2025. One major reason for the prolongation is to allow PEFCRs (Product Environmental Footprint Category Rules) to be finalised for apparel and footwear. Once the PEFCRs are finalised, it will be necessary to consider to what extent the PEF methodology could influence EU Ecolabel criteria. Generally speaking, there are 5 options that could be considered:

- Option 1: Business as usual, meaning no integration of PEF in the EU Ecolabel
- Option 2: Carry one PEF study in preparation to criteria development (e.g. to identify hot-spots and trade-offs)
- Option 3: Develop EU Ecolabel criteria based on an existing or on-purpose developed PEFCR
- Option 4: EU Ecolabel criteria based on PEF thresholds
- Option 5: EU Ecolabel criteria based on PEF classes of performance

Options 1-4 could potentially be applied without changing the EU Ecolabel Regulation (EC) No 66/2010. Which option is most appropriate will depend on the future scope for EU Ecolabel textiles (currently the scope goes beyond just apparel products) and the availability and reliability of primary input data that would need to be used in the PEF model.

High level policy on green claims

A major driver for the whole PEF policy is the idea of having a consistent methodology for quantifying the environmental impacts of a product over its entire life cycle that can be expressed in a simplified way to consumers when they are making purchasing decisions.

A move towards this approach is supported by statements in the EU Green Deal ("*Companies making ´green claims´ should substantiate these against a standard methodology to assess their impact on the environment*") and the revised Circular Economy Action Plan ("*the Commission will also propose that companies substantiate their environmental claims using Product and Organisation Environmental Footprint methods*"). .

However, it must be understood that the quality of such methodology and the results generated is only as good as the data going in. Good quality data about sorting and recycling processes is essential in order to accurately capture and quantify the environmental benefits of increased recycling and also to flag any potential trade-offs. For this reason, **task 2** looks precisely at information currently available for textile sorting and recycling.

Ecodesign

The current ecodesign Driective (2009/125/EC) has traditionally focussed on energy efficiency requirements for energy-using or energy-related products. However, a shift towards also addressing material efficiency requirements in a more systematic manner has also been considered of interest. Under mandate M/543, CENELEC has been working on the EN 4555x series of standards that aim to define methods for assessing material efficiency aspects of energy-related products. For example, durability, remanufacturability, reparability, reusability, upgradability, recyclability, recoverability or product designs and how to assess reused and recycled content.

Looking beyond energy-related products and focussing specifically on textiles, Bauer et al.(2018) proposed a series of material efficiency measures that could be applied in a hypothetical ecodesign regulatory approach. The requirements were as follows:

Table 11. List of potential ecodesign requirements for textiles

Requirement	Themes addressed	Description	Type of requirement		
			Informative	Threshold	Other
1. Declaration of, and/or minimum threshold for recycled content	Recycling	Textile products must carry a visible label with a declaration of the percentage by weight content of recycled materials AND/OR products within [stated fibre group] must contain a minimum of X% recycled material by weight.	✓	✓	
2. Durability of fasteners	Durability	Fasteners should be able to be fastened and unfastened X number of times without failure.		✓	
3. Availability of spare parts	Durability, Reparability	The producer must make spare parts available for X years after product has been on sale, or alternatively must provide spare parts with the product (e.g. extra buttons, thread of correct colour, replacement zips etc.).			✓
4. Design for disassembly	Durability, Reparability, Reusability, Recyclability	The product logo, buttons and zips should be removable within X seconds Seams should be disassembled within X seconds but without reducing durability under normal use and care. Instructions should be provided on how to do this.		✓	
5. Provision of detailed bill of materials	Recyclability, Recycled content	The product must include, or link to, a list of all materials included in the product and at what level they are pure or mixed with other materials, and the share they make up by weight of the product down to a chosen threshold (e.g. 1%). Products that are made from a single material (with tolerance around 98%) must be stampled with a "100% recyclable" stamp.	✓		

Requirement	Themes addressed	Description	Type of requirement		
			Informative	Threshold	Other
6. Care and maintenance labelling	Durability, Reparability	The product must be accompanied with information (or link to information) on recommended care and maintenance tips that can prolong the lifetime of the product (and reduce use phase impacts)	✓		
7. Dimensional changes during washing and drying	Durability	Between minus X% and plus X% for woven products, and durable non-wovens, other knitted products		✓	
8. Colour fastness to washing	Durability	Colour-fastness to washing must be at least X (test score) for colour change and at least X (test score) for staining		✓	
9. Colour fastness to perspiration (acid, alkaline)	Durability	Colour-fastness must be at least X (test score for colour change and staining)		✓	
10. Colour fastness to wet rubbing	Durability	Colour-fastness to wet rubbing must be at least X (test score)		✓	
11. Colour fastness to dry rubbing	Durability	Colour-fastness to dry rubbing must be at least X (test score)		✓	
12. Colour fastness to light	Durability	Colour-fastness to light must be at least X (test score)		✓	
13. Resistance to pilling and abrasion	Durability	Fabrics shall resist pilling of a minimum of at least X (test score)		✓	
14. Chemical content – organic fluorine	Recyclability	The total content of organic fluorine must not exceed X µg F/g garment.		✓	

Source: Bauer et al., 2018.

Many of the ecodesign requirements listed above are currently covered by the EU Ecolabel criteria for textiles and the remainder could potentially be included in a future version of EU Ecolabel criteria. The main difference to emphasis between possible ecodesign and EU Ecolabel criteria is in the impact that they would have on the market. Ecodesign sets minimum mandatory requirements for all relevant products placed on the EU market whereas the EU Ecolabel is a voluntary initiative (currently with around 65 licenses awarded that cover over 7000 products),

Textile services: EU Ecolabel, Green Public Procurement (GPP), Eco-Management and Auditing Scheme (EMAS) or Organisation Environmental Footprint (OEF)

The current focus of the EU Ecolabel and the PEF policies in the textile sector is at the **product level**. However, both policies can potentially be applied at the level of the **service offered** or the **whole organisation**. Such policies could also be used to potentially recognise, require, reward, assess or verify specific circular business models operating in the textile sector and even link to extended producer responsibilities as well such as take-back or buy-back. However, first it would be necessary to review what current business models are out there (**task 3**).

It is the opinion of the authors that all of the above policies should at least form part of the discussions regarding the EU Sustainable Textile Strategy and the Sustainable Products Initiative.

4 Review of current and emerging technologies for sorting and recycling textile fabrics and clothing

4.1 Task 2 – Current and future perspectives in sorting and recycling technologies and capacity

4.1.1 Objective and scope

As identified under Task 1, quantities of textiles separately collected for reuse and recycling are expected to increase significantly by 2025 and there will be a need for significant increased capacity in sorting and recycling as global reuse markets become saturated.

This task comprises a review of sorting and recycling technologies, with a main focus on sorting technologies as a precursor to recycling in order to provide a screenshot of the state-of-the art of available technologies that are expected to deal with the increased amount of textile waste towards 2025. The review focuses on both existing and planned capacities in Europe at a relatively high technological maturity level that handle sorting and recycling of post-consumer textiles.

The review of recycling technologies is taken at a more superficial level to avoid overlaps with a recently initiated DG GROW project that has a deep investigation of recycling technologies as its main focus. Thus, the review of recycling technologies consists of a literature review covering the core principles of each technology type with examples of that technology type in operation. Moreover, the challenges that sorting and recycling technologies face in order to achieve a circular economy are addressed.

4.1.2 Methodology

The review of technologies has initially been conducted as a literature study where all relevant technologies in Europe have been mapped and reviewed from a defined set of relevant criteria, as seen in Table 12 below. Some information could not be gained from literature alone, and such information gaps were filled via supplementary interviews with proponents of the specific technology. Interview questions can be found in Annex A. Table 12 provides an overview of the scope and methodology used for the review of technologies.

Table 12: Overview of the methodology under Task 2

Textile treatment technology		Scope	Information gathering method
Sorting	Manual sorting	An in-depth review of examples of these systems / technologies with following information types (where the proponent has been able and willing to share this): - Inputs: textile types and categories that can be sorted - Necessary pre-treatment processes - Range of output types and qualities and how these fit into the wider picture of the circular economy for textiles - Process efficiency - Challenges and limitations - Current and expected capacity in EU in short/medium term - Current/ future costs/kg - Current/ future energy use/kg	Literature review supplemented as necessary by survey/ interviews with proponents of selected *example* systems/ technologies
	Manual sorting with aiding techniques		
	Fully automated sorting		
Recycling	Chemical recycling	An initial brief study of the various types of chemical, mechanical and thermal recycling technologies for post-consumer textiles and specific examples of such technologies was undertaken. This includes the following information types for each technology category (described very briefly):	Literature review

Textile treatment technology		Scope	Information gathering method
	Mechanical recycling	- **Input requirements** (fibre types, rough tolerance of contaminants) - Output types and quality - **Example products** that can use the outputs - **Examples of companies** that have developed this type of technology and current TRL	

4.1.3 Sorting technologies

A necessary precursor of all textile recycling is sorting and/or quality checking of waste textiles to provide the required inputs to one or more recycling technologies. The relative tolerance and level of specificity required for inputs to the recycling process, determines the level of detail and accuracy required in the sorting process. For example, sorting textile waste for inputs to recycling of cotton-rich fabrics for use as industry wipes can be carried out manually, whereas sorting/filtering of inputs to a chemical recycling process for polycotton, where the share of cotton/polyester is critical in determining the share of chemical compounds for the process, requires accurate monitoring and quality control of fibre composition.

Sorting is the process that immediately follows the separate collection of used textiles and textile waste. Collected textiles are transported to sorting facilities, often crossing country borders. The sorting facilities are typically privately owned by a wholesaler where the outputs are sold on global markets.

The sorting process can potentially be an important component of economic and environmental costs of the recycling process, as the better the textiles are sorted into pure fractions (e.g. 100 % cotton), the bigger the chance of selling the textiles to a recycling facility where it can be recycled.

In the sorting facilities, used textiles are sorted to determine their further fate: reuse (and for which market), recycling (and which type of recycling) or landfill/Incineration. The value of the circular economy for textiles goes hand-in-hand with the waste hierarchy as it is defined in the basic waste management principles in the EU Waste Management Directive (EU Waste Framework Directive, 2021) (see Figure 18 in Chapter 3, for a comparison of the economic value of the reuse and recycling fractions); reuse is prioritised, followed by economically viable recycling, while the bottom two rungs of the waste hierarchy energy recovery and landfill are considered outside the scope of the circular economy. Thus, sorting can take place in one or several consecutive phases. If there is a reusable component of the textiles being sorted, the sorting of that component is targeted via *manual sorting*. Following this the non-reusable waste may enter another process for sorting into inputs for recycling. This process is often automated. Alternatively, (depending on the input requirements for recycling) sorting for recycling can take place simultaneously with sorting for reuse during the manual sorting; this requires the use of sophisticated aiding technology for the manual sorters.

Sorting technologies and facilities can, thus, be divided into three general types of sorting:

- Manual sorting (including specialised manual sorting)
- Manual sorting with sophisticated aiding techniques
- Automated sorting.

These are considered individually below.

4.1.3.1 Manual sorting

Overview

Manual sorting is not a technology as such, as it is performed by humans and usually done without technological aids apart from conveyor belts and other feeding technologies.

Manual sorting is the most widespread textile sorting approach used in Europe with hundreds of sorting facilities sorting hundreds of thousands of tonnes of used textiles. In France alone, for example, there were 54 sorting centres operating in 2018, sorting just under 160 000 tonnes of used textiles (EcoTLC, 2019). Under Task 1c it was estimated that between 1.7 and 2.1 million tonnes of textiles are collected annually across EU-27, all of which requires manual sorting. From 2025 and beyond this is tentatively predicted to grow by between 65 000 and 90 000 tonnes per year, with perhaps half this growth in the years up to 2025.

In manual sorting plants, which vary significantly in size from sorting a few hundred tonnes to over a hundred thousand tonnes per year, textiles are sorted by experienced employees into typically over a hundred product categories and mixes for reuse, according to style, type, and size of garment, seasonal changes, end markets and more. Indeed, sorting for reuse markets cannot be carried out using automated processes, and it is unlikely that an automation of sorting for functional quality aspects of textiles will be possible in the foreseeable future.

The more experienced the sorting staff are, the more cost-effective and efficient the sorting becomes. It takes roughly six months for a new employee to learn how to sort used textiles for the reuse markets and even longer to master it efficiently [48]. This also indicates that increased collection of reusable textiles is likely to lead to increases in the number of manual sorting jobs, as the process is an irreplaceable component of the value chain, and one that cannot currently be substituted by technical solutions.

Thus, manual sorting is a necessary precursor to all recycling of post-consumer used clothing. Its starting point is the unsorted collected feedstock of used textiles and reuse is prioritised for economic and environmental reasons. Non-reusable textile waste can be seen as a by-product of manual sorting, which is generally focused on reuse markets.

As manual sorting is often more expensive than automated sorting due to the higher labour costs, it is primarily used for sorting of textiles with an expected high percentage of reusable textiles that are sellable on global reuse markets. A reducing share of reusable textiles in collected textiles would compromise the business model of the manual sorting facilities. As described earlier in Task 1C (Chapter 3.3.3) the quality of collected textiles is decreasing, potentially due to an increase in fast fashion combined with increasing C2C trade via online and physical exchange platforms.

Process

Textiles that go to manual sorting facilities are typically collected as donations via unmanned bring banks which is the primary method of used textile collection in Europe (see Task 1C – Chapter 3.3.3). An analysis of collected textiles in the Nordic countries showed that approximately 70 % of the current textile collection is collected via shops and containers (Watson et al, 2016). These textiles are typically sold to wholesalers with sorting facilities either as 'original', e.g. completely unsorted still in the plastic bags they were delivered in, or following a pre-sorting carried out by the collector where they skim off the best quality reusable textiles for sale in their own second-hand retailers. In the Nordic countries, for example, three quarters of exported used textiles for detailed sorting by wholesalers comprise unsorted 'original' (Ibid).

Following receipt of used textiles at a sorting centre, all non-textile waste is removed as the first part of the manual sorting process. At this phase, batches of textiles that are contaminated by rainwater, mould, oil etc. are also removed. This pre-filtering can be carried out by less-skilled personnel in an initial feed-in phase. The next phase is to remove non-reusable clothing and textiles. Non-reusable textiles can be identified through damage such as rips and tears, miscolouring, missing components etc.

The reusable fraction is then passed on (typically via conveyor belts) to the most skilled sorting personnel to sort these into different categories, using their sight and sense of touch. The number and type of categories the reusable textiles are sorted into depends on the facility and on the demand. Some facilities sort according to the style, type, colour, season, target group and condition, and some even sort by fabric or fibre composition. For instance, Danish sorting facility Trasborg sorts textiles into 110 different categories for export, while Wieland in the Netherlands and SOEX in Germany both sort into between 350 and 400 different categories.

The premium part of the reusable clothing (typically referred to as the "cream") is usually sold in second-hand stores in the country of origin or in other European markets. This is typically roughly 10-15 % of the total 'original' collection. Second-grade reusable textiles are typically exported to Eastern European, South American or Middle eastern markets. A special grade often called tropical mix of lightweight garments are often sold in sub-Saharan African markets. The lowest quality reusable textiles often find their way to Pakistan and other Asian markets.

Wholesalers aim to recycle the non-reusable fraction as far as possible because the squeezing of economic conditions for wholesalers (see also under Task 1C – Chapter 3.3.3) in global reuse market forces sorting facilities to find markets for all fractions of textiles to avoid the payment of waste management fees. This means that even if they have to pay for recyclers to receive the non-reusable textiles this is preferred if the price is lower than the costs of waste management (Watson et al, 2020c).

The recycling type that has given the best price historically is cutting of cotton-rich textiles (bedlinen etc.) into wipes for use in industrial facilities. White cotton wipes gain a better price than coloured cotton wipes for

[48] Personal comm., Ergün Arkin, production manager at Trasborg

which prices are now close to zero. Denim is another textile waste fraction for which there is some demand and value for use in mechanical cotton recycling. Other textile waste types of mixed fibres can potentially be used as input into mechanical recycling for production of painters' rugs, insulation and other low-grade products (Watson et al, 2016) also referred to as downcycling, but such markets are close to saturation.

The recyclable fractions mentioned above can all be sorted manually since the named recycling processes have relatively high tolerances and it is relatively simple to identify cotton-rich bedlinen, denim etc. without the need for technological aids.

However, as already described under Task 1c, many of these markets are close to or already saturated (Ljungkvist et al, 2018). New types of chemical and mechanical recycling closed-loop (textile to textile) or open-loop (textile to other high-quality product) high quality recycling often have lower tolerances for contaminants and as such require technological aids to identify fibre types and material compositions. A manual sorter cannot, for example, distinguish between 70/30 polycotton and 50/50 polycotton blend. A knowledge of this is important when tailoring chemical recycling processes to the incoming textile material.

Table 13: Manual sorting characteristics and capacity

Input types	Original unsorted collected used textiles or pre-sorted used textiles with best qualities removed for sale in local second-hand retailers.
Necessary pre-treatment processes	Pre-sorting to remove non-textile waste products and textiles contaminated by rain, mould, kitchen waste etc.
Output types	Up to 350+ categories of reusable clothes; plus various grades of recyclable textiles: cotton-rich fabrics for industrial wipes; denim; cotton-rich textiles for other types of mechanical recycling.
Process efficiency	Experienced sorting personnel can sort between 100 to 150 kilos of textiles per hour.
Challenges and limitations	Manual sorting is relatively expensive due to labour costs It is difficult to determine detailed fibre compositions by hand – only rough sorting by fibre-type is possible
Current and expected capacity in EU	Current separate collection of used textiles across the EU-27_{2020} is estimated to lie within the range 1.7 to 2.1 million tonnes. From 2025 and beyond annual separate collection of textiles is predicted to grow by between 65 000 and 90 000 tonnes per year, with perhaps half this growth in the years up to 2025. All of this is assumed to need manual sorting
Current and future costs/kg	This varies from country to country due to different labour costs across Europe.
Current and future energy use/kg	Not known.

4.1.3.2 Manual sorting with sophisticated aiding techniques

Manual sorting with sophisticated aiding techniques is also often referred to as semi-automated sorting. It operates the same way as manual sorting but includes some automation. Here we do not refer to normal automated techniques typical of most modern sorting facilities for feed-in of textiles to manual sorters and transportation and baling of sorted fractions, but rather to technological aids for assisting in the actual sorting of fibre types and grades for reuse and recycling (Palm et al, 2014). This can for example be hand-held scanners that can be used by the manual sorters to assist them in determining material content.

The main advantage of assisted manual sorting compared to fully automated sorting of non-reusable textiles is that the sorting for high-quality recycling can theoretically be carried out at the same time as sorting for reuse rather than requiring a new facility and processing stage. This can reduce space needs and costs. On the other hand, the technique may be less cost-efficient than a two-stage process of ordinary manual sorting for reuse followed by automated sorting of the non-reusable textiles for recycling, due to the need to pay for labour to sort the recyclables as well as the reusables.

Examples of manual sorting with sophisticated aiding techniques are LSJH in Finland and TEXAID in Switzerland.

Lounais-Suomen Jätehuolto Oy

Lounais-Suomen Jätehuolto Oy (LSJH) is a municipal waste management company owned by 17 Finnish municipalities (Lounais-Suomen Jätehuolto, 2021a). They are currently piloting a combined sorting and fibre-opening line where separate collected textile waste will be processed. This development forms part of the Finnish Telaketju programme (Telaketju, 2021a). The investment into this facility is initiated by the anticipated obligation to separately collect textiles by 2023 in Finland as well as an objective to treat all collected textile waste within Finland rather than exporting them.

The sorting includes four steps where the first three pre-sorting steps are all done manually with the possibility of the 17 municipalities doing these pre-sorting steps themselves to avoid costs. The pre-sorting steps comprise: 1) removal of contaminants and non-textiles from the separately collected textile waste; 2) additional removal of reusable items; and 3) removal of items not suitable for mechanical textile recycling and multilayer garments.

The fourth and final stage of pre-sorting is done manually by either LSJH or the municipalities with the use of a handheld near infra-red (NIR) scanner that assists in determining the material composition of each waste item allowing sorting into different fractions for specific recycling technologies. The handheld IR-scanner is owned by LSJH but can be rented by the municipalities (Interreg Nord-Vesteuropa, 2018). It is developed by an external technology provider and has the size of a mobile phone, thus making it easy to carry around by the sorting personnel. Sorting algorithms (software) have also been developed by the technology supplier, but LSJH owns all intellectual property rights. The sorting algorithms are stored on a cloud-based platform that can be accessed by all municipalities and other partners involved in the sorting process (Watson et al, 2020a).

The municipalities pay a waste management fee to LSJH for the pre-sorted textiles, but the fee is set lower than the normal per kg cost of incineration, to encourage municipalities to sort the textiles. The more pre-sorting steps the municipalities carry out themselves, the lower the waste management fee they have to pay to LSJH. One of the objectives is to eliminate the waste management fees for textiles and maybe even have a situation where municipalities can *sell* the pre-sorted textile waste to LSJH.

Once sorted into different recycling products, the textiles will enter a fibre-opening line that will cut the textile into strips, remove hard items and tear and bale the textiles. The output of the process is reusable textiles for local and regional markets, sorted waste fractions for input to recycling such as 100 % cotton, 100 % wool, 100 % polyester and 50:50 polycotton, sorting residuals for use in composites and sorting residuals for incineration. The technology can be used in combination with any algorithm defined by the material composition needs of a recycling company.

A textile waste refinement plant will open in Paimio, Finland in 2021. The 3,000-square-metre plant is being developed by Rester Oy, which will recycle 12 000 tonnes of end-of-life textiles and industrial waste materials per year. LSJH, will hire part of the plant and it is expected that by 2023 it will be processing household textile waste collected and sorted by LSJH (Lounais-Suomen Jätehuolto, 2021b).

Table 14: Lounais-Suomen Jätehuolto characteristics and capacity

Input types	Textile waste collected by municipalities. This may or may not contain reusable textiles.
Necessary pre-treatment processes	Pre-sorting is done in four levels. Municipalities are offered to collaborate on the pre-sorting process. They are rewarded with a lower waste management fee for each level of pre-sorting they perform. Pre-sorting levels include manually removing contaminants and non-textiles, followed by manual sorting of reusable items. The final pre-sorting step is removal of multi-layer garments and other items not suitable for mechanical textile recycling.
Output types	The output of the process is reusable textiles for local and regional markets plus sorted fractions for recycling such as 100 % cotton, 100 % wool, 100 % polyester and 50:50 polycotton, but also sorting residuals for use in composites and sorting residuals for incineration. The technology can in theory be programmed with algorithms for any material composition wished for by a recycling company.
Process efficiency	The facility will be designed for 1 ton per hour processing capacity. Currently, one person can sort approximately 43 kilos of textile an hour, but the target is to get the sorting speed up to 80-90 kilos per person per hour.
Challenges and limitations	The near-infra-red scanning technology is only used for non-reusable textiles as it cannot determine the composition of multi-layered garments (hence the pre-

	treatment phase). Moreover, it cannot identify fabrics that have another material in the core of the yarn.
Current and expected capacity	Operation of a fibre-opening line in a pilot factory is planned to be completed during 2021. The fibre-opening line will have a capacity of 5 000 tonnes.
Current and future costs/kg	Not known.
Current and future energy use/kg	Not known.

TEXAID

TexAid is a Swiss company that collects, sorts and recycles used textiles. Since 2008 the sorting personnel at the TexAid sorting plant in Schattdorf in Switzerland have been using a headset that help them classify every single textile by material, quality and texture using their voice. This voice-controlled sorting system is linked up to a computer that ensures that each piece of textile, via a belt and air blowers, finds its way to the correct storage container. This is done via an air blast that sends the textiles to a stillage or a large bag. The voice-operated pre-sorting system has been integrated to facilitate the sorting of textiles into 60 categories.

All non-reusable textiles are fed into an automated belt that moves 100-200 kilos of textiles at a time to a platform where the sorting personnel check the quality. When the quality is defined, the operator names the category of the textiles into the headset microphone and places it on a belt that will take the fraction to the correct container. A screen shows the category stated by the operator on a screen, to allow voice reading mistakes to be identified quickly. The belt will not start moving before the voice-controlled sorting system understand the fraction said. Every person in the sorting facility undergoes training in the use of the system to make sure that the technology understands their pronunciation of each category.

The technology has helped increase the sorting capacity and brought down unit costs, thus making TexAid competitive with Eastern European sorting facilities that have lower labour costs. The technology is mostly aimed at reusable fractions but is also used for recyclable fractions for which detailed fibre composition is not necessary.

Table 15: TexAid characteristics and capacity

Inputs	All types of pre-sorted textile and textile-related articles, such as post-consumer textile waste.
Necessary pre-treatment processes	There is a need for manual pre-sorting prior to the more detailed sorting. In the pre-sorting waste and textiles for reuse are removed.
Output	The pre-sorting has four output categories: 60 % textiles for reuse, 30 % for textile recycling, 10 % waste products for incineration.
Process efficiency	The current capacity is 1,5 tons per hour.
Challenges and limitations	Small items and yarns cannot be sorted as they can be stock in the belt. Furthermore, the belt cannot handle big items such as duvets.
Current and expected capacity	2.000 tons of sorted garments a year.
Current and future costs/kg	Not known.
Current and future energy use/kg	The current energy consumption is approximately 100kW per hour.

Fully automated sorting of non-reusable textile waste

These systems are focused on sorting of the non-reusable residuals from manual sorting facilities or for sorting of collected textile waste that has been determined as having low reusable content and value.

Most recycling processes are optimized for specific fibre types as input material. In particular, new types of innovative chemical and mechanical closed-loop (textile-to-textile) or open-loop (textile to other high-quality product) high quality recycling often have low tolerances for contaminants and as such require technological aids to identify fibre types and material compositions.

Fully automated sorting has the potential to provide low cost sorting of non-reusable textile wastes accurately by material compositions to fit any type of material demand. Such technologies have been under development for some years and are now at the cusp of being developed at industrial scale. Among the most promising technologies are near-infrared spectroscopy (NIR) as used by Fibersort in the Netherlands and SIPTex in Sweden, hyper-spectral imaging as used by Resyntex in Germany and radio frequency identification (RFID) as used by Tex.IT in Sweden.

Fibersort

Fibersort is a European Interreg funded project (Interreg North-West Europe Fibersort, 2021) where during a 3-and-a-half-year period a demo plant for automated textile sorting using near-infrared spectroscopy was built and operated outside of Amsterdam. The project was coordinated by Dutch non-profit organisation Circle Economy (Circular economy 2021) and ended in March 2020, where the demo plant went on to be commercialised and now operates in an industrial setting. However, the current capacity is not large enough for Fibersort to define themselves as a full industrial textile sorting plant.

The Fibersort sorting system consists of an automated feed-in system where textile items are scanned by a near-infrared scanner that scans an approximately 5 cm diameter circle of the surface of the item to define the fibre type or fibre combination of the textile fraction as well as colour. Currently, the facility sorts the textiles into 45 different categories consisting of a mix between fibre types or fibre blends and colours, but they are planning on increasing this to 90 different categories.

The colour sorting makes the sorted textiles easier to sell for recycling afterwards and reduces the need for bleaching and colouring processes during recycling. There is no limit on categories, as the scanners algorithms can be calibrated into sorting any kind of combination of fibres and colours. However, items with a lining or multilayer fabric cannot be sorted correctly. Furthermore, the facility does not include any equipment for fibre opening, so it is not possible to remove non-textile items from the textiles or tear them after sorting.

When the scanned textiles match with one of the programmed fibre composition algorithms these are removed from the belt by high pressure bursts of air that blow the items into the correct container. The textiles that do not match with any of the pre-programmed algorithms for fibre-composition continue down the belt. The items are currently bailed manually but it is possible for the technology to be used with automated bailing.

The algorithms for the sorting system are developed by Valvan Bailing Systems that have developed sorting programs for both pure fibres and fibre blends as well as colour. In theory, it is possible to develop algorithms for all types of fibre blends, but at the moment there have only been developed algorithms for fibre types and blends with a current or expected recycling market.

Table 16: Fibersort characteristics and capacity

Inputs	Non-reusable textile waste.
Necessary pre-treatment processes	Textiles are manually pre-sorted into three fractions; reusable textiles, waste and Fibersort input material for recycling.
Output	Monofibres: wool, cotton, acrylic, polyester, viscose and polyamide. Blends: polycotton, wool-polyamide and wool-acrylics. The sorted fibres have a low level of contamination and can serve as mono-fibre inputs in mechanical as well as chemical recycling.
Process efficiency	At 90 % machine efficiency a throughput of 1080 kg/hour can be obtained. However, it is possible to add further robot-arms to the system to increase the speed of the sorting. It is estimated that one experienced sorter can sort between 310 and 360 kilos of textiles per hour.
Challenges and limitations	Multi-layered items can be problematic to sort since the NIR reader only reads the upper surface of the textile product. The current key challenge is finding viable market for the sorted fractions.
Current and expected capacity	The sorting facility still has a relatively low capacity but with suitable investment this can be upscaled rapidly
Current and future costs/kg	Not known.
Current and future energy use/kg	Not known.

SIPTex

The SIPTex sorting technology in Sweden was developed under two projects funded by the Swedish Innovation Agency Vinnova and coordinated by IVL Swedish Environmental Research Institute (Vinnova funding programmes, 2021). A test plant was built and run between 2016 and 2018 in Avesta, northwest of Stockholm (IVL Svenska Miljöinstitutet, 2021). In 2020 an industrial scale plant was constructed by Staedler and Tomra, in Malmö, Sweden, with a potential capacity of 24 000 tonnes a year of textile waste sorting (Sysav, 2021). The facility will be part run by Sysav, a municipal waste company owned by 14 municipalities in southern Sweden.

The facility consists of a feeding unit, three near-infrared scanning units, an additional sorting unit for removal of wrongly sorted items and a baling unit. The textile items fed into the system passes under a first scanning unit where they are matched with the programmed specifications for the first sorting unit (e.g. percentage of cotton) and is sorted out as a positive fraction. The rest of the textiles continues to the next sorting unit that may be programmed to remove a second fibre or colour combination, before the remainder continues to the third sorting unit for a third sorting process.

This process means that three different textile categories can be sorted in one single sorting loop. Currently, six different fibre types are sorted, but additional sorting programs will be developed at the request of potential customers. The sorted categories are taken to a container for the specific fractions where a sensor gives a signal when the container is full. The personnel then has to push a button manually to empty the container.

The sorted categories are automatically bailed and are expected to be sold as quality-assured recycling-products for fibre-to-fibre recycling and the sorting rests for other recycling purposes, e.g. use as industrial wipers or for non-woven products such as insulation.

Table 17: SIPTex characteristics and capacity

Inputs	Non-reusable textile waste. The sorting facility will accept garments, household textiles, textiles from hospitals and industrial waste as input material.
Necessary pre-treatment processes	Reusable textiles should be pre-sorted. Furthermore, the input textiles should not be contaminated. This is addressed in dialogue with the customers delivering the textiles.
Output	Acrylics, cotton, polyester, viscose and wool fibres and other fibres if they are in demand in the market. There have only been test runs at the facility. The official start of the operation will start by the end of September 2020. Until then, they do not have any official output products yet. However, there are no limitations in terms of fibres because the program can learn to sort everything. Only specific purity, such as e.g. 80 % cotton, can be problematic.
Process efficiency	The technical capacity is 2,5 tons/hour. It is estimated that one person can sort between 900-1500 kg an hour.
Challenges and limitations	The scans cannot always identify mixed materials, for example in garments consisting of several layers such as lining, padding and outer materials. Does not allow for fibre separation as it sorts garments by the majority of fibre type it is made up by. There are no plans of including any equipment for removing buttons, zips and other non-textile components nor include fibre opening (tearing) equipment.
Current and expected capacity	Current capacity is 8 000 tons but there are expectations of a maximum annual capacity of 24 000 tons when at full scale and working 24 hours under 3 shifts. This is expected to be the capacity for some years as it will demand a further investment to scale up further.
Current and future costs/ kg	Not known
Current and future energy use/kg	Not known. This will be assessed during spring 2021.

4.1.4 Recycling technologies

A variety of textile recycling technologies are in use or under development globally. They typically fall into two broad categories: mechanical recycling technologies, where the waste textile is physically manipulated to recover materials, fibres or fabrics, and; chemical recycling, where the waste textile is chemically treated to dissolve and extract the useful component(s).

Mechanical recycling processes are currently the most prevalent. Mechanical recycling typically includes cutting, tearing and needling (removing non-textile components) processes, which tend to physically degrade the textiles. As such, many forms of mechanical recycling comprise open-loop cycling, and the produced material is often of a lower quality than the original textile. Typical products from mechanical recycling include industry wipes, padding and filling for the car industry, acoustic and thermal insulation at well as non-woven mats. Approximately 20 % of the used textiles that are separately collected in Europe each year are used as industry wipes or other recycling purposes on European and global markets (Kösegi, 2018).

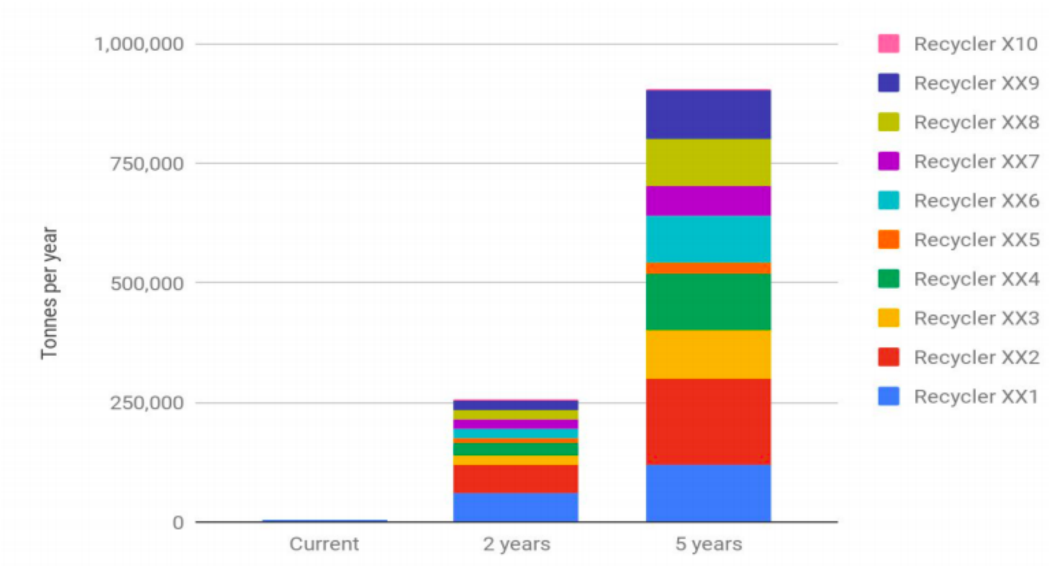
Some mechanical recycling processes can, however, be used to recover fibres or materials that can be used in new yarn: so-called fibre-to-fibre recycling. It is important to note, here, that much of today's mechanical recycling that produces a woven textile product is based on non-textile feedstock and in many cases is based on simple mechanical processes, where the feedstock such as PET bottles is heated, melted and made into raw material for extrusion of new polymer fibres.

Other fibre-to-fibre recycling processes rely on chemical recycling technologies. These technologies reduce textiles to their base components, which can then be re-spun into new fibres, yarns and textiles. The chemical process is often preceded by a mechanical process. Chemical recycling for non-plastic fibres such as wool or cotton is not currently at the same technological readiness level as polyester recycling[49].

It is estimated that significantly less than 1 % of separately collected used textiles are recycled using current fibre-to-fibre (chemical and mechanical) recycling technologies[50]. However, a wide range of innovative fibre-to-fibre technologies are emerging at different scales across Europe and in other global regions. Although many are still not operating at full industrial scale, some facilities are expected to expand their capacity substantially over the next few years.

Figure 26 shows the anticipated capacity growth for 10 chemical fibre-to-fibre recycling companies operating globally that use emerging technology, selected from the textile waste trading platform, Reverse Resources', database and network. It should be taken into account that the 10 recyclers might not be representative for the whole Reverse Resources database; however, the figure illustrates the fact that the textile recycling industry anticipates a hugely significant increase in chemical recycling capacity in the coming 2-5 years.

Figure 26: Predicted recycling capacity of 10 textile-to-textile chemical recyclers over next 5 years



Source: Reverse Resources, presentation by Nin Castle at Telaketju webinar, September 2020

It is hoped that increased fibre-to-fibre recycling will be driven in part by an increased demand for recycled textile fibres from the textile industry. Brands such as H&M, INDITEX and IKEA, have set targets to increase

49 Hemkhaus, M., Hannak, J., Malodobry, P., Janßen, T., Griefahn, N.S., Linke, C. (2019) Circular Economy in the Textile Sector. Report by GIZ and Adelphi for the German Federal Ministry for Economic Cooperation and Development

50 Ellen MacArthur Foundation (2017) A new Textiles Economy: Redesigning Fashion's Future, Circular Fibres Initiative.

the recycled content in their production of new textiles, even though this is currently mostly met through recycled PET-bottles used as polyester fibre (Telaketju, 2021a).

However, aside from required maturation of the technologies involved, fibre-to-fibre recycling of textiles has additional challenge. Almost a third of all textile waste includes items that makes them unsuitable for fibre-to-fibre recycling, such as multi-layer clothing and textiles with a blend of three or more different fibre types. These and other challenges are considered later in Chapter **Error! Reference source not found.**.

A broad and representative list of recycling technologies has been compiled following stakeholder consultation and a review of the literature. Table 18 presents an overview of some current recycling technologies and technologies under development in the field of both mechanical, chemical and thermal recycling. The list mainly includes European recycling technologies but some companies from outside Europe have also been included.

Table 18: Overview of textile recycling initiatives/companies and technologies

Name	Country	Input	Output	Description
Chemical recycling technologies				
Amber Cycle	USA	Polyester and polycotton blends.	Pellets useable for yarn and fabrics.	Pilot plant that separates polyester from other textile fibres. The recovered material is then used to produce new PET pellets and polyester fibres.
Aquafil	Italy	Nylon 6 form pre- and post-consumers waste, such as fishing and aquaculture nets, old carpets, and Plastic and textiles scraps	"ECONYL(R) Regenerated Nylon 6 polymer and yarns, used in engineering plastics applications, and in carpets, garments and accessories manufacturing	Nylon 6 is depolymerized into the monomer caprolactam, which is purified and further re-polymerized into ECONYL(R) Regenerated Nylon, a polymer with quality and properties as Nylon from crude oil. The polymer is then spun and reprocessed into yarns for carpet and textile applications
Evrnu	USA	Blends	MMCF, PET	Post-consumer textiles are treated with solvents to extract the cellulosic component. The resultant solution is then re-spun into new fibre.
Hkrita	Hong Kong	Blends	MMCF, PET	Supports a variety of innovative projects for the recovery material from post-consumer textiles and respinning to new yarn. Focused on chemical recycling of cellulose to new polymer.
Infinited Fiber	Finland	Cotton	Cellulose carbamate yarns for fabrics and clothing	Chemical cotton recycling method applicable to existing viscose and pulp factories. Textiles are shredded, reduces and the cotton elements isolated, reduced to a cellulose carbamate powder then dissolved and re-spun into new fibres.
Ioncell	Finland	Cotton and cellulose-based materials	Cotton-like yarn for fabrics and clothing	Cellulose from recycled cotton fabrics and other sources can be dissolved using ionic liquid to extract hemicellulose fibres which can be spun into new yarn using dry-jet wet spinning.
Ioniqa	Nether-lands	Polyester	Pellets for clothing	Depolymerisation of the input material in solution, with subsequent re-polymerisation to the desired plastic type. Currently in the pilot phase where 10.000 tons of PET from food packaging is processed annually.
Refibra	Austria	Pre- and post-consumer cotton waste	Yarn for fabrics and clothing.	Cellulose from recycled cotton is dissolved using an organic solvent, then mixed with recycled Loycell pulp and processed into new fibres.

Name	Country	Input	Output	Description
Re:newcell	Sweden	Cotton and viscose	Pulp that can be made into yarn for fabrics and clothing.	A chemical method where textiles are turned into a slurry. Contaminants are removed from the slurry, thereafter the slurry is dried and turned into bales of pulp. This pulp can be used as the basis for spinning new fibres in existing processes.
SaXcell	Nether-lands	Pure cotton	Fibres for yarn and clothing.	Cotton textile waste is sorted, ground, chemically decolourised and prepared for existing wet spinning processes like viscose or lyocell.
Södra Cell: OnceMore	Sweden	Cotton and poly-cotton blends	Pulp for yarn, fabrics and clothing	The process separates the cotton component of waste clothing, the cotton cellulose is combined with cellulose from wood to produce a high-quality pulp suitable for spinning new fibre. Currently the pulp is 20 % recovered cotton, with a target of 50 %. Long-term target is an annual capacity of 25000 tons.
Tyton Bios cience: Circ	USA	Blends	MMCF and PET	Post-consumer textiles reduced using super-heated water and chemicals, and the resulting solution re-spun to new fibres.
Worn Again	UK	Cotton, polyester and polycotton. Up to 20 % of contaminants can be filtered out.	PET resin and cellulosic pulp for yarn, fabrics and clothing.	A closed looped solvent system separating cotton and polymers. Plant planned for 2021.
Mechanical recycling technologies				
Altex	Germany	Industrial textiles, home textiles, clothes. All textile materials.	Fibres useable for insulation, automotive industry, geotextiles and drainage	Input textiles are torn by needle rollers pulling in opposite directions. Process all types of textile material and produce blended or single fibre suitable for a range of applications.
Antex	Spain	Post-industrial polyester and other synthetic fibres.	Yarn for the clothing or automotive industry.	Currently at pilot scale recycling post-industrial textile waste into new yarns.
Cardato	Italy	Wool, cashmere and wool-polyester and wool-polyamide blends.	Yarn or fabric for new clothing,	Processes 700 tons a year.
European Spinning Group	Belgium	Cotton, denim and polyester.	Yarn for different applications	Post-consumer textiles are made into blends for denim, towels, tents and workwear on different colours.
Reverso	Italy	Only 100 % wool garments can be processed.	100 % wool and cashmere yarns.	Pre-and post-consumer wool is washed, shredded and spun into new yarn.
Wolkat	Nether-lands	All natural and synthetic material textiles.	Textiles with 65-95 % recycled fibre content.	Post-consumer textiles are sorted after colour and material, then mechanically processed into fibres that are either spun and woven into fabric or used in non-woven products. Has a capacity of 30 000 tons a year.

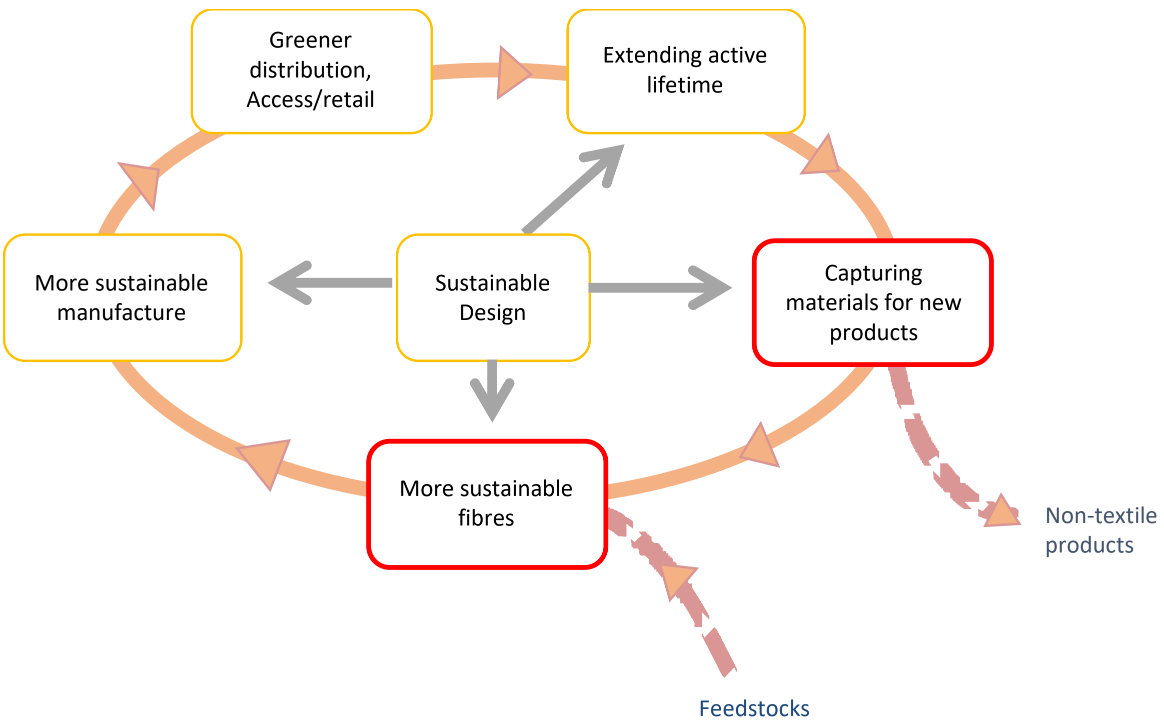
Name	Country	Input	Output	Description
Re:Mix	Sweden	Textiles containing elastane, requirements of purity are not yet determined.	Elastane yarn.	A thermomechanical technique to separate elastane from other textile fibres is being developed. Through this method, raw material pellets can be extracted which can be used to produce new thread through injection moulding.

4.1.5 Challenges to fibre-to-fibre recycling and potential solutions

A range of stakeholders, including fashion companies and other textile companies, collectors and recyclers, have an interest in increasing fibre-to-fibre recycling of textiles but face challenges in doing so (Elander & Ljungkvist, 2016; Watson et al, 2017). Some of these challenges are technical including shortening of fibre lengths, separation of fibre types in products with fibre mixes and the presence of persistent chemicals in some specialised products. Others are system problems related to gathering and sorting sufficient quantities of recyclable used textiles and at the same time not closing off environmental-preferable reuse pathways.

As several previous studies have shown (Watson et al, 2017), it is a challenge that recyclability is rarely considered in the design process. Other considerations have higher priority – it can e.g. be a question of mixing fibre types in order to give the product a specific expression or to give stretch, a matter of durability, or a combination of lightness and warmth, which might suggest a fibre mix. The complete value chain for sustainable textiles is presented in Figure 27 showing many entry points for more sustainable and circular textiles and with recycling marked with red.

Figure 27: Value chain for sustainable textiles



Source: Watson et al (2018c)

The wished characteristics are often in conflict with design for recycling, and for many products it is still not possible to find recyclable fabrics and products that meet these functional needs, although design innovation can help to tackle this problem. A study developing a set of ecodesign requirements for textiles clearly articulated these conflicting requirements (Bauer et al, 2018), and noted that design for recyclability should not undermine product durability since extending lifetime brings greater benefits than recycling (Schmidt et al, 2016).

There is a significant literature on barriers to increased recycling of post-consumer textiles and on the use of recycled material in new textile products. Table 19 provides an overview of barriers and potential solutions as identified in the literature.

Table 19: Barriers to fibre-to-fibre recycling and potential solutions

Barrier	Themes addressed	Explanation	Possible solution
Lack of automated sorting technologies	Technology	Lack of effective, industrial scale, automated sorting technology for separation of textile waste from households, by colour and fibre type, prevent large-scale fibre recycling. (WRAP UK, 2019)	Targeted, tailored financial support for R&D, piloting and upscaling to industrial level
Lack of high-quality recycling technologies	Technology	Limited quality in mechanical recycling processes for processing household textile waste (reduction in fibre length), and limited availability and evidence of efficiency, economic profitability and scalability for chemical recycling. (Ellen Macarthur Foundation, 2017)	
Lack of mature solutions in chemical recycling	Technology	Lack of mature solutions in chemical recycling means that mechanical recycling is the only solution for a number of types of textile fibres. Mechanical recycling shortens and weakens fibres that have already been shortened by wear and washing in first-generation fabrics. Chemical recycling can produce fibres that approach virgin quality, but processes are typically not technologically mature or not economically viable. (WRAP UK, 2019)	
Blended fibres and materials are a challenge for fibre-to-fibre recycling	Incoming material flow of used textiles	Clothes that contain mixed fibres, a high content of elastane and hard elements such as buttons, zippers are difficult to recycle even in high-quality processes. This is particularly problematic for the current chemical recycling solutions (Ibid)	Development and use of a minimum standard for EcoDesign criteria with a focus on durability, reparability, ease of disassembly and ease of recycling (provided this does not undermine durability). Green public procurement with an emphasis on eco-designed textiles. Ecolabels including criteria on these aspects.
Washing clothes in households reduces the quality of the material	Incoming material flow of used textiles	Excessive washing or drying at high temperatures reduces the quality (and especially the length) of the fibres which are input factors in mechanical reprocessing. Short fibres make it necessary to mix in a large proportion (over 70 %) of virgin fibres to achieve the required quality. (Ibid 2021)	Advising through care labels or otherwise reduced temperatures and increased uses between washes
Low availability of some fibre types	Incoming material flow of used textiles	For some fibres, such as wool, too low a volume is collected and sorted to provide a stable material flow to the market's supply side. (Watson et al, 2017)	
Missing and incorrect product	Incoming material	Detailed information about the materials in used garments is necessary to ensure high quality in	Support or require the use of technology such as RFID tag

Barrier	Themes addressed	Explanation	Possible solution
labelling	flow of used textiles	the recycling processes. One third of garments have washed out or lack of labelling. In addition, the labels do not always state the correct material composition in a garment. (WRAP UK, 2019)	or similar for textiles put on the market. Requirements for (easily accessible) content declaration for the material composition available for textile products that are marketed
Risk of chemical contamination	Incoming material flow of used textiles	Some brand manufacturers highlight concerns about human health when using mechanically recycled fibres in clothing production for new markets, especially for sensitive groups. A large number of hazardous chemicals are used in textile production. (Ibid 2021)	Stronger regulations / restrictions for which chemicals can be used in textile production Taxes on chemicals in clothing Green public procurement of textiles including chemical restrictions Better promote ecolabels, such as the EU Ecolabel, with chemical restrictions
Challenges related to durability	Quality of recycled material	The use of mechanically recycled fibres can have a negative impact on technical service life or quality. This in turn affects the brand and the consumer's expectations and experiences. Longer service life is associated with greater potential environmental benefit from recycling. (Watson, et al, 2017)	Development of guidance on how designers can design with recycled content without compromising durability
Lack of communication between textile supplier and brand chain	Information related	There is a lack of a common language and a common understanding of what brands want on the one hand, and what can be realized by textile recyclers on the other. (Ellen Macarthur Foundation, 2017)	Stronger communication/matchmaking between brands and producers of recycled content yarns and fabrics
Lack of knowledge about the market for recycled textiles	Information related	Many of the newer players in textile collection have little knowledge about markets and do not handle textiles according to the waste hierarchy – with the exception of the textiles for reuse. (Koszewska, 2018)	
Lack of traceability of chemical content	Information related	Lack of information about chemical content in disposed garments reduces the possibility of securing fully or partially recycled textiles without dangerous, persistent (substances that do not easily degrade in the environment) chemicals. (Ellen Macarthur Foundation, 2017)	Support or require the use of technology such as RFID tag or similar for textiles put on the market Requirements for (easily accessible) content declaration for the material composition available for textile products that are marketed Green public procurement criteria for recycled material that requires third-party documentation Better promote ecolabels, such as the EU Ecolabel, with chemical restrictions
Lack of traceability of recycled material	Information related	As with virgin materials, transparency in the recycling value chain is also necessary, so that brands can be sure that the stated proportion of	Use of standards such as Global Recycle Standard

Barrier	Themes addressed	Explanation	Possible solution
		recycled material in yarns and fabrics corresponds to reality. (Koszewska, 2018)	
Expensive for brands to add new routines and systems	Economic	The use of recycled material in new clothes can require new routines, and this is an added expense. (Ljungkvist et al, 2018)	Needs commitment from top management in brand
High costs for logistics	Economic	The textile industry is global, and the fibre-to-fibre industry will also have to have a global scope, but transport costs can be high compared to the value of the recycled materials. (Ibid 2021)	Investments in recycling plants near large sorting plants
High cost of recycled material	Economic	Due to the need for high purity in constituent materials and lower scalability, recycled yarn and fabric are generally more expensive than virgin material. (WRAP UK, 2019)	Taxes on virgin textile materials
Lack of economic sustainability in textile sorting and recycling	Economic	This is currently too expensive, which means that 1) only low prices can be paid for material input factors, and 2) that output factors cannot outperform virgin material. (Elander & Ljungkvist, 2016)	Financial support for the collection and treatment of non-reusable textiles. Support can come from manufacturers (via extended producer responsibility (EPR) or municipalities (financed by savings on waste management costs). Targeted, tailored financial support for R&D, piloting and upscaling to the industrial level of automated sorting, as well as mechanical and chemical recycling.
Lack of incentives for investment in recycling	Economic	Investment requires significant long-term capital investments. Decisions are often made from a short-term and profit-maximizing perspective, due to low profitability and a lack of long-term business relationships between customer and supplier. Textile recyclers are unlikely to invest in additional capacity without specific fibre-to-fibre recycling partners committing to buying raw materials from them. (WRAP UK, 2019)	Setting up recycling ecosystems including brands, waste companies and recyclers Comprehensive mapping of composition of textile waste
Lack of demand from industry and consumers for garments made from recycled material	Market	Consumers on the whole appear unprepared to pay more for garments containing recycled material. This may be due to a perception that recycled clothes are of lower quality and durability; that recycled clothes do not justify additional expense, that the environmental claims associated with recycled clothes may be unsubstantiated, that there is little context for the environmental impact of clothes, or other factors. (Ibid 2021)	Minimum criteria for green public procurement for recycled content in textiles (where it does not affect lifetime). Ecolabels including criteria on these aspects. Attitude campaigns about the effects of clothing consumption and information and the promotion of longer life, sharing, reuse, repair and purchase of clothes from recycled material.
Low market price for virgin textile fibers	Market	Compared to the price of recycled fibres, the market price for virgin textile fibres is low. This undermines any incentive for recycling. (Elander	Virgin fibre tax

Barrier	Themes addressed	Explanation	Possible solution
		& Ljungkvist, 2016)	
Limited selection of colours in recycled material	Market	The selection for designers when it comes to colours of yarns and textiles of mechanically recycled material is somewhat limited. (Watson et al, 2017)	
Lower costs for competing recycled materials	Market	Used PET bottles are a source of recycled polyester, and this is cheaper and cleaner than polyester from garments disposed of by consumers. (Ellen Macarthur Foundation, 2017a)	Specified proportion of recycled material from post-consumer textiles in green procurement and ecolabel criteria
Barriers to trade in textile waste	Regulatory	Used textiles are subject import duties and licenses in many countries, which imposes both financial and administrative guidelines on importers / recyclers. (Koszewska, 2018)	Development of criteria for when both 'original' and processed textiles suitable for reuse and recycling markets are waste (EoW). Be careful to ensure that these comply with the requirements of Article 6 of the Waste Framework Directive.
Lack of coherent rules for waste collection	Regulatory	The EU defines used textiles as waste, and strict rules for transport, storage and treatment of waste pose challenges for collection and recycling. (Palm et al, 2015)	Development of clear guidance for collectors of used textiles and municipal waste companies in terms of legal definitions of waste / non-waste, ownership of used textiles, criteria for when there is waste (EoW), rules / guidelines for good business practice and ethical guidelines for collectors etc. Assign the responsibility for granting exemptions for the use of textile collection (even when considered waste) to an independent nation
Ownership uncertainty	Regulatory	Non-reusable textiles are considered waste. As such, they are officially owned by the municipality in question, which must therefore give special permission to organizations that want to collect and sell this "waste". (Elander & Ljungkvist, 2016)	
Challenges of establishing return systems for own products	Systemic	Negatively affects textile companies that want to establish "closed-loop recycling" where their own used products are used to produce new ones. (Watson et al, 2017)	
High labour costs for redesign / upcycling	Systemic	To the limited extent that it is practiced, redesign and repair typically takes place locally. However, the labour costs in developed countries are so high, and the price of imported new clothes so low, that redesign and repair is seldom economically viable. (Gram-Hanssen et al, 2017)	VAT or tax reduction on re-use, repair and upcycling activities
Resistance to change from parts of the textile industry	Systemic	F2F (fibre-to-fibre) recyclers must be integrated as fibre suppliers in the clothing supply chain. Conservative attitudes among buyers - clothing manufacturers, brands and retailers - hamper this as it transcends existing processes and systems. New fibre suppliers must be integrated holistically with current yarn production processes. (WRAP UK, 2019)	

It is clear from Table 19 that the barriers to recycling are not limited to product design issues but include economic, market-related, information-related, and systemic problems. These challenges cannot be met by a single group or in a single place in the value chain. There is a clear need for increased coordination and exchange of information between actors; in particular between designers/brands/producers and sorters/ recycling companies and technicians developing new recycling technologies.

4.1.6 Future perspectives on sorting and recycling

Both manual and automated or semi-automated sorting will be key elements of a future circular economy for used textiles in Europe. Manual sorting is, and will remain, an essential first step to identify, separate and sort reusable textiles into a wide variety of different types and grades of clothing and textile products for sale on global reuse markets. Reuse is the preferred option for used textiles both from an environmental and economic point of view and manual sorting is, in the foreseeable future, the only means by which sorting for reuse can take place.

Automated or semi-automated sorting on the other hand will be the preferred process for the non-reusable waste outputs of the manual sorting process or for the processing of other textile waste (e.g. pre-consumer factory waste) that has no reusable content. Automated sorting can efficiently and accurately sort most textile wastes by colour and fibre type including a range of fibre blends ready for input into high quality mechanical or chemical recycling.

While manual sorting personnel can sort between 100 to 150 kilos of textiles per hour, advanced facilities for automated sorting can sort between 900-1500 kg per person each hour. This higher efficiency is necessary since the output of the process has a much low economic value than the reusable fractions from the manual sorting process.

Automated sorting technologies have only recently become ready for upscaling to industrial scale and capacity across Europe is currently just a few thousand tonnes per year. Significant investments will be needed over the next few years to sort the hundreds of thousands of tonnes of non-reusable textiles that are expected to be collected each year as we approach the 2025 requirement for the separate collection of textiles waste. Manual sorting capacity will also need to be expanded by 65 000 to 90 000 tonnes each year, after 2025 and perhaps half this growth in the years up to 2025.

Due to the low economic value of the non-reusable waste textiles from manual sorting plants, it may be both economically and environmentally advantageous to locate automated sorting facilities close to, or directly integrated with, manual sorting facilities. The same could also be true of recycling facilities.

Manual sorting of textiles is currently not evenly spread across Europe but is clustered in a number of countries that specialize in sorting and wholesale activities: among these France, Germany, Poland, the Netherlands, Belgium, Romania, Hungary and Spain. Table 20 provides a non-comprehensive overview of manual sorting capacities in a number of European countries.

Table 20: Current estimated manual sorting capacity in selected countries

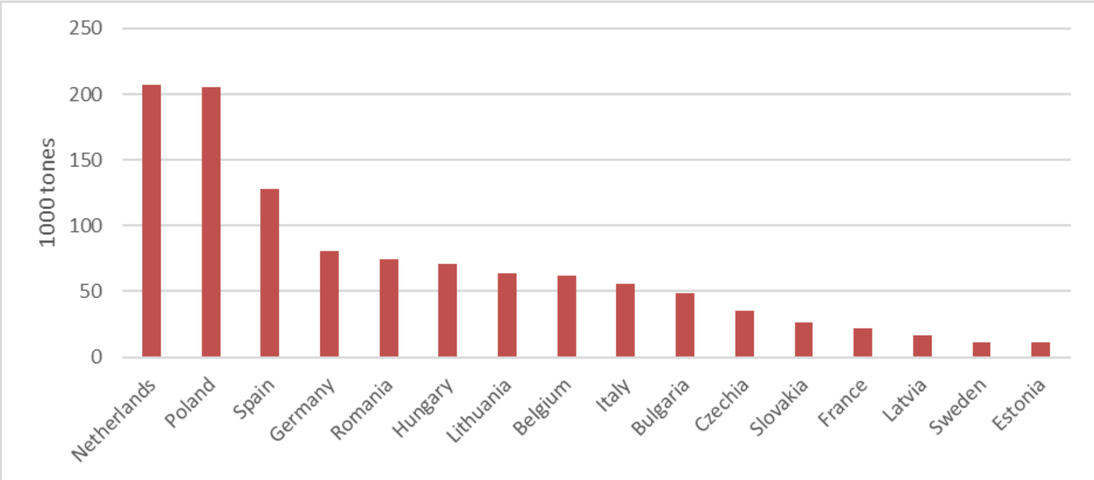
Country	Annual estimated manual sorting capacity
France	196 000 tonnes
Germany	190 500 tonnes
The Netherlands	234 000 tonnes*
Belgium	100 000 – 120 000 tonnes
Hungary	100 000 tonnes
Spain	100 000 tonnes
Bulgaria	35 000 tonnes
Switzerland	5 000 tonnes

Source: (except for the Netherlands) EuRIC (2020) pers. comm.

*The EuRIC (2020) value for the Netherlands seemed too low (128 000 tonnes) and so a more appropriate figure of 234 000 tonnes has been inserted, from the FFact report (2018)[51]

For the countries that have not mapped their sorting capacity, data on imports of used clothing and rags (CN codes 6309 and 6310) can be used as a lower limit of manual sorting capacity. Poland, for example, is not included in Table 20 but its high level of imports indicates a manual sorting capacity of somewhere in the order of 200 000 tonnes.

Figure 28: Imports of used clothing and rags (2018 data)



Data source: UN Comtrade data

The countries with the highest current manual sorting capacities may make most sense for location of automated sorting and recycling technologies in coming years. However, some countries such as Finland and Sweden, that don't have large manual sorting facilities or large quantities of non-reusable textile waste looking for solutions, have nevertheless invested, both with public and private finding, in the development of automated sorting and fibre-to-fibre recycling technologies. The Netherlands is also at a similar stage of development.

Telaketju in Finland (Telaketju, 2021) and the Circular Textile Valley (DCTV Dutch Circular Textile Valley, 2021) initiatives in the Netherlands aim to establish eco-systems of waste companies, research organisations and brands that may prove to be the blueprint for the successful development of closed loop recycling of post-consumer textiles over the coming years. In a similar vein, Euratex plans to promote the development of five recycling hubs around Europe focusing on regions with existing textile production that can act as a demand (see Box 7). There is likely to be some overlap between the two; for example, Telaketju looks to be the centre of one Euratex ReHub.

Box 7: EURATEX - ReHubs (EURATEX, 2020b)

EURATEX, the European Apparel and Textile Confederation, has proposed establishing five regional hubs within the EU to manage the several million tonnes of discarded textiles that will be collected with full implementation of the Waste Framework Directive's demand for separate collection of waste textiles. This will help attain the economies of scale needed for investments in the necessary infrastructure and improvements in current recycling technologies.

Ownership of the the ReHubs is likely to reflect the local norms and that nature of the local textile industries, but is anticipated to involve an assortment of actors along the textile value chain. Siting the ReHubs near European textile and apparel districts will help direct the recycled materials into textile markets and engage the European textile industry. Five candidates to host the ReHubs have emerged: Belgium, Finland, German, Italy and Spain – although the hubs will service surrounding countries, and could specialise in materials relevant to local industries.

The ReHUbs will pool efforts and investments from over 100 businesses across Europe, and help generate green jobs – estimates predict one job for every 1000 tonnes of textiles collected, sorted and recycled.

51 FFact, 2018. Onderzoek naar de massabalans van het in Nederland ingezamelde afgedankte textiel en de route en resultaten van de verwerking. Rijkswaterstaat – WVL. Available online here.

Although the development of mechanical and chemical fibre-to-fibre (closed loop) recycling may be the central thrust of current research and development projects, a significant share of non-reusable textiles is not suitable as input to this type of recycling. While advances are being made chemical processes have yet to be found that can recycle many of the fibre blends that are currently placed on the market. The composition of non-reusable textiles waste arising in Europe is largely unknown and this knowledge gap may be hindering private investment in industrial scale recycling facilities. The sampling that has been carried out by FiberSort of 1 tonne of textiles waste from each of 5 European countries, found that only a quarter was suitable for fibre-to-fibre recycling using mature or close to mature technology (Interreg North-West Europe, 2018).

It is, therefore, likely that open loop recycling solutions will remain an important part of the solution for the additional non-reusable post-consumer textiles collected each year after 2025 (a capacity that will need to grow by 65 000 to 90 000 tonnes each year). Open loop recycling does not necessarily mean downcycling. There are several examples of high-quality products that are produced using textile waste such as furniture, acoustic insulation boards, ventilation flow components and others. This is recognized by the French producer responsibility organisation for clothing, textiles and shoes, Eco-TLC that invests 3 % of producer fees in research and development, with a focus on recycling. Several of the 44 different projects that have so far been funded by this money are examples of high-quality open loop recycling (ECO TCL R&D Projects, 2021).

In general, a strong link between sorting and recycling will be needed to enable both closed loop and open loop recycling. Some recycling processes already have integrated pre-treatment of textiles, including the removal of non-textile hardpoints and shredding, while other processes can only accept pre-treated textile waste. This means that many fibre-to-fibre recycling technologies are still heavily dependent on a well-sorted, uniform input from sorting facilities in order to produce the right kind of outputs from their technology.

Nascent technologies that embed in clothing information about the textile composition could provide one avenue to improve sorting efficiencies and improve outlooks for fibre-to-fibre recycling. Requirements to use technology such as RFID tags or similar for textiles put on the market, or content declaration for the material composition available for textile could be a solution to this challenge.

5 Task 3: Circular economy perspectives on business models in the textile sector

5.1 Introduction

Over the last two decades, a substantial amount of business models has emerged in the textile sector that promote aspects of socioeconomic fairness, sustainability and circularity as core elements of their concept (Gillabel et al, 2021). While companies offering fair trade fashion and organic clothing have established a steadily growing market niche in the fashion sector, the European Commission's new Circular Economy Action Plan (CEAP) (EC, 2020 - COM (2020) 98 final) defines new challenges to the textile sector as a whole.

The CEAP aims at accelerating the transition towards a circular economy in the EU, which shall be based on the regenerative use of resources. In concrete terms, it mentions the following policy targets (ibid):

- increasing recycled content in products, while ensuring performance and safety;
- enabling remanufacturing and high-quality recycling;
- mitigate global warming and other environmental impacts;
- restricting single-use and avoiding premature obsolescence;
- introducing a ban on the destruction of unsold durable goods;
- incentivising product-as-a-service or other models where producers keep the ownership of the product or the responsibility for its performance throughout its lifecycle;
- mobilising the potential of digitalising product information, and including solutions, such as digital passports, tagging and watermarks;
- rewarding products based on their sustainability performance, while linking high performance to incentives."

They can become starting points for the development of business models that, as a whole or at least partially, offer a unique circular value proposition: "improving product durability, reusability, upgradability and reparability, addressing the presence of hazardous chemicals in products, and increasing their energy and resource efficiency. Especially for textiles, the above cited goals are to be achieved through the Sustainable Products Initiative that will apply in priority to textiles. The CEAP states that strengthening industrial competitiveness and innovation in the sector requires industry and stakeholders to develop new business models which are to be achieved through the Sustainable Products Initiative that will apply in priority to textiles. To this end, the CEAP prescribes measures to get the CE strategy up and running in the textile sector (ibid):

- "applying the new sustainable product framework [...], including developing ecodesign measures to ensure that textile products are fit for circularity, ensuring uptake of secondary raw materials, addressing hazardous chemicals, and empowering businesses and consumers to choose sustainable textiles and facilitates access to reuse and repair services;
- improving the business and regulatory environment for sustainable and circular textiles in the EU, in particular by providing incentives and supporting product-as-service models, circular materials and production processes, and increasing transparency through engagement and cooperation,
- providing guidance to achieve high rates of separate collection of textile waste, which Member States have to ensure by 2025;
- boosting sorting, reuse and recycling of textiles, driving change through innovation, and encouraging industrial applications and regulatory measures, such as e.g. extended producer responsibility."

The new CEAP provides a clear incentive for individual companies in the textile industry to benefit from a transition towards circular economy compatible business models: closed loop models can increase their profitability and increase their resilience against shortages in the supply of pristine raw materials and fluctuations in resource prices, for instance cotton commodities (MacDonald and Meyer, 2018). Citizens might also benefit from the implementation of the circular economy. It will bring about a whole new range of sustainable services, product-as-service models, including digital solutions will provide for efficient and affordable products, which last longer and are designed for reuse, repair, and high-quality recycling (ibid).

In the textile sector, there are already a number of business activities that are linked to the aforementioned circular economy principles, such as the so called "slow fashion" concept featuring improved product durability and reparability, initiatives to take back and reuse clothing, as well as leasing, rental and sharing services, addressing fast fashion and overconsumption (Gillabel et al, 2021). In addition, there are still many textile companies with traditional business models linked to textile tailoring and care, which serve the idea of keeping garments usable for a long period such as traditional costume and alteration tailors, laundries, dry cleaning services. These companies rarely advertise their services under the concept of circular economy, although they aim to achieve the same goal.

Nevertheless, ambitious entrepreneurs in the textile sector are developing and implementing innovative ideas on how to bring the principles of the circular economy to life through technical and social innovation, logistics and collaboration, and new marketing strategies.

In this section, examples of good practice in different countries are mapped in terms of production and consumption models including second-hand clothing, repair services, product reparability features and use of recycled content. This task aims to identify enterprises or initiatives (i.e. social entrepreneurs) in the apparel and clothing market, which implement the circular economy concept in their business operations, thus making this approach workable as part of their value chain. The mapping of circular business models serves to establish the empirical data base, which will be analysed to derive a set of circular economy-related business models. This in turn could facilitate the dialogue with companies, initiatives and stakeholders, and foster the exchange and dissemination of innovative concepts throughout the sector.

5.2 Review of circular business models in literature

In a first step, the existing literature describing circular business models (CBMs) was reviewed to describe the current state of play of circular business models in the textiles sector. The following studies and reports were analysed:

- Elander, M.; Watson, D.; Gylling, A.C. for Mistra Future Fashion (2016) Evaluation of business models for increased reuse, collective use and prolonged lifetime of textiles.
- CTP (2015) Service-based BM & circular strategies in the textiles sector,
- CNA Federmoda (2020) Best practices in terms of production and consumption models, repair services, product reparability features and recycled content: Italian textile and apparel business models (contribution from CNA Federmoda within the stakeholder consultation for this study)
- Ellen MacArthur Foundation (EMF, 2017): A New Textiles Economy: Redesigning fashion’s future. Part II Chapter 2 “Transform the way clothes are designed, sold, and used to break free from their increasingly disposable nature”
- Danish EPA. Best Practice Examples of Circular Business Models (2016) esp. Chapter 3
- Fontell and Heikkila (2017): Model of Circular Business Ecosystem for Textiles
- JRC (2014) Environmental Improvement Potential of textiles (IMPRO Textiles)
- CircularPP project (2019) Alternative business models available for circular procurement. ttp://circularpp.eu/wp-content/uploads/2019/11/WP2.2-report.pdf
- Keldermann (2019) Increasing the use of recycled textiles through business models and policy. International Institute for Industrial and Environmental Economics. Lund University, Sweden, online at: https://lup.lub.lu.se/luur/download?func=downloadFile&recordOId=8975125&fileOId=8975127 (last accessed 24.11.2020)
- EURATEX (2020) Position paper. Circular Textiles. Online available under: https://euratex.eu/wp-content/uploads/EURATEX-Prospering-in-the-Circular-Economy-2020.pdf
- EEA (2021) A framework for enabling circular business models in Europe. Available online: https://www.eea.europa.eu/themes/waste/resource-efficiency/a-framework-for-enabling-circular
- EEA (2021) Plastic in textiles: towards a circular economy for synthetic textiles in Europe. Available online: https://www.eea.europa.eu/themes/waste/resource-efficiency/plastic-in-textiles-towards-a
- Eionet (2021) Plastic in textiles: potentials for circularity and reduced environmental and climate impacts. Available online: https://www.eionet.europa.eu/etcs/etc-wmge/products/plastic-in-textiles-potentials-for-circularity-and-reduced-environmental-and-climate-impacts/@@download/file/ETC_2.1.2.2._plastic%20in%20textiles_final_edited%20for%20website.pdf

This literature scan was based on the following questions: What characteristics describe a circular business model? What are advantages of CBMs in terms of contribution of different CBMs to Circular Economy? What kind of challenges exist for CBMs? What could strengthen existing CBMs and which kind of support (i.e. policy intervention) could help CBMs to proliferate within the EU textiles sector? Information incorporated in the studied literature was collected under these questions and the information is summarised under the following sub-sections.

5.2.1 Definition, description, characteristics and systematization of circular business models

Generally speaking

A company´s business model describes "the rationale of how an organization creates, delivers, and captures value." (Osterwalder & Pigneur, 2009, quoted in empirica, 2014). A circular business model is defined according to Jonker et al (2018): "a circular business model is the description of how value creation and retention is organised between parties" (Jonker et al, 2018). The OECD defines circular business models as those that "serve to reduce the extraction and use of natural resources and the generation of industrial and consumer wastes. Circular business models use already existing materials and products as inputs and therefore their environmental footprint tends to be considerably smaller compared to traditional business models" (OECD, 2019). According to EEA, the circular economy can be defined "as one that is restorative, and one which aims to maintain the utility of products, components and materials and retain their value" (EEA, 2016). Gillabel et al, (2021) define circular business models "as a combination of value creation, value proposition and value capture strategies".

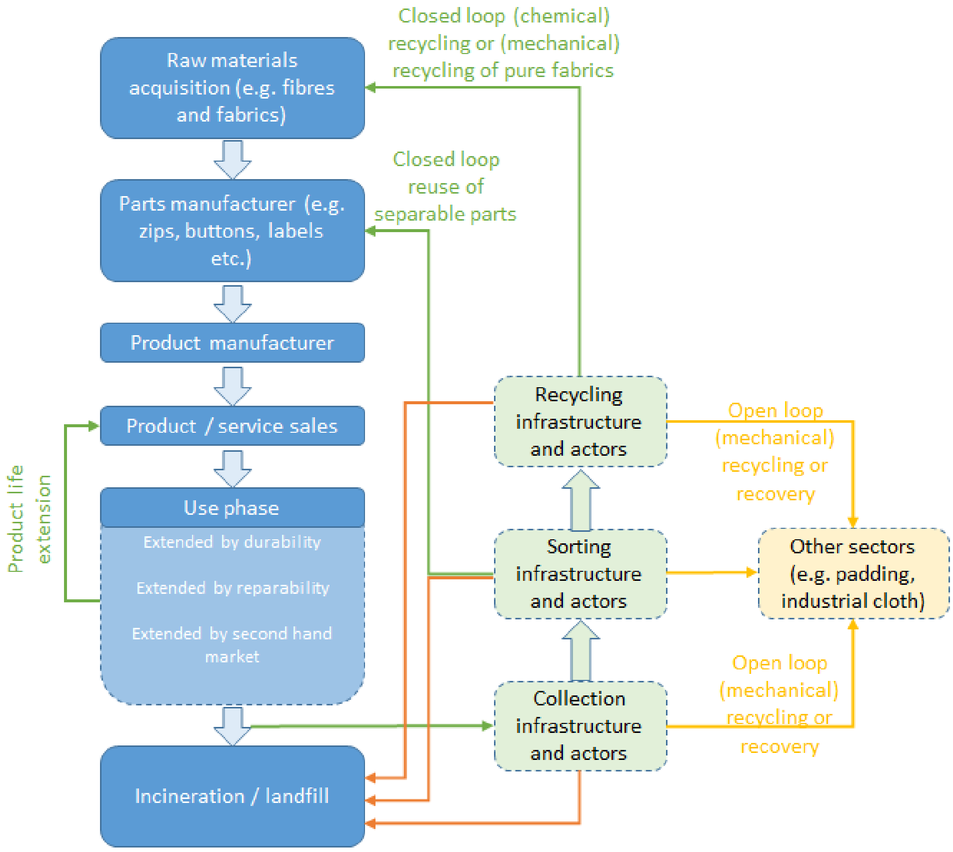
Regardless of the different definitions quoted above, it is noteworthy that there is no commonly agreed on definition of CBM, a lot of authors provide a lot of different definitions (ibid and Kirchherr et al, 2017). The concept of value creation can be expressed by using nine descriptive elements: customer segments, value proposition, channels, customer relationships, revenue streams, key resources, key activities, key partnerships and cost structure (Danish EPA, 2016). According to Teece (2010), the essence of a business model "defines the manner by which an enterprise delivers value to customers, entices customers to pay for value, and converts those payments to profit: it thus reflects management's hypothesis about what customers want, how they want it, and how an enterprise can organise to best meet those needs, get paid for doing so and make a profit".[52]

Within the textile sector

A textiles circular business model (CBM) describes the creation of added value during the use phase of textile products or afterwards. In contrast to the linear economic models (business as usual), where value creation ends at the point of sale, CBMs aim to exploit value by maintaining or restoring the function of textile products as long as possible. It is important to note that non-financial values should also be taken into account when assessing circular value creation. Circularity can also be achieved by converting obsolete textile products into a useful and valuable input for new production processes, thus avoiding waste (CTP, 2015). Figure 29 illustrates the hierarchy of circular economy approaches against the background of a schematic product life cycle which covers all phases from the manufacture of raw materials through production and use until disposal (blue rectangles). CBMs are usually used in the use phase where they provide a service to the customer that physically available products cannot normally provide to the same extent. Other types of CBMs incorporate different life cycle stages as well (such as design and manufacturing of durable products, collection & reselling of post-consumer textiles and their recycling). While the value of physical products diminishes during the use phase as they become unfashionable or subject to wear over time, a CBM generates revenue by keeping the desired product function alive, thus preventing products from becoming waste. CBMs for textiles may encompass one or more circular activities, such as repair, refurbishment or recycling – but also the design of new textile products for better performance (i.e. durability) or for material efficiency (e.g. reparability, recyclability, separability of different components etc.) in a circular economy context can be considered a CBM.

[52] GftZ estimate. Nicole Kosegi personal communication

Figure 29: Circular hierarchy of business models at different stages in the value chain



Source: adapted from DEPA (2016)

CBMs can address various positions in the life cycle. This fact determines their respective value proposition within the circular hierarchy, even though they may deal with various aspects of circularity simultaneously.

The difference to business-as-usual approaches in a linear economy is blurred as there are many aspects that apply to both models and differ only in their characteristics or relevance. In comparison to linear business models, CBM may require more B2B and B2C collaboration, coordination within networks of interdependent but independent actors/stakeholders as well as closer communication with customers and stakeholders (Fontell and Heikkila, 2017, p.16; Staicu, 2018). Some CBMs establish a reverse value chain and bridge the gap between actors that do not normally communicate directly with each other (such as fashion brands, retailers and recycling companies).

According to the CTP (2015), three typical approaches for CBMs can be distinguished:

- value creation from waste,
- servitization (pay-per-use) which implements the principle of offering functionality over ownership (Probst et al, 2016),
- sufficiency (using fewer physical products or extending the service life of existing ones),
- promoting efficient use of resources, which means using secondary or decrease consumption of primary raw materials.

Elander et al (2016) identified the following potential success factors for circular business models that create value by facilitating reuse, collective use and prolonged lifetime of textiles:

- Access to (free) materials
- Access to volunteers
- Efficient logistics
- Finding the right material/garments
- Finding understanding from investors/financial institutes

- Good agreements with suppliers
- Keeping the customer interested
- Rapid establishment of the brand /business model
- Time since establishment

These elements of potential success show a snapshot of stakeholder views collected by Elander et al (2016). However, most of the success factors are not specific to circular business models and pose rather typical challenges for any company regardless of the business model. It should also be borne in mind that these stakeholder views represent the current situation these companies operate, i.e. they form a niche market within a linear structured fashion market. In a more circular market ecosystem several of these success factors could be questioned. For example, access to commodities, such as free materials and volunteer work is likely to become a matter of pricing as the demand for used clothing and labour increases.

A study on the financial viability and potential profits of five exemplary business models was conducted by WRAP UK in 2013. The findings suggests that there is potential for a business case to be realised that combines strong financial performance with reasonable savings in the numbers of garments going to waste. Regarding the future development of CBMs in the textiles sector, it was concluded that "if sufficient demand can be created, they have the potential to be even more commercially viable at a large scale and generate significant resource benefit".

There is a variety of options on how to categorise circular business models (Elander et al, 2016). Best known, according to Fontell and Heikkila (2017), is the list of key CBMs presented by Accenture (2014):

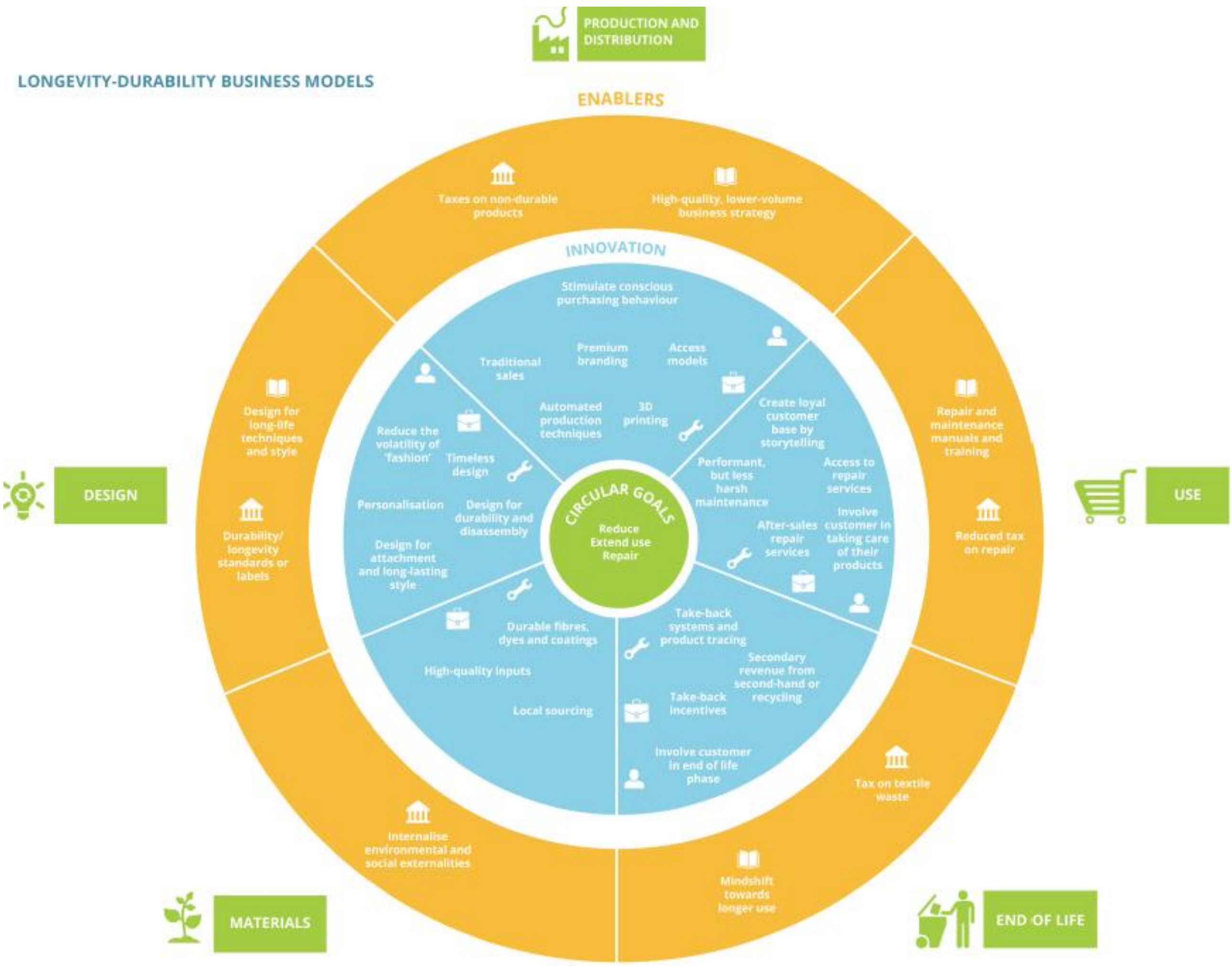
- Circular supplies trough eco-friendly production and bio-based or recycled input material;
- Resource and energy recovery out of disposed products or by-products;
- Product life extension by repairing, reuse of components and reselling;
- Sharing platforms which enable increased utilization rate of products (Consumer-to-consumer);
- Product as a service or B2B/ B2C leasing where the retailer retains ownership.

The European Environment Agency`s European Topic Centre on Waste and Materials in a Green Economy (ETC/WMGE) has published an underpinning report on business models in the circular economy (Gillabel et al, 2021). The report provides an analytical framework for circular business models (see Figure 30), which categorises measures to effectively implement circular economy models and ideas for scaling them up as part of a transition to a circular economy in Europe. The framework focusses on the following elements of innovation in circular business models for the textiles sector, based on a life-cycle concept:

- Technical innovation
- Social innovation
- Policy enablers
- Behavioural and education enablers

Figure 30 below shows the results of the analytical framework applied for circular business models that enable longevity and durability of textiles. Such CBMs use various value strategies to preserve the product and material value of textiles, including sufficiency (consumption reduction), prolonging active use of textiles and also maintenance and repair activities. Moreover, the innovation of product design towards enabling circularity and marketing strategies focussing on circularity related narratives (i.e. premium branding of durable and high-quality products, timeless design) are mentioned.

Figure 30: EEA analytical framework for CBMs showing innovations and enablers for longevity and durability of textiles



Source: (EEA 2021)

The EEA analytical framework above moves clockwise in the direction of the textile product lifecycle, starting with materials at "6 o´clock" (centre-bottom). On the outer ring, in orange, a number of enabling actions of particular relevance to policymakers are mentioned that could drive a shift towards increased circularity. Durability is a key enabler, with a clear need identified for standardised ways of measuring and labelling durability. Once in place, tax incentives/disincentives could be put in place for durable/non-durable products – although this would be something to be decided at Member State level.

Tax incentives for repair services are also considered as an enabling action. This is an important consideration but is only part of the equation. Especially in higher labour cost countries, the cost of repair for lower end garments can sometimes even exceed the cost of buying a new equivalent garment, and in such situations, simply reducing taxes on repair is not going to solve the problem. For this reason, a shift towards more durable, and thus higher quality and more expensive garments is likely to make repair activities much more appealing to owners. Another option that would contribute to a higher base cost for new garments, and thus making repair interventions more appealing, would be the return to import tariffs on textile goods although this would be a decision that is in the hands of trade organisations.

Tax on textile waste is a potentially useful enabling action which, coupled with the upcoming requirement to collect post-consumer textile waste, would encourage public authorities to maximise textile recycling from collected waste. However, the impacts of such a tax on social enterprises and actors involved in the collection and sale of second hand clothing could find such tax converting poor quality second hand clothing from a zero net cost inconvenience into a loss-making burden.

The innovative aspects in the blue parts of the EEA framework above are directly related to actions of producers and consumers. Design for durability and disassembly could be aided by the development of textile specific requirements, perhaps using the EN 4555x series of standards as a starting point for inspiration.

Take-back systems could form part of a broader Extended Producer Responsibility (EPR) scheme which could be linked to the upcoming requirement for post-consumer textile collection or be independent of such a system. However, take-back schemes would likely create a new dynamic in the second-hand clothing sector, where commercial actors paying a fee to have collection bins placed on public streets may consider any legislated take-back schemes from clothing shops as creating competition on an unlevel playing field with a large number of sites compared to the current competition from social enterprises.

Not so clearly stated in the EEA framework is the incorporation of recycled content. This is a key innovation necessary to drive the market for textile recycling technologies,

Other mapping studies may categorise CBMs differently, however, referring to similar circular strategies. For instance, DEPA (2016) uses a different framework for categorising the various types of circular business models. It notes that "Circular business models are special in the sense that they look for value creation in places usually of little interest to companies that operate in the traditional linear production paradigm." In other words: CBM create value where other companies rather externalise environmental and social costs.

5.2.2 Societal and environmental benefits

The answer to the question what circular business models contribute to the Circular Economy presents at the same time the advantages that CBMs bring for society and the environment. The evaluated studies list several aspects:

CBMs usually necessitate closer collaboration along the value chain in order to pass on product-related information such as repair guidelines. As many companies engage in partnerships, this leads to more value chain-related transparency and better opportunities for joint approaches to sectoral challenges. Second, if CBMs adopt B2C communication, they could better respond to the consumer needs, e.g. a leasing business model can provide consumer access to high quality garments.

Customised production and second-hand shops that provide the option to get garments "with a history", entail emotional durability, thus a strong liaison to a garment prolongs its life, if it can additionally be repaired, even better. Sufficiency based CBMs are a vehicle to transport this attitude and support behavioural change. Finally, CBMs can be a driver for innovation as CBMs have a potential to induce improvements for the environment (CTP, 2015). CBMs could contribute to recovery in line with planetary boundaries. They can support effective material consumption and resource extraction and create value through the provision of services but not of products. A proper design for recycling aims at avoiding hazardous chemicals; longer transport distances and the emissions. Thereof long distances can be replaced by shorter ways with less emissions to the nearby recycling plant or second-hand shop.

Gillabel et al (2021) emphasise that shifting companies towards a circular economy is crucial to reduce the environmental impact of textile consumption. The implementation of CBMs can be approached as part of their corporate social responsibility policy. In the raw material procurement phase of the textile life cycle, CBMs help reduce the consumption of energy, water, land and chemicals, as well as reduce the production of waste. During the production and distribution processes, digitalisation offers opportunities to radically reduce resource consumption for the production of textiles and packaging, but also for transport.

5.2.3 Strategic advantages and opportunities for and motivation of CBM.

According to EMF, reducing the cost of materials lowers a company's variable costs. There is also environmental and social value to be gained, which in the linear system is currently not accounted for but should be accounted for in a truly circular and sustainable system. That means, the more value creation occurs in the inner circle of the EMF's model, the greater the savings in embedded costs (externalities) and thus the greater the profitability. Furthermore, circular business models open up the possibility for additional revenue streams and sales markets. For example, value creation can be increased by investing in durable and recyclable fibres in combination with a take-back system for post-consumer textiles. Another possibility is to use a garment multiple times, e.g. in leasing, for repair services or through monetisation on the second-hand market. In addition, a company can obtain a higher market price for products with higher quality or for unique pieces of customised production. With the European Circular Economy Strategies, CBMs could have access to subsidies or other incentives provided by the policy makers and thus support the transition to the circular economy.

Of strategic character are aspects such as competitive advantages by doing "something different" than competitors, a better stock price performance, customer loyalty, and resilience against constraints in the availability of imported raw materials. As both consumers and manufacturers are currently paying more attention to sustainable consumption and production, companies could create green jobs and reduce environmental impact (Elander et al, 2016). By doing so, they can make consumers feel good about "actively taking part in a new system that provides sustainable solutions" (CTP, 2015) and thereby meet the expectations of new customers. A CBM could act as a risk mitigation concept and provide with greater resilience against volatile markets. For example, active participation in the second-hand clothes market reduces dependencies on global value chains. EMF provides information on the benefits, growth expectations and investment opportunities of CBMs on the circular investment opportunities of the industry (EMF, 2020).

Among the driving forces for companies to innovate in circular business models in the textiles system are "the creation of closed textile loops to ensure future raw material supply and reduce the pressure on virgin resources; profit-making opportunities; an aspiration to create a more sustainable mindset, including reduced consumption, among their customers; the creation of green jobs; and responding to direct customer demand, for example for repair services" (Gillabel et al, 2021).

5.2.4 Limitations and hurdles

Despite the advantages mentioned above for CBMs compared to linear business models, circular activities are often hardly competitive outside existing market niches. It could be argued that the main reason for this is because social and environmental costs are not sufficiently monetized or reflected in product prices.

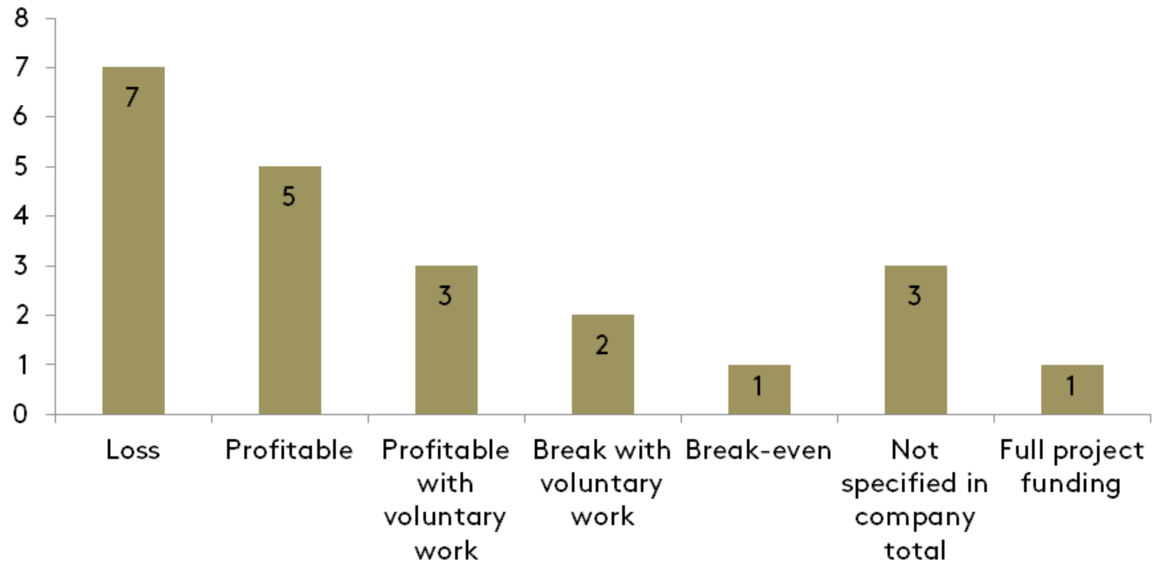
The cost of new textile products imported from low-labour cost countries by big volume buyers remains very low and dominates the textile product market in the EU. CBMs are generally small scale operations that will struggle to compete against larger companies due to economies of scale and a global and competitive supply market for virgin fabrics and semi-manufactured products.

The complexity of the global supply chain makes it difficult for final product producers to guarantee compliance with certain social or environmental criteria further up the supply chain. On the other hand, social and environmental criteria in the supply chain for CBMs would be almost irrelevant, because their starting materials would be second-hand clothes or textile waste.

With producers following a more linear business model, a lack of mandatory social requirements for textile products on the EU market means there is no need for producers to invest in long-term supply contracts or to have better control over their full supply chain. Instead, producers can simply choose the best offers when needed, often from intermediaries. Consequently there is no need to pay extra via indirect costs associated with supply chain verification by schemes such as ILO, GOTS or Bluesign or with the underlying guaranteed salaries of workers in the supply chain.

Environmental impacts are not monetized either. For example, textile production is not covered by the Emissions Trading Scheme (Directive 2003/87/EC) in the EU and even if it was, it might only make textile production in the EU even less competitive than in countries not covered by a similarly ambitious Emissions Trading Scheme. The potential of PEF to calculate an overall environmental footprint could offer a potential route to trying to monetize environmental impact of textile products in the future – but such an approach would only really make sense if it was mandatory to report on PEF for all related products on the EU market in the first place. Furthermore, there is no environmental cost associated with the disposal of textile waste, which is free for consumers and currently makes little difference to public authority waste management costs. This situation could potentially change if extended producer responsibility schemes involved take-back or buy-back commitments – although this very development itself could potentially hamper independent CBMs in cases where all unwanted or damaged apparel was being first passed through the retailers via EPR.

Figure 31: Current profitability of exemplary business models in the textile sector (n=22)



Source: Elander et al. (2016)

The reasons are multiple: From an economic point of view, the production of high-quality products is usually associated with higher raw material costs, i.e. for garments designed for longer periods, better fibre materials and fabrication must be used. Such high-quality materials cause a higher retail price on the one hand but offer a cost saving potential on the other side. Nevertheless, especially in the textile sector, the abundance of possible service ideas that can be offered on the market is limited, as the products themselves (garments) are usually not particularly sophisticated. And new clothes are too cheap to justify the effort of recovering old product components, such as buttons, for reuse.

The contemporary method for accounting value and record in balance sheets does not fully reflect the immaterial benefits that CBMs bring to society. The performance of services and indirect strategic advantages such as environmental savings are more challenging to evaluate; thus, it is more difficult to advertise with.

Regulations and policy incentives as well as established business practices of other economic actors are often not pronounced to support current CBMs, e.g. there are open questions regarding ownership, logistic, trade and hygiene regulation and responsibilities (incl. different end-of-waste criteria definitions).

The concept of the circular economy requires a broader shift in consumer thinking (CTP, 2015) towards greater acceptance of services associated with durable and reusable clothing. Up to the time at which CBMs will have become mainstream, they will rely on consumers who bring a high level of idealistic commitment. Therefore, it remains a challenge to attract new customers for CBMs, as such a concept-oriented market is slow to develop (Circle Report). Communicating new types of circular services to consumers requires the development of a marketing strategy that focuses on the value added to the consumer rather than the conceptual ideas behind the circular economy.

In addition, industry partnerships and collaborations along the value chain need to be established, which might be challenging considering the global value chains and diverse consumer segments and needs. As long as companies in the textile industry generate most of their revenues from linear economic operations (sales of new consumer products), CBMs will remain dwarfed and could not become economically viable because they may depend on cross-subsidisation (CTP, 2015). Elander et al (2016) identified other than financial barriers, notably practical barriers (73 %), awareness and communication difficulties (68 %), legal barriers (18 %) and technical barriers (10 %).

5.2.5 Options for improvement

The rapid growth of customer to customer sales platforms has shown how CBMs with a clear and direct economic benefit do not require any special promotion, they are self-propagating and do not need any intervention or improvement. Repair-based CBMs are self-propagating in certain cases (e.g. with high-end garments) but face significant barriers in higher labour cost countries if the products to be repaired are relatively inexpensive, Regardless, the potential benefit of new green jobs in the repair sector is worth consideration. There are also some cultural barriers about wearing the same clothes over long periods of time and of course the constant pressures of changing fashions.

Access-based CBMs for the leasing of clothing articles tends to be limited to high value clothing articles that would only be used for special occasions. From an environmental perspective, the advantages of using such one garment much more intensively in comparison to producing 40 identical garments that are only used once per year by their owners, are clear. Scaling up this model would result in a shift of jobs from raw material production stages to the customer-facing, repair and cleaning stages of the sector. In fact, dry-cleaning in an environmentally friendly manner would be an important area to avoid potential trade-offs and further increase the environmental benefits of access-based CBMs over full individual ownership models. Access-based models can be a win-win from an economic perspective if the ratio between rental price and purchase price is well chosen. A clear understanding of insurance conditions is also needed, perhaps similar to the model with car rental. However there may be some sentimental barriers that prevent further penetration of these CBMs (e.g. wedding dresses).

To help overcome some of these economic, social and cultural barriers, the clear communication of the social and environmental impacts of textile product consumption and the potential benefits delivered by different CBMs, both to consumers and to actors in the textile sector, is crucial.

Being sustainable is becoming fashionable in the garment industry but with this desirable trend comes the risk of green-washing. Circularity has to be understood as being a major part of sustainability and the different facets of circularity need to be explained. The use of simple language is needed in educating policymakers, investors and potential consumers so that the benefits and added value of CBMs can be easily grasped and incorporated into public and corporate social responsibility policies. In terms of public policy, this could be driven by a carrot style voluntary approach (e.g. ecolabel criteria or fiscal incentives) or by a stick style approach (e.g. selective tax raises or ecodesign style mandatory requirements) at Member State level.

There is a need for strategic planning involving both public and private organisations in terms of textile waste management infrastructure and logistics. Existing networks are set up to focus primarily on obtaining the best second-hand clothing. The leftover material tends to go towards open loop recycling or for energy recovery at best. For the foreseen additional waste textiles that will be collected in coming years, there is a need for investment in sorting and recycling capacities to ensure that these textile wastes can be recycled in closed loops (i.e. going back into textile products) and not just end up being incinerated or landfilled.

Improvement potentials across the whole textile value chain are analysed by Manshoven et al (2019). One important area for improvement is the design phase of new clothing. The literature suggests several circular design strategies: enhancing the consumers emotional attachment[53] to products can be instrumental to prolong a products lifetime, choose high-quality fabrics, timeless colours that are easy to combine, user instructions, maintenance kits and spare parts, stitching instead of gluing, removable zippers and buttons, etc.

In manufacturing, emphasis can be placed on cleaner production through more efficient production processes. This can be realised through various means beside energy efficiency, e.g. the manufacture of products can use more innovative technologies. New technologies can make use of a distributed network with optimised digital communication of machines via Internet of Things. Local production, additive manufacturing (use of 3D printers) could also be named. On the other hand, material efficiency through secondary raw material use, reduction of production waste, and the reuse of components could boost circularity in manufacturing.

5.3 Examples of good practice concerning circular business models in the textile sector

5.3.1 Scope of the assessment

This section provides an aggregated overview of CBMs in the textile system, compiled from examples of companies promoting their products and services in relation to the key elements of the circular economy. The purpose of this analysis is to provide an empirical basis (albeit limited in scope) for the SWOT analysis (see section 6). The first step was to compile a mapping list of CBM examples of companies that advertise products or services whose value proposition aligns with the activities described in the “butterfly” model (EMF 2012). Business models that do not conform to the “butterfly” model were not selected, even if they provide social and environmental positive impacts.

[53] This refers to the consumer's feelings about a product. It is assumed that a consumer is less likely to throw away a product that carries pleasant emotions, such as nice memories. Thus, emotional attachment is seen as instrumental to reducing waste.

This initial list of business examples was anonymised, and aggregated information on their respective business models were derived. This list represents the inclusion list (see Table 21). It is structured in five categories of circular activities: Reduce, Reuse, Repair, Redesign, Recycle, also called the "five R's" grouping (Grimstadt et al. 2015), (Ted Europe 2021). It should be noted that not all business models which are categorised under "Recycle" were analysed in detail, but only those that do not overlap with Task 2 objectives and other EC ongoing research projects on textiles recycling (Watson 2018a). The compilation of CBM includes only those cases in which a business activity promoted in the context of circularity constitutes a core component of a company's value proposition.[54] Excluded from the list are cases where the circular activity is more like a marketing tool for customer retention in an otherwise linear business environment.

Table 21: List of keywords / phrases to identify companies implementing CBM in the textile system (based on EMF's "butterfly" model of the circular economy)

1. Reduce	2. Reuse/ share/ redistribute	3. Repair	4. Redesign/ upcycle/ repurpose	5. Recycle
- Design product for long life - Tailor product to specific users - Extended guarantees - Supplier guidance for use optimisation	- Assist Consumer-toconsumer (C2C) sharing of wardrobes - Assist C2C resell of products - Leasing/rental of own products - Leasing/rental of other products - Take-back and resell of own products - Collection and resell of other products	- In-brand repair services - Independent repair services - Contractual arrangements for repair - Assist customers in doing own repairs	- Redesign and resell of unsold collections - Producing new clothing from used fabrics - Sale of products with bio-based content	- Design for ease of recycling (design for disassembly, understanding composition of materials, modular design, reducing hazardous substances) - Take-back of own products and recycle into new products - Sale of products with recycled content - Traceability actions

Source: own definitions

It was found that the inclusion list still leaves some room for business models that either do not contribute to the general idea of the five types of activities performed by circular business models (compare Table 21 and Figure 1) or were deemed to be too much of a special case. For this reason, some exclusions criteria have been set up (see Table 22).

While both, profit and non-profit organisations are within the scope, governmental initiatives and authorities were excluded. It is assumed that for the leather and fur sector, business models comparable to the clothing sector-specific models exist. Therefore, unless CBMs exclusively for leather and fur are discovered during project work different from CBMs in the textile sector, they were not specifically addressed in the analysis. Leather and fur materials in textile products were considered in the same way as other textile products, but no particular focus was placed on their circularity (notwithstanding the existence of other sustainability aspects, which were excluded).

Non-clothing textile products such as carpets, upholstered furniture and technical textiles are not included in this analysis. Business models only addressing individual aspects as described in Table 22 below are out of scope. It was found that even if exclusion criteria were applied, the compilation of companies matching the scope of this study became too long if the geographical scope was not limited to the EU (28).

[54] A company's value proposition tells potential customers why they should buy its products or services, rather than its competitors' offerings.

Table 22: Exclusion List

Types of organisation	Governmental organisations
Types of products	- Leather and fur unless the business model is highly relevant to circular economy and hitherto does not exist for textile products - Carpets, upholstery and technical textiles - Smart textiles
Exclude models that only concern	- Cleaner production unless this specifically concerns emissions of persistent chemicals that could inhibit recycling - Initiatives to give rise to social benefits / workers' rights improvements unless they also have a dedicated circular economy aspect - Use of 'greener' alternative materials (such as organic fibres), unless these are: 1) more durable 2) more recyclable 3) contain closed-loop recycled content (bottle to recycled fibre are excluded) - Development of regulations or policy instruments - National/regional EPR systems - Development of technology unless this is instrumental for the business when selling a product or service

Source: own definitions

5.3.2 Methodology

The inclusion criteria describe all conceivable circular business models in the textile sector, compiled from the literature review. These different business models have been contrasted against practical examples that create value by applying circular business models. The empirical approach of compiling a list of companies performing circular activities (the five "R"s) was chosen in order to assign CBMs of concrete companies to one of the five categories of circular activities. By assigning the businesses to CBMs, it became possible to filter out the most relevant business models within the framework of the matrix analysis. This selection process helps prioritise the CBMs which are then further processed in this section. The following explains all steps in detail.

A list of circular businesses was developed in part making use of the following resources:

- Stakeholder recommendations made during the first stakeholder meeting.[55]
- European Circular Economy Stakeholder Platform (Clothing and Fashion industry), accessible online under https://circulareconomy.europa.eu/platform/en/sector/clothing-and-fashion-industry (data interrogation on 19th of February 2020).
- European Clothing Action Plan (ECAP) participants and initiatives presented in ECAP's "Circular Textiles. Ready to market", chapter "Boosting Circularity Examples" (ECAP 2019).
- The global fashion agenda (network of the private sector) (Globalfashionagenda 2020).
- German Sustainable Textiles Alliance (a multi-stakeholder initiative) (Partnership for Sustainable Textiles 2020).
- Scientific literature: e.g. Elander et al. (2016), CTP (2015), Watson et al. (2014), Grimstad et al. (2015).
- Nordic Council of Ministers: 10 Nordic brands engaged in textile-to-textile recycling (Diva-Portal 2021).
- The consultants' expertise.
- Recommendations from relevant stakeholders.

All information on enterprises extracted from the above sources was compiled in a provisional list subject to their compliance with the inclusion criteria. Thereafter, the compilation was examined against the exclusion criteria. The provisional list consists of 92 items, ten of which were subsequently removed after applying exclusions (see 5.1). The final list of enterprises in scope contains 82 items. For each of these enterprises, a short description of their business concept is included and links to more information are provided. Furthermore, the business models' position within the circular business model framework was outlined according to the Circular Economy "butterfly" diagram (see Figure 1), comprising the five categories "Reduce-Reuse-Repair-Redesign-Recycle".

55 Find the protocol of the meeting in the BATIS Stakeholder Platform.

Difficulties arose during the compilation of the list and the categorisation into these five categories: It was found that the decision whether a particular business is to be included on the basis of the analysis of its marketing or of a third-party description is a highly subjective process. For instance, it was doubtful whether to include (social) enterprises focusing on collection and redistribution of post-consumer textiles. Their contribution to the circular economy highly depends on the treatment and destination of the used textiles after collection. Another difficulty arose in determining the degree to which circularity plays a role in the business operations of a company, i.e. whether it is a unique selling point or just a subsidiary aspect of value creation in a conventional business. This was the reason why a differentiation between primary and secondary business operations became necessary.

"Primary" means that circularity-related activities are the unique selling point or represent the core of value creation of an enterprise (even if a company does not advertise the word "circular"). In contrast, "secondary" means that circular business operations run parallel to conventional ones, or that at least a dual value creation takes place in that company. Some large fashion retailers, for example, offer their customers the possibility of returning used textiles, which merely serves the purpose of customer retention rather than the implementation of the concept of circularity. This could address e.g. different needs in assistance, support, etc. Finally, one should acknowledge that the CBMs list represents a snapshot of businesses that either use online marketing instruments (making them more visible to the research community) or use circularity-related keywords in their public communication. Traditional tailor shops and local neighbourhood repair services that do not use online advertising or have online advertisement in a language different from English, German or Danish[56] may not be representted in the list by reflecting their number on the market accurately. Hence, the list is not at all-encompassing and, even with regard to the presented business models, some data might be missing (e.g. years of initiation of an enterprise).

The matrix organises the CBMs mentioned in the inclusion list according to their position in the value chain, so that a business model can always be linked to one of the five R's and one step in the value chain (see matrix in chapter 5.3.3.2).

For a selected group of cases, factsheets were prepared, inter alia, on the basis of interviews conducted with experts in the field of circular business models.[57] Factsheets on the TOP 5 Circular Business Models can be found in Annex B to this report.

5.3.3 Analysis

5.3.3.1 Longlist of enterprises and statistical analysis

In the following, the statistical analysis of the enterprises included in the mapping of CBM examples list helps provide a broader view of business models diversity and the rationale of their existence. It is important to bear in mind that the post-consumer textile sector may include a large number of companies and initiatives that have not been identified as being circular, since the relevant keywords have not been used in advertising, or because these companies/initiatives are not part of the networks that were the basis for the compilation.

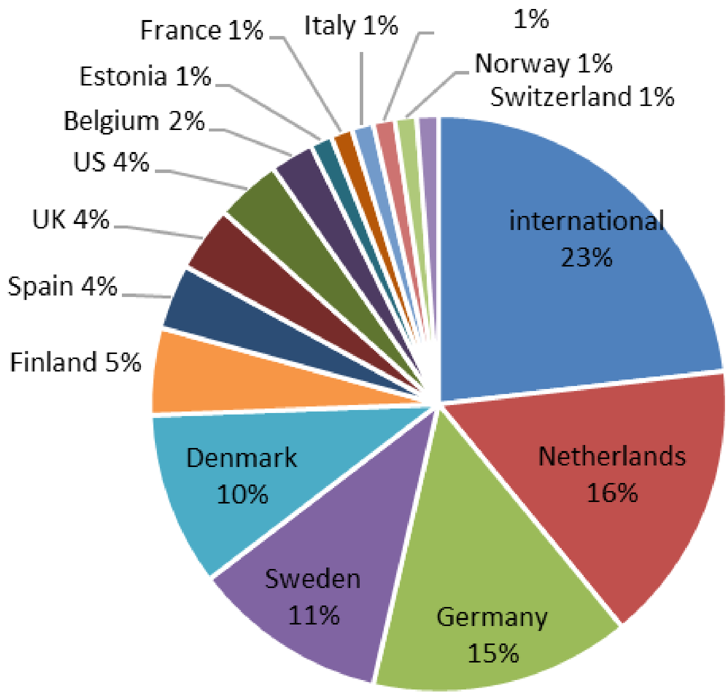
In general, the list consists to 67 % of primary and to 26 % of secondary businesses. For 7 %, it is unknown whether they generate profit exclusively via a circular business model or not.

Figure 32 shows how circular business models contained in the list are distributed over different countries. One quarter (23 %, 19 initiatives) are operating on an international level, meaning that they are multinational companies. Half of the businesses (52 %) are located in the Netherlands, Germany, Sweden or Denmark. This is because circular business models were in the focus of studies that have been published at an earlier date. The last quarter of business models is located in various other European countries.

[56] Those are the languages which were used when compiling the mapping list of CBM examples.

[57] E.g. the European Environmental Agency has published a report on circular business models with the textiles industry: Gillabel et al (2021): Business Models in a Circular Economy, Eionet Report -ETC/WMGE 2021/2

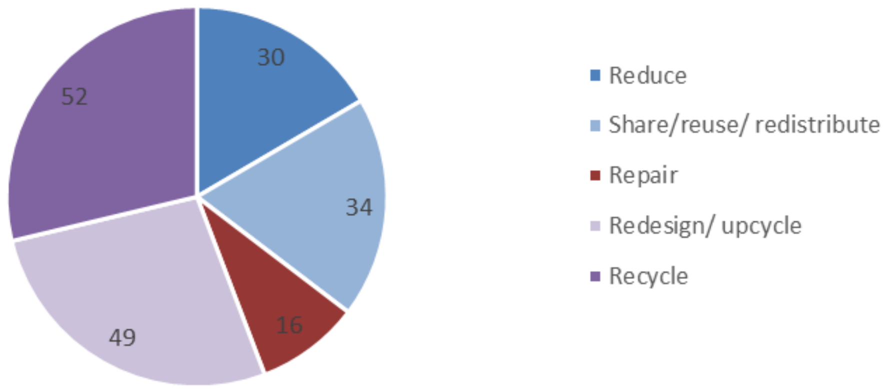
Figure 32: Businesses in the list per country (n=82)



Note: The category "international" applies if a multinational operating business model is meant.
Source: own graphic

Figure 33 represents the distribution of elements of the Circular Economy within the businesses in the mapping list of CBM examples. For initiatives providing various services, double counting is possible.

Figure 33: Distribution of elements of the Circular Economy



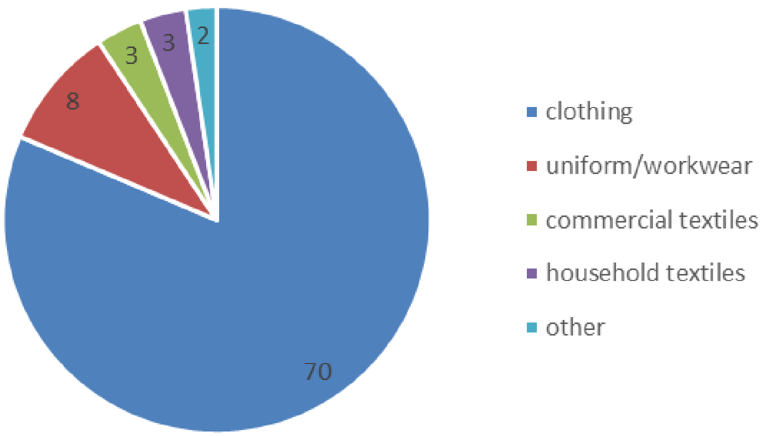
Note: Double counting is possible when for initiatives falling under several categories/ provide various different services.
Source: own graphic

As can be seen in

Figure **33**, recycling and upcycling make more than 50 % of the total. However, the inner circles of the circular economy butterfly wing (blue categories in the graph above) should be prioritised following the rationale of the waste hierarchy[58]: The further inside the circle, the higher on the level of the waste hierarchy.

The inclusion and exclusion of five "R" criteria leave room for different textile product types that could be addressed through the business models. However, clothing is the product type which most of the business models in the list focus on (~80 %). Other types of textile products are workwear, commercial textiles (e.g. hospital bedsheets) and household textiles, as indicated in the Figure below.

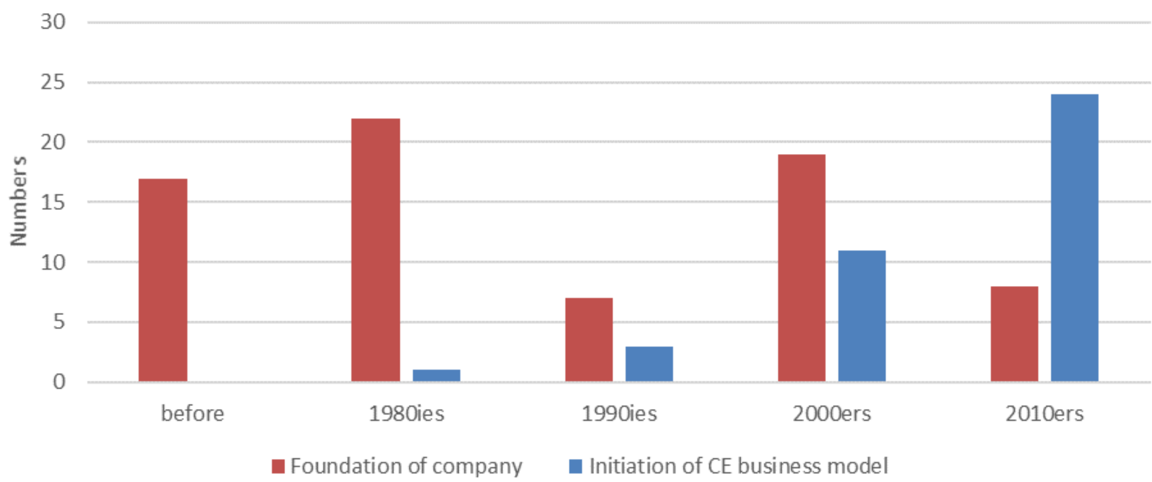
Figure 34: Distribution of textile product type included in the businesses



Note: Double and triple counting is possible in cases where an organisation is active in several categories
Source: own graphic

Figure 35 illustrates that a growing number of enterprises have adopted a circular business model over the course of time. However, the number of such companies has only significantly increased from the 2010s onwards. Most of the enterprises on the list were founded before 2010, but most of these companies have not yet developed a business model that prioritises and implements circular economy aspects in. Only during the last 10 years, the relationship between foundation and the initiation of a circular campaign has been reversed, which means that, from then on, existing companies started to focus on circular and sustainable sales strategies.

Figure 35: Foundation of companies and initiation of circular business models per decade



[58] The waste hierarchy refers to the 5 steps included in Art. 4 of the European Waste Framework Directive (Directive 2008/98/EC): Prevention – Reuse & prepare for reuse – Recycle – Recover - Disposal

Note: Respectively, for 43 and 27 initiatives years of initiation of CE business model and of foundation of the company were unknown
Source: own graphic

5.3.3.2 Matrix analysis of circular business models

Table 23 shows a matrix that organises a CBM in accordance to the different R's of the EMF Butterfly Model in columns while the rows represent the position of a CBM within the value chain, namely design – production – trade – use – post-consumption waste management. Those CBMs that do not belong to any of the R's either to the circularity or to any level on the value chain, were assigned to the category "others" and were sorted at the end of each row and column. In the cross sections of the boxes, the business ideas (items from the inclusion list) are listed, each of which can be assigned to the value chain stage (life cycle scale) and the corresponding "R" (scale of circularity).

The entries from the list that pursue or implement the respective business idea are then assigned to the business ideas in the boxes. A number coding of the entries from the list rather than the mentioning of the full names of the companies has been chosen to make the table more comprehensive. The number coding can be found in the legend below the table. Summarising, this makes it possible to structure and analyse the business models from the mapping list of CBM examples in more detail, and finally provides the reasoning for the selection of business modes to be analysed further.

Table 23: Selection Matrix on circular business models

	Reduce	Share/ reuse/ redistribute	Repair	Redesign/upcycle/ repurpose	Recycle	Others
Design	Design for durability and long life (high quality fibres)	/	Design for disassembly Design for repair	Redesign of unsold collections (new tailoring, use of the fabric, use as spare parts)	Design for recyclability Design for disassembly Understanding composition of materials Reducing hazardous substances Recyclable materials	/
Production	/	/	/	Producing new clothing from used clothes, fabrics, yarn	a) Produce based on recycled content (from recycled fibres) [59] b) Pre-consumer waste recycling	a) Management of supply chain / Transparent supply chain b) Social standards c) Produce-based on bio-based content / "sustainable fibres" d) Environment-friendly production
Retail / Distribution	Customised production On demand production Extended guaranties	Leasing/rental of own products Leasing/rental of other suppliers' products Deposit	Contractual arrangements for repair Independent repair service In-brand repair service	resell of unsold collections	/	consultancy for circular retail business models circularity label

[59] From recycled textiles

	Reduce	Share/ reuse/ redistribute	Repair	Redesign/upcycle/ repurpose	Recycle	Others
Consumption [60]	Supplier guidance for optimal use and handling (e.g. washing instructions)	Assist C2C sharing of wardrobes and resell of products	Assist consumers in doing own repairs	/	/	/
Post-consumer waste [61]	/	Collection and resell/rent of own used products Collection and resell of others' products	/	Collect/ Take back and upcycle[62] (*)	Collect/ Take-back and recycle[63]	a) Collection for charity reasons b) Waste traceability

[60] incl. C2C 2nd life and repair
[61] incl. B2C 2nd life
[62] Existing fabrics are used in comparison to "collect and recycle" where it goes down to fibers
[63] Material can be used as secondary raw material for different products not only clothing

The first aspect of the analysis to be considered is the number of entries per box. For this purpose, the following Table 24 was created. It shows the same rows and columns as the selection matrix (Table 23). The cells now indicate the number of CBMs counted per box. Totals were calculated per row and column. The colours code the total number per row and column going from green (lowest amount counted) to yellow, orange and red (highest amount counted).

Table 24: Matrix analysis: Numbers of examples per box and sums per row and column with colour coding with respect to the highest numbers

	Reduce	**Reuse**	**Repair**	**Upcycle**	**Recycle**	**SUM**
Design	6	-	3	-	8	**17**
Production	-	-	-	-	27	**27**
Retail	3	14	7	-	-	**24**
Consumption	4	5	6	-	-	**15**
Post-C. Waste	-	9	-	16	17	**42**
SUM	**13**	**28**	**16**	**16**	**52**	

Note on Table 24: The colouring indicates the number of CBMs counted per column and row going from green (lowest count) to yellow, orange and red (highest count)
Source: own compilation

Some BMs were attributed to the category "others". These can be grouped into the BMs that address

1. Sustainability, but not circularity, e.g. bio-based content and environmentally friendly production. (18 BMs).
2. Social criteria, e.g. transparent supply chain management, social standards for workers and collection for charity reasons (7 BMs).
3. Circularity, but not attributable to one of the R's: consultancy for circular retail business models in the textile sector, circularity label promotion (2 BMs).

It was decided to exclude BMs that focus on sustainability and on social compatibility from the matrix analysis for two reasons: first, to focus the result on the circular economy criteria, and second, since these BMs could not be assigned to the five "R" categories on the circularity scale.

Several observations emerged:

- Overall, both the last column and the last row contain the vast majority of BMs that can be described as "circular." This means that initiatives that focus on recycling of post-consumer textiles are the most common. On the life cycle, the CBMs that build upon the use of recyclates are in second place. The "recycling" criterion does not necessarily mean that the recycled feedstock originates from recycled textiles. More commonly, recycled polyester originated from recycled PET bottles. This is more like cascade recycling, rather than the making textiles circular.
- Second on the scale of circularity are businesses models that are promoting reuse. This is mainly an aspect of the retail stage where sharing and rental services are allocated. However, reuse can also be addressed in the consumption and post-consumption stage.
- The cells in table 24 that list most examples are in descending order: "Products with recycled content" (27 examples), "take back and recycle" (17) or "upcycle" (16) and "rental services" (14 examples). The results suggest that many BMs feature product take back and use recycled content in the production.
- A significant number of business models address sustainability issues in different ways. While this is a desirable direction for the sector, it is not considered a primary aspect of the circular economy and therefore plays only a marginal role in this analysis.
- The second aspect to be described is observations regarding the distinction between primary and secondary BMs. To this end, the matrix analysis was performed once more, considering primary BMs and secondary BMs separately. Overall, there were more primary than secondary models.

Table 25: Matrix analysis of only the primary CBMs: Numbers of examples per box and sums per row and column with colour coding with respect to the highest numbers

	Reduce	Reuse	Repair	Upcycle	Recycle	SUM
Design	6	-	2	-	6	**14**
Production	-	-	-	-	13	**13**
Retail	2	12	5	-	-	**19**
Consumption	1	3	6	-	-	**10**
Post-C. Waste	-	6	-	13	9	**28**
SUM	**9**	**21**	**13**	**13**	**28**	

Note: lowest count: green; yellow and orange: medium count; red: highest count
Source: own compilation

Compared to the matrix which includes both, primary and secondary business models, no difference can be observed in the distribution of evaluated businesses on the circularity scale. This means that a comparable share of the businesses was found in each of the R-categories. At the life cycle level, however, the second most common phase is the retail phase where the high number of rental and sharing businesses becomes relevant.

Table 26: Matrix analysis of only the secondary CBMs: Numbers of examples per box and sums per row and column with colour coding with respect to the highest numbers

	Reduce	Reuse	Repair	Upcycle	Recycle	SUM
Design	-	-	-	-	2	**2**
Production	-	-	-	-	12	**12**
Retail	-	1	3	-	-	**4**
Consumption	3	2	-	-	-	**5**
Post-C. Waste	-	3	-	3	6	**12**
SUM	**3**	**6**	**3**	**3**	**20**	

Note: lowest count: green; yellow and orange: medium count; red: highest count
Source: own compilation

Comparing the two tables (25 and 26), it becomes clear that along the value chain, secondary business models[64] are mainly associated with the "production" stage. The most common campaigns are those on recycled or sustainable fibres. Furthermore, many initiatives can be assigned to a combination of the categories "other" and "production". These business ideas are not exclusively related to CE but are rather an indication that many BMs consider some aspects relating to circularity and sustainable consumption.

Another aspect to consider is that only one third of the enterprises use the word "circularity" (and synonymous words) in their marketing, although all of the 82 BMs fulfilled the inclusion criteria. In this respect, there seem to be country-specific differences: While a BM in one country benefits from depicting the "circular" character of his/her business, consumers in another country are not so much triggered by circular economy but only by elements such as "recycling" or "sustainability" or lifestyle-related incentives.

5.3.3.3 Unique value propositions of circular business models

CBMs differ in terms of value creation from business models in the traditional apparel industry that relies on fast fashion trends and mass consumption. When compiling the list, a number of unique selling points that

[64] See the definition in chapter 5.3.2

distinguish CBMs from their linear operating competitors have been identified. The analysis is based on the information retrieved from companies' and initiatives' marketing statements (i.e. from their websites):

1. Value creation in circular business models is often based on provided **services** such as leasing and repair. This attitude is quite common in use of commercial textiles, however, there are also examples where this principle applies to fashion and clothing.
2. In terms of of value creation, circular business models are often implemented by a **community of entrepreneurs and supporters/customers,** either within the brand or within a consumer segment. This is especially true for brokerage companies that bring together potential users of second-hand clothing with previous owners of used clothing. For instance, a community-based social media campaign matched pre-owners and interested buyers of second-hand products.
3. The idea of sustainable consumption in the circular economy context often constitutes the crucial driving force for businesses to thrive within a sustainability-oriented community. While clothing repair, reuse and sharing is not a new invention per se, **circularity forms the** "reason-to-be" of some initiatives, mostly implemented by social entrepreneurs.
4. Virtual or physical **proximity** of circular businesses enables direct communication between entrepreneurs and customers. One example of this is a take-back service that initiates multiple one-to-one exchanges between a customer and the brand. Other companies provide mass customisation or individual repair support.
5. **Targeting** a small consumer segment (e.g. baby clothes) or **specialisation** on certain products (jeans, underwear & socks, …) is another characteristic of the business models.
6. At the same time, circular business models often include certain **sustainability** standards and ecological or fair-trade offers. That explains why business models are directed towards informed customers interested in sustainability, who are aware of the negative effects of fast fashion.

5.4 Discussion

5.4.1 Circular business models in the textiles sector

The evaluation of circular business models shows that "good practices" are the oldest and most common ones: mending, sewing, repairing, sharing, donating, and second-hand use. Many CBMs focus on the end-of-life phase and facilitate the collection of post-consumption textiles and their valorisation as second-hand goods. The increased use of recycled content in the production of new fibres can be interpreted as the least burdensome manner to move from a linear to a cyclical business model. Before apparel designers and fashion brands begin to redesign their products considering recyclability and durability aspects, a demand (market pull) for durable, repairable, reusable and recycled clothing needs to be developed. However, from the point of view of the large fashion industry, such features of commercial products are only "nice to have", unless reuse, repair or recycling turn into a competitive advantage. To this end, the markets set the scene, meaning that creation of a market for second-hand and reparable products and products containing recycled fibres is key to the success of circular economy businesses on the market.

In today's apparel retail market, CBMs have been introduced by some retailers as a mere add-on to the predominantly linear business models. The purpose of this undertaking is usually to improve brand reputation and consumer loyalty as the take-back of old garments can be advertised as a socially and environmentally sound practice. Moreover, the take-back offerings are crucial to attract consumers to visit the store.

It was shown by DEPA (2016), that in the case of a big clothing brands the take-back program was seen as a means to increase the in-store traffic and consumer loyalty. Furthermore, if customers receive a discount voucher when they return clothes and free up space in their wardrobes it is more likely to buy again, which increases sales. CBMs are thus abducted to the advantage of the linear model. CBMs are also sometimes promoted in a blanket way, e.g. when an existing business model is promoted as "circular" without doing much to reduce textile waste. For example, leasing companies provide customers with new products instead of reusing clothes from previous leasing cycles.

According to EMF, the further inside the circle of the five "R"s, the larger the savings of embodied costs, and thus, the bigger the potential to be profitable. Theoretically this is right, but practically this can be challenged as linear BMs mostly externalise embodied costs, e.g. for waste management and pollution from production.

For instance, one company analysed by CircularPP (2020) faced the "difficulty in competing with the pricing of competitors, […] when improving their production processes in terms of environmental and social protection", while "the traditional modus operandi of the fashion industry is based on environmental and social exploitation that allows bringing down prices." Moreover, some external costs may not even arise with poor working conditions.

Thus, EMF's argument might not always reflect accurately the common practice, and if linear models do not take external costs into account, then the argument that inner circles save external costs cannot be used as a motivation for CBMs. While there are many motivated enterprises switching to CBMs, some motivations should be questioned. For example, if the change is only aimed at gaining access to subsidies.

The aims should not be to make CBMs accessible only to the high-income population (Fontell and Heikkila, 2017). Against this background, the question remains whether CBMs really reduce material flows in the textile market in the short term: If companies switch to sharing and second-hand models, is it not rather a shift from the previous charity work and third-party business to the core business of the previous linear models?

Stakeholders also argued that CBMs have the potential to make clothing cheaper despite the increasing cost of primary resources, since the utilisation of a garment is improved. However, it is questionable whether the savings in material costs will influence consumer prices, as other costs could increase in return, such as e.g. logistics costs.

The study "Avoiding blind spots" (EEB, 2020) addresses certain risks of CBMs in general, which focus on the four topics of social, market-related, environmental and governmental risks. **Social** blind spots are identified mainly with regards to labour conditions and wage protection in supply chains and warehouses, as well as regarding the fact that CBMs will not contribute to a socially more equal access to products and services due to digital and financial restrictions.

When rental services were to supersede businesses that offer repair and reuse services, recycling of textiles could be more profitable than resale. Rebound effects can occur, however, if take-back offers for used products are used as a customer loyalty or marketing instrument and combined with discounts for new products. This would be an incentive for more consumption rather than a reduction in consumption. Quality assurance and consumer acceptance could also play a role. Several environmental risks of circular business models were found by EEB (2020), an argument is that despite that circular and sustainable aspects are often combined, CBMs will not inherently be environmental-friendly business models, thus, they might not necessarily change the material base of the products. Products can still contain a high share of polyester fibres and material blends which are sourced back to fossil fuels.

Recycling processes are not scalable yet and are energy-intense; they will not necessarily explicitly address water use and pollution, land use and human toxicity risks from hazardous materials. Another risk could be associated with reverse logistics (online) purchases which are thought to develop even more in CBMs and transportation because of sharing. Finally, at the end of multiple lifetimes, products might improperly be disposed of resulting in low recovery and recycling rates.

Additionally, a CBM is not inherently solving other than environmental problems, e.g. they will not necessarily change the current wealth, profit and power distribution, nor address gender equality for low-skilled vs. high-skilled workers and male leadership. Ultimately, it remains to be shown whether the spread of circular business models in the textile sector contributes to the overarching goal of CE, the decoupling of economic growth and resource consumption (see EEB, 2019).

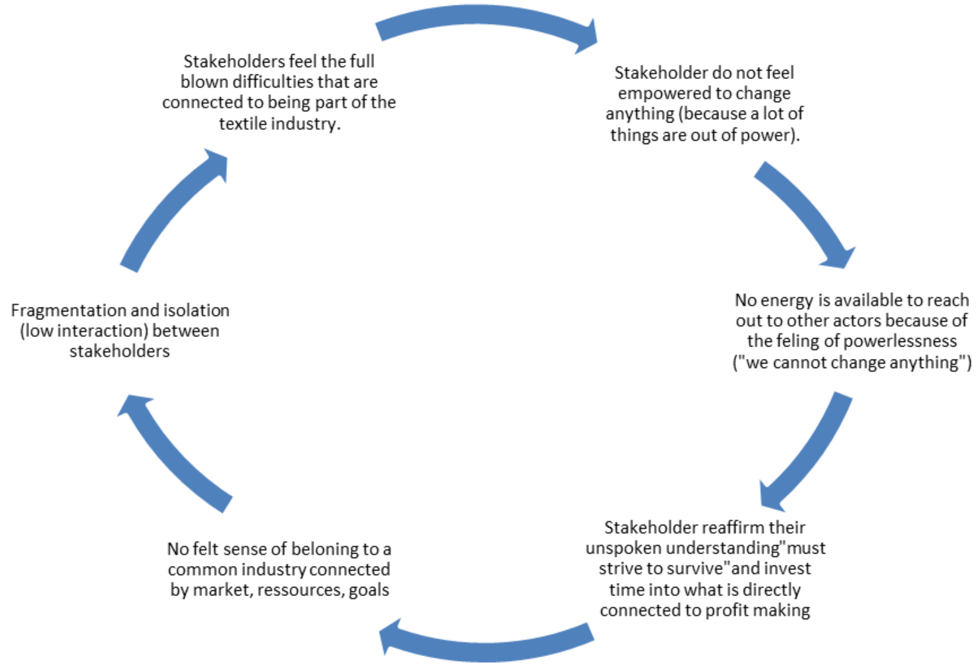
5.4.2 Political and societal context

Based on the EU Strategy for Sustainable Textiles (see chapter 3.1) the transition to a more circular textiles industry can take place in the following three areas: business models, policy actions and consumer behaviour. While task 3 focuses on business models rather than consumer behaviour, during the first stakeholder working group meeting in March 2020, stakeholders suggested to include the consumer perspective into circular business models and also pointed out that business models should be seen in the context of the over-arching production and consumption system.

5.4.2.1 Policy action

In terms of policy interventions related to the economic framework in which circular economy models operate, stakeholders noted that the current linear economy makes it difficult for circular economy models to be adopted successfully. This, however, is not an obstacle related to the aspects of a CE model itself. The current business practices in the globalised economy hamper circular business models with a competitive disadvantage because they cannot externalise social and environmental costs to the extent the global textile industry does. Disadvantages for circular business models are likely to persist as long as the textile sector continues to externalise the costs of the environmental burden that are associated to textile products. Against this backdrop, Staicu et al (2018) outlined elements that may hinder the transition to a circular economy, shown in Figure 36.

Figure 36: Elements which hinder the transition to a circular economy



Source: Staicu et al. (2018)

In order to support a transition to a circular economy, the following examples of policies could be applied to one extent or another.

Table 27: Overview of examples of policy instruments that support the transition to a circular economy

Financial	Product policy	Waste policy	Enhancing cooperation
- Ad hoc investments and or detaxation - VAT reduction on second-hand goods and repair services - Investment in BAT - Tax on virgin material[65] - Grant or awarding of promising start ups - Subsidies	- Ecodesign requirements for reparability, durability, recyclability - EU Ecolabel - EU GPP - Recycled content targets - Quality / min. durability standards - Ban substances of concern to enhance recyclability - EPR (with eco-modulated fees)[66] - Product design policy with targets for enhanced reusability, reparability, recyclability	- Ban on production waste - Waste collection targets - Targets for recyclability - Assigning cost to waste disposal or incineration higher than costs for sorting and recycling	- Organize reverse logistics schemes by boosting cooperation of retailers - Shared logistics - Kick starting social initiatives and cooperations - Provide training at corporate level - Between raw material and waste material handlers - Access to technical information - Availability to spare parts and repair skills (at reasonable prices)

Source: own compilation

65 e.g. in the form of refunded virgin payments (RVP) schemes

66 Revenues from such schemes could be refunded to those producers that use recycled fibres in their products, e.g. proportionally to the share of recycled content (Elander, et al, 2017).

In terms of financial policy, measures related to taxes would be implemented at Member State level unless it relates to EU import tariffs. Grants and subsidies to promote circular activities and support investment in the EU textile sector could be awarded via regional, national or European funding mechanisms.

In terms of product policy, it is worth considering the potential role of ecolabels, public procurement, PEF and ecodesign. ISO 14024 Type I ecolabels have the potential to promote, in a voluntary manner, ambitious criteria that target circularity aspects related to product durability, design for reparability, design for disassembly and design for recyclability. However, ecolabels should be used to define and verify such aspects that are specific for textile products, and ideally based on textile-specific standards rather than generic standards. Ecolabels can really drive the market to improve and products designed for circularity can be recognised in different ways, depending on how the ecolabel criteria should be arranged or weighted. However, there is a need to build upon the useful work of the EN 4555x standards and develop clear methods and rating systems for textile product designs.

Green Public procurement (GPP) can be a powerful driver for incentivising green suppliers. The minimum technical specifications set in GPP criteria must reflect products and services that are already currently on the market, However, award criteria can be used to “test the market” in more ambitious circularity aspects. Such award criteria reward tenderers that can meet them by adding points to their bid but do not exclude tenderers who cannot meet them (but they will not earn award points for their tender). Examples in the Netherlands demonstrate that the business-to-business (b2b) suppliers of work wear are moving ahead and become more circular in contrast to businesses in the business-to-consumer (b2c) market segment. This is partly caused by public sector procurement tenders increasingly demanding more circular products, but also because, in contrast to the consumer market, the issue of quality of garments is more important for work wear and clever combinations between circularity and quality are sought. Considerations for Public Procurement in order to promote CBMs were studied e.g. in the ReBUS project (REBus, 2020) (funded by EU Life Programme) and CircularPP project[67] (funded by EU Interreg Baltic Sea Region Programme). Some relevant outcomes are summarised below:

- Consider the functionality of clothing as a service instead of the direct purchase of clothing articles;
- In public procurement, explore the feasibility of contract clauses for take-back guarantees for used clothing, such as uniforms or work wear; Consider end-of-life treatment that prioritizes, repair and resale or donation, and leaves recycling as a last option;
- Consider material choices and design (e.g. recycled material, mono-material clothing) when purchasing new clothing;
- Consider use-phase educational campaigns or the potential of some suppliers to provide a holistic service covering these aspects;
- Consider collaboration with partners dealing with local and regional collection, repair and donation;
- Consider the use of clothing managers that can facilitate keeping track of ensuring the responsible use/re-use of clothing.

Looking to potential future policies, the PEF methodology could have a significant impact on how EU Ecolabel criteria are developed and could potentially lead to PEF-based green claims being made on products. Such a policy instrument could perhaps be an effective tool for determining fiscal incentives/disincentives that aim to internalise environmental costs associated with textile products. The importance of reliable and accessible primary data for both textile production and for textile sorting and recycling is essential if the environmental benefits and trade-offs of textile recycling are to be well understood.

The possible future application of ecodesign type mandatory requirements for material efficiency in textile products could be stipulated if a suitable set of standards have been defined for assessing textile product features such as design for reparability, design for recyclability etc.

In terms of waste policy, there is a pressing need for intervention from public authorities to ensure that first of all, the infrastructure is in place to collect the major increases in post-consumer textiles. Each Member State will have to decide on which options they wish to employ, but this could be any one or more of: extended producer responsibility schemes for retailers or kerbside collection containers that are operated by public authorities, private companies or charitable organisations. Care will need to be taken about how the new collection system(s) will impact on existing operators in the sector.

The logistics necessary to deal with the extra collected textile waste will depend on what technologies and capacities are available for sorting and recycling textile wastes. Failure to prepare these capacities in time is

[67] Downloaded from http://circularpp.eu/wp-content/uploads/2019/11/WP2.2-report.pdf (last accessed 16.11.2020)

likely to result in very high percentages of post-consumer textile waste being collected separately only to be landfilled or incinerated together with mixed wastes.

5.4.2.2 Consumer behavioural change

Consumer acceptance of circular business models was analysed by two studies, inter alia:

- Gwodz et al (2017) analysed consumer behaviour patterns “in the purchase, use and maintenance, and discard phases”. The outcomes of this study are based on a survey (4617 adult consumers, aged 18–65) from four different countries (Germany, Poland, Sweden, and the U.S.) which we divide into five segments based on clothing consumption behaviour. In addition to differences in the purchase behaviour and a varying degree of openness to alternative business models, this research “identified differences in willingness to pay for clothing made of material that is more environmentally friendly than conventional fabrics” (Gwodz et al, 2017).
- The EMF (2020) remarks that they “indirectly engage with customers through our network partners (e.g. our #WearNext) (Ellen Macarthur Foundation, 2021) campaign in conjunction with the New York City Department of Sanitation, LWARB's 'Love not Landfill' campaign)” (Love not Landfill, 2021).

The success of any business model depends on two principal factors (i) being economically competitive and (ii) appealing to customers. Where the appeal to customers generates a perception of added value, this can fully or partially compensate for business models that are less economically competitive.

While most consumers realise that sustainable behaviour is good, this does not necessarily influence their own individual behaviour, which is often dominated by price signals, convenience and social factors. If demand for CBMs and products with recycled contents is going to increase beyond the current niches that they occupy, it is going to be necessary for them to become more economically competitive and/or for consumers to buy into the environmental and social benefits that CBMs can bring. Clear communication to consumers and simple concepts about sustainability in the textile sector are needed to educate customers.

There is a need to shift from potential social embarrassment about paying low costs for second-hand clothing from charitable organisations to questioning the working conditions and pay of workers who produced extremely low cost brand new textile articles. The prevalent attitude so far has been that cheap new products are “a bargain”, and viewed in a positive light.

Efforts to educate consumers to move towards a more circular approach with textile products should also recognise the differences in attitudes between males and females in general. For example, attitudes towards second-hand clothing have radically changed in recent years thanks to online peer-to-peer platforms where second hand clothing is directly advertised online by the owner and sold via the same platform. This has become especially popular among young female adults who share similar styles and tastes and can rapidly alter their wardrobes with maximum convenience from the comfort of their home. Such platforms can also have a social media element, enhancing the desire for users to build a good reputation.

The scope for positive impacts in improved circularity are much higher in some market segments and demographics than others. For example, clothing for small children, school uniforms and adolescents often becomes prematurely obsolete simply due to growth of the owners. However, some of these demographics are also acutely sensitive to peer judgment, where buying and wearing second-hand clothing could be perceived negatively. In a social context

6 Task 4: SWOT analysis

This section presents an analysis of Strengths, Weaknesses, Opportunities and Threats (SWOT) of the textiles production and consumption system in the EU. SWOT is a simple way of assessing how best to implement a strategy. The tool helps policy makers to realistically assess what can be achieved with a strategy and what they should focus on. This SWOT analysis specifically addresses the implementation of circular economy (CE) related business approaches in the European textile and clothing market and textile recycling sector against the background of the EU Sustainable Textiles Strategy. Based on the analysis presented in the previous sections of this study, a baseline scenario for "business as usual" in the EU textile and apparel market is compared to a scenario that assumes widespread implementation of CE in the EU textile sector. The focus is on existing and new business models that can put principles of the CE into practice. In this way, they contribute to reducing the environmental impact of textile consumption by reducing the amount of waste textiles. The results of the SWOT analysis serve to inform policy makers, economic actors and stakeholders about the possible success factors as well as obstacles to achieving CE at scale.

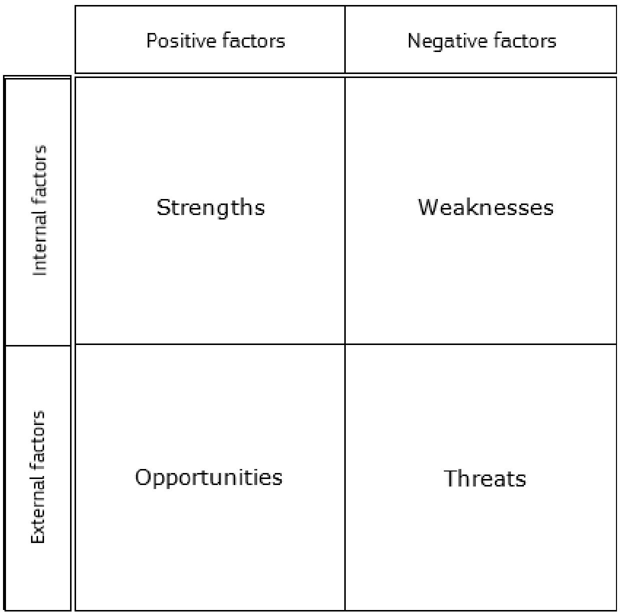
6.1 Methodological approach

A SWOT analysis is a method that is frequently used for strategic planning and foresight. The method's acronym "SWOT" refers to Strengths, Weaknesses, Opportunities and Threats, which are evaluated in relation to the situation of an economic actor and the success of a business model in a given context (e.g. market environment).

The SWOT assessment of a particular business option does not necessarily lead to a decision on a particular action. Rather, it can help to identify areas that need to be considered when planning the target. Whether the outcomes of a particular action are desirable or undesirable depends on the respective actor's attitudes as well on the societal and regulatory circumstances under which an undertaking takes place.

The evaluation criteria are usually mapped within a matrix that consists of four sections (Figure 37):

Figure 37: Elements of the SWOT matrix



In general, the four evaluation criteria are defined as follows:

- Strengths refer to an actor's internal resources that give it a competitive advantage in the contemporary marketplace.
- Weaknesses refer to an actor's internal circumstances that put it at a disadvantage in today's market.
- Opportunities refer to external circumstances and potentials that could be used to the actor's competitive advantage in the future.
- Threats refer to external circumstances or developments that could impose a competitive disadvantage on an actor in the future.

Normally, in a SWOT analysis, the four evaluation criteria are analysed from an actor-specific perspective. That means, a company for instance evaluates, which external and internal factors positively or negatively influence its current position in the market. This study, on the other hand, does not analyse concrete companies in their market environment, but takes a meta-perspective on the situation of abstracted business models under the different conditions of linear versus circular economic regimes. Rather than looking at individual companies in the market, the SWOT considers the situation of generic textile recycling businesses and emerging circular business models (CBM) at large. This abstract perspective on the aggregated textile and recycling sector helps to understand the implications of a potential shift from a linear to a circular economy, which is the consequence of a policy intervention as envisaged by the European Commission's Circular Economy Action Plan in combination with the expected EU Strategy for Sustainable Textiles (EC, 2021).

Against this background, the business models (BMs) of companies and textile recyclers in today's textile sector were compared with the BMs of emerging business models that aim to create value by implementing principles of CE. At this point it should be borne in mind that it depends on the economic and regulatory framework conditions, i.e. linear or circular economy, which result the SWOT analysis arrives at when considering one and the same business activity. For instance, a garment refurbishment business can do well in a linear economic environment because the market offers access to almost unlimited and low-cost feedstock of old textiles. In a circular economy, the amount of discarded post-consumer clothing would be much lower, depriving the refurbishment business of an important commodity. An advantage under the current linear economy could turn into a weakness when the circular economy system is fully implemented (and vice-versa). In order to capture the success factors and constraints of business models under the two different economic regimes, the SWOT analysis is therefore carried out on the basis of two scenarios:

- **A business-as-usual (BAU) scenario** stands for the contemporary linear economy approach in the textile sector. This means, the economy is driven by profit through the sale of textile products that are used and then discarded once they appear no longer useful and valuable. There would be no active policy intervention to encourage increased circularity in the EU textiles sector or detailed guidance about how to implement the requirements for collecting post-consumer textile waste.

- **A circular economy scenario** represents the implemented objectives of the European Commission's CEAP in the textile sector. This means, the opportunity to generate profit remains the key economic driver but the means of value creation should shift away from only selling new goods towards selling services (including sharing economy, repair and refurbishment services, as well as sorting and recycling of post-consumer textiles). This scenario is evaluated based on assumptions of how the respective actors would react to the changed circumstances.

In this sense, *Strengths* and *Weaknesses* refer to the status quo situation of the EU apparel market and recycling sector, reflecting the competitiveness of the industry in a predominantly linear organised market.

The *Opportunities* and *Threats* refer to the possible impacts due to a shift of the sector from linear to circular ways of operating. The opportunities and threats of the respective business models (linear or circular) are reciprocal. The term 'threat' is here interpreted as a risk that may emerge from prospective changes in the economic and regulatory environment, such as resource scarcity, increasing waste prices, extended producer responsibility and consumer acceptance.

The term 'risk' is defined as "the effect of uncertainty on objectives", according to the international risk-management standard ISO 31000. The definition applies a neutral evaluation of the term 'risk', seeing a risk as something that must be accepted in order to achieve goals.

This definition of the term 'risk' (and 'threat' for the matter of the SWOT method) hinges on two aspects:

1. **Uncertainty**: the limited knowledge on the modalities that influence the outcome of actions which are undertaken in order to achieve certain objectives. Uncertainty influences decision-making towards the course of action that is taken to realise objectives.
2. **Objectives**: the intended goal of actions. Objectives are actor-specific and can differ widely among actors, stakeholders, bystanders, regulators and the society as a whole. From an undertaker's perspective, the objectives could be phrased as 'harnessing economic benefits to make profit'. This applies under both the linear and the circular economic systems. From a societal perspective, the objectives are perhaps more complex, and could be stated as 'increasing societal and environmental wellbeing by closing loops in textile material flows, preventing resource depletion, and reduce the generation of textile waste'.

In the context of this study, the overarching goal against which the SWOT analysis takes place is interpreted as a paradigm shift from a linear to a circular economic system. This derives from the objective of European Commission's Action Plan for a Circular Economy: "*to accelerate the transition towards a regenerative growth model that gives back to the planet more than it takes, advances towards keeping its resource consumption within planetary boundaries, and therefore strives to reduce its consumption footprint and double its circular material use rate in the coming decade.*"

In the following section, the current BAU scenario of the textile and clothing market and the textile recycling sector in the EU is assessed on the basis of the results of Tasks 1 to 3 (as presented in Chapters 3 to 5). The focus is on clothing and textiles produced, imported and used (task 1) or processed at end of life according to the practices described in task 2. In addition, the circular business models detailed in task 3 are evaluated under the assumption that they currently operate in a market niche within the predominantly linear economic environment. The same analysis is then performed for the circular economy scenario, assuming that the majority of companies in the textile sector follow this approach. For better readability, the results of the SWOT analysis are not presented in the four-quadrant matrix, but in the form of a bulleted list.

6.2 Results of the SWOT analysis

6.2.1 Business-as-usual scenario: linear economy

Table 28: SWOT of the European textile industry operating in a linear economy

Strengths	- EU textile companies operate on a global scale, exercising control over the top level in the textile supply chains. - Well-established supply chain and retail systems, both set up for linear operation with large and fast throughput of new fashion collections. This can be seen as a self-stabilising lock-in effect leading to market dominance. - Dominance of big fashion brands on the market combined with retail system. - Cost savings due to scale logistics and the possibility to externalise social and environmental costs. - The textile industry located in the EU is specialised on technical textiles and high-quality garments, there is more profit to gain than with clothing, home-textiles etc. - Technical and functional innovation in the specialty fashion sector (e.g. functional out-door clothing, smart textiles).
Weaknesses	- The large share of textile imports indicates a high dependence of the EU on global supplies of raw materials and finished products, especially with regard to agricultural-based fibre raw materials and cheap labour in developing countries. - Dependence from textiles imports for consumption in the EU hampers sustainable supply chain management. - Relatively low technical and functional innovation in the fashion sector is compensated by fast changing design features. - Domestic EU production contributes only a minor share of the sectors total turn-over.
Opportunities	- High market demand for low-priced fashion products caused by very short life cycles and high replacement rates of fashion products due to rapidly changing design trends and decreasing

	physical product quality - EU consumers have relatively high purchasing power and willingness to consume low-cost fashion products. - Continuously high demand for short-lived fashion products due to: o Consumers' cultural habit of fashion shopping as a leisure activity o Consumers' cultural habit to value new fashion with brands over physical product quality of clothing o Consumers' general preference for new clothes as opposed to a certain aversion to second-hand clothes, possibly attributed to the perception of used cloths displaying lower social status - Consumption of second-hand clothing remains generally low compared to consumption of new clothing although there are a few examples of where this exceeds 15 % of consumption (Baltic States) - The absence of legal obligations, such as extended producer responsibility, helps to externalise social and environmental costs.
Threats	- Vulnerability of the textile sector, which is adapted to mass sales, against crisis-related disruptions in sales, and reduced consumer confidence, as observed during the Covid 19 lockdown. Consequence is stockpiling of unsold commodities that turn to waste unused. - Future legislative changes in waste law may impose extended producer responsibility that entails stricter obligations for the take-back and recycling of post-consumer textiles. - High degree of fragmentation and globalisation in the whole textile value chain makes it difficult to implement more sustainable/circular approaches and better social justice and workers' rights. - Increasing drought and soil degradation due to global warming threatens agricultural cotton production in key growing countries. Consequence can be shortages in supply of fibre raw materials followed by increasing commodity prices. - Rising public awareness of microplastic pollution in the environment can lead to a decline in the consumer acceptance of synthetic fibres (such as polyester) and may lead to stricter legal requirements.

Table 29: SWOT of contemporary textile collectors, sorters and re-users/recyclers operating in a predominantly linear economy

Strengths	- A thriving collection and processing sector for post-consumer clothing for global reuse markets has existed for decades and is well established across much of Europe. - Large differences in average income and standard of living between global regions allow a cascade of used clothing from richer to poorer countries generating value for the collectors and sorters. - Strong knowledge of global second-hand clothing markets and economic viability of collection and sorting for these markets. - The used textile sector has in general a positive public image due to the large share of charitable organisations and social enterprises engaged in the sector
Weaknesses	- Only the best quality reusable textile fraction has any real economic value for used textiles collectors and sorters - Sorting for second-hand/reuse markets can only be carried out manually and is threatened by high wage levels in much of Europe. - Existing textile recycling technologies are mostly limited to low quality options such as cutting (of cotton-rich) textiles into industry wipes, use in insulation, upholstery padding or other low-grade and low value products. - Difficult ratio of return on investment hampers technological innovation in the textile recycling sector. - Automated sorting of non-reusable textiles by fibre type and colour to provide input to quality mechanical and chemical recycling is only just beginning to emerge at industrial scale
Opportunities	- Ready availability of post-consumer clothing due to mass consumption and very short service lives of new clothing - Consumers typically discard/donate clothing after relatively short usage leading to high value on global reuse markets. - Consumers are not aware of the commodity value of their used clothing and thus donate them, rather than selling them and gaining the value themselves (changing). - Advanced technologies for automated fibre identification, separation and recycling have been developed that could be scaled up for larger throughput processing of post-consumer textiles. - Increasing EU production of fibres indicates a potential domestic market for recycled fibres.
Threats	- In most EU Member States, a large percentage of post-consumer clothing still ends up as part of municipal waste and is not available for reuse or recycling. - Demand for second-hand clothing in Europe, especially western Europe is relatively low and only the top-quality clothing can be sold locally. - Consumers are beginning to see the commodity value of their best quality used textiles and are selling these themselves rather than donating them to textile collectors. - Decline in quality of products put on the primary market (fast fashion) is also undermining the economy of used textile collection and processing. - Global second-hand markets for used clothing are becoming saturated due to increasing supply of used textiles globally but stagnated demand further reducing prices for reuse - The definition of when the collection of used textiles is and is not defined as waste collection differs from Member State to Member State. This can cause legal obstacles to the collection and transport of used textiles across Europe. - Demand for recycled fibres and fabrics is low due to the low cost of virgin fibres and lack of producer and consumer interest in recycled content. - Many textiles are produced using fibre blends which hinders closed loop recycling. - There is a lack of information on the fibre composition and chemical content of post-consumer textiles. Collected textiles include products from thousands of different producers. This this makes it difficult to gather material inputs for advanced recycling technologies that require specific fibre composition. - The vast majority of clothing consumed in Europe is produced elsewhere. This presents logistics obstacles to closed-loop recycling of waste arising in Europe. - There is currently little planning reliability for investments in textile recycling and technical

	innovation due to lack of policy targets for circularity, and lack of data on the overall fibre composition of non-reusable textile waste - Data on current status of circularity in textiles is limited due to lack of EU-level requirement for reporting on the separate collection and treatment of post-consumer textiles. This inhibits optimal design of policy measures for increasing circularity

Table 30: SWOT of contemporary circular business models operating in a linear economy

Strengths	- CBM currently occupy a niche market that satisfies the demand for fair trade, organic and refurbished clothing. This niche market has been growing slowly but steadily. - Circular businesses are usually rooted in local communities / neighbourhoods, which gives them credibility and acceptance at a micro scale. Existing CBM appear to benefit from small but reliable demand by educated, socially and environmentally conscious consumers. - Enthusiasm of activists and non-profit initiatives to volunteer in developing circular businesses, raising public acceptance and educating consumers to generate a demand for sustainable, fair-trade and reusable clothing. - So far, circular enterprises exist on a small and local scale, so by and large they escape the fierce competition that characterises the mainstream apparel market. - An increasing number of established large brands are flirting with CBM as a side-line. These CBM can be backed financially by the brand until they can pay for themselves - CBM tend to operate close to the consumer and can thus be responsive to consumer needs
Weaknesses	- Internalisation of social and environmental costs (e.g. domestic labour costs, compliance to EU environmental standards) leads to higher market prices of circular products compared to linear ones. - Many CBM's in textiles are young start-ups with little previous business experience. - There is also a lack of knowledge in the sector on what works/does not work economically and commercially due to the sector's young age and small size
Opportunities	- Large potential availability of post-consumer textiles for use in CBM. European consumers purchase over 2.6 million tonnes of suits, jackets, coats, trousers, shirts and blouses each year, or over 6 kg per capita. These products have high potential for reuse and are typically found in second-hand shops across Europe. - Emergence of a new lifestyle among sectors of the younger generation that turn their backs on fast fashion, brand fetishism and mass consumption in general. Consumer trends increasingly cherish a sharing economy or sufficiency (being happy with fewer possessions). - Influencers in social media and communication of ideas, guidelines, etc via the Internet help the growing CB community in the EU (and internationally), to network, exchange ideas and further innovate. - A growing sharing economy from a wide range of sectors in organising and promoting sharing platforms and repair/rehabilitation enterprises upon which CBM in the textile sector can build/piggyback. Consumers who are already familiar with the idea of sharing and reusing other products could be more easily nudged to adopt these habits in the clothing sector as well. - Eco labels for textiles present potential to introduce CE requirements and sustainability claims. - Green public procurement provides opportunities for kick-starting CBM and further promotion of more circular textile services.
Threats	- The majority of consumers still perceive the idea of sharing clothes as something odd or nerdy (exception: high couture and costumes). - The majority of consumers still perceive second-hand clothing as something that is below their social status or that is not fashionable enough for them (possible exception: exclusive fashion or children's clothes). - Decline in quality of fashion products put on the primary market entails higher efforts in repair and maintenance of post-consumer textiles. - Significant and persistent competitive disadvantage of repair services due to low price of new clothing and textiles - Competition from traditional clothing recyclers and new economy-of-scale recycling technologies,

	such as chemical recycling could hamper the growth of CBM beyond their current market niche.

Regulators perspectives:

France is the only EU-member state (MS) with comprehensive reporting obligations on all used textile collection, including textiles that are not classified as waste. France is also the only MS that currently has an extended producer responsibility (EPR) scheme for clothing and household textiles (and shoes) (Sweden and the Netherlands plan to adopt EPR for textiles in the coming years).

Article 9 of the Revised Waste Framework Directive requires Member States to measure reuse according to a methodology developed by the European Commission in 2019. It also requires the EC, based on reporting by MS, to determine how reuse can be encouraged including through the adoption of reuse targets. Textiles is one of the key product groups identified for reporting by Member States in draft reporting methodology. The final methodology is yet to be agreed and no reporting has taken place in MS. --> High ambitions could encourage further efforts of the recycling sector to overcome current problems, meaning that resources could stay within the EU.

6.2.2 Circular economy scenario

Table 31: SWOT of the European textile industry operating in a circular economy

Strengths	- EU textile companies still operate on a global scale, exercising control over the top level in the textile supply chains. - Well-established supply chain and retail systems still exist but need to be adjusted to cope with product take-back and handling via return logistics. - Big fashion brands are likely to continue dominating the market and retail system. - Cost savings due to economy of scale logistics still apply but perhaps to a lesser extent. - Functional textiles and high-quality garments may gain in EU domestic demand. - In the new circular economy, locally placed businesses may have competitive advantages over brands based outside Europe in offering CBM to consumers.
Weaknesses	- Many linear-based blends will find the transition to a circular economy challenging requiring top management level commitment, new approaches to product design, material sourcing, meeting minimum quality standards etc. - An increasing focus on durable and re-usable clothing that is also repairable will reduce volume of consumption and force existing brands to look for new ways to make money. This can be higher prices for the higher quality garments, offering repair services and more.
Opportunities	- With higher availability of domestic supply with recycled fibres and fabrics, the dependence of producers on virgin resources with volatile prices will lessen. - Domestic value creation of the EU textile industry may increase as a result of relocating parts of the production chain back in the EU.
Threats	- Possibly lacking consumer acceptance of recycled content in fashion products and higher prices for higher quality products. - The introduction of extended producer responsibility and other regulatory / policy actions towards the circular economy of EU green deal may reduce the possibility to externalise social and environmental costs. This will lead to better cost truth in the market and curb the sale of low-priced, low-quality clothing.

Table 32: SWOT of contemporary textile collectors, sorters and re-users/recyclers operating in a circular economy

Strengths	- Established textile collectors, sorters and wholesalers are well-placed to take advantage of the new opportunities presented by a new circular economy and already have global value chains in place to sell reusable and recyclable textiles - Established collection and reuse actors may be able to outcompete start-ups if they move fast to adapt their business models.
Weaknesses	- Many contemporary collectors of used textiles, especially charitable collectors, may not be ready for the transition and need for flexibility and competitiveness in business models that the circular economy will bring. - VAT/tax-free status of charitable collectors may be challenged as calls for level playing field in a growing economic sector increase. - Automated sorting capacity for the large quantities of non-reusable textile waste that will become available is not in place and will require significant investments.
Opportunities	- The introduction of collection, reuse and recycling targets in the EU may increase the access to post-consumer textiles as a feedstock for sale on reuse and recycling markets. - Mandatory or voluntary eco-design criteria on durability, reparability and recyclability of textiles will increase the quality and value of the collected stock and improve economic viability of the sector. - Green public procurement, ecolabels and minimum standards for recycled content in new clothing would increase the market demand and price for recycled fibres and improve the economic viability of collection, sorting and recycling. - Circular economic thinking will become mainstreamed both in businesses and among consumers and demand for pre-used (second hand) clothing will increase in Europe. - Investment risk for new recycling technologies and facilities will be significantly reduced and large investors will place their money in these industries.
Threats	- Increased C2C exchanges of used clothing via CBM exchange platforms and competition from other circular businesses may reduce charitable and commercial collectors' access to the best quality reusable clothing and significantly undermine their business model. - Post-consumer collection targets in the EU could overwhelm capacity of the post-consumer textile sector. Investments in the expansion of sorting and recycling capacity will become necessary. - Recycling opportunities will be severely hampered by lack of information and traceability of the chemical content of post-consumer textiles. Could be solved through global introduction of RFID tags.

Table 33: SWOT of contemporary circular business models operating in a circular economy

Strengths	- Under changed market regime (circular) and favourable regulatory circumstances, the CBM will move out of a niche market and become mainstreamed - Existing CBM can harness their experiences and customer reputation to grow. - Small and local CBs can benefit from spatial proximity to customers and personal customer interaction. This lowers the transport distances and service response time. Upscaled CE enterprises should strive to anchor in spatial proximity to customers as this is an asset.
Weaknesses	- The up-scaling process in CBM will make these initiatives more commercial and profit-oriented, consequently limiting the access to volunteer work force, causing higher labour costs. - Growing out of a niche market will partly disconnect CBM from their initial customer base, which has been motivated by mere idealistic motives. Instead, the future customer base will be more sensitive to product price, service quality and convenience. - The present CBMs will lose a unique selling point as circular economy turns to be the default business concept.
Opportunities	- The increasing demand for repair and maintenance services for clothing is likely to create a huge opportunity for new jobs across the EU MS. This applies above all for local businesses (SME) but may also promote Internet-based CBM. The availability of quality clothing to the sharing, second-hand and repair businesses will increase and so does the market demand for such services. - Emerging CBMs may be more attractive to venture capital, as the circular economy offers them favourable market conditions and legal foundations.
Threats	- The up-scaling process in CBM is likely to increase internal competition and will consequently result in a selection process among CE enterprises according to market mechanisms. - SME-sized CBMs will compete with the established fashion industry and retail sector, which will also have to adapt to the circular system. These established companies will either imitate the entrepreneurial ideas of the small CBMs or develop their own circular services. Ultimately, the challenge for small CE enterprises to establish themselves in the market is the same as for all new enterprises.

References

Akı, S.U., Candan, C., Nergis, B. and Önder, N. 2020. Understanding Denim Recycling. A Quantitative Study with Lifecycle Assessment Methodology, in: Textile Industry and Waste edited by A. Körlü, Ege University.

Austrian Federal Environment Agency 2019. Verwertung von gesammelten Alttextilien. Ermittlung der Anteile von Altkleidern und Altschuhen zur Weiterverwendung, zum Recycling und zur Beseitigung von HUMANA People to People Österreich (Treatment of separately collected used textiles and shoes by Humana People to People in Austria). Umweltbundesamt. Vienna. Available at: https://humana.at/wp-content/uploads/2021/03/humana-people-to-people-oesterreich-studie-umweltbundesamt1.pdf

Austrian Ministry of Environment 2020. Die Bestandsaufnahme der Abfallwirtschaft in Österreich 2020 (Inventory of Austrian Waste Management). available at: https://www.bmk.gv.at/dam/jcr:04ca87f4-fd7f-4f16-81ec-57fca79354a0/BAWP_Statusbericht_2020.pdf.

Ballinger, A. and Hogg, D. 2015. The Potential Contribution of Waste Management to a Low Carbon Economy. Main Report. Eunomia Research & Consulting Ltd., Bristol.
Available at: https://zerowasteeurope.eu/downloads/the-potential-contribution-of-waste-management-to-a-low-carbon-economy. last accessed 05.05.2020

Bauer, B., Watson, D., Gylling, A.C, Remmen, A., Hauris Lysemose, M., Hohenthal, C. & Jönbrink, A-K. 2018. Potential Ecodesign Requirements for Textiles and Furniture; Nordic Council of Ministers. TemaNord 2018:535

Bhardwaj, V. and Fairhurst, A. 2010. Fast fashion: Response to changes in the fashion industry. In: The International Review of Retail, Distribution and Consumer Research Vol. 20, No 1, pp. 165–173. doi: 10.1080/09593960903498300.

Boston Consulting Group and Global Fashion Agenda 2017. Pulse of the Fashion Industry Report.

Boucher, J. and Friot, D. 2017. Primary microplastics in the oceans: A global evaluation of sources, In: IUCN International Union for Conservation of Nature, pp. 20-34. doi:10.2305/iucn.ch.2017.01.en.

Branchevereniging Kringloopbedrijven Nederland (BKN) 2021. 100 % Kringloop.
Available at: https://100procentkringloop.nl/over-branchevereniging-kringloopbedrijven-nederland/

Bukhari, M., Carrasco-Gallego, M. & Ponce-Cueto, E. 2018. Developing a national programme for textiles and clothing recovery. Waste Management and Research Vol 36, Issue 4, 2018.
Available at: https://journals.sagepub.com/doi/full/10.1177/0734242X18759190

BVSE 2020. Bedarf, Konsum und Wiederverwendung von Bekleidung und Textilien in Deutschland. Available at: https://www.bvse.de/dateien2020/1-Bilder/03-Themen_Ereignisse/06-Textil/2020/studie2020/bvse%20Alttextilstudie%202020.pdf

Circular economy 2021. Website. Available at: https://www.circle-economy.com/

CircularPP 2020. Case: Better World Fashion. available at: http://circularpp.eu/case-better-world-fashion

CTP (Circle Economy Program) 2015. Service-based BM & circular strategies in the textiles sector, available at: https://s3-eu-west-1.amazonaws.com/stjm/20160330092502/Service-based-business-models-and-circular-strategies-for-textiles-2015-SITRA-STJM.pdf (last accessed 13.07.2020)

Czech Republic 2017. Report on the implementation of the Waste Management Plan 2015-2016 available at: https://www.mzp.cz/C1257458002F0DC7/cz/plneni_narizeni_vlady/$FILE/OODP-Zprava_o_plneni_POH_CR_2015_2016_20170105.pdf

Dahlbo, H., Aalto, K., Eskelinena, H., Salmenperäa, H. 2017. Increasing textile circulation—Consequences and requirements. Journal of Sustainable Production and Consumption Volume 9, January 2017, Pages 44-57

Dutch Circular Textile Valley (DCTV) 2021. Wij verbinden, vernieuwen en versnellen de transitie naar circulair textiel en circulaire mode in Nederland. Available at: https://www.dutchcirculartextile.org/

Déchets infos 2019. Textiles: vers un réagrément à l'identique? 18.12.2019 Available at: https://dechets-infos.com/textiles-vers-un-reagrement-a-lidentique-4921480.html

Diva-Portal 2021. Textile-to-textile recycling - Ten Nordic brands that are leading the way. Available at: http://www.diva-portal.org/smash/record.jsf?pid=diva2%3A1147645&dswid=-3754

Doane, D. 2012. Living in the Background: Homebased Women Workers and Poverty Persistence. In: SSRN Journal. 2012, doi:10.2139/ssrn.1629273

Dubois, M., Sims, E., Moerman, T., Watson, D., Bauer, B., Egebæk, K., Bel, J-B, Mehlhart, G. 2020. Guidance for separate collection of municipal waste. Report by EY, PlanMiljø, ACR+ and Öko-Institut for the European

Commission. available at: https://op.europa.eu/en/publication-detail/-/publication/bb444830-94bf-11ea-aac4-01aa75ed71a1

ECAP 2019. ECAP and used textiles, June 2019. Available at: http://www.ecap.eu.com/wp-content/uploads/2020/04/B9_Del_Guidance-for-Textiles-Collections.pdf

ECAP 2021. http://www.ecap.eu.com/take-action/consumer-behaviour-change/

ECO TCL R&D Projects 2021. Roads to innovation – R&D Projects. Available at: https://refashion.fr/pro/sites/default/files/fichiers/Chemins-Innovation2019_EN_BD.pdf

Ecolabel 2021. 10 strengths: How the Nordic Swan Ecolabel and the EU Ecolabel promote circular economy. Available at: https://www.ecolabel.dk/en/why-choose-ecolabelling/circular-economy/10-strengths

Ecolabel Index 2021. All ecolabels on textiles. Available at: http://www.ecolabelindex.com/ecolabels/?st=category,textiles

EcoTLC 2019. Annual Report 2018. Available at: https://www.ecotlc.fr/ressources/Documents_site/EcoTLC_2018-Annual-Report_web.pdf

EcoTLC 2020. Annual Report 2019. Available at: https://refashion.fr/pro/sites/default/files/fichiers/ECO_TLC_EN_BD.pdf

EEB 2019. Decoupling Debunked. available at: https://eeb.org/library/decoupling-debunked/ (last accessed 12.04.2021)

EEB 2020. Avoiding Blind Spots. available at: https://eeb.org/library/avoiding-blind-posts-promoting-circular-and-fair-business-models (accessed 12.04.2021)

Elander, M. & Ljungkvist, H. 2016. Critical aspects in design for fiber-to-fiber recycling of textiles. Mistra Future Fashion report 2016:1 Stockholm: Mistra Future Fashion.

Elander, M., Sörme, L., Dunsö, O., Stare, M. & Allerup, A. 2014. Konsumtion och återanvändningav textilier. SMED rapport Nr 149 2014. Norrköping: Sveriges Meteorologiska och Hydrologiska Institut

Elander, M., Watson, D. and Gylling, A.C. 2016. Evaluation of business models for increased reuse, collective use and prolonged lifetime of textiles, for Mistra Future Fashion,

Ellen MacArthur Foundation (EMF) 2012. Towards the Circular Economy Vol. 1: an economic and business rationale for an accelerated transition. Available at: https://www.ellenmacarthurfoundation.org/publications/towards-the-circular-economy-vol-1-an-economic-and-business-rationale-for-an-accelerated-transition, last accessed 05.05.2020.

Ellen MacArthur Foundation (EMF) 2017. A New Textiles Economy: Redesigning fashion's future. Available at https://www.ellenmacarthurfoundation.org/publications/a-new-textiles-economy-redesigning-fashions-future last accessed: 04.02.2021.

Ellen MacArthur Foundation (EMF) 2020. 10 circular investment opportunities for a low-carbon and prosperous recovery. available at: https://www.ellenmacarthurfoundation.org/assets/downloads/Fashion.pdf (accessed 24.11.2020)

Ellen Macarthur Foundation 2021. WearNext - Make Fashion Circular joins forces with City of New York and fashion industry to tackle clothing waste. Available at: https://www.ellenmacarthurfoundation.org/news/wearnext-make-fashion-circular-joins-forces-with-city-of-new-york-and-fashion-industry-to-tackle-clothing-waste

Empirica 2014. The Need for Innovations in Business Models Final Policy Brief. Gesellschaft für Kommunikations- und Technologieforschung mbH. Available at: https://ri-policy-analysis.eu/fileadmin/ripolicies/documents/bmi/policy_brief/bmi_policy_brief_final_v2_5_with_errata.pdf

Ernst & Young 2015. Identification of technologies possible for support for waste prevention. Available at: https://www.mzp.cz/C1257458002F0DC7/cz/projekty_po8_opzp_2007_2013/$FILE/OODP-2_4%202_6_MZP_FIN-20160810.pdf

Esteve-Turrillas, F. A. and de la Guardia, M. 2017. Environmental impact of Recover cotton in textile industry. In: Resources, Conservation and Recycling 116, pp. 107–115.

EU Waste Framework Directive 2021. EUR-Lex Document 32008L0098. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0098

Euratex 2020a. Facts and Key Figures of the European Textile and Clothing Industry. Available at: https://euratex.eu/wp-content/uploads/EURATEX-Facts-Key-Figures-2020-LQ.pdf

EURATEX 2020b. ReHubs A joint initiative for industrial upcycling of textile waste streams & circular materials. Available at: https://euratex.eu/wp-content/uploads/Recycling-Hubs-FIN-LQ.pdf

European Clothing Action Plan (ECAP) 2019. Circular Textiles Ready to the market. available at: http://www.ecap.eu.com/wp-content/uploads/2019/02/Circular-Textiles-Ready-to-market-booklet.pdf, last accessed 22.07.2020

European Commission (EC) 2014. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Towards a circular economy: A zero waste programme for Europe (No. COM (2014) 398). Brussels, Belgium. available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52014DC0398, last accessed 04.05.2020

European Commission (EC) 2018. Behavioural Study on Consumers' Engagement in the Circular Economy. Prepared by LE Europe, VVA Europe, Ipsos, ConPolicy, and Trinomics.
Available at: https://ec.europa.eu/info/sites/info/files/ec_circular_economy_final_report_0.pdf

European Commission 2020a. Sustainability.
Available at: https://ec.europa.eu/growth/industry/sustainability_en (accessed 30.09.2020)

European Commission (EC) 2021. EU strategy for sustainable textiles.
Available at: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12822-EU-strategy-for-sustainable-textiles

European Commission (EC) 2021b. The Combined Nomenclature.
Available at: https://ec.europa.eu/taxation_customs/business/calculation-customs-duties/what-is-common-customs-tariff/combined-nomenclature_en

European Environment Agency (EEA) 2014. Environmental Indicator Report 2014: Environmental impacts of production-consumption systems in Europe. available at: https://op.europa.eu/en/publication-detail/-/publication/1cca7600-d5ba-4eac-a6bd-b89b5485cd00, last accessed 04.05.2020.

European Environment Agency (EEA) 2016. Circular economy in Europe — Developing the knowledge base. EEA Report 2/2016.

European Environment Agency (EEA) 2021. A framework for enabling circular business models in Europe, Briefing no. 22/2020.

European Parliament and Council 2011. REGULATION (EU) No 1007/2011 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 September 2011 on textile fibre names and related labelling and marking of the fibre composition of textile products and repealing Council Directive 73/44/EEC and Directives 96/73/EC and 2008/121/EC of the European Parliament and of the Council. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011R1007&from=DA

Europroms 2008. Europroms User Guide on ProdCom data.
Available at: https://ec.europa.eu/eurostat/documents/120432/4433294/europroms-user-guide.pdf

Eurostat 2019. Where do our clothes come from? available at: https://ec.europa.eu/eurostat/web/products-eurostat-news/-/EDN-20190422-1, last accessed 04.05.2020

Eurostat 2020. EU population in 2020: almost 448 million.
Available at: https://ec.europa.eu/eurostat/documents/2995521/11081093/3-10072020-AP-EN.pdf/d2f799bf-4412-05cc-a357-7b49b93615f1

Eurostat 2020a. Circular economy – Overview. Available at: https://ec.europa.eu/eurostat/web/circular-economy (accessed 30.09.2020)

Eurostat 2021a. Statistics on the production of manufactured goods. Available at:
https://ec.europa.eu/eurostat/web/prodcom/data/database

Eurostat 2021b. International trade in goods, focus on Comext. Available at:
https://ec.europa.eu/eurostat/web/international-trade-in-goods/data/focus-on-comext

Eurostat 2021c. International trade in goods – aggregated and detailed data. Available at:
https://ec.europa.eu/eurostat/cache/metadata/en/ext_go_agg_esms.htm

FFact 2020. Massabalans textiel 2018. Onderzoek naar de massabalans van het in Nederland ingezamelde afgedankte textiel en de route en resultaten van de verwerking. Report commissioned by Rijkswaterstaat – WVL, Ministerie van Infrastructuur en Waterstaat

Fontell, P. and Heikkila, P. 2017. Model of circular business ecosystem for textiles, VTT Technical Research Centre of Finland. Available at: http://ethica.fi/en/circular_business_ecosystem_for_textiles/

Fråne, A., Askham, C., Gíslason, S., Kiørboe, N., Ljungkvist, H., McKinnon, D., & Rubach, S. 2017. The Nordic textile reuse and recycling commitment – a certification system for used textiles and textile waste. Nordisk Ministerråd. TemaNord 2017:545

Gazzetta Ufficiale 2020. DECRETO LEGISLATIVO. 3 Sept. 2020, n. 116. Available at: https://www.gazzettaufficiale.it/eli/id/2020/09/11/20G00135/sg

Gillabel, J., Manshoven, S., Grossi, F., Mortensen, F.L., and Coscieme, L. 2021. Business Models in a Circular Economy, Eionet Report -ETC/WMGE 2021/2.
Available at: https://www.eionet.europa.eu/etcs/etc-wmge/products/business-models-in-a-circular-economy

Global LCA Data Access 2021. secondary LCA datasets available for textiles or textile processes. Available at: https://www.globallcadataaccess.org/search?query=textiles&page=3

Globalfashionagenda 2020. Forum for sustainability in fashion.
Available at: https://www.globalfashionagenda.com/ (accessed 13.07.2020)

Gram-Hanssen, I., Brodal Johansen, I. J., Askham, C., Rubach, S., & Valente, C. 2017. Forbrukerundersøkelse: Arbeidspakke 1 i Redesign QR prosjektet. Østfoldforksning rapport for Fretex

Greendeals 2021. B-14 2 Green Deal inzameling textiel. Available at: https://www.greendeals.nl/sites/default/files/downloads/GD142-Duurzame-inzameling-textiel.pdf

Grimstad K.I., Laitala, K., Schragger, M., Follér, A., Paulander, E. et al. for NORDEN 2015. Mapping sustainable textile initiatives. And a potential roadmap for a Nordic action plan. http://dx.doi.org/10.6027/TN2015-545

Gwodz, W., Nielsen, K.S., Müller, T. 2017. An Environmental Perspective on Clothing Consumption: Consumer Segments and Their Behavioral Patterns. Sustainability, 9(5), 762, https://doi.org/10.3390/su9050762

Hultén, J., Johansson, M., Dunsö, O., Jensen, C. 2016. Plockanalyser av textilier i hushållens restavfall, En kartläggning av mängder och typ av kläder, hemtextilier och skor. Report by IVL and SCB in Swedish for SMED. Re2240-15-007

IDEA 2021. proprietary database from Japan. Available at: http://idea-lca.com/?lang=en

Implementing Decision 2019/1004. Annex V of Implementing Decision (EU) 2019/1004. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019D1004&from=EN

Interreg North-West Europe 2018. Industry reference Sheet Fibersort. Retrieved from Interreg North-West Europe: https://www.nweurope.eu/media/8337/fibersort-industry-reference-sheet-updated.pdf

Interreg North-West Europe Fibersort 2021. Fibersort: Closing the loop in the textiles industry. Available at: https://www.nweurope.eu/projects/project-search/bringing-the-fibersort-technology-to-the-market/

ISO 31000 — Risk management, ISO/Guide 73:2009(en) Risk management — Vocabulary. Available at: https://www.iso.org/obp/ui/#iso:std:iso:guide:73:ed-1:v1:en

IVL Svenska Miljöinstitutet 2021. Miljöministern besöker IVL:s textilsorteringsanläggning; Pressmeddelande - 14 November 2017 08:30. Available at: https://www.mynewsdesk.com/se/ivl_svenska_miljoinstitutet_ab___/pressreleases/miljoeministern-besoeker-ivl-s-textilsorteringsanlaeggning-2270012

Joint Research Centre - JRC 2010. International Reference Life Cycle Data System (ILCD) Handbook - General guide for Life Cycle Assessment - Detailed guidance. First edition March 2010. EUR 24708 EN. Luxembourg.

Jonker, J., Kothman, N. Faber and Montenegro Navarro N. (eds.) 2018. Organising for the circular economy, A workbook for developing Circular Business Models. Available at:
https://circulareconomy.europa.eu/platform/sites/default/files/organising_for_the_circular_economy_ebook.pdf

JRC 2014. Environmental Improvement Potential of Textiles. Joint Research Centre Scientific and Policy Reports. European Commission.

JRC 2020. EU Green Public Procurement (GPP) Criteria for Textile Products and Services Guidance Document. Joint Research Centre of the European Commission. Available at:
https://ec.europa.eu/environment/gpp/pdf/200406_JRC120265_eu_green_public_procurement_criteria_for_textile_products_and_services_guidance_document.pdf

Kirchain R., Olivetti E., Miller T., Greene S. 2015. Sustainable Apparel Materials: An overview of what we know and what could be done about the impact of four major apparel materials: Cotton, Polyester, Leather, & Rubber. In: Resources 3 (1), S. 319–339. DOI: 10.3390/resources3010319.

Kirchherr, J., Reike, D., Hekkert, M. 2017. Conceptualizing the Circular Economy: An Analysis of 114 Definitions. Resources, Conservation & Recycling 127 (2017) 221–232.

Kösegi 2018. Applications and markets for post-consumer textiles.

Koszewska, M. 2018. Circular Economy — Challenges for the Textile and Clothing Industry. In: Autex Research Journal 18 (4), S. 337–347. DOI: 10.1515/aut-2018-0023.

Légifrance 2021. Article 541-10 in the French Environmental Code. Available at: https://www.legifrance.gouv.fr/affichCode.do?idSectionTA=LEGISCTA000023268652&cidTexte=LEGITEXT000006074220&dateTexte=20150819

Ljungkvist, H., Watson, D., & Elander, M. 2018. Developments in global markets for used textiles and implications for reuse and recycling. Rapport for Mistra Future Fashion. available at: http://mistrafuturefashion.com/wp-content/uploads/2018/05/Mistra-Future-Fashion-2018-4H.-Ljungkvist-D.3.3.4.1.pdf

Lounais-Suomen Jätehuolto 2021a. Lightening the load for tomorrow's world. Available at: https://www.lsjh.fi/fi/

Lounais-Suomen Jätehuolto 2021b. Nordic countries' first large-scale end-of-life textile refinement plant to open in Paimio in 2021. Available at: https://www.lsjh.fi/en/nordic-countries-first-large-scale-end-of-life-textile-refinement-plant-to-open-in-paimio-in-2021/

Love not Landfill 2021. Available at: https://www.lovenotlandfill.org/

MacDonald, S. and Meyer, L. 2018. Long Run Trends and Fluctuations in Cotton Prices. available at: https://mpra.ub.uni-muenchen.de/84484/

Manshoven, S., Christis, M., Vercalsteren, A., Arnold, M., Nicolau, M., Lafond, E., Mortensen, F.L., and Coscieme, L. 2019. Textiles and the environment in a circular economy. Eionet Report - ETC/WMGE 2019/6. European Topic Centre Waste and Materials in a Green Economy. available at: https://www.eionet.europa.eu/etcs/etc-wmge/products/business-models-in-a-circular-economy/@@download/file/2.1.2.4.%20ETC%20Eionet%20Report%20Circular%20Business%20Models_final_edited%20for%20website.pdf

Mazzei, C. 2020. Material textiles flows and value chains: Italian post-consumer textile and apparel market. Report for CNA Federmoda. Report submitted to Joint Research Centre.

Migiro, G. 2020. Top 10 Textile Importing Countries In The World, WorldAtlas, in Economics. Available at: https://www.worldatlas.com/articles/top-10-textile-importing-countries-in-the-world.html

Miljögiraff 2016. LCA of recycling cotton. Report number: 75. Hg. v. Miljögiraff. Gothenburg. available at: www.esu-services.ch/fileadmin/download/publicLCI/wendin-2016-LCA%20on%20Rec%20Cotton%20Miljogiraff%2075%20report%20for%20HM.pdf, last accessed 16.08.2020.

Naturvårdsverket 2016. Förslag om hantering av textilier – _Redovisning av regeringsuppdrag. Naturvårdsverket (Swedish EPA), available at: https://www.naturvardsverket.se/Miljoarbete-i-samhallet/Miljoarbete-i-Sverige/Regeringsuppdrag/Arkiv/Hantering-av-textilier/

Nørup 2019. An environmental assessment of the collection, reuse, recycling and disposal of clothing and household textile waste. PhD Thesis from Danish Technical University (DTU).

Nørup, N., Pihl, K., Damgaard, A., Scheutz, C. 2019. Evaluation of a European textile sorting centre. Material flow analysis and life cycle inventory. In: Resources, Conservation and Recycling 143, S. 310–319. DOI: 10.1016/j.resconrec. 2019.01.010.

OECD 2019. Business Models for the Circular Economy. Opportunities and Challenges from a Policy Perspective. available at: https://www.oecd.org/environment/business-models-for-the-circular-economy-g2g9dd62-en.htm

Oeko Institut and PlanMiljø 2020. Methodology for the reporting of re-use of products and rules for the reporting of reusable packaging: Report for European Commission. available at: https://op.europa.eu/en/publication-detail/-/publication/9878e12a-1bc4-11ea-8c1f-01aa75ed71a1

Official Journal of the European Union 2018. DIRECTIVE (EU) 2018/851 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 May 2018 amending Directive 2008/98/EC on waste (Text with EEA relevance). Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L0851&from=EN

Osterwalder, A. and Pigneur, Y. 2009. Business Model Generation. A Handbook for Visionaries, Game Changers, and Challengers.

OVAM 2017. Implementation plan for household waste and comparable industrial waste. available at: https://www.ovam.be/sites/default/files/atoms/files/HA-uitvoeringsplan-VR-20161609-def-LR.pdf

OVAM 2019. Huishoudelijk afval en gelijkaardig bedrijfsafval 2018: Opvolging van de indicatoren in het uitvoeringsplanpublicatiedatum. OVAM, Flanders.

OVAM 2020. Owards a circular economy monitor for Flanders: an initial interpretation. available at: https://www.ovam.be/sites/default/files/atoms/files/Towards%20a%20circular%20economy%20monitor%20for%20Flanders%20%20-%20an%20initial%20interpretation%20by%20OVAM.pdf

Oxford Economics 2018. Combatting Illicit Trade: Consumer Motivations and Stakeholder Perspectives

Palm, D., Elander, M., Watson, D., Kiørboe, N., Salmenperä, H., Dahlbo, H., Rubach, S., Hanssen, O.J., Gíslason, S., Ingulfsvann, A. S., & Nystad, Ø. 2015. A Nordic textile strategy: Part II: A proposal for increased collection, sorting, reuse and recycling of textiles. Nordic Council of Ministers TemaNord 2015:513

Palm, D., M. Elander, D. Watson, N. Kiørboe, H. Salmenperä, H. Dahlbo, K. Moliis, K.A. Lyng C. Valente, S. Gíslason, H. Tekie, S. Harris, T. Rydberg 2014. Towards a Nordic textile strategy: collection, sorting, reuse and recycling of textiles. Temanord Report for the Nordic Council of Ministers

Partnership for Sustainable Textiles 2020. A Multi-Stakeholder Initiative. Available at: https://www.textilbuendnis.com/en/uebersicht/ (accessed 13.07.2020)

Payet, J. 2021. Assessment of Carbon Footprint for the Textile Sector in France. Sustainability 2021,13, 2422.

Pihl, K. 2020. Assessment of textiles collection potential in Recycling Stations. Report published by Humana People to People

Probst, L., Frideres,L., and Cambier, B. 2016. Servitisation - Pay-per-use. Business Innovation Observatory, PwC Luxembourg.

REBus 2021. Your resource efficient business model journey. Available at: http://www.rebus.eu.com/implementing-a-rebm/guide-for-circular-procurement-rebms/ (last accessed 16.11.2020)

Recycling International 2020. International used clothing markets stifled. Article May 6th 2020. Available at: https://recyclinginternational.com/corona-virus/likely-surge-in-textile-scrap-collections-with-nowhere-to-go/30302/

RepaNet 2018. RepaNet-Tätigkeitsbericht und Re-Use-Markterhebung 2018 (RepaNet Activity and Reuse Report 2018). available at: https://www.repanet.at/repanet-taetigkeitsbericht-und-re-use-markterhebung-2018/

Repanet 2021. Website. https://www.repanet.at/

Rijkswaterstaat 2020. Samenstelling van het huishoudelijk restafval, sorteeranalyses 2019 (Composition of household residual waste, sorting analysis 2019). Rijkswaterstaat. Dutch Ministry of Infrastructure and Water. available at: https://www.afvalcirculair.nl/onderwerpen/linkportaal/publicaties/downloads/downloads-0/samenstelling-7/

Rivoli, P. 2005. Travels of a T-shirt in the Global Economy: An Economist Examines the Markets, Power, and Politics of World Trade. John Wiley & Sons, 1st April 2005.

Rreuse 2019. Vision for a New Fashion Season: Social and Circular, 16.12.2019. Available at: https://www.rreuse.org/vision-for-a-new-fashion-season-social-and-circular/

Rreuse Activity Report 2019. Rreuse Activity Report 2019. Available at: https://www.rreuse.org/wp-content/uploads/rreuse-final-activityreport19.pdf

Sandin, G. and Peters, G.M. 2018. Environmental impact of textile reuse and recycling – A review. In: Journal of Cleaner Production 184, S. 353–365. DOI: 10.1016/j.jclepro.2018.02.266.

Schmidt, A., Watson, D., Roos, S. 2016. Gaining benefits from discarded textiles. LCA of different treatment pathways. Copenhagen: Nordic Council of Ministers (TemaNord). available at: http://gbv.eblib.com/patron/FullRecord.aspx?p=4690709.

SIPTex 2019. Swedish Innovation Platform for Textile sorting (2016-2018). Available at: https://www.vinnova.se/en/p/siptex--swedish-innovation-platform-for-textile-sorting/

SMED 2018. Svenska textilflöden-textilflöden från välgörenhet och utvaldaverksamheter. Rapport på uppdrag av Naturvårdsverket Avtal: 2240-17-004På. available at: http://www.diva-portal.org/smash/get/diva2:1241255/FULLTEXT01.pdf

Sphera - gabi-database 2021a. Extension database XV: Textile finishing – GaBi Solutions. Available at: http://www.gabi-software.com/support/gabi/gabi-database-2020-lci-documentation/extension-database-xv-textile-finishing/

Sphera Solutions GmbH 2021. Process data set overview page. Available at: http://lcdn.thinkstep.com/Node/showProcess.xhtml?uuid=89863fd0-3306-11dd-bd11-0800200c9a66&stock=Free_GaBi_data

Spin it 2021. proprietary database from France. Available at: https://textile.cycleco.eu/auth.php#2

Staicu, D. and Pop, O. 2018. Mapping the interactions between the stakeholders of the circular economy ecosystem applied to the textile and apparel sector in Romania, Management & Marketing. Challenges for the Knowledge Society, Vol. 13, No. 4, pp. 1190-1209. DOI: 10.2478/mmcks-2018-0031

Swedish Government 2015. Circular Economy – elements for the new proposal. Non-paper 2015–06–26. available at: http://www.regeringen.se/49e7e9/contentassets/eb8110de24394134920d420fe30bc928/circular-economy--elements-for-the-new-proposal.pdf

Swedish Government 2019. Utkast till sakpolitisk överenskommelse mellan Socialdemokraterna, Centerpartiet, Liberalerna och Miljöpartiet de gröna, available at: https://www.socialdemokraterna.se/download/18.1f5c787116e356cdd25a4c/1573213453963/Januariavtalet.pdf

Swedish Government 2020. Producentansvar för textil – en del av den cirkulära ekonomin. Betänkande av Utredningen om producentansvar för textile. Statens Offentliga Utredninga. Stockholm 2020.

Sysav 2021. About the facility. Available at: https://www.sysav.se/en/siptex/#block4v

Ted (tenders electronic daily) Europe 2021. Available at: https://ted.europa.eu/udl?uri=TED%3ANOTICE%3A100659-2020%3AHTML%3AEN%3AHTML&tabId=1&tabLang=en

Teece 2010. Business Models. Business Strategy and innovation. Long Range Planning 43, 172-194.

Telaketju 2021a. Textile recycling. Available at: https://telaketju.turkuamk.fi/en/about-telaketju/

Textil Exchange 2021. Recycled Claim Standard (RCS) + Global Recycled Standard (GRS). Available at: https://textileexchange.org/standards/recycled-claim-standard-global-recycled-standard/

Umweltbundesamt (UBA) 2016. Jahrespublikation des Umweltbundesamtes: Schwerpunkte 2016. available at: https://www.umweltbundesamt.de/sites/default/files/medien/2546/publikationen/sp2016_web.pdf, last accessed 25.06.2020

Umweltbundesamt ProBas 2021. Prozessorientierte Basisdaten für Umweltmanagement. Available at: https://www.probas.umweltbundesamt.de

UN Comtrade Database 2021. Comtrade API for exports of CN code 6309. Available at: https://comtrade.un.org/data/

UN Environment Programme 2020. Sustainability and Circularity in the Textile Value Chain - Global Stocktaking. Nairobi, Kenya.

United Nations Economic Commission for Europe (UNECE) 2018. UN Alliance aims to put fashion on path to sustainability. available at: https://www.unece.org/info/media/presscurrent-press-h/forestry-and-timber/2018/un-alliance-aims-to-put-fashion-on-path-to-sustainability/doc.html, last accessed 04.05.2020.

Vinnova 2021. Swedish Innovation Platform for Textile Recovery (SIPTex) (2015-2016). Available at: https://www.vinnova.se/en/p/swedish-innovation-platform-for-textile-recovery-siptex/ ;

Wang, J., Kamath, N., Saurav, S. 2016. Handbook of Research on Strategic Supply Chain Management in the Retail Industry. DOI: 10.4018/978-1-4666-9894-9.

Watson et al 2018c. Inclusion of Nordic textile and fashion work within the UN One Planet network. available at: http://norden.diva-portal.org/smash/get/diva2:1289685/FULLTEXT01.pdf

Watson, D, Trzepacz, S. & Gravgård Pedersen, O. 2018b. Mapping of textile flows in Denmark. Danish Environmental Protection Agency Project no. 2025. available at: https://www2.mst.dk/Udgiv/publications/2018/08/978-87-93710-48-1.pdf

Watson, D. and Palm, D. 2016. Exports of Nordic Used Textiles: Fate, benefits and impacts: Policy Brief. available at: http://norden.diva-portal.org/smash/get/diva2:1058123/FULLTEXT01.pdf

Watson, D., Aare, A. K., Trzepacz, S. and Dahl Petersen, C. 2018a. Used Textile Collection in European Cities. Study commissioned by Rijkswaterstaat under the European Clothing Action Plan (ECAP).

Watson, D., Elander, M., Gylling, A. C., Andersson, T., & Heikkilä, P. 2017. Stimulating Textile-to-Textile Recycling. Nordic Council of Ministers TemaNord2017:569

Watson, D., Kant Hvass, K., Moora, H., Martin, K.; Nausėdė, V., Gurauskiene, I., & Akule, D. 2020b. Textile circularity in the Baltic countries: current status and recommendations for the future. Nordic Council of Ministers TemaNord Report. available at: http://norden.diva-portal.org/smash/get/diva2:1466009/FULLTEXT01.pdf

Watson, D., Kiørboe, N., Palm, D., Tekie, H., Harris, S., Ekvall, T., Lindhqvist, T., Lyng, K-A for NORDEN 2014. EPR Systems and new business models. Reuse and recycling of textiles in the Nordic region.

Watson, D., Palm, D., Brix, L., Amstrup, M., Syversen, F., Nielsen, R. 2016. Exports of Nordic Used Textiles: Fate, benefits and impacts. TemaNord Report 2016:558, Nordic Council of Ministers

Watson, D., Trzepacz, S., Kiørboe, N., Elander, M., Ljungkvist Nordin, H., Lander Svendsen, N., & Wittus Skottfelt, S. 2020a. Towards 2025: Separate Collection and Treatment of Used Textiles in 6 EU countries. available at: https://www2.mst.dk/Udgiv/publications/2020/06/978-87-7038-202-1.pdf

Watson, D., Trzepacz, S., Rubach, S. & Moltu Johnsen, F. 2020c. Kartlegging av brukte tekstiler og tekstilavfall i Norge. Report commissioned by the Norwegian Environmental Directorate.

Woolridge, A.C., Ward, G.D., Phillips, P.S., Collins, M., Gandy, S. 2006. Life cycle assessment for reuse/recycling of donated waste textiles compared to use of virgin material. An UK energy saving perspective. In: Resources, Conservation and Recycling 46 (1), S. 94–103. DOI: 10.1016/j.resconrec.2005.06.006.

WRAP UK 2016. Textile collection guide: A guide for local authorities and textile collectors.

WRAP UK 2017. WRAP Materials Pricing Report, 11.01.2017. Available at: https://www.wrap.org.uk/content/materials-pricing-report

WRAP UK 2019. Fibre to fibre recycling: An economic & financial sustainability assessment.

WRAP UK 2019. Materials Pricing Reports. available at: https://www.wrap.org.uk/content/materials-pricing-report

WTO 2020. World Trade Statistical Review. World Trade Organization. available at: https://www.wto.org/english/res_e/statis_e/wts2020_e/wts2020chapter06_e.pdf

List of abbreviations and definitions

B2B / B2C	Business to business /Customer
C2C	Customer to Customer
CAS number	Chemical Abstracts Service Registry Number
CBM	Circular business model
CBs	Circular businesses (companies that have a circular business model)
CE	Circular Economy
CEAP	Circular Economy Action Plan
CN	Common Nomenclature
CO_2	Carbon dioxide
DG GROW	The Commission's Directorate-General for Internal Market, Industry, Entrepreneurship
EEA	European Economic Area
EMF	Ellen MacArthur Foundation
EPA	Environmental Protection Agency
EPR	Extended Producer Responsibility
EU-27	27 member states of the European Union (EU)
F2F	fibre-to-fibre
FU	Functional unit
GDP	Gross domestic product
GWP	Global warming potential
ILCD	International Reference Life Cycle Data System
ISO	International Organization for Standardization
JRC	Joint Research Centre
Ktonnes	1000 metric tonnes
LCA	Life cycle assessments
LCI	Life cycle inventory
NACE codes	Statistical Classification of Economic Activities in the European Community
PE-PP	Polyethylene and Polypropylene
PET	Polyethylene terephthalate
PRO	Producer Responsibility Organization
ProdCom	Eurostat’s statistics database on of manufactured goods and services
SME	Small and medium-sized enterprises
SWOT	Analysis of Strengths, Weaknesses, Opportunities and Threats
UPR	Unit Process datasets
USD	Unites States Dollar
VAT	Value-added Tax
WFD	Waste Framework Directive

Countries:

AU	Austria
BE	Belgium
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
ES	Spain
FI	Finland
FR	France
IT	Italy
LT	Lithuania
LV	Latvia
NL	Netherlands
SE	Sweden
UK	United Kingdom of Great Britain and Northern Ireland
USA	United States of America

List of Boxes

List of Figures

List of Tables

Annex A: Questions for interviews with representatives of sorting facilities

1. Which textile types and categories can be sorted at your facility?
2. Are there any challenges or limitations in terms of which types of textiles that can be sorted?
3. What is the current and expected capacity of input? E.g. tonnes/day or tonnes/year.
4. Are there any necessary pre-treatment processes?
5. What is the current and expected capacity of the process? E.g. tonnes/hour.
6. Are there any challenges linked to the sorting process?
7. What is the current and expected future energy use per kg treated textile?
8. Which types of output does the process have? What is the quality of these?
9. Where are the textiles sent to after the sorting process?
10. What is the current cost per kg treated textile?
11. What is the current TRL of the technology?

Annex B: Factsheets about the TOP 5 Circular Business Models from Literature Review

Title / Description	Sharing/platform models (mostly C2C)
Position in the Life Cycle	Utilization/reuse/consumption
Contribution to the CE targets (R's)	Reduce, reuse; enabling increased utilization rate of products through shared use/access/ownership, maybe repair
Description of business model: How and out of which resource is the value generated?	Products are being reused instead of disposed of which creates additional value without using additional resources, customers resell clothes they already have or exchange them with other customers. A business operates a platform that creates revenue through advertising or by keeping a percentage of the money that is paid for the clothing.
Importance of partnerships/ collaborations	This business model is based on the facilitation of consumer interaction. Business partnerships and collaborations may be of importance for storing huge amounts of clothing for B2C leasing. Collaborations with brands that help spreading awareness of these kinds of platform models are also very helpful. A partnership with a packaging firm would be of advantage.
Description of relation to customers	The customers need to be aware of the advantages a sharing and/or platform model has in order to neglect buying fashion that is new, caters to the concept of ownership as a status symbol and isn't very costly so you can change your clothing style whenever new trends arrive. Their motivation is mostly either caring for the environment and acting against climate change or saving money and still having different clothes available constantly. It might also make the customers feel like they are part of a community. Overall, the concept is appealing to people of a wide age range because everyone gets rid of some clothing once in a while. A lot of people are already donating used clothes or bringing them to collecting points which concurs with this business model. Generations have an easier access to platforms that use apps or the internet in general especially since they are widely advertised on social media platforms, but the concept is interesting for everyone regardless of age.
Implementation	Online sharing platforms in clothing libraries or privately between consumers
Strengths	The appeal of having a bigger variety of clothing without having to pay a lot of money or the clothing taking up a lot of space. This can reduce environmental depletion because less amounts of new clothing are needed to satisfy a bigger number of customers.
Weaknesses	Clothing must survive significant wear and tear from multiple users meaning raw materials might cost significantly more. Logistics may be a problem unless the clothing is shipped directly from C2C. Firms have limited budgets and investment possibilities to establish the infrastructure needed for sharing platforms.
Opportunities	Change in way of thinking, service instead of ownership. Starting point of new business models that enable long-term continuity of our standard of living.
Threats / Risks	Without a mind shift to valuing service instead of ownership this model cannot reach enough people in order to actually make a difference. Sharing platforms are only attractive as long as a lot of diverse people use them
Title (and other related models/similar terms)	Recycling/material recovery models
Position in the Life Cycle	Disposal, manufacture
Contribution to the CE targets (R's)	Material Reuse, reduce, recycle
Description of business model	At the End-of-life of a product it is collected and separated into pure fibre material which is then used to manufacture new products.
Importance of	Increased cooperation between recyclers, designers, producers and consumers is crucial to

Title / Description	Sharing/platform models (mostly C2C)
partnerships/ collaborations	further increase the quality and quantity of (closed loop) recycling. Remanufacturing/recycling needs to be combined with some form of take-back or product-service model, this requires collaborative approaches and partnerships e.g. with retailers to lower costs of logistics and take-back schemes. Education and awareness needed to stimulate cooperation between raw materials producers and waste handlers because they are companies that normally operate at totally different ends of linear value chains.
Description of relation to customers	Customers need to be aware of recycling opportunities and advantages in order to make the effort of bringing clothing to collection points instead of just disposing of them.
Implementation	Retailers can establish take-back schemes or recycling companies their own collection points.
Strengths	Resources are being conserved for as long as possible (especially important in light of sustainability, climate change, growing population), contributes to circular economy; can make closed loops possible, useful life is being prolonged, resource efficiency, decreased need for new products and virgin raw material, cascaded use possible (materials are being brought from one industry to another), respond both to emerging market demand and to inner supply chains requesting green criteria as a leitmotiv, can contribute to less land use and soil contamination related to raw material mining
Weaknesses	Inherent recyclability is not a given; pure fibres are vital for fibre recycling, lack of proper design for recycling (e.g. blended materials, abundance of material options, trimmings), lack of design that enables disassembly of components to separate them into 'pure' material streams which can make separation of materials too costly or impossible to achieve. The vast diversity of materials makes it difficult to set up separate collection and transportation systems in a cost-effective manner, effective return logistics are a challenge. Lack of cost-effective recycling technologies available; higher volumes are needed to make it profitable. Recycling costs fluctuate depending on market demand; it is difficult to make steady price arrangements with all value chain players.
Opportunities	Recycling can replace single life cycle inputs, helps establishing circular economy by closing the loop, interesting for future businesses when recycling becomes more cost effective because of prices of virgin resources rising and/or when policy incentives are in place e.g. taxes on the use of virgin material. If you internalize the environmental costs of virgin fibres that creates an economic advantage for recycled fibres and ecological advantage which can help dealing with resource shortage
Threats / Risks	Cost of material recovery (cost of reverse logistics and recycling) are higher than the value of the materials in most cases making the value of the business model for Closed loop and Recycling more focused around brand value and/or premium pricing of closed loop/recycled products, new textile products based on recycled materials and fibres should not remain as luxury products affordable only to a few people, should be available to the mass market

Title / Description	**Service instead of ownership/leasing-models/ access-based business models, product-service systems (PSS)**
Position in the Life Cycle	Retail; Consumption
Contribution to the CE targets (R's)	Reduce, Reuse, Repair The use phase is prolonged leading to more efficient material/resource consumption. As one product is used by several customers, overall production can be reduced because less products fulfil the need of more customers. The service a product brings to the customer as well as the profit the production volume brings to the producer is not necessarily connected to the consumers individual ownership of a product. It is assumed that the leasing provider is incentivised to maximise the valorisation of existing assets (products) and keeps them in the loop as long as possible. Thus, material use and consequently, waste production, can be decreased. Because the producer remains owner of the product, it is rather of advantage for the producer to consider reuse, repair, remanufacture and/or recycling in the design phase or prolong the products life through repair services.
Description of business model: How and out of which resource is the value generated?	The service of a product is provided without having to buy it: instead of selling the product, rather the service, with which a product fulfils the customer needs, is sold. Often, this might have lower costs involved for the consumer than to buy new products. There are different leasing or renting models.
Importance of partnerships/ collaborations	Collaboration with external repair service or cleaning providers, garment suppliers
Description of relation to customers	B2C: mostly middle aged, aware of sustainability; increased consumer loyalty; sometimes consumer have social experience of being part of community; Importance of communication, e.g. about environmental impacts; providing information about how to use/maintain a product for increased longevity
Implementation	B2B: Workwear renting or leasing, possibly including cleaning and repair services B2C: Leasing clothes, possibly with included repair; Fashion library; clothing rental
Strengths	Consumer behaviour, decreasing social status of ownership Consumer loyalty Producer encouraged to consider durability and reparability
Weaknesses	Financial feasibility? Not inherently positive environmental impacts by itself, sustainable effects are not guaranteed Taking over existing second-hand markets/commercializing existing informal, uncommercial reuse/shared use models Logistics Acquiring members is a slow process
Opportunities	Mindshift of consumer (issues: possibly limited choice, no ownership) and industry (rethink: more collaborations, communication strategy)
Threats/Risks	Need to assess amount of resource reduction and rebound effect
Title / Description	Repair & reuse models
Position in the Life Cycle	Design, Retail & Consumption
Contribution to the CE targets (R's)	Reduce, Reuse, Repair The use phase is prolonged leading to more efficient material/resource consumption. A product, that otherwise would have been disposed of, can be reused by other customers or reused in other purposes (cascading use/repurposing) or, if the reason for the intended discarding was that it is broken, repaired. Overall, the demand for new clothing declines as more and more products are used longer since they can fulfil the needs of several users

Title / Description	Service instead of ownership/leasing-models/ access-based business models, product-service systems (PSS)
	during their (cascading) use phase. Customers don't necessarily have to buy a newly produced product. Material use and consequently, waste production, can be decreased. A company's motivation to ensure that the durability lasts several reuse cycles encourages design for reparability.
Description of business model: How and out of which resource is the value generated?	Second-hand shops (also online), informal non-commercial (flea market, "Kleidertausch", "U-Laden", repair café,
Importance of partnerships/ collaborations	Collaboration with external repair services, collaborative logistics systems for take back, retailers
Description of relation to customers	B2B: Leasing providers can offer product-service systems to public procurers that are committed to policy targets regarding resource efficiency and waste prevention. B2C: mostly middle aged, aware of sustainability; sometimes consumer have social experience of being part of community; Importance of communication, eg. about environmental impacts; selling spare parts; providing repair manuals or even repair kits; providing information about how to use/maintain a product for increased longevity; provide discount/voucher if old product is returned
Implementation	Second-hand shops (also online), informal non-commercial (flea market, "Kleidertausch", "U-Laden", repair café,
Strengths	Product durability is encouraged
Weaknesses	Products are sometimes designed in a way that makes repairing barely possible, not always guaranteed access to spare parts, missing efficient take-back of products
Opportunities	Growing environmental awareness in customers mindset, financial incentives for repair/reuse
Threats/Risks	Need of country-wide collection / take back infrastructure / logistics

Title / Description	Long living, circularity-friendly designed fashion products
Position in the Life Cycle	Design
Contribution to the CE targets (R's)	Reduce, Repair, Up-/Recycle A product is designed to increase the ability to repair, remanufacture or recycle. Thus, the use phase is prolonged leading to more efficient material/resource consumption. Different Strategies of circular design (by Bocken et al. 2016): "Design for ease of maintenance and repair", "Design for upgradability and adaptability", "Design for attachment and trust", "Design for a technological cycle" and "Design for a biological cycle" and avoiding dangerous chemicals. Through this circular design, all the other circular activities in later life-cycle stages are enabled and encouraged and more economically feasible. Overall, the demand for new clothing declines as more and more products are used longer since they can fulfil the needs of several users during their (cascading) use phase. Consumers do not necessarily have to buy a newly produced product. Material use and consequently, waste production, can be decreased. A company's motivation to ensure that the durability lasts several reuse cycles encourages design for reparability.
Description of business model: How and out of which resource is the value generated?	Providing exclusive, durable superior quality products with a long lifetime; increasing emotional value
Importance of partner-ships/ collaborations	Collaboration with external repair and/or recycling services
Description of relation to customers	B2B: Public procurement as a driver for market demand for circular designed workwear, uniforms, protective cloths. Ecolabelling and circularity certificates are assets that generate competitive advantage on the market. B2C: typical consumers are middle aged, aware of sustainability; sometimes feel good being part of a like-minded community; Importance of brand image, communication, e.g. about organic/"chemical-free" materials; providing information about how to use/maintain a product for increased longevity; provide discount/ voucher if old product is returned.
Implementation	Warranty, included repair service
Strengths	Driver for innovation
Weaknesses	Because high quality products are more expensive, consumers are less willing to buy/only certain part of consumers can afford, missing efficient take-back of products, market and consumer can limit the success of designs
Opportunities	Growing environmental awareness in customers mindset, financial incentives
Threats/Risks	Collection infrastructure/logistics

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