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Textiles and the Environment
The role of design in Europe's circular economy

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1 Introduction

Over the coming decade, Europe will face the double challenge of tackling environmental and climate impacts, while at the same time recovering from the economic and social impacts of the COVID-19 pandemic. The targets set by the European Green Deal and the Next Generation EU recovery plan serve as a guidance to transform the EU into a prosperous, fair, and inclusive society, while adhering to the ambitious path towards a competitive, climate-neutral, healthy, pollution-free and resource-efficient economy. Transitioning to a resource-efficient and climate neutral economy implies significant changes to existing production and consumption systems.

The 2020 Circular Economy Action Plan (CEAP) of the European Commission has identified textiles as a key product value chain and a comprehensive EU Strategy for Textiles is due to be released by Q1 of 2022. This strategy will aim at strengthening industrial competitiveness and innovation in the sector, boosting the EU market for sustainable and circular textiles, including the market for textile reuse, addressing the perverse effects of fast fashion and driving new business models.

While technological changes, such as the development of sustainable textile fibres, resource-efficient industrial production systems and improved sorting and recycling technologies for high-quality textile recycling are essential for this transition, it is increasingly clear that a true circular and sustainability transition beyond incremental improvements will require fundamental changes to the textiles system as a whole. Not only textile technologies and production processes need rethinking and a fundamental transformation, but also consumption patterns, social norms - on fashion for example -, business models, waste collection and processing. To achieve this, the textiles sector needs to be encouraged and supported to implement and scale up the many solutions and innovations - both technological and social – many of which already exist, while engaging in further research and development.

Also, a systemic view is needed to avoid rebound effects and the shifting of environmental and social burdens to other areas or outside Europe (e.g., export of textile waste to countries where waste treatment is less advanced). There is an important role for social innovation that facilitates sustainable behaviour, such as easy access to reused clothing and textile repair services. Adequate policy measures and awareness raising can assist in bringing about a fundamental mind shift towards more sustainable textiles consumption patterns, away from fast fashion.

An important measure for enabling the shift to a sustainable textiles system is the development of eco-design guidelines and requirements to ensure that textile products are fit for circularity, by ensuring the uptake of secondary raw materials, tackling the presence of hazardous chemicals and improving product durability, repairability and recyclability. The Commission is expected to propose a Sustainable Product Initiative (SPI), which will extend the EU Eco-design Directive beyond energy-related products to the broadest range of products possible, including textiles, with the ambition to establish sustainability principles for products that support circularity.

To inform decision-making and in support of the implementation of the objectives of the 8th Environmental Action Plan and the CE Action Plan, the European Environmental Agency (EEA) is building a knowledge base on the European textiles system and its environmental impacts. In December 2019, the EEA briefing *Textiles in Europe's Circular Economy* (EEA, 2019) and its underpinning ETC report *Textiles and the environment in a circular economy* (ETC/WMGE, 2019) identified EU textiles consumption as the fourth highest-pressure consumption category for the use of primary raw materials and water after food, housing and transport, and fifth for greenhouse gas (GHG) emissions. In 2021, the follow-up briefing and report on *Plastics in textiles* (EEA, 2021b; ETC/WMGE, 2021b) focused on the specific challenges related to the increasing share of synthetic textiles, acknowledging their unique properties yet their high climate impacts, the lack of significant recycling activities and the risks on microfibre shedding. Finally, the briefing and report on circular business models (EEA, 2021a; ETC/WMGE, 2021a) developed a framework and highlighted potential circular business models for textiles and how their implementation can be facilitated by a combination of technological, business and social innovation and policy and behavioural enablers. It also showed that the design stage is crucial in determining future options for circularity.

The aim of this report is twofold. Firstly, in chapter 2, the focus is on following-up on the previous work and inform the further policy making and policy implementation process on circular and sustainable textiles by updating previously published data, information and knowledge on European consumption, production and trade of textiles and the related environmental and climate impacts. Production, trade and consumption data are updated to the latest year available at the time of publication (i.e. 2020). Since 2020 was dominated by the outbreak of the global COVID19 pandemic, the reported volumes may not be fully representative of the sector 'in normal circumstances'. For that reason, a comparison with the last 'normal year (i.e. 2019) and trend data (2010-2020) are provided in order to present a more nuanced picture. Secondly, the report will take a sustainable product design perspective, discuss its evolution, and focus on identifying eco-design principles applicable to textile products. To unlock the mitigation potential of these eco-design principles, the whole textiles system including circular business models, consumption behaviour and policies will be covered (chapter 3). In this way, this report aims to contribute to the implementation of the EU Strategy for Textiles and the EU Sustainable Product Initiative. The scope of this report will be focused on clothing and household textiles, while footwear and technical textiles will be mentioned depending on data and information availability.

2 Trends in production and consumption of textile products in Europe

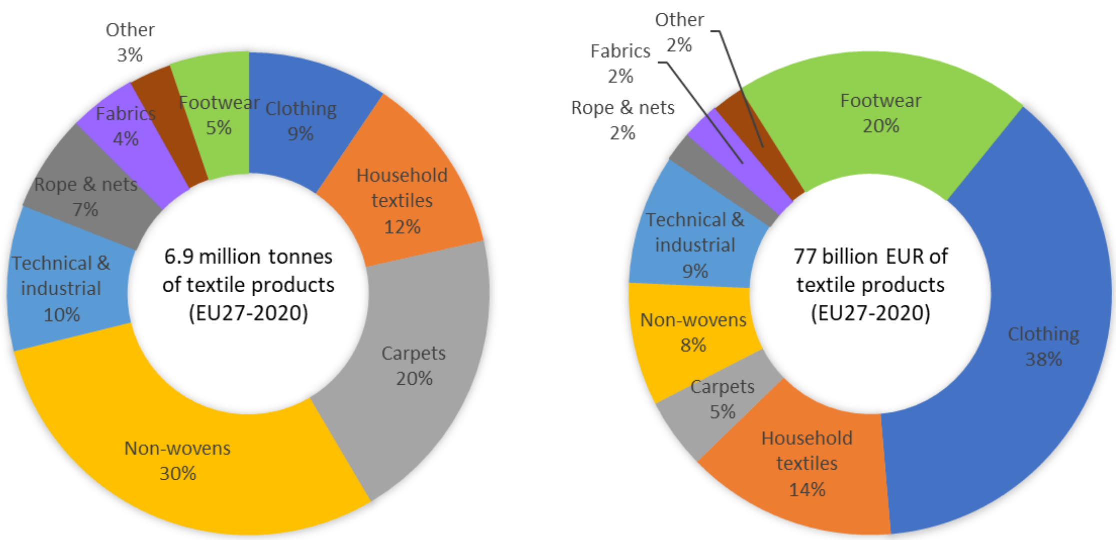
2.1. Production and consumption trends

EU production

The textiles sector is important for European industry. In 2019, the EU textile and clothing sector had a turnover of 162 billion EUR, employing over 1.5 million people across 160 000 companies. However, for 2020, the COVID-19 crisis caused a dramatic drop in turnover by -9 % for textiles as a whole and by -17 % for clothing (Euratex, 2021).

In 2020, 6.9 million tonnes of finished textile products[1] were produced in EU27[2], representing a value of almost 77 billion EUR. EU production specialises in carpets, household textiles and other textiles (including non-wovens, technical and industrial textiles, ropes and fabrics) (Figure 2.1). While only 9 % of EU textiles related production volume is clothing, it represents 38 % of production value (29 billion EUR), indicating clothing items are high-value products compared to their low weight. Apart from finished textile products, the EU is a significant producer of intermediate products for textiles, such as fibres, yarns and fabrics (Köhler et al., 2021).

Figure 2.1 EU27 production of textile related products, 2020, in million tonnes and billion EUR



Source: Eurostat [DS-066431]

While EU production of textile products had been gradually increasing over the last decade, a drop in production volume and value can be observed in 2020 compared with 2019 numbers[3] (Figure 2.2). This drop in production volume is most outspoken for footwear (-36 %), general clothing articles (about -20 % on average), and technical and industrial textiles (-43 %). On the contrary, production of other wearing apparel (i.e. baby clothes, sportswear and scarfs) and household textiles showed a sharp increase with 53 % and 18 % respectively. It is to be expected that the response to the COVID-19 pandemic, involving stay-at-home measures and closures of companies and shops, has caused an overall decrease in textiles

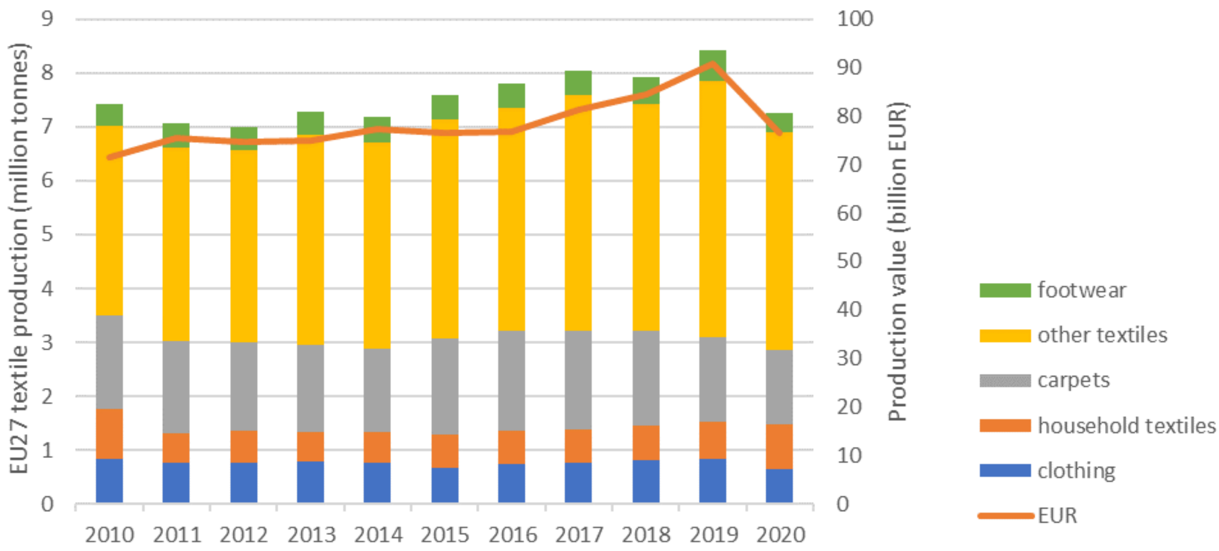
1 Terminology to describe different groups of textile products is explained in Annex 1

2 Textile product types are reported in several different units in Eurostat. Volume estimates (in kg) for the different product types were calculated using the conversion factors provided by Eurostat.

3 For comparison, production volume in 2019 was 7.8 million tonnes, with a value of 91 billion EUR (Eurostat DS-066431).

production and demand (Euratex, 2021), while inducing a shift in purchasing behaviour towards sports and leisure wear (BBC, 2021; Ell, 2021) (Box 2.1).

Figure 2.2 EU27 production of textile related products, 2010-2020, in million tonnes and billion EUR

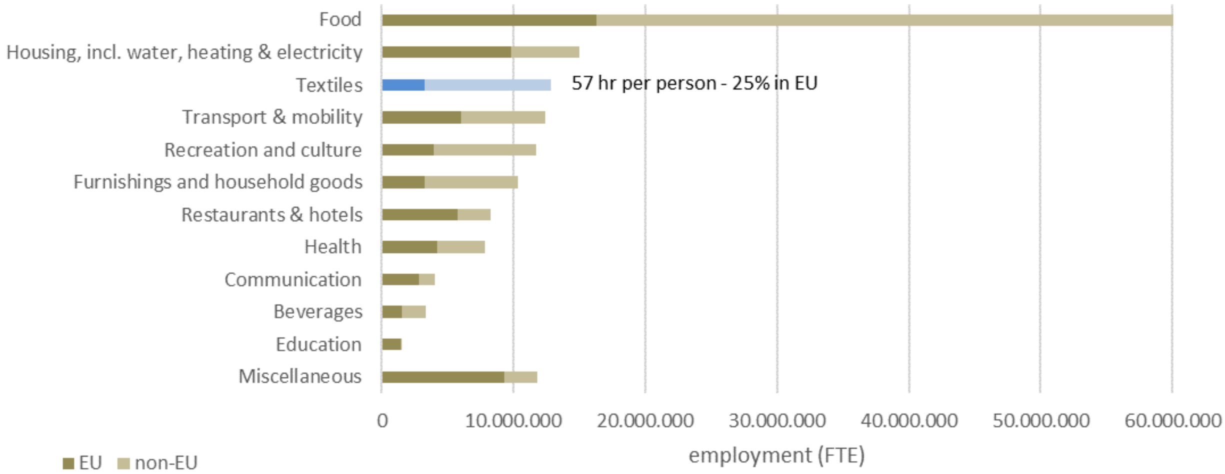


Source: Eurostat [DS-066431]

With regard to employment, the textiles sector is labour intensive compared to other sectors. To produce the amount of clothing, textiles and footwear consumed in the EU27 in 2020, almost 13 million full-time equivalents (FTE)[4] were employed worldwide throughout the supply chain, which corresponds to about 57 working hours per European. This makes the textiles sector the third largest employer worldwide, after food and housing (Figure 2.3). Clothing is responsible for half of this employment. However, only about one quarter of this employment takes place in Europe, illustrating the highly global nature of the textiles value chain and the large share of imports from outside Europe. Note that textiles and food are the two domains with the lowest share of European employment.

[4] 1 FTE = 2,000 working hours per year

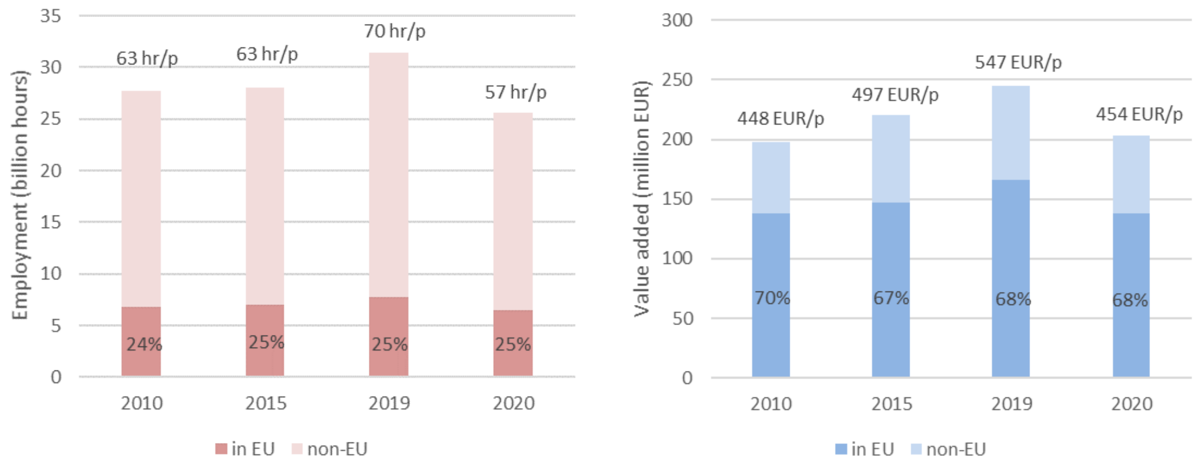
Figure 2.3 The use of employment in the upstream supply chain ([5]) of EU household consumption domains, FTE (1 FTE = 2000 working hours), 2020.



Source: Exiobase v3.8.1

After a consistent increase in employment between 2010 and 2019, both employment levels and added value have levelled off in 2020, (Figure 2.4), under the influence of the COVID-19 pandemic (Box 2.1). It is remarkable to note that, while the share of employment taking place in Europe was at about 25 % in 2020, the share of added value created in Europe was about 70 %, implying that high-value activities (including retail) are mainly done in Europe. Both shares have remained relatively constant over the past 10 years (Figure 2.4).

Figure 2.4. Use of employment and value added in the upstream supply chain [6] of EU textiles consumption, billion working hours and billion EUR, 2010-2020.



Note: modelled 2020 data are adjusted to match actual 2020 consumption levels
Source: Exiobase v3.8.1

5 This includes all activities in industrial and service sectors in the production and supply chain of the textile products up to purchase by households. It excludes the use of the textile products and the treatment at end of life.

6 This includes all activities in industrial and service sectors in the production and supply chain of the textile products up to purchase by households. It excludes the use of the textile products and the treatment at end of life.

Box 2.1 Impact of the COVID-19 pandemic on the textiles sector in Europe and worldwide

It is clear that the outbreak of the COVID-19 pandemic has put severe pressures on the global economy overall. Manufacturing industries suffered from supply shortages, labour shortages and partial shutdown of factories. Especially those sectors involved with mobility (i.e. automotive and aviation sector) and those sectors requiring personal contact and interaction, such as culture and recreation, have been very hard hit, while other such as the pharmaceutical and digital sectors were less affected (Vet et al., 2021).

Also, the textiles sector has been hard-hit. On the supply-side, the global interconnectedness of the fashion industry makes it particularly vulnerable to supply disruptions and market uncertainty. On the demand-side, reduced consumer confidence leads to decreasing expenditure and demand. Next to a decline of in-store sales due to shop closures, even online sales had declines between 5 and 20 % across Europe (Amed et al., 2020). According to a study by McKinsey, fashion companies globally faced a profit decline of about 90 % in 2020. A Euratex survey in April 2020 indicated that almost all (96 %) respondents anticipated a reduction in sales as a result of the COVID-19 pandemic, while about two thirds of respondents reported multiple anticipated challenges related to investments, company finances and production processes, including supply and logistic problems (Euratex, 2020b), while about 80 % of companies had to temporarily lay off workers (Euratex, 2020a).Moreover, the crisis has reinforced existing structural inequalities and power inbalancies within the textile value chain (Brydges and Hanlon, 2020). For example, when orders are cancelled, this disproportionately felt by the most vulnerable in the supply chain, namely the workers and farmers. Especially for contract labourers, home based workers, migrants, daily wage workers and piece rate workers, order cancellations lead to immediate loss of income, since social protection coverage is absent or limited in most production countries (Clean Clothes Campaign, forthcoming).

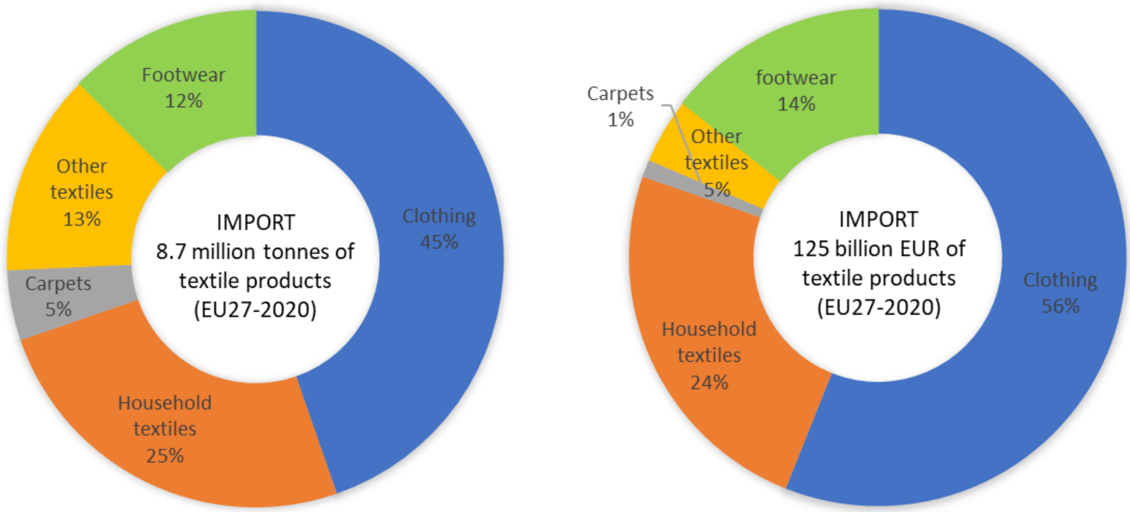
These difficult economic conditions are expected to persist in 2021, leading to bankruptcies, store closures and job losses across the sector. Despite various efforts to retain jobs, it is expected that employment in the textiles industry could decline with up to 8 % worldwide (about 158 000 jobs) and that 6 % of companies (about 13 000) could disappear by the end of 2021 (Euler Hermes & Allianz, 2020). Textile workers in low-cost manufacturing regions such as Bangladesh and India are expected to be hardest-hit as extended unemployment will aggravate poverty and national healthcare systems are inadequate (Amed et al., 2020). Fast fashion is affected most by the slump in sales, as prolonged shop closures and reduced sales lead to increasing amounts of unsold seasonal stock, forcing retailers and brands to sell at discount or to destroy unsold stocks. Fashion articles with seasonless design, such as underwear and quality basics, are less affected by stock loss as items can be sold year-round or repurposed for new seasons, while consumers turn to affordable essentials and “fewer, better items” (Amed et al., 2020).

EU trade

The textiles sector is highly globalized, with Europe being an important importer, but also a significant exporter, of textiles. In 2020, 8.7 million tonnes of finished textile products were imported in EU27, representing a value of 125 billion EUR[7]. Clothing accounts for 45 % of imports in terms of volume, before household textiles, other textiles (non-wovens, industrial textiles, ropes, etc.) and footwear. In terms of trade value, clothing is the predominant textile product, accounting for about 56 % (Figure 2.5). EU imports mainly from China, Bangladesh and Turkey (Euratex, 2020b).

7 Only extra-EU27 trade is included in the numbers, i.e. trade between EU27 member countries and non-EU27 countries. Trade between EU27 member countries is excluded.

Figure 2.5. Import of textile related products in EU27, 2020, million tonnes and billion EUR



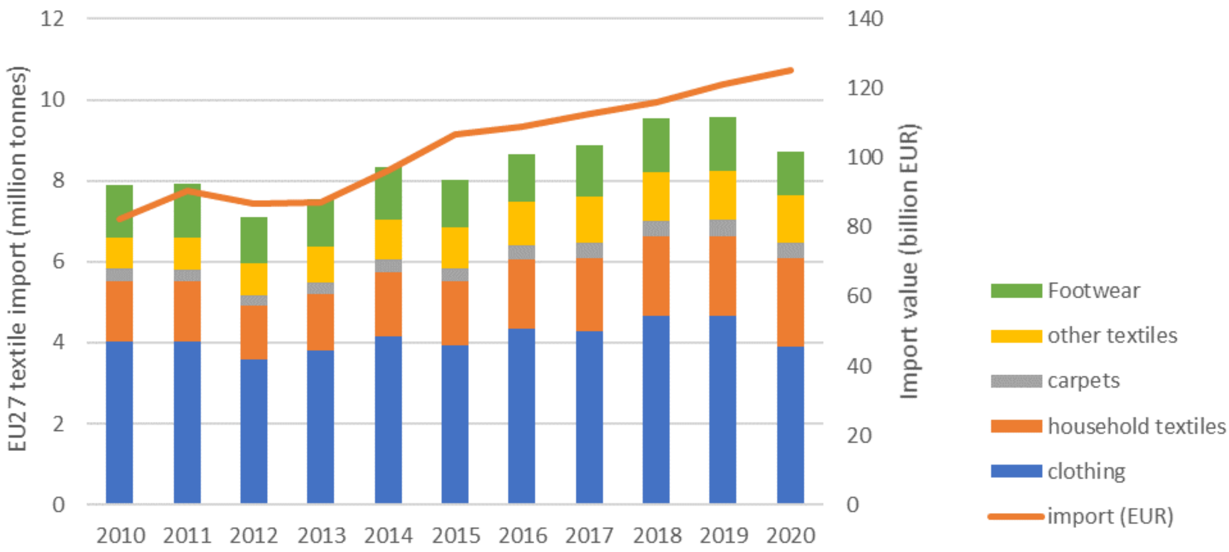
Source: Eurostat [DS-1062396]

Import volumes decreased significantly in 2020 compared to 2019[8], although import value increased (Figure 2.6). While imports of footwear and most clothing articles decreased with about -20 % (both in volume and in value), imports of household textiles increased slightly in volume (+10 %), but almost tripled in import value. This increase can largely be attributed to the massive imports of face masks and textile-based protective equipment as a result of the COVID-19 response[9]. Overall, EU member states spent 33 EUR per person on facemask imports in the first semester of 2020 - although differences between member states are considerable - amounting to about 14 billion EUR, which is a 1,800 % increase compared to the same time span in 2019 (Eurostat, 2020). As scarcity issues arose with the supply of face masks at the start of the pandemic in March-April 2020, prices of masks skyrocketed, explaining the huge difference in volume and value increase.

[8] For comparison, import volume in 2019 was 9.6 million tonnes, with a value of 121 billion EUR (Eurostat DS-1062396).

[9] Facemasks are part of CPA 2.1 product group 13.92, which shows a sharp increase in import value from 10 billion EUR in 2019 to 30 billion EUR in 2020.

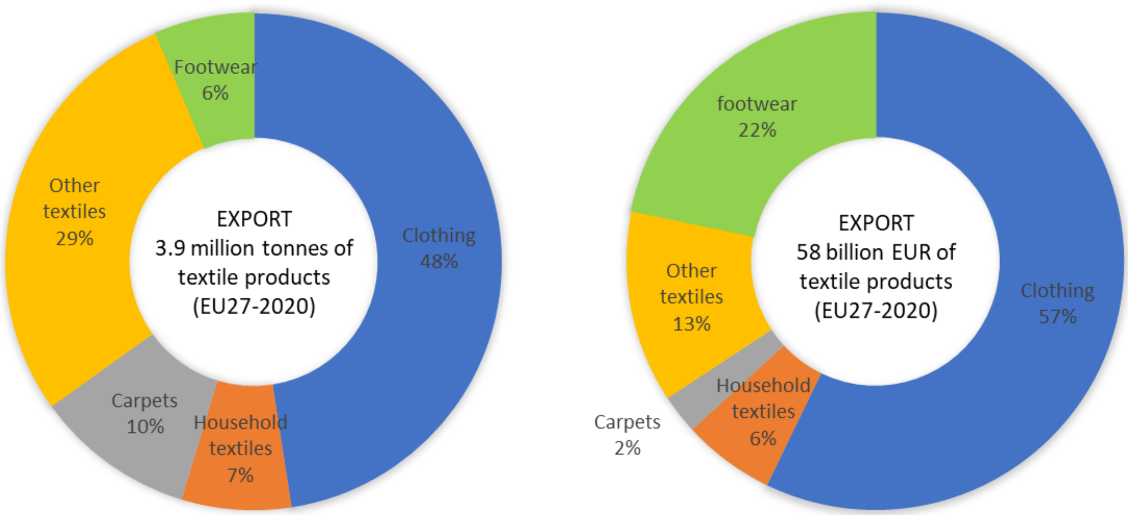
Figure 2.6. Import of textile related products in EU27, 2010-2020, million tonnes and billion EUR



Source: Eurostat [DS-1062396]

Moving now from looking at the imports to the exports, in 2020, 3.9 million tonnes of finished textiles were exported, representing a value of 58 billion EUR[10]. Clothing accounts for 48 % of exports in terms of volume, before household textiles, carpets and other textiles (non-wovens, industrial textiles, ropes, etc.). In terms of export value, clothing is the predominant textile product, accounting for about 57 % (Figure 2.7). EU exports most to UK, Switzerland and US (Euratex, 2020b).

Figure 2.7. Export of textile related products from EU27, 2020, million tonnes and billion EUR

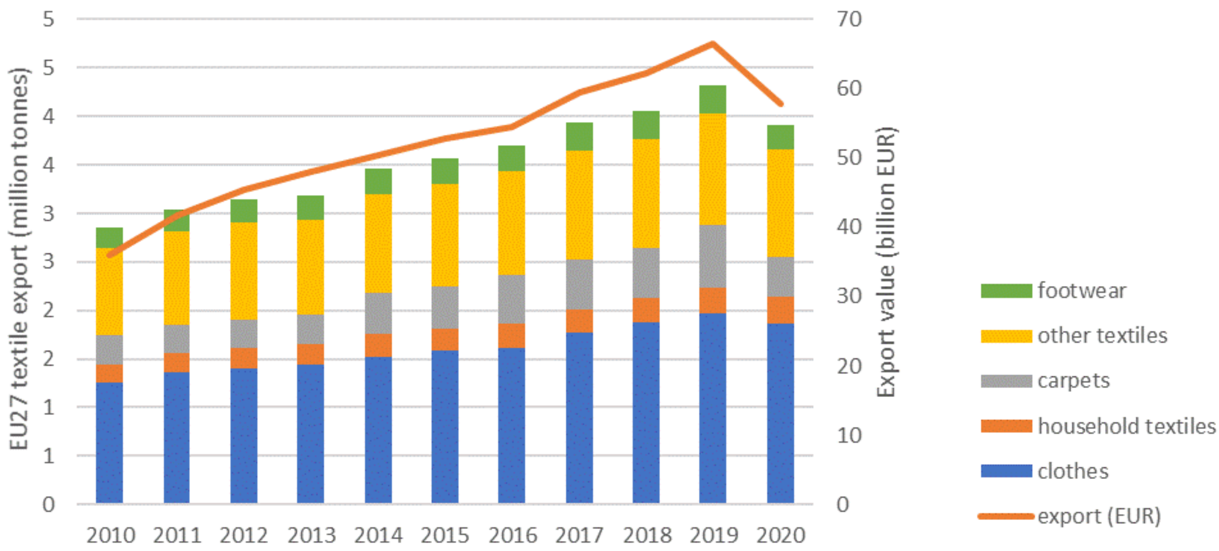


Source: Eurostat [DS-1062396]

10 Only extra-EU27 trade is included in the numbers, i.e. trade between EU27 member countries and non-EU27 countries. Trade between EU27 member countries is excluded.

Export volumes and value decreased in 2020 compared to 2019[11] (Figure 2.8), which is probably due to the COVID-19 pandemic. While the decrease could be observed for almost all product types (e.g. about -15 % for clothing and footwear), export of carpets showed the largest decrease in terms of volume (-38 %). On the other hand, other wearing apparel[12] was the only product group showing a significant 46 % increase in export volume, although this did not result in an increased export value. As these trends correspond to the change in production volumes that was observed (see above), it looks like an increased demand for particular textile products (such as sportswear) from outside the EU has been the driving factor.

Figure 2.8. Export of textile related products from EU27, 2010-2020, million tonnes and billion EUR



Source: Eurostat [DS-1062396]

EU consumption

European households consume a lot of textile products. In 2019, as in 2018, Europeans spent on average 600 EUR on clothing, 150 EUR on footwear and 70 EUR on household textiles (Eurostat [nama_10_co3_p3]), while showing large expenditure differences across countries (Köhler et al., 2021).

The yearly textiles consumption estimates come with a high degree of uncertainty, and different studies have yielded different numbers, often using different scopes and calculation methods. In the EEA briefing on textiles, a textile consumption of 25 kg per person was estimated, including clothing, footwear and home textiles (EEA, 2019). A recent JRC study estimated a yearly consumption of 10.0 kg of clothing and 2.3 kg of household textiles per person, amounting to a total of 5.4 million tonnes in 2018 (Köhler et al., 2021). When calculating the 'apparent consumption'[13] based on production and trade data from 2020 (see above) – and excluding industrial/technical textiles and carpets -, a total 'apparent' textiles consumption of 15 kg per person per year is estimated consisting of, on average, about 6 kg clothing, 6.1 kg household textiles and 2.7 kg footwear. For 2020, this amounts to a total apparent consumption of 6.6 million tonnes of textile products in Europe (Figure 2.9).

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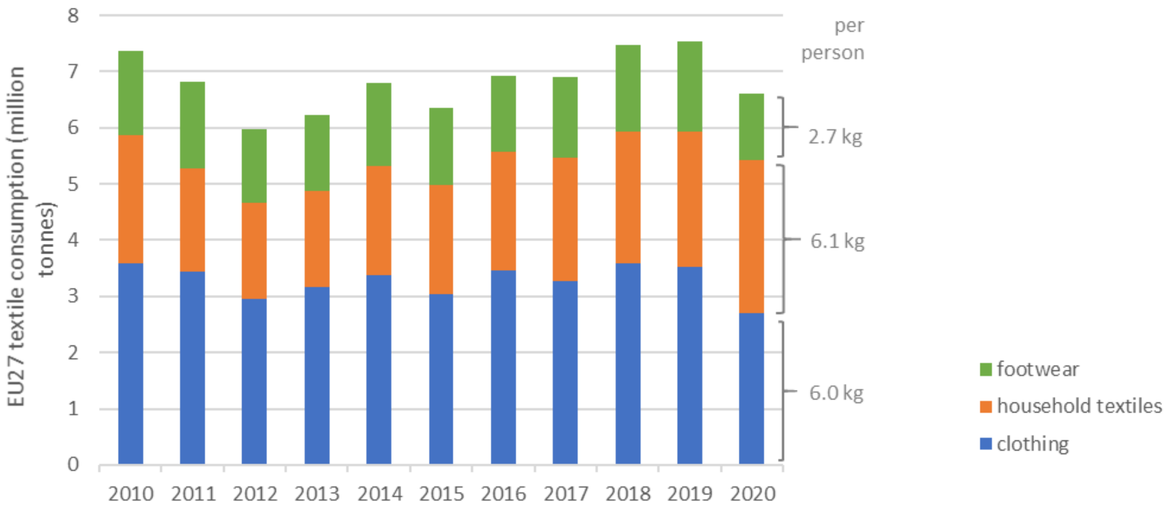
11 For comparison, export volume in 2019 was 4.3 million tonnes, with a value of 66 billion EUR (Eurostat DS-1062396).

12 group 14.19, including baby clothing, sportswear and scarfs

13 Apparent consumption = production + import - export

Figure 2.9 EU27 apparent consumption of clothing, footwear and household textiles (excluding fur and leather clothing) (calculated as production + import – export), 2010-2020, million tonnes and kilograms per person



Source: calculated, based on Eurostat [DS-066431] and Eurostat [DS-1062396]

Consumption of clothing and footwear decreased significantly in 2020 compared to 2019 [14], while the consumption of household textiles increased slightly (Figure 2.9). Over the last decade, it can be seen that the apparent consumption of clothing and footwear, while fluctuating from one year to another, stays relatively constant. The consumption of household textiles seems to be increasing slightly.

Table 2.1 and Figure 2.10 break down the EU27 consumption of textiles into different product types. The table shows data for the last decade, in which 2010-2019 can be regarded as a 'normal' trend, while 2020 may be regarded as 'atypical' due to COVID-impact[15]. Figure 10 shows the 2020 consumption of different types of clothing, footwear and household textiles per person.

Table 2.1 Apparent consumption of clothing and household textiles, per product type, EU27, 2019-2020.

2.1 CPA Product group	Example items	EU27 Consumption (kg per person)			
		2010	**2015**	**2019**	**2020**
15.2	Shoes	3.4	3.1	3.6	2.7
Total footwear		**3.4**	**3.1**	**3.6**	**2.7**
14.39	Pullovers, cardigans	1.3	1.1	1.3	1.0
14.31	Stockings, tights, socks	0.6	0.6	0.6	0.5
14.2	Articles of fur	<0.01	<0.01	<0.01	<0.01
14.19	Baby clothes, sportswear, scarfs, handkerchiefs	1.3	1.2	1.3	1.3
14.14	Blouses, shirts, T-shirts, underpants, pyjamas	2.8	2.5	2.6	2.0
14.13	Coats, jackets, trousers, skirts, suits, dresses	1.8	1.2	1.7	0.8
14.12	Workwear	0.2	0.3	0.3	0.3

14 For comparison, apparent consumption of clothes, footwear and household textiles in 2019 was 17 kg per person, amounting to 7.5 million tonnes in total (Eurostat DS-066431 and DS-1062396).

15 When analysing the impact of the COVID-19 pandemic on textile product consumption it can be seen that especially consumption of outerwear (jackets, trousers, shirts,…) dropped with over 50 %, while footwear consumption decreased with about 25 % between 2019 and 2020. Only workwear, socks, sportswear and baby clothes remained at the same level as 2019. Also the consumption of technical textiles decreased. On the other hand, consumption of household textiles (including facemasks) increased with 13 %. These shifts can largely be attributed to the COVID-19 pandemic which forced people to stay at home.

14.11	Leather clothes	0.04	0.03	0.02	0.02
Total clothing		**7.4**	**8.1**	**7.9**	**6.0**
13.92	Bed linen, towels, curtains, furnishings, tents, sails	5.1	4.4	5.4	6.1
Total household textiles		**5.1**	**4.4**	**5.4**	**6.1**
TOTAL (clothing, footwear and household textiles)		**15.7**	**16.8**	**16.9**	**14.8**

Source: calculated, based on Eurostat [DS-066431] and [DS-1062396]

Figure 2.10 EU27 apparent consumption of clothing, footwear and household textiles , 2020, kg per person

Source: EEA and ETC/WMGE, illustration by EEA

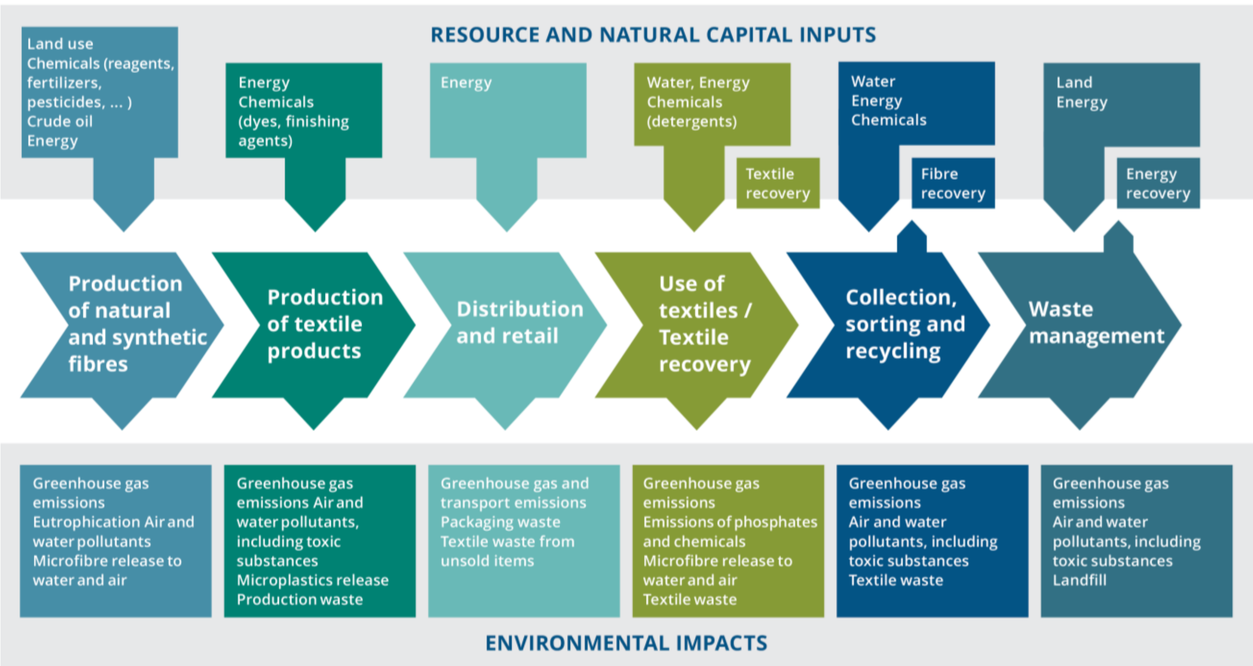
In view of a circular economy, different textile products have a different potential. Overall, about 60 % of clothing consumption consists of outerwear, such as coats, shirts and trousers. On the one hand, these product types are often susceptible to fashion trends, shortening the use period despite the fact that their technical lifetime is not yet exceeded, while, on the other hand, they typically have a high potential for reuse. Baby clothes are typically used only for a short period of time, which makes them less prone to wear and tear. As a result, these product types are often sold in second-hand shops or donated for reuse. On the contrary, intimate garments such as underwear and socks are typically used by their first owner until their technical end-of-life, which contributes to their lower potential for reuse (Köhler et al., 2021). Similarly, household textiles are less likely to be offered for reuse and will often end up in textile waste or mixed waste at their end of life. The relation between textile product types, their design and potential for circularity is further explored in Chapter 3.

Clothes and sporting goods are the most popular textile products to purchase online. In 2019, about 40 % of online shoppers bought clothing and sporting goods online (Euratex, 2020b). During 2020, as a result of lockdown measures and physical shop closures during the COVID-19 pandemic, e-commerce in almost all sectors (except travel and tickets) increased. Still, an increase in e-commerce has been predicted before the pandemic kicked in. For example, Interpack predicted a doubling of e-commerce between 2018 and 2021 (Interpack, 2020). Also, for textiles, an overall increase in online sales could be observed although the picture is nuanced: while purchases of casual clothing and home furnishings increased, sales of footwear and formal wear decreased (Ecommerce Europe, 2021).

2.2. Environmental and climate impacts

The production and consumption of textiles has significant impacts on the environment (Figure 2.11). Environmental impacts in the production phase include the impacts related to the cultivation and production of natural fibres (e.g. land and water use, fertilizers and pesticides) and the production of man-made fibres (e.g. energy use, chemical feedstock) (ETC/WMGE, 2021b). The manufacturing of textile products requires energy and water, and uses a broad variety of chemicals (e.g. dyes, finishing agents). Distribution and retail is responsible for transport emissions and packaging waste. Also, significant volumes of unsold textile products end up as waste. During use and maintenance – washing, drying and ironing – electricity, water and detergents are used and chemicals and microfibres are emitted to the waste water. At end-of-life, textiles are collected, sorted and reused, recycled or incinerated. Separate collection rates vary greatly between countries, as was show by a recent study by the Joint Research Centre (Köhler et al., 2021). Still, a significant amount of textiles end up in the mixed waste, resulting in incineration or landfill.

Figure 2.11 Environmental impacts across the textiles life-cycle



Source: adapted from ETC/WMGE (2019)

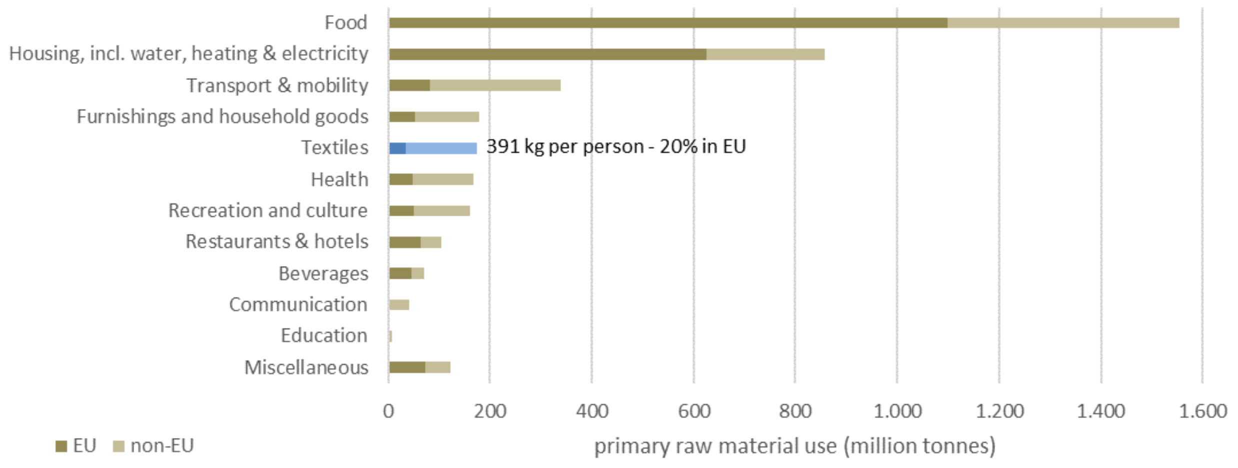
In the study 'Textiles and the environment in a circular economy' (EEA, 2019; ETC/WMGE, 2019), four environmental impact categories to which the textiles sector is a major contributor were discussed and quantified, namely resource use, water use, greenhouse gas emissions and land use. Calculations were based on the Exiobase v.3.4 model, extrapolating consumption data from 2011 to 2017 (Stadler et al., 2018). In this study, these environmental impacts are updated using the Exiobase v3.8.1 model, which contains full data up to 2015 and modelled data up to 2020 (as full data are not available yet). To match with the actual 2020 consumption data from Eurostat, the modelled results are adjusted accordingly. The full methodology is described in Annex 1. As a result of the different modelling approach, the reported 2019 impacts in this report will differ from those reported in the previous report. However, it is important to note that the results need to be considered as 'orders of magnitude' and 'indicative trends', rather than as absolute quantities. For this reason, also 2010-2020 trendlines are included in the following sections.

Raw material use

To produce all clothing, footwear and household textiles purchased by EU households in 2020, an estimated 175 million tonnes of raw materials were used, amounting to 391 kg per person (Figure 2.12). Roughly 40 % of this is attributable to clothes, 30 % to household textiles and 30 % to footwear (including leather shoes). This ranks textiles as the fifth highest consumption domain in terms of primary raw material use, at roughly the same level as health, furnishings and household goods, and recreation and culture[16].

This environmental impact includes all types of materials used for the production of natural and synthetic fibres, such as fossil fuels, chemicals, fertilizers, and all building materials, minerals and metals used for the construction of production facilities. Transport and retail of the textile products are included as well. Only 20 % of these primary materials are produced or extracted in Europe, showing the global nature of the textiles value chain and the high dependency of European consumption on imports. Cotton farming, fibre production and garment construction take place mostly in Asia (ETC/WMGE, 2019).

Figure 2.12 The use of primary raw materials in the upstream supply chain ([17]) of EU27 household consumption domains, million tonnes, 2020



Note: modelled 2020 data are adjusted to match actual 2020 consumption levels
Source: Exiobase v3.8.1

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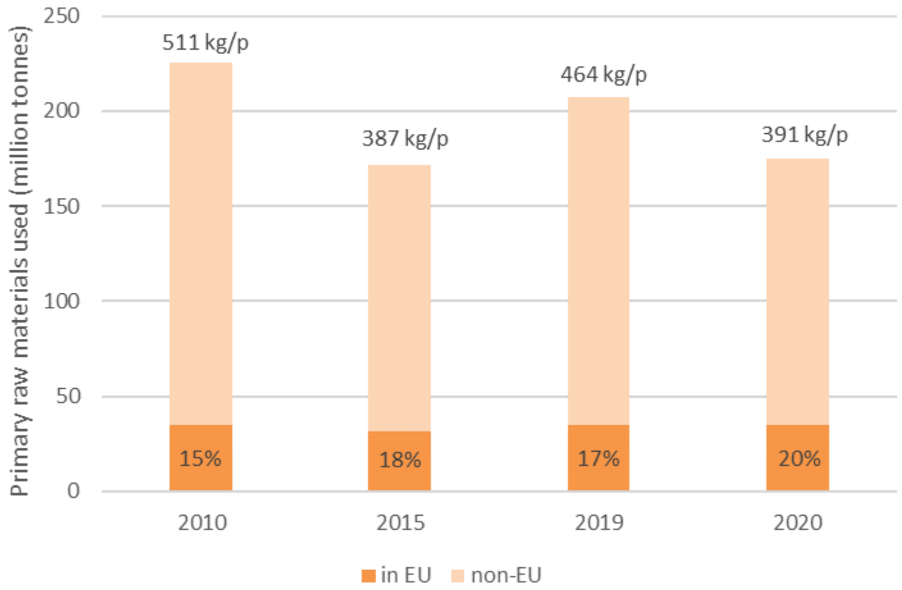
16 For comparison, at 2019 consumption levels, an estimated 207 million tonnes of raw materials were used, amounting to 464 kg per person. In 2019, textiles was ranked as the fourth highest consumption domain in terms of primary raw material use, at roughly the same level as health, furnishings and household goods and recreation.

17 This includes all activities in industrial and service sectors in the production and supply chain of textile products up to purchase by households. It excludes the use of the textile products and end-of-life.

Figure 2.13 shows the trend in raw material use for textiles between 2010 and 2020. In line with the reduced consumption levels for 2020, the amount of primary raw materials used has decreased in 2020. The share of materials extracted in Europe remains relatively constant at 15-20 %, but has slightly increased in 2020 as a result of reduced imports.

Figure 2.13 The use of primary raw materials in the upstream supply chain ([18]) of EU27 household consumption domains, million tonnes, 2010-2020



Note: modelled 2020 data are adjusted to match actual 2020 consumption levels
Source: Exiobase v3.8.1

Water use

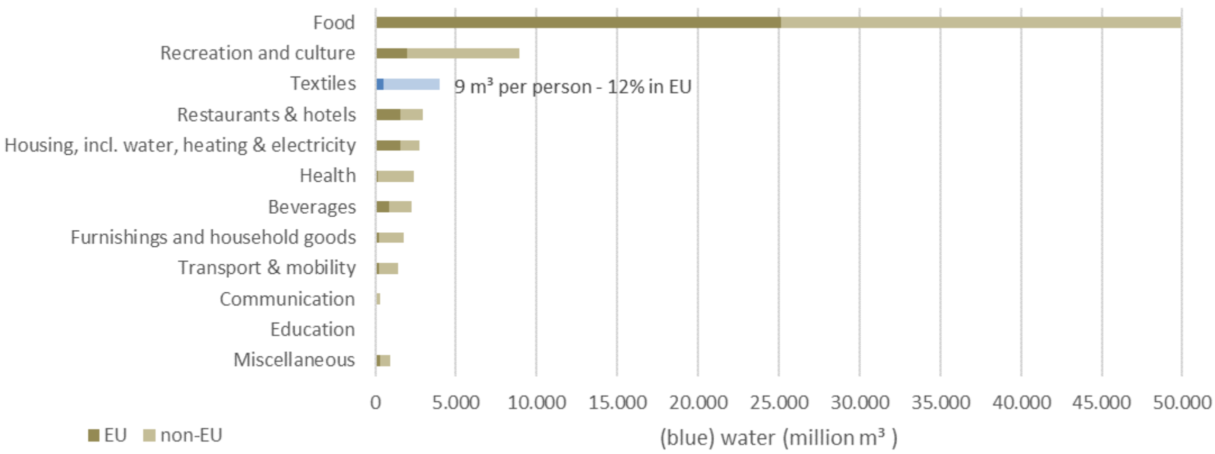
When considering water use, a distinction is made between 'blue' water (surface water or groundwater that is consumed or evaporated during irrigation, industry processes or household use) and 'green' water (rain water stored in the soil, typically used to grow crops) (Hoekstra et al., 2012). To produce all clothing, footwear and household textiles purchased by EU households in 2020, about 4,000 million cubic metres (m^3) of 'blue' water were required, amounting to 9 m^3 per person, ranking textiles consumption in the third place after food and recreation (Figure 2.14). Additionally, about 20,000 million m^3 of 'green' water were used, mainly for the production of cotton, which amounts to 44 m^3 per person[19]. "Blue" water is used equally in the production of clothing (40 %), footwear (30 %) and household and other textiles (30 %). "Green" water is mainly consumed in the production of clothing (almost 50 %) and household textiles (30 %), in which cotton production is the most water-consuming.

Water consumption for textiles consumed in Europe mostly takes place outside Europe, 12 % and 14 % for blue and green water, respectively. It is estimated that the production of 1 kg of cotton requires about 10 m^3 of water, typically outside Europe (Chapagain et al., 2006a).

[18] This includes all activities in industrial and service sectors in the production and supply chain of textile products up to purchase by households. It excludes the use of the textile products and end-of-life.

[19] For comparison, at 2019 consumption levels, an estimated 4.900 m^3 of 'blue' water and 44,000 million m^3 of 'green' water were used, amounting to, respectively, 11 m^3 and 53 m^3 per person. Textiles was ranked on third place for 'blue' water usage.

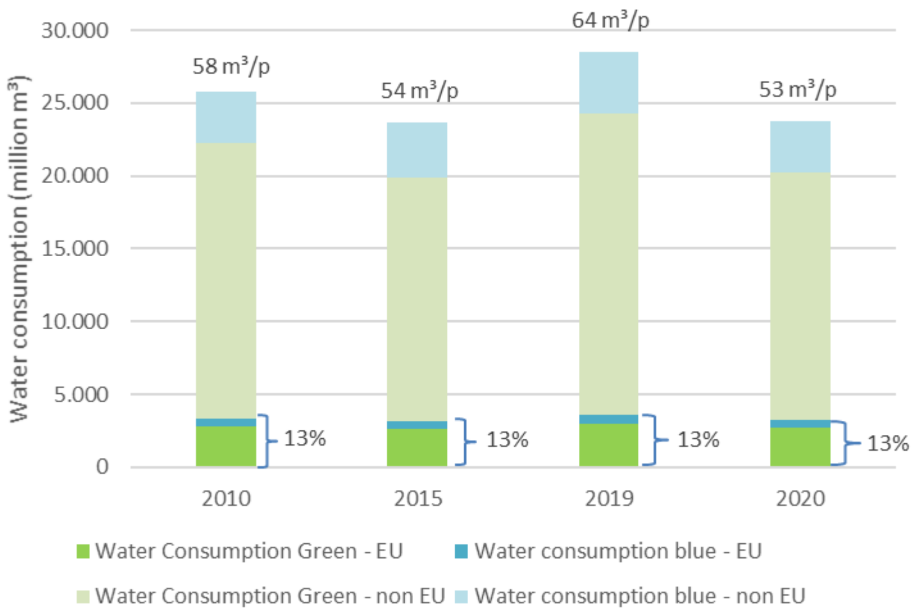
Figure 2.14 Water use in the upstream supply chain ([20]) of EU27 household consumption domains, million m³ (blue) water, 2020



Note: modelled 2020 data are adjusted to match actual 2020 consumption levels
Source: Exiobase v3.8.1

Figure 2.15 shows the trend in water use for textiles between 2010 and 2020. Over the years, about 13 % of total water consumption (green and blue water) is consumed in Europe, while the majority is consumed outside Europe, mainly in Asia where fibre production and textile manufacturing take place.

Figure 2.15 Water use in the upstream supply chain ([21]) of EU27 household consumption domains, million tonnes, 2010-2020



Note: modelled 2020 data are adjusted to match actual 2020 consumption levels
Source: Exiobase v3.8.1

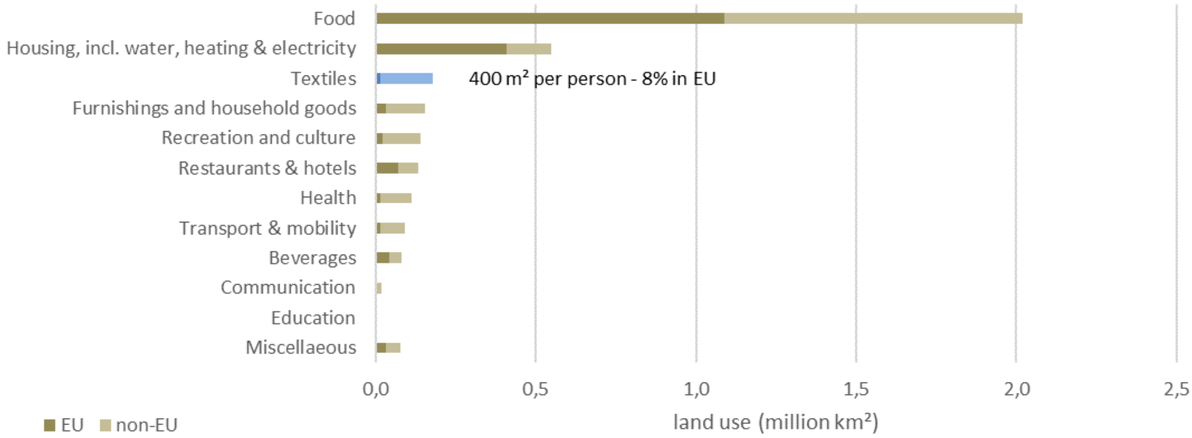
[20] This includes all activities in industrial and service sectors in the production and supply chain of textile products up to purchase by households. It excludes the use of the textile products and end-of-life.

[21] This includes all activities in industrial and service sectors in the production and supply chain of textile products up to purchase by households. It excludes the use of the textile products and end-of-life.

Land use

The land use in the supply chain of textiles purchased by European households in 2020 is estimated at 180,000 km², or 400 m² per person (Figure 2.16)[22]. Only 8 % of this land use takes place in Europe itself. Over 90 % of land use impact outside Europe, and is mostly related to (cotton) fibre production in China and India (ETC/WMGE, 2019). Also animal-based fibres, such as wool, have a significant land use impact (Lehmann et al., 2019). This makes textiles the third most important impact on land use after food and housing. 43 % of this is attributable to clothes, 35 % to footwear (including leather shoes, which have a high land use because of the need for cattle pasture) and 23 % to household and other textiles.

Figure 2.16 Land use in the upstream supply chain ([23]) of EU27 household consumption domains, million km², 2020



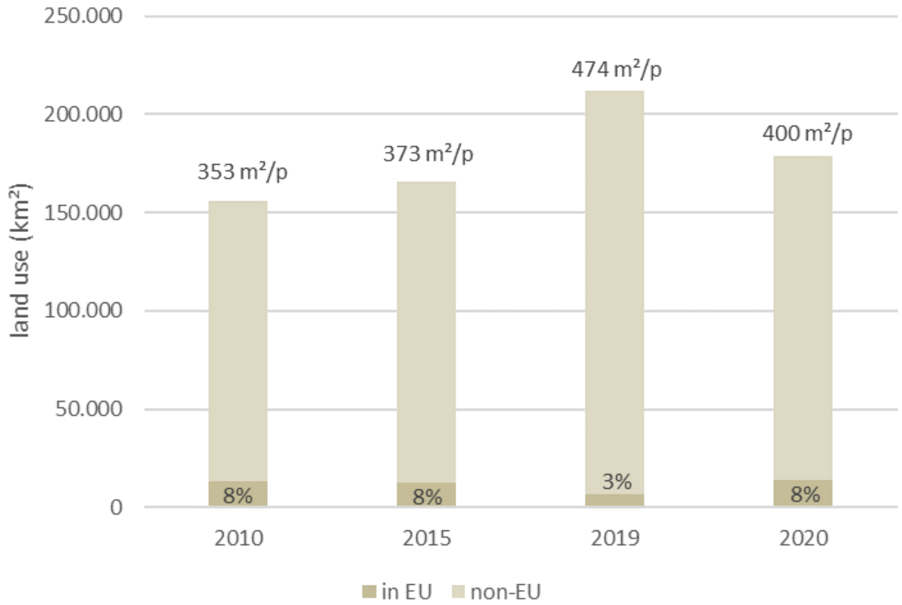
Note: modelled 2020 data are adjusted to match actual 2020 consumption levels
Source: Exiobase v3.8.1

Figure 2.17 shows the trend in land use for textiles between 2010 and 2020. Land use has dropped considerably in 2020 following the consumption reduction. The data suggest that while the share of European land use decreased between 2015 and 2019, it returned to 2010-2015 levels in 2020.

22 For comparison, at 2019 consumption levels, an estimated 212,000 km² of land was used, amounting to 474 m² per person. Textiles was ranked on third place for land use.

23 This includes all activities in industrial and service sectors in the production and supply chain of textile products up to purchase by households. It excludes the use of the textile products and end-of-life.

Figure 2.17 Land use in the upstream supply chain ([24]) of EU27 household consumption domains, km², 2010-2020



Note: modelled 2020 data are adjusted to match actual 2020 consumption levels
Source: Exiobase v3.8.1

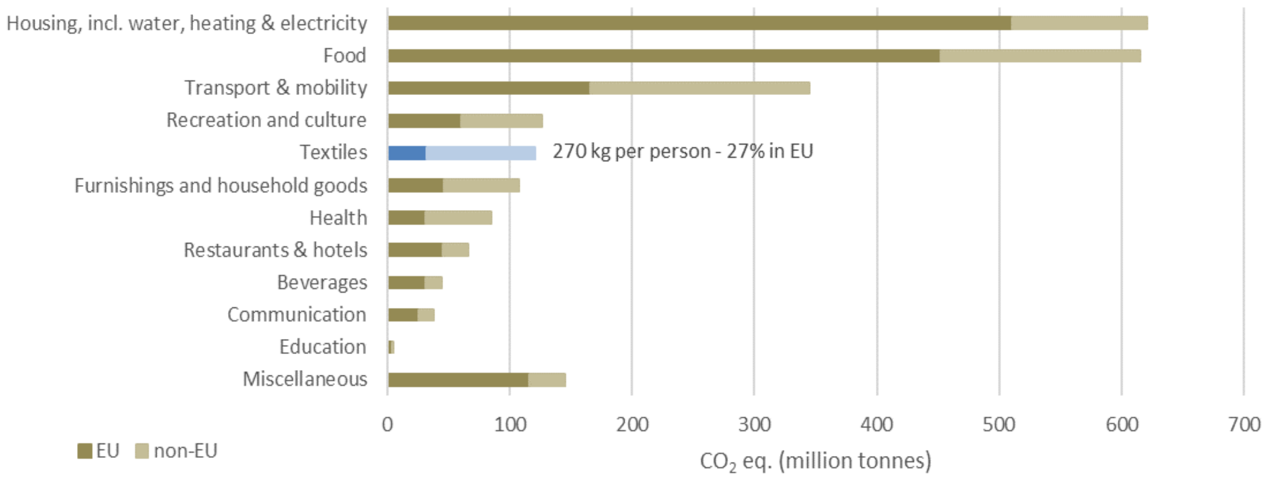
Greenhouse gas emissions

In 2020, the production of textile products consumed in the EU generated total greenhouse gas emissions of 121 million tonnes CO_2-eq in total, equivalent to 270 kg CO_2-eq. per person. This makes textiles responsible for the fifth largest climate impact among household consumption domains, after housing, food and transport (Figure 2.18)[25]. Half of this is attributable to clothes, 30 % to household and other textiles and 20 % to footwear. While greenhouse gas emissions have a global effect, about 75 % are released outside Europe, in the important textile-producing regions in Asia (ETC/WMGE, 2019).

24 This includes all activities in industrial and service sectors in the production and supply chain of textile products up to purchase by households. It excludes the use of the textile products and end-of-life.

25 For comparison, at 2019 consumption levels, an estimated 140 million tonnes of CO_2eq was emitted, amounting to 313 kg CO_2eq per person. Textiles was ranked on fourth place for greenhouse gas emissions, at roughly the same level as recreation and culture.

Figure 2.18 Greenhouse gas emissions in the upstream supply chain ([26]) of EU27 household consumption domains, million tonnes CO_2eq., 2020

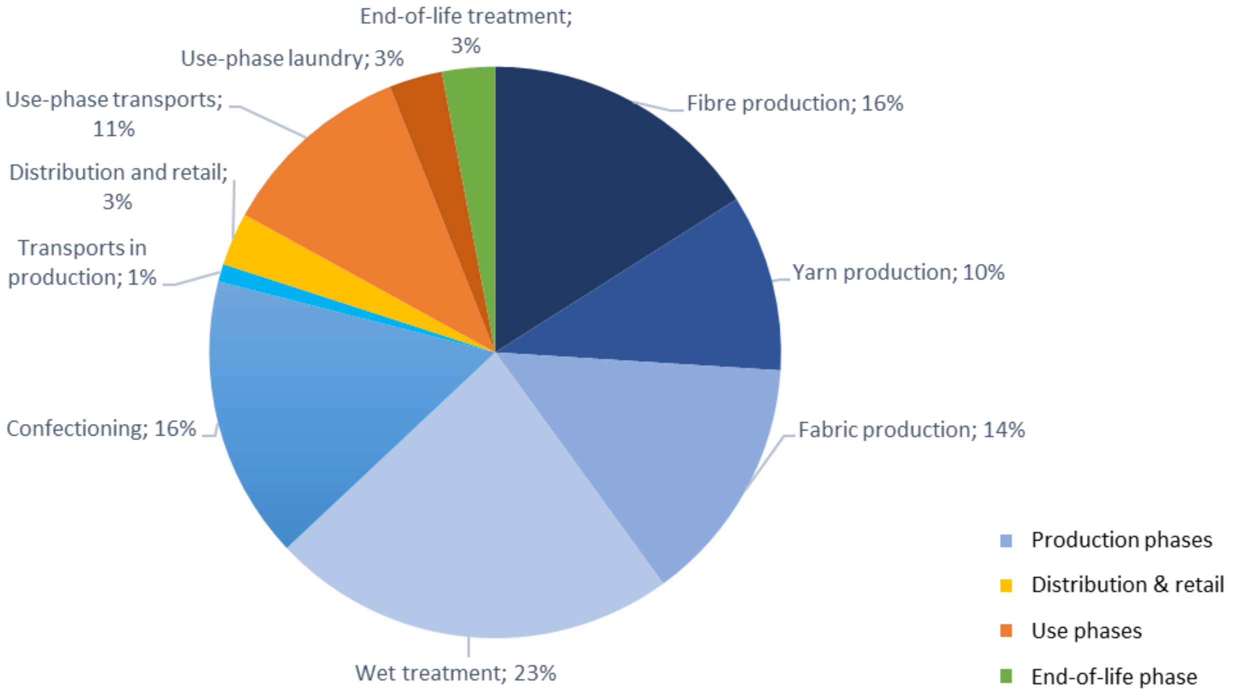


Note: modelled 2020 data are adjusted to match actual 2020 consumption levels
Source: Exiobase v3.8.1

About 80 % of the total climate change impact of textiles occurs in the production phase, 17 % in the use phase, and 3 % during end of life (ECOS, 2021; Östlund et al., 2020). The greenhouse gas emissions of textile production originate from fibre production, varying between 0.5-9.5 kg CO_2 eq per kg fibre (ETC/WMGE, 2021b), yarn and fabric production, dyeing and finishing steps and confectioning. Textiles made from cotton fibres generally have the lowest climate impact, while those made from synthetic fibres -and especially nylon and acrylic- have a much higher climate impact due to their fossil origin and the large energy consumption during production (ETC/WMGE, 2021b; Beton et al., 2014). During the distribution phase, climate change impacts are typically caused by transport and retail activities, while in the use phase laundry, including washing, drying and ironing are main contributors. End-of-life treatment entails collection, sorting, recycling (which only takes place to a very limited extent), incineration and disposal. A study by Östlund et al. estimated the relative contribution of the different lifecycle stages in the climate impact of (Swedish) clothing consumption, with textile production being responsible of 80% of the climate impacts (Östlund et al., 2020) (Figure 2.19). Alternatively, a calculation by the Joint Research Centre in 2014 estimated that production was responsible for 52% of climate impacts, distribution for 5% and use for 45% (Beton et al., 2014).

[26] This includes all activities in industrial and service sectors in the production and supply chain of textile products up to purchase by households. It excludes the use of the textile products and end-of-life.

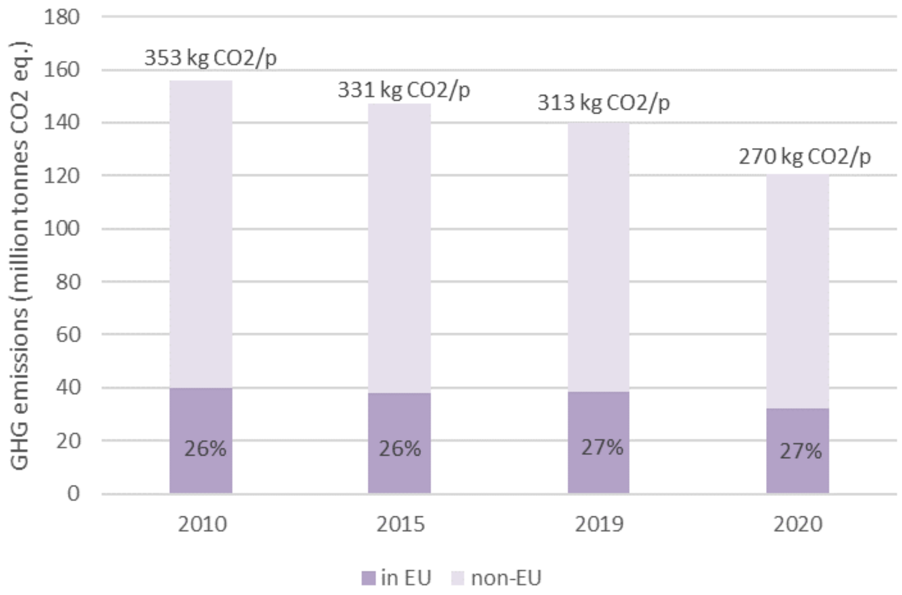
Figure 2.19 Contribution of the different life cycle stages to the climate impacts of Swedish clothing consumption



Source: Östlund et al. (2020)

Figure 2.20 shows the trend in greenhouse gas emissions for textiles between 2010 and 2020. A consistent decrease in greenhouse gas emissions can be observed over the course of these 10 years, while consumption levels stayed constant or increased slightly. This suggests that the greenhouse gas emission intensity of textile consumption (i.e. the amount of emissions per volume of consumption) has been decreasing between 2010-2019. For 2020, the decrease is at least partially a consequence of reduced consumption. About three quarters of greenhouse gas emissions take place outside Europe, in the manufacturing regions, a figure that has not changed much over the last 10 years.

Figure 2.20 Greenhouse gas emissions in the upstream supply chain ([27]) of EU27 household consumption domains, million tonnes CO_2eq, 2010-2020



Note: modelled 2020 data are adjusted to match actual 2020 consumption levels
Source: Exiobase v3.8.1

2.3. Circular business models in the EU textiles sector

In order to reduce the environmental impact of the textiles production and consumption, a shift towards circular economy practices is crucial in order to save on raw material use, energy use and waste generation (ETC/WMGE, 2019). In response to this, business models have emerged in the textiles sector, that are centered around socio-economic fairness, sustainability and circularity. These models focus on the use of renewable or recycled materials, the elimination of hazardous chemicals, product durability and repairability (ETC/WMGE, 2021a). Additionally, resale, rental and sharing services are emerging that aim to reduce overconsumption. The Ellen MacArthur Foundation estimates that such business models, that decouple revenues from raw material production, have the potential to grow from 3.5% of the global fashion market today to 23% by 2030 (Ellen MacArthur Foundation, 2021a).

Since 2010, the number of companies embracing circular business models has increased significantly, both start-ups and existing companies (Köhler et al., 2021). Not to forget, many existing textile companies working on textile tailoring, repair and maintenance (e.g. tailors, laundries, dry cleaning services) have always worked towards the idea of textile durability and extending lifetimes, without adhering explicitly to the concept of 'circular economy'.

An analysis of case studies by JRC shows that most circular business models focus on product take back and use of recycled content, while those aimed at circular design are still limited – mainly targeted towards design for durability, repair and recycling (Köhler et al., 2021). However, while the EU-wide textiles collection rate in 2019 was estimated to be around 39 %, it is expected to significantly grow towards 2025 when the obligations of the revised Waste Framework Directive to separately collect end-of-life textiles will enter into force.

27 This includes all activities in industrial and service sectors in the production and supply chain of textile products up to purchase by households. It excludes the use of the textile products and end-of-life.

A more sustainable and circular textile industry should value quality over quantity, moving away from the mass-consumption paradigm that causes increasing pollution and waste and relies on cheap labour outside Europe. In order to maximise the economic and environmental potential of circular business models, textile products need be (re)designed to be physically and emotionally durable and be able to be remade and recycled at the end of their use (Ellen MacArthur Foundation, 2021b). The relation between business models for textile products, their design and potential for circularity is further explored in Chapter 3.

3 Eco-design of textile products in a circular economy

3.1. An evolving role for product design in a transition towards a circular economy

In the Circular Economy Action Plan (CEAP), the EU strategy for textiles aims to improve the business and regulatory environment for sustainable and circular textiles. The EC is committed to propose textile-specific and horizontal actions along the whole value chain, to make the textile ecosystem fit for the circular economy, addressing weaknesses regarding sustainable production, sustainable lifestyles, presence of substances of concern, improving textile waste collection and recycling in the Member States as well as capacity building (European Commission, 2021a).

Released in parallel with the CEAP in March 2020, the EC published a new Industrial Strategy for Europe reinforcing the role and ability of EU industry in leading the change for achieving the European Green Deal's objectives (European Commission, 2020). As this Industrial Strategy was published one day before the World Health Organization announced the COVID-19 as a pandemic, the EC recently released an updated version ensuring that its industrial ambition takes full account of the new circumstances following the COVID-19 crisis. Building on the ecosystem-based approach outlined in last year's Industrial Strategy, this update explains that the textile sector was one of the most hit sectors by the crisis due to the shutdown of retail outlets (see Box 2.1). Reaffirming the priorities set in March 2020's Communication, the EC proposes new measures for boosting the recovery, strengthening the Single Market resilience, dealing with the EU's strategic dependencies and supporting the business case for the green and digital transitions (European Commission, 2021b).

As one of the key priorities within these interlinked European strategies and resulting initiatives' ambitions, is the importance of designing sustainable products. As introduced above (see Chapter 1), the sustainable products policy legislative initiative which especially aims at widening the scope of the Ecodesign Directive beyond energy-related products will give priority to product groups such as textiles. The Roadmap for the EU strategy for textiles mentions that "*the initiative will underline possible approaches for improving design for sustainability (ensuring the uptake of secondary raw materials and tackling the presence of hazardous chemicals, among others), facilitating its future implementation"* and *"will also propose actions to promote more sustainable production processes*" (European Commission, 2021a).

Using a life cycle perspective, Chapter 2 and particularly Figure 2.11 gave an overview of GHG emissions and environmental impacts associated with textile products. First introduced by De Winter and Kols in 1994 and widely used since that time, it has been estimated that about 80 % of a product's environmental impacts are already determined during the design stage (De Winter and Kols, 1994). Integration of environmental considerations at an early phase of a product development process, thus, appears as an essential approach for enhancing the environmental performance across a product life cycle, and 'designing sustainable products'.

This approach significantly developed and evolved during the last 30 years (Bhamra and Hernandez, 2021; McAloone and Pigosso, 2017; Kim et al., 2020; Ceschin and Gaziulusoy, 2016). In order for policy-makers to establish an adequate and dynamic regulatory framework supporting the design of sustainable and circular textiles, as well as facilitate and accelerate the implementation of this practice within the industry, it is important to first (re-)introduce the evolution of 'design for sustainability' field. A brief and illustrated overview (Figure 3.1) of this evolution is presented below. Some concrete illustrations of this evolution on the textile's ecosystem are presented in Annex 3.

Establishment of eco-design, 1985 -2010

Several authors discussing the evolution of 'design for sustainability' field consider Victor Papanek's book 'Design for the Real World: Human Ecology and Social Change' published in 1985, as the seminal work introducing environmental considerations into the engineering design area (Ceschin and Gaziulusoy, 2016). Early adoptions of 'green' attitudes by the industry mainly focused on identifying environmental concerns created during a manufacturing process and developing end of pipe approaches as corrective measures to clean up any environmental problems (McAloone and Pigosso, 2017). '**Green' design** thus primarily focused on lowering environmental impacts through redesigning individual qualities of individual products (e.g. reducing the amount of material used in a product, replacing hazardous substances with non-hazardous ones, etc.) (Ceschin and Gaziulusoy, 2016).

In the late 1990s, companies started to realize that products could cause different sorts of impact, not only during the manufacturing processes, but also throughout their entire life cycles, from raw material extraction through manufacturing, use and final disposal. **Eco-design** thus emerged as a promising and more proactive industrial approach aiming to 'reduce the environmental impact of each stage of the product life cycle' (McAloone and Bey, 2009). Reflecting the main difference and strength over 'green' design, the introduction of life cycle thinking was associated with efforts to increase resource efficiency throughout the entire product lifecycle. Eco-design has then been one of the most widely adopted concepts in industry in the area of design for sustainability. Still valid and used today, the EEA glossary for instance refers to eco-design as "*the integration of environmental aspects into the product development process, by balancing ecological and economic requirements. Eco-design considers environmental aspects at all stages of the product development process, striving for products which make the lowest possible environmental impact throughout the product life cycle*" (eco-design - EEA glossary, 2001).

Between 1990 and 2010 and for enabling its implementation within companies, many methods and tools were then developed by industry and the research community. Going along with this emergence, policy-makers supported this development with the adoption of policies targeting producers and the extension of their responsibility beyond the point of sale. An 'Eco-design' framework Directive for energy-consuming equipment was first proposed in 2003 by the European Commission, and the Ecodesign Directive 2005/32/EC adopted in 2005. During this period, most resulting actions for implementing eco-design were taken at an operational level, looking mainly at the product level and from a strict design perspective (McAloone and Pigosso, 2017). Bhamra and Hernandez for instance mention that eco-design was mainly framed as a product-oriented approach working on linear models of production and consumption and focusing on material and energy efficiency (Bhamra and Hernandez, 2021).

Systems perspective on eco-design, 2010-2020

Towards 2010 and while successful pilot cases have been demonstrated, eco-design implementation within the industry was still limited. Only very few companies were able to demonstrate the business benefits linked with eco-design implementation (McAloone and Pigosso, 2017). Research has then focused on a more systemic view of the environmental and social challenges faced to pursue a more sustainable development. Consequently, it has been observed that design as a discipline extended its boundaries into new areas such as social design and product-service systems (Bhamra and Hernandez, 2021).

For some products the actual end of lifespan is indeed not caused by technical issues, but rather issues such as psychological obsolescence. The way consumers interact with the product can also lead to substantial environmental impacts during the use phase (Cooper, 2012; European Topic Centre on Waste and Green Economy, 2020). Building on these observations, Ceschin and Gaziulusoy explain that design researchers thus started to focus on the user-product relationship and the role of design in strengthening that relationship. Approaches such as **emotionally durable design** were emerging. More 'traditional' eco-design approaches were therefore starting to incorporate different models of behaviour change from social sciences. Similarly, design for '**Sustainable Behaviour Change**' tools and guidelines have been developed by the research community. Still related to the integration of social issues in product development, the same authors even refer to the emergence of **design for the Base of the Pyramid**

(BoP[28]). While considerable knowledge and know-how in product innovation was gained in industrialised countries, much of this is not directly applicable to low-income contexts. These authors explain that designing and developing solutions at the BoP requires addressing specific issues that are different from those in high-income markets (Ceschin and Gaziulusoy, 2016).

In parallel, the focus on products has been expanded to systems. It has gradually been understood that environmental gains achieved through resource efficiency at a product level can be directly and indirectly counteracted with the rebound effect, an increase in consumption levels (European Environment Agency, 2017). **Design of eco-efficient and sustainable Product-Service Systems** (PSS) thus appeared as a promising alternative and wider approach. The idea behind these systems is to provide users and consumers with the utility they want to satisfy their needs, but with fewer physical products, relying more on services and alternative ways of using products but without the consumer owning them (Tukker and Tischner, 2006). From an environmental perspective, it has been widely discussed that PSSs could potentially decouple economic value from material and energy consumption. However, designing PSSs requires a different and more systemic approach than designing individual products. PSSs are indeed complex artefacts composed of products, services, and a network of actors who produce, deliver and manage the PSS (Ceschin and Gaziulusoy, 2016).

Perspectives for a sustainable and circular economy, 2020-…

Limitations already appeared in the implementation of product-service systems. Several authors explain that the current 'lock-in' in linear production and consumption systems do not favour their wider adoptions (EEA, 2021a). A transition towards a circular economy thus provides new perspectives in the design research area. The focus of 'design for sustainability' has now shifted to the design for circularity (Bhamra and Hernandez, 2021; McAloone and Pigosso, 2017; Kim et al., 2020; Ceschin and Gaziulusoy, 2016). This shift requires more holistic approaches, with the need **to design for System Innovations and Transitions**. While 'design for sustainability' has extended its initial scope to complex systems, only incremental approaches have been adopted by the industry and engineering design research still perceive sustainability as a technical issue (Bhamra and Hernandez, 2021). Increased value chain collaborations and an enhanced maturity for businesses in integrating sustainability considerations are necessary.

Often based on the R-list (i.e. recover, recycling, repurpose, remanufacture, refurbish, repair, re-use, reduce, rethink, refuse, etc.) circular product design strategies are also being proposed by the research community. Designing for high-quality recycling, for reuse, for disassembly, for remanufacturing, for refurbishment, etc. are these complementary design strategies for which tools, guidelines and frameworks are being developed (Bocken et al., 2016; Le Blévennec et al., 2019; Circle Economy, 2020; The Policy Hub, 2020). The deployment of digital technologies such as the Internet of Things (IoT) and Artificial Intelligence (AI) is foreseen to provide designers with new capabilities. Several authors indeed agree to say that the digital transformation of our industry and society will open new perspectives in the integration of design thinking and human-centred approaches (Bhamra and Hernandez, 2021; Kim et al., 2020; McAloone and Pigosso, 2017).

While until now these two areas have been evolving in parallel, technological innovations need to be complemented by **sustainable social innovation** (EEA, 2021a). It is foreseen that the emergence of socio-cultural movements (e.g. right to repair movement) will influence and again expand the scope of sustainable product design. Listed from short to long term challenges, Kim et al. for instance presents future directions, being: "*massive adoption of existing eco-design methods and tools by industry, development of long-term industrial vision by companies, integration of environmental aspects to the same level as economic considerations, expanding the sustainability spectrum by integrating the social dimension, data and design analytics integration and wider adoption of the systems perspective*" (Kim et al., 2020).

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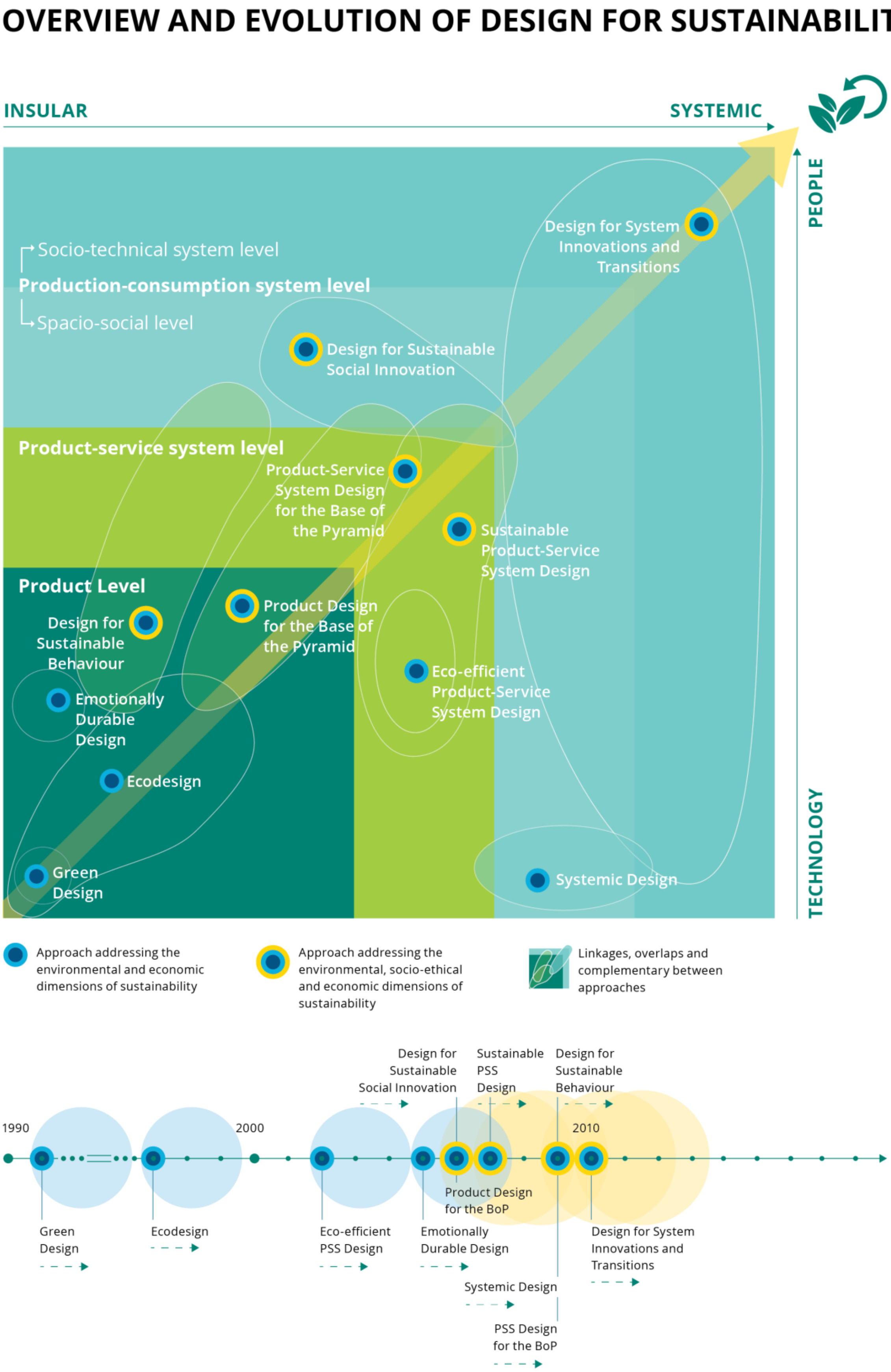
[28] The BoP is the poorest portion of the global population living with an annual income below a certain Purchasing Power Parity threshold

Designing for circularity provides the most recent evolution of design for sustainability. This expansion of a technical and product-centric focus towards a focus on large scale system level changes (taking into consideration both production and consumption systems) shows that this latest evolution requires many more disciplines than engineering design. When discussing sustainable product design in a circular economy, none of the quoted authors mention that lower innovation levels are less important than systemic ones. It is the combination of innovation at product levels, new business models, social practices and for system transitions that will lead to envisioning future circular and sustainable systems (Ceschin and Gaziulusoy, 2016). Inspired and adapted from Ceschin and Gaziulusoy, this evolution is visually summarized with Figure 3.1.

Figure 3.1 Overview and evolution of Design for sustainability



Source: adaption from Ceschin and Gaziulusoy, 2016, illustration by CSCP

Chapter 2 provided an updated overview of our current linear European textile ecosystem. By illustrating the evolution of design for sustainability, this section reflected on the role of product design in a transition towards a circular economy. The outcomes from these two first Chapters reflect a clear gap between the huge environmental impacts of our current production and consumption system and actual uptake of this design research area by the textile industry. For contributing to the implementation of the EU strategy for textiles, the next section will provide an overview of circular product design strategies applicable to textile products. To unlock their mitigation potential, the interactions of technical principles with other systemic dimensions is described.

3.2. Applying eco-design principles to textile products and enabling conditions towards circularity

Today's fashion is faster and faster – and keeps on accelerating at breakneck speed (ECOS, 2021). Reducing resource use and prolonging the useful life of textiles have the highest potential to reduce environmental impacts associated with textile products. Circular product design strategies must enable clothes to last longer and favour product value retention. While it is necessary to enable the recycling and reutilisation of materials ("closing the loop"), life-extending strategies such as design for durability, ease of reuse, repair and remanufacturing should be prioritized ("slowing down the loop"). Preventing the presence of hazardous chemicals, and limiting toxic emissions and microplastics release at all stages should also be enabled by product design.

As mentioned in section 3.1, circular product design strategies, as well as associated tools and guidelines applicable to textile products, are being developed (Bocken, Circular Fashion, 2019; Pauw et al., 2016; Bakker et al., 2014). As shown in Figure 3.1 (summary figure of section 3.1), innovation at different levels is required to ensure that the implementation of these principles leads to an actual reduction of environmental impacts.

Currently most business models in the textiles value chain are designed and optimised to fit the linear system. Unlocking circular product design potential in the textiles sector will require a profound change of business models, involving rethinking the logic of the three value dimensions: what value is proposed; how value is created and delivered; and how value is captured (EEA, 2021a; ETC/WMGE, 2021). Although, a business model provides a link between the individual firm and the larger production and consumption system in which it operates (Boons and Lüdeke-Freund, 2013), within the sustainable production and circular business model research communities, it has been common to investigate the production system, while the consumption system has received scant attention.

Transition to a circular economy in the textile sector requires not only the technical and product-centric focus of eco-design, but also collaboration and strategies across society by governments, companies and citizens, exemplified via consumers´ behaviour and education integrated into the value proposition together with the necessary technical and policy tools. These essential collaborations and strategies can be defined as circular economy enablers, facilitating and shaping the transformation of businesses, organizations and individuals towards the circular economy.

Understanding the meaning of the key circular economy enablers can help businesses as well as governments and consumers to see the scale of the opportunities, and challenges, involved and what wider issues to consider when taking first steps towards circularity in every sector. For instance, a more conscious relationship with the products and services, acknowledging the human and material resources that went into their production, could likely lead to a higher awareness of the value of circular, sustainably designed textile products.

Circular textile product design needs to be combined with tailored information and education campaigns. Consumers are often unaware of, or do not fully grasp, the applied circular model behind specific textile products and services, and often perceive second-hand, recycled fibers and repaired products as of lower quality. In a study conducted by the European Commission in 2018, it emerged that consumers are willing to engage into circular economy via the purchasing of products and services, mainly due to increasing concern about environmental impacts of the linear economy and to a lesser extent from their desire to save money (Cerulli-Harms et al., 2018). A Eurobarometer´s research has shown that 77 % of EU citizens would be willing to pay more for products, if they can be certain that those are environmentally friendly (Cerulli-Harms et al., 2018).

Companies, accordingly, need knowledge about consumer preferences so as to be able to put forward business models that can convince and support consumers towards shifting their purchasing behaviour (Viciunaite and Alfnes, 2020). *Ad-hoc* communication efforts are key to successful mainstreaming (EEA, 2021a; ETC/WMGE, 2021). Increasing understanding and awareness can drive education which in turn contributes to positively alter behaviours leading to the creation of a market for circular textile products.

Policy measures can also provide appropriate incentives for change: e.g., supporting designing out hazardous substances have had a great impact, not only directly on consumer health and safety, but also indirectly by taking away an important barrier for recycling materials for use in new applications (EEA, 2021a; ETC/WMGE, 2021). Standardisation can also play an essential role for monitoring and ensuring the compliance with requirements from specific policy instruments (ECOS, 2021).

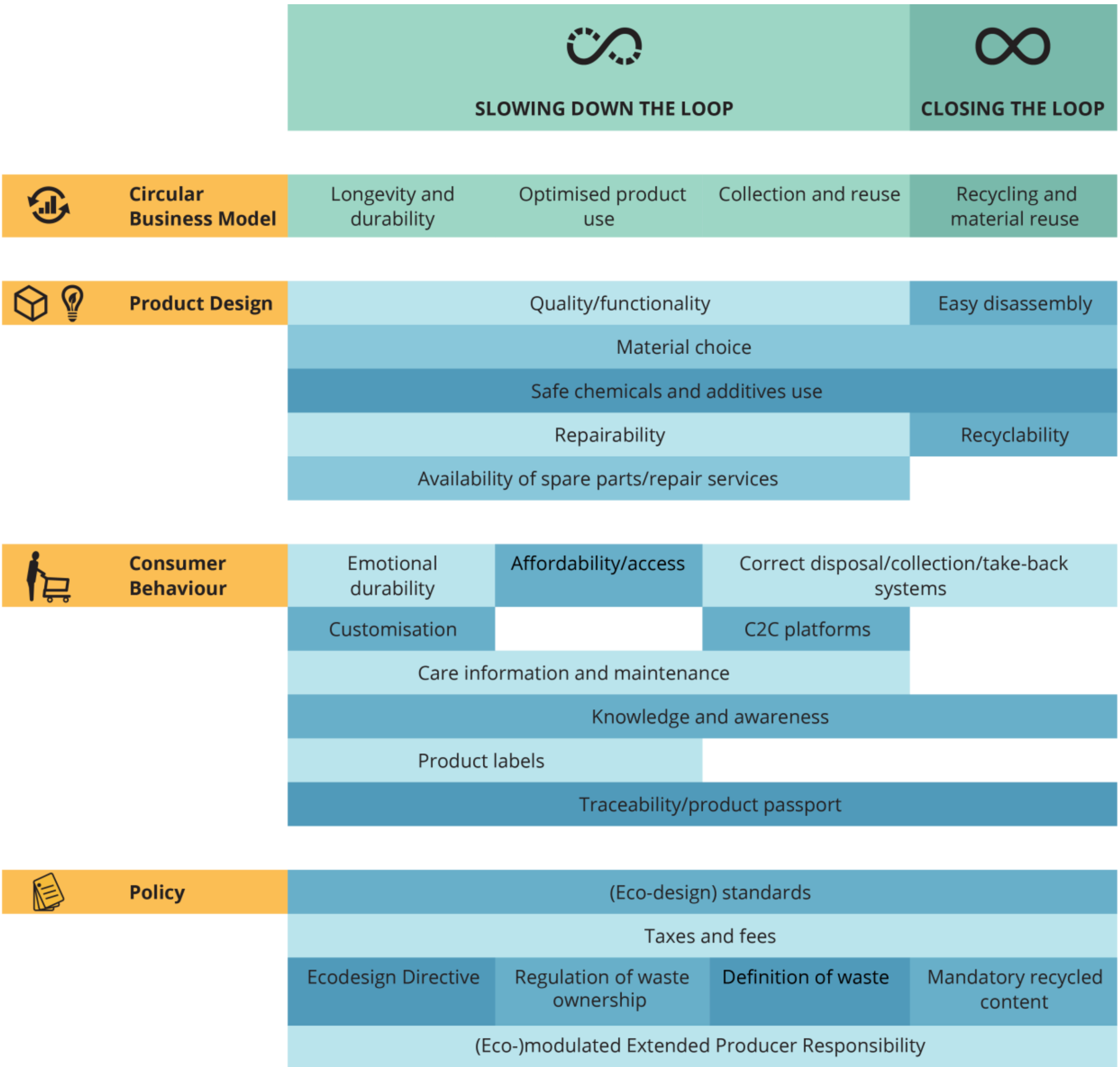
Although, the Eco-design Directive (EU, 2009) and the EU Ecolabel (2010) have paved the way in contributing to improve the circularity of several product types, the above-mentioned sustainable products policy initiative and EU strategy for textiles should play an essential role for expanding the scope and provide a level playing field for those companies that are willing to improve the circularity of their textile products.

The challenge is to discover the appropriate combination of these enabling technical, business, social and policy factors that results in mainstreaming the circular design of textile products.

In this report, the analysis builds upon the EEA circular business model analytical framework showing how three types of enablers need to interconnect and operate together around specific circular goals highlighting how specific types of business model, and technical and social innovation can be required to implement a given circular goal in a given lifecycle phase (EEA, 2021a; ETC/WMGE, 2021a). The existing analytical elements are further complemented by an overview of the eco-design principles and their interlinkages to the different textile business models and respective enablers using a life-cycle thinking perspective.

Specifically, the subsequent sections discuss the different business model options that could support the shift towards a circular textiles system and how the design phase plays a critical role in relation to each of them. Respectively, eco-design principles for a more sustainable sourcing of fibres, for ensuring an optimal resource use during production, for an environmentally sound and safe use phase, for extending textiles lifetime, and for recycling and enabling material reuse are analyzed against defined circular business models typologies: for longevity and durability, optimized resource use, collection and reuse, and recycling and material reuse (Figure 3.2).

Figure 3.2 Overview with linkages between circular business model, product design and enabling conditions



Source: EEA and ETC/WMGE, illustration by EEA

The overview of technical eco-design principles is based on a non-comprehensive review of identified guidelines for textile products, existing and proposed measures, criteria and requirements in relevant policy instruments or again recent reports, studies and/or textiles-related initiatives from industry and academia (the entire review including the list of document sources can be retrieved in Annex 4).

Longevity and durability

Selling durable textile products, focused on delivering a longer product life: a process which can start already in the design phase enabling not only the products to last longer, but also by applying a design facilitating easy maintenance and repairability. Increasing textiles durability allows for longer use and reuse of products and represents, according to some studies, the “single largest opportunity” to reduce environmental impacts related to greenhouse gas (GHG) emissions, water demand and waste generation of textiles (Cooper et al., 2013). For example, it has been estimated that extending the life of clothes by nine extra months can reduce carbon, water and waste footprints by 20 to 30 % (Cooper et al., 2013);

while reducing a single new garment production by 5 % through increased duration of first use, reuse, and repair would deliver environmental benefits equivalent to 20 tonnes of GHG emissions (Cooper et al., 2013), and if the number of times a garment is worn were doubled, GHG emissions would decrease by approximately 44 %, as compared to the production of a new garment (WRAP, 2013). There is the need to change the concept of fashion to more sustainable practices and lifestyles, supporting longer product use (EEA, 2021a; ETC/WMGE, 2021a).

The notion of fashion, involving fast changing trends, is, to a certain extent, contrary to a shift to more durable, long-life products with timeless style. It is necessary to address and increase customer satisfaction and brand loyalty while triggering behavior changes. Over the last 20 years, the use-time of clothes decreased 36 % upon, on average, using each garment between seven or eight times (Lujan-Ornelas et al., 2020; Ellen MacArthur Foundation, 2017). Furthermore, higher production costs and lower production volumes resulting in higher sales prices also pose a competitive disadvantage compared to more low-cost brands: fueled by unsustainable patterns of mass production and cheap labour, particularly from Asia (EEA, 2021a; ETC/WMGE, 2021).

A circular approach in enabling longevity and durability of textile products starts with the **use of materials** that conserve resources themselves and are converted into long-lasting products. The materials used for a textile product not only determine the structure of the value chain and supply chain, but they also leverage the possibilities for keeping the textile products longer in use, enhancing durability while simultaneously enabling easier repairing. In order to increase the durability and hence the quality of garments, a number of underlying design principles or potential requirements have been defined in literature or are already part of existing product standards or eco-labels. An overview of these principles or requirements can be found in Table 3.1.

Table 3.1 Design for longevity and durability, identified principles

Design for longevity and durability		Applicability	Testing and compliance schemes
#	**Principle / requirement**		
1.	Ensure limited dimensional changes during washing and drying	Generic	Standard ISO 5077
2.	Ensure colour fastness to washing	Generic	Standard ISO 105 C06, C08, C09
3.	Ensure colour fastness to perspiration (and saliva)	Generic	Standard ISO 105 E04
4.	Ensure colour fastness to (dry and wet) rubbing	Generic	Standard ISO 105 B02, Standard ISO 105 X12
5.	Ensure colour fastness to light	Generic	Standard ISO 105 B02
6.	Ensure fabric resistance to pilling and abrasion	Generic	Standards ISO 12945-1:2000, ISO 12945- 2:2000, EN-ISO 12947
7.	Provide care and maintenance information	Generic	Standard ISO 3758:2012
8.	Select durable fasteners	Fasteners	D2061-03 ASTM international for zippers
9.	Ensure an easy disassembly	Components and accessories (logo, buttons, zips etc)	
10.	Ensure availability of spare parts / Provide repair kits	Components and accessories (extra buttons, thread of correct colour, replacement zips, etc)	Proof of availability of spare parts
11.	Ensure the product is fit for purpose	Fabrics, linings, components, stitch types, etc	

12.	Provide multi-functionality	Occasion wear, Children clothing	

These aspects relate to what could be considered as the overall **quality of the textile products** and are important contributing factors to product longevity and durability. For example, according to research, 40 % of all reasons for consumers to discard clothes are linked to (functional) changes of garments, like a hole or tear, worn out look, loss of elasticity or shape, stains, colour change or fading colours, ... (Laitala et al., 2015), dimensional changes during washing or drying, or colour fastness of garments do also influence the usage lifetime of textiles products. Accordingly, these principles assessed and benchmarked against a set threshold value could contribute to defining the circular quality of a textile product, setting specific targets and thus preventing low-quality textile products entering the market.

These principles call for innovation in the way clothes are made, including the way fabric is constructed and chosen: converging towards an optimised palette of materials – including blends where these are needed for durability, functionality and in some instances personal safety. Their application is a complex process which needs to account for different factors e.g., the more different materials and chemicals are used, the more difficult ; the development of new materials where no current ones are suitable to provide both the desired functionality and recyclability. In this context, some companies have started using different materials, such as organic cotton, organic wool, native natural fibres like flax or hemp and cellulose-based fibres that reduces energy and water consumption and the generation of emissions, as alternatives to conventional cotton (e.g., Tencel; Bembergis). In the case of sustainable synthetic fibres, milk or other animal proteins are now being processed instead of crude oil.

Concurrently, new technologies have given way to a new generation of textiles. This is the case of nanotechnology applications that provide high durability to the products and different properties, e.g., self-cleaning textiles (Busi E., et al., 2016). These new products have dust and dirt repellence, significantly reducing the washing cycles necessary to keep the garment in good condition, and hence reducing the use of resources (Busi E., et al., 2016). However, these innovations are still at the beginning of their development and their environmental performance including their full impacts on the circular potential (e.g., impact on dispersion of nano-parts during use, on the user's health, on recyclability) as well as their environmental impacts and possible health risks require further research and analyses.

As the average quality and durability of clothing on the market increases, so should the average use of garments. Accordingly, it is also crucial to address **consumers' knowledge and awareness** about the material(s) they are purchasing. From the perspective of the consumer, durability has two meanings: physical and emotional. Addressing physical aspects can be achieved for example, via eco-labels which can be central to communicate the value of buying higher quality and longer-lasting items.

While emotional durability is linked to the feelings about buying a new item of clothing: consumers want a garment that makes them feel and look good. This positive connection could also be further fostered by appropriate **care information and services,** also considering that a large part of the environmental impacts generated by the textile products' use is derived from the water consumption and electricity during the washing, drying and ironing cycles (Busi E. et al., 2016). Although, care labels are not a legal requirement in the EU (aside from Austria), brands can use them to prevent returns and help customers care for their clothes while reducing negative environmental impacts (Baydar, G., Ciliz, N., Mammadov, A., 2015; Van Der Velden et al., 2014). Examples are the Ginetex symbols cover washing, bleaching, drying, ironing and dry cleaning. In 2014, Ginetex created the Clevercare initiative. The Clevercare logo leads consumers to a website advising them to wash less frequently, at lower temperatures, air dry instead of tumble drying, iron only when necessary, and minimise dry cleaning.

Additionally, a garment with emotional durability will continue to be worn by the consumer because it has a strong and positive association. This in turn, would increase demand for **repairing services**. Retailers could provide repair and other services in-store and form partnerships with repair and restyle providers based in local communities. Several brands already offer in-store repair and incentivise users to keep their garments well maintained, in particular, outdoor clothing brands (e.g., Patagonia; Houdini Sportwear). Producers could also make **spare parts** available for a minimum number of years after product has been on sale, or alternatively provides spare parts or basic repair kits with the product (Bauer et al., 2018).

Sparking consumers interests and triggering quality purchases can also be encouraged via the use of new technologies that provide **customization of products** for maximum customer satisfaction. This could open up opportunities to introduce more clothing services, such as garment restyling or consulting, advice on upgrades, customisation, and mending at home[29].

Nonetheless, this is not the case for all textile products: for certain clothing types, there is already a demand for high-quality, durable clothes, like e.g., coats, jumpers, jeans, socks, hosiery, and underwear, which represents 64 % of garments produced globally for both women and men (Ellen MacArthur Foundation, 2017). For others, a similar demand is currently hindered by lack of information about the materials sources and quality which often prevent consumers from making the best choices.

In addition, to behavioural and educational enablers, policy tools specifically **market-based policy instruments** could be increasingly used to achieve environmental objectives by encouraging targeted changes in business practices. The range of instruments include taxes and fees (e.g., applied to specific products, materials or certain uses of materials), subsidies (e.g., to support certain desirable alternatives, production processes), a harmonized extended producer responsibility (EPR) schemes (in particular those that include an element of fee modulation based on materials and/or their sources or new ones enabling harmonized eco-modulation of fees concept to consistently reward circular design) (EuRIC, 2020; OECD, 2017).

Optimized resource use

While an inclusion of the consumption perspective is clearly necessary for designing for an optimized resource use, production systems have currently been the main focus of related innovations. From a technological perspective, companies have been focusing on the reduction and optimization of water and energy use (e.g., via the implementation of waterless dyeing techniques; or of minimum number of BAT energy efficiency techniques); the reduction of air emissions and water pollution via the use of safe chemicals and diversified biodegradable materials as well as an increased transparency in the type of materials and substances employed.

As in other sectors, the circular economy transition is leading the textile industry to introduce models that move away from outright ownership to access to products. The value proposition of these types of business models focuses on the delivery of the service (access and performance). These business models enable the products to remain property of the company, while the customer pays for having access to their use. The “hassle” of service and maintenance is taken over by the manufacturer or retailer (value creation and delivery). The user can enjoy the benefits of performance and access to a service. With regard to the way value is captured, the pricing is per unit of service (e.g., time, number of uses, performance) (EEA, 2021a; ETC/WMGE, 2021a).

Access-based business models already exist in different textile markets: business-to-business, such as carpet and workwear leasing; business-to-consumer, such as tent rentals and clothing libraries; or consumer-to-consumer, such as the sharing of camping gear, through online platforms (EEA, 2021a; ETC/WMGE, 2021a). However, over the last years, an emerging trend has been to carry these rental schemes to everyday wardrobes. Adopted in the textile sector, **access-based business models** have the potential to reduce the use of new material, thus leading to lower resource use by increasing the use rate

29 Source: https://www.ellenmacarthurfoundation.org/explore/fashion-and-the-circular-economy

of the product stock (EEA, 2021a; ETC/WMGE, 2021a) and contributing to reduce textiles waste. Nonetheless, still less than half of used clothes are collected for reuse or recycling when they are no longer needed (Lujan-Ornelas et al., 2020). A study has estimated that **47% of all fibre entering the fashion value chain becomes waste** throughout the myriad of different stages of production from fiber, yarn, fabric up to a garment[30]. Presently, less than 1% of textile waste is recycled into new fibres for clothing and the non-reusable fraction is mostly downcycled into industrial rags, upholstery filling and insulation, or is incinerated or landfilled[31].

There are currently companies that offer clothing subscription services, in which customers pay a weekly, monthly or annual fee to rent a specific number of garments. This allows consumers to change their wardrobe frequently: accessing a product for a short period of time after which they can return it to the service provider, without acquiring new clothes, thus reducing the use of new materials and the generation of waste (examples are clothing lease and subscription models, from US-based Rent the Runway's rental service targeting working women, to Frontrow's designer clothes rental service in the UK) (Mugge, 2018). Furthermore, certain segments of the textile industry are particularly wasteful, such as kids wear: as children outgrow their clothes so quickly, force parents to regularly buy new items (such as the Danish start-up Vigga offering subscription babywear). Once discarded, over half of garments end up in mixed household waste and are subsequently sent to incinerators or landfill (Mugge, 2018). By introducing a circular access-based business model based on subscription-based leasing service, companies enable parents to lease organic maternity and children's wear and thus reduce the demand for new clothes. According to some companies, the leasing model has the potential to reduce a child's textile waste up to 80 %, by directing clothing that has been outgrown to new customers, and collaborating with a company that recycles the worn-out clothing to produce new garments; and to reduce expenses[32].

For textile products with longer use periods, such as carpets or building interiors, access-based models typically come with complementary services, such as installation, maintenance and repair. In this case, the main value proposition is not price, as service-models are often more expensive than ownership in the long run, but rather convenience and guaranteed, hassle-free performance (EEA, 2021a; ETC/WMGE, 2021). This is especially relevant in the business-to-business context, as companies can save on investment budgets and replace them by recurring working costs (EEA, 2021a; ETC/WMGE, 2021).

As for the previous typology of circular business models, the Table 3.2 below provides a snapshot of identified eco-design principles contributing to the optimization of resource use, mostly from a production perspective.

30 Source: https://reverseresources.net/news/how-much-does-garment-industry-actually-waste

31 Source: https://ec.europa.eu/research-and-innovation/en/horizon-magazine/latest-trend-keeps-clothes-out-landfill

32 Source: https://www.ellenmacarthurfoundation.org/explore/circular-design

Table 3.2 Design for optimized resource use, identified principles

#	Design for optimized resource use — Principle	Applicability	Testing and compliance schemes
1.	Reduce water use	Water-using processing facilities (weaving, dyeing, printing, finishing)	Cradle to Cradle Certified™, HIGG FEM Water use, STeP by OEKO-TEX
2.	Limit water pollution	Water-using processing facilities (weaving, dyeing, printing, finishing)	ZDHC Wastewater Guidelines, Cradle to Cradle Certified™, HIGG FEM Wastewater, Clean By Design, STeP by OEKO-TEX
3.	Ensure biodegradability of auxiliaries and finishing agents	Fibre and yarn processing facilities	EU Ecolabel, Blue Angel: the German Ecolabel for Textiles
4.	Reduce energy use	Production facilities	HIGG FEM Energy use, STeP by OEKO-TEX, Cradle to Cradle Certified™, EU Ecolabel, Green Circle Certified
5.	Limit emissions to air	Production facilities	GHG emissions HIGG FEM Energy use, Renewable Energy Certificate, STeP by OEKO-TEX, Cradle to Cradle Certified™
			Air pollutants HIGG FEM Air pollutants, EU Ecolabel, the Blue Angel for textiles, STeP by OEKO-TEX, Cradle to Cradle Certified™
6.	Reduce waste	Production facilities	ISO 14001, UPMADE® Certification, SCS Recycled Content Certification
7.	Use safe chemicals and processes	Production facilities	Zero Discharge of Hazardous Chemicals Manufacturing Restricted Substance List, Bluesign, Cradle to Cradle Certified™, ECO PASSPORT by OEKO-TEX, Global Recycled Standard
8.	Increase transparency on chemical formulations	Production facilities	ToxFMD Screened Chemistry®, GreenScreen® Certified, SciVeraLENS Screened Chemistry
9.	Procure fibres/yarn that incorporate recycled and/or reclaimed content in fibres/yarn	Fibres	Recycled Claim Standard, Global Recycle Standard, SCS Recycled Content Certification, UL Recycled Content Verification, Intertek's Green Leaf Mark, C2C Certification
10.	Procure fibres from renewable sources	When fibers are made (partially) from virgin cellulose and virgin-protein based materials	When fibers are made (partially) from virgin cellulose Global Organic Textile Standard, Organic Content Standard, Regenerative Organic Certification
			When fibers are made (partially) from virgin-protein based materials Responsible Wool Standard, Responsible Down Standard

In view of optimal use of resources, setting up design requirements certifying a minimum content of recycled material could further stimulate optimal resources use - while indirectly increasing content collection - reuse as well as recycling – including the use in new products and potentially bringing new sorting and waste recovery streams. For example, the inclusion of recycled fibres is perhaps most relevant for rapidly discarded fast fashion and least relevant for textiles whose active lifetime is determined by technical durability e.g., bed-linen, towels, basic underwear etc. (Bauer B., et al., 2018).

Several international **certifications and labels** - e.g., the EU Ecolabel for textile products, the Blue Angel for Textiles, the Global Recycled Standard, the UPMADE, the Global Organic Textile Standard (GOTS), the Organic Content Standard (OCS) etc. - have already paved the way to an optimized resource used as well as to a more transparent and better communication with respect to the environmental and social impacts of their textile products. For example, GOTS forbids the use of chemicals dangerous to health and also regulates the water and energy consumption and the OCS guarantees the traceability of organically grown materials. Similarly, the Better Cotton Initiative, Nordic Swan Ecolabel etc. consider the environmental and health aspects of the material used in the products and engaged in precise communication standards (Luján-Ornelas C., et al., 2020).

There may also be the need to include design requirements to exclude environmentally disadvantageous recycled materials (also other than those containing hazardous chemicals) from contributing to the declared recycled content (Bauer, et al., 2018). This would require e.g., LCA-based evidence of disadvantageous processes. Furthermore, market-based tools should also ensure that recycled materials are used for proper functions, the reuse of resources in textiles may not always be the most optimal route for recycled waste (Bauer, et al., 2018).

To actually decouple the generation of profit from the use of resources in terms of production and sales volume, it now depends on the complementary inclusion of the consumption perspective since design. The products need to survive wear and tear by multiple users and be easy to clean (EEA, 2021a; ETC/WMGE, 2021). Companies need to design **durable and reparable products**, so they can guarantee quality and performance without the need for frequent interventions and replacements; e.g., additional costs for life extension are offset by additional revenues, because the company can use the product longer. Also, **recyclability** or the potential for subsequent **reuse** in different applications can be an important driver as it conserves product or material value and avoids waste treatment costs (Lindström, 2019). Furthermore, it will be crucial to account for possible trade-offs when implementing those processes. For example, centralizing advanced textile recycling technologies might require the shipping of textiles (with the associated climate impact), and shift textile manufacturing locations (causing socio-economic impacts). Furthermore, recycling processes require resources and energy and can themselves impact water quality. Life cycle-based studies should thus be undertaken of proposed actions and technologies to ensure these offer environmental and socioeconomic benefits to the textile system as a whole (UNEP, 2020).

At the same time, policy enablers necessary to successfully adopt access-based business models demands include specific **regulations with regard to ownership, transport and trade** of textiles including waste streams as well as **regulatory incentives** e.g., subsidies linked to the environmental performance, or VAT reduction, (eco-modulated) EPR.

To realize the full potential of these business-to-consumer models, other crucial enablers are represented by **consumers behaviours and knowledge**. Only if consumers perceive the ample benefits and limited risks in alternative ownership models and see these as viable alternatives to the traditional purchase access-based business models can be successfully implemented. However, one of the main challenges is that consumers do not currently appear to take responsibility for prolonging products' lifetimes themselves making the broader up-take of access-based business models in the textile sector difficult. There is the need to shift 'mindset' and behaviours via targeted communication strategies and market engagement that address consumers concerns while concurrently better informing them about greenwashing practices. For example, it has been demonstrated that consumers have concerns related to the ownership and responsibility of these types of products. Specifically, they encounter fears concerning the risks and responsibilities of such contract-based service agreements (Mugge, 2018). Thus, it has been argued that companies should also develop a cultural understanding of ownership and if careful consideration is given to, not only price and convenience, but also to deeply-held values of consumers related to trust and responsibility, while designing these services (Mugge, 2018).

These models need also to actively foster reduced production and consumption behaviours while encouraging a “do more with less mentality” as literature and practice indicate this type of servitization models are not inherently more eco-efficient and that careful attention to detail is required to realise the benefits (Mugge, 2018; Sitra and Circle Economy, 2015).

Collection and reuse

A third main pathway towards increased circularity in the textiles system is focusing on extending the useful life of textiles beyond the first user. Business models built around the collection and resale of textiles aim to exploit residual value by collecting discarded products and preparing them for reuse (EEA, 2021a).

Collecting and reselling used textile products can attract new customer groups, increase customer loyalty, demonstrate corporate responsibility and generate additional revenues for brands or manufacturers. However, various conditions determine the success of this model, such as brand image, style and market maturity, as well as high product quality (Hemkhaus et al., 2019). As a result, all product design principles or guidelines related to design for longevity and durability are also applicable to this circular business model (see Table 3.1).

Next to product quality, product type also has an impact on the potential for reuse. Baby or children’s clothes are typically used only for a short period of time, which makes them less prone to wear and tear. As a result, these product types are often sold in second-hand shops or donated for reuse. In 2020, more than 80 % of best-selling clothes on the second-hand platform Vinted in France was from the brand Petit Bateau, a French manufacturer of baby and children clothes (Statista, 2021). Next to baby- and children clothes, also luxury brands, designer or vintage pieces are typically sold for reuse (ETC/WMGE, 2021a).

Understanding **consumer behaviour** and his attitude and motivation towards disposal of textiles is an important enabling factor in this model as this determines the way a collection system should be set up, which partners (e.g. logistics partner) are important and how money raised from collecting and processing is used (WRAP, 2021). Increased consumer awareness and convenient collection schemes, whether via containers on the street, door-to-door, in-store or by return mailings, can encourage consumers to hand over their waste textiles to collection schemes (ETC/WMGE, 2021a; WRAP, 2021). Especially information about what happens with the collected textiles and offering an incentive, e.g. a money-off voucher motivates consumers to use take-back services (WRAP, 2021). However, such discount vouchers may increase collection rates for reuse but may also encourage increased consumption of new resources as consumers free up space in their wardrobes (ETC/WMGE, 2021a; Köhler et al., 2021).

A 2020 ING survey shows that about 20 % of consumers regularly buy pre-owned clothes which means that participation in pre-owned markets is still generally low. Especially a younger group of consumers, more in particular Gen Z[33] and Millennials[34], drive the secondhand market. Of these age groups, more than 40 % have shopped secondhand apparel, shoes or accessories in the past 12 months (ThredUp, 2021). These groups take advantage of **online C2C (consumer-to-consumer) platforms** to offer and buy used clothes with minimal effort (ING, 2020). The COVID-19 crisis has increased the popularity of these platforms, which will also benefit from the further grow of the second-hand market, which is expected to have a compound annual growth rate of 15 % to 20 % globally over the next five years (Boston Consulting Group, 2020). While this increased consumer-to-consumer reuse is beneficial from a circular economy

33 ‘Generation Z’ is typically used to refer to people born between 1995 and 2010.
34 ‘Millenials’ is typically used to refer to people born between 1980 and 1995.

point of view, it diverts the high-value reuse fraction from the collection and sorting schemes, which highly impacts profitability (Köhler et al., 2021). As a consequence, the right policies and incentives need to be put in place to make the economics work.

Policy enablers necessary to successfully adopt collection and reuse business models include specific **regulations with regard to transport and trade** of collected textiles and establishing more specific **targets for (prepare for) reuse.** Next to this, also **regulatory incentives** such as VAT or tax reductions on reuse activities and eco-modulated extended producer responsibility schemes to raise funding to support investment in collection and reuse and recycling capacity are important enablers (ECOS, 2021; ETC/WMGE, 2021a).

Recycling and material reuse

While the previous pathways focused on 'slowing down the loop', by reducing resource use and prolonging the useful life of textiles, this last circular business model enables to 'close the loop', by turning waste textiles into raw material for new textiles production chains. Material reuse can be done at the level of the fabric via remanufacturing, also often referred to as 'upcycling', and at the level of the fibre via recycling. Both result in a reduction in the need for virgin raw materials and a reduction in textile waste generation (EEA, 2021a).

Despite the interest of a broad range of stakeholders, recyclability of textiles is rarely considered in the design process (Watson et al., 2017). Due to specific functional needs (e.g. give stretch), aesthetical reasons (e.g. use of prints or layers) or economic reasons (e.g. mixing natural fibres with less expensive synthetic fibres), other considerations in the design process are given priority over design for recycling. This results in almost a third of all textile waste being unsuitable for fibre-to-fibre recycling (Köhler et al., 2021).

Especially with mechanical recycling of textiles there are still technical challenges such as chemicals like dye stuff and finishes which cannot be removed and shortening of fibre lengths which makes it more difficult to spin yarns. Blended fibres or materials are also a major barrier for fibre-to-fibre recycling. Especially a high content of elastane makes a product difficult or impossible to recycle. However, a wide range of innovative fibre-to-fibre recycling technologies are emerging at different scales. Although many are still not operating at full industrial scale, some are expected to expand their capacity substantially over the next few years (Köhler et al., 2021). This however complicates setting specific requirements for design for recyclability as products that are not (fully) recyclable today could be tomorrow. The principles or requirements for recyclability should be considered under readily available current technology (ECOS, 2021). An overview of the product design principles impacting recyclability can be found in Table 3.3.

Table 3.3 Design for recycling and material reuse, identified principles

Design for recycling and material reuse		Applicability	Testing and compliance schemes
#	**Principle / requirement**		
1.	Use a single material	Generic	
2.	Provide materials composition information	Generic	
3.	Provide bill of chemicals	Generic	
4.	Ensure an easy disassembly	Components and accessories (logo, buttons, zips etc)	
5.	Eliminate the use of metal rivets	Jeans	
6.	Engage with partners to define intended cycling pathways	Generic	Cradle to Cradle Certified™ Product Circularity

Textile products containing (non-removable) buttons, zippers or other accessories are difficult to recycle, especially in chemical recycling processes. Trims that cannot be easily disassembled for removal can cause additional waste fabric at the recycling stage as they are often removed by cutting (Ellen MacArthur Foundation, 2021d). In order not to disturb the recycling process or create additional waste streams, trims or accessories should be easily removable allowing for reuse and recycling at the end of use (Bauer et al., 2018; Ellen MacArthur Foundation, 2021d).

Low-density stitching could be used for **easy disassembly** of particular parts, but should not compromise on product strength or safety (e.g. creating choking hazards for children). The past few years, there have been a number of innovations to accommodate easy disassembly, such as disintegrating stitching/sewing yarn that melts in specialized ovens (e.g. Resortecs) or disintegrates via microwave technology (e.g. Wear2Go), reversible crosslinking-decrosslinking systems that can bond-debond reversibly after applying a triggering mechanism (e.g. acid, heat, UV light) or supramolecular polymer adhesives for (reversible) bond-debond.

In 2019, the Ellen MacArthur Foundation's 'Make Fashion Circular' initiative launched The Jeans Redesign, a set of guidelines to create denim jeans aligned with the principles of the circular economy, meeting minimum requirements for durability, traceability, and recyclability. One of the insights after two years of applying the Jeans Redesign Guidelines, was that the majority of participants (65 %) managed to eliminate the (metal) rivets from their products by substituting it with bar tracks, reinforced stitching or embroidery techniques contributing to an improved recyclability (Ellen MacArthur Foundation, 2021c).

To enable high-value recycling of textile products, textile products should include a list of all materials (a **bill of materials**) included in the product and at what level they are pure or mixed with other materials (e.g. in weight percentage), as textile recycling processes have different input requirements (Bauer et al., 2018; Ellen MacArthur Foundation, 2021d; Köhler et al., 2021). For example, the concentration of chemicals needed in a chemical recycling process are highly dependent on the precise fibre mix and are also sensitive to the presence of other materials (Bauer et al., 2018). Textile labels containing the fibre composition of the product are mandatory in the EU for textiles intended for sale to the end consumer (Textile Label, 2021).. However, due to missing labels because of consumers cutting out the label, unreadable labels due to washing or labels not indicating the correct material composition, manual sorting of discarded textile products is labour intensive, costly and cannot provide enough suitable input for some recycling technologies to scale (WRAP, 2019; Bauer et al., 2018; Köhler et al., 2021; Hemkhaus et al., 2019). RFID tags in the product, currently already used by numerous clothing manufacturers to track stock levels, could also be used to store information on material composition that could be retrieved by the sorting facility. Integrating or sewing the RFID tag into the garment could prevent consumers from removing the label, but could however contaminate the input stream of the recycling process. Advanced (semi-) automated sorting techniques that use near infrared (NIR) to optically identify and sort discarded textiles such as Fibersort or Simtex, could increase sorting efficiency and accuracy but still have difficulties identifying coated or laminated products (e.g. a big print).

Not only the presence of certain materials can pose obstacles to recyclability, but also the presence of certain chemicals or chemical additives, such as dyes, water repellents, anti-wrinkle agents, …. Particularly with mechanical and thermo-mechanical recycling, these substances stay present in the recycled fibres. Declaring the chemical content of a textile product through a **bill of chemicals** could help prevent toxic chemicals from recirculating (ECOS, 2021).

A textile product designed for recyclability may conflict to a certain extent with product durability and longevity. For textile products where its useful lifetime is mainly determined by technical strength rather than style or fit, using material blends (e.g. polycotton) can be a more durable choice than mono-materials (e.g. only cotton) (Bauer et al., 2018). Making fibre or material choices does not only depend on recyclability under readily available recycling technology, but also on product type and characteristics. An **increased dialog and cooperation along the value chain** can help material suppliers gain a better understanding of the reasoning behind a manufacturer's material specifications, which could result in jointly developing or setting goals for recyclable fabrics (Watson et al., 2017).

Designing and making a product for recyclability is only effective if the loop is actually closed and the used textile products are separately collected. Although there are no figures for all EU countries, the collection rate[35] of used textiles in the EU varies significantly from 4.5 % in Latvia to 45 % in the Netherlands (Köhler et al., 2021). This means that the majority of disposed clothing and household textiles are disposed of in mixed municipal waste streams. Raising **consumer's awareness** and improvements in consumers messaging that textiles do not belong in the regular household waste, combined with an adequate collection infrastructure are key to increase the collection rate and enable recycling and material reuse (WRAP, 2019). **Consumer behaviour** also affects the quality of collected textile products. Due to excessive washing or tumble drying at high temperature, the fibres are damaged, affecting the quality of the fibres to be recycled. This is especially the case for mechanically recycled fibres. Advising the consumer through care labels on e.g. frequency of washing or recommended washing temperature, could help limit this quality loss (Köhler et al., 2021).

As already mentioned in Chapter 2, there is an increased consumers interest in fair and sustainable fashion; where it is made, which materials are being used and whether they are recyclable. However, it is a complex story to tell and missing **knowledge** on recycling strategies and materials (e.g. use of mono-fibres versus blended fibres) are barriers for consumers to adopt more circular consumption practices (Hemkhaus et al., 2019; ING, 2020). However, manufacturers or brands can educate consumers online, via mobile apps, and in store. Stronger consumer awareness can create demand for recyclable products or products made with recycled fibres and increase the willingness to pay more for sustainable products until recycling processes are improved and prices can compete with virgin fibres (Hemkhaus et al., 2019). According to a 2020 ING survey, about 70 % of engaged consumers would be prepared to pay more for fully-recyclable clothes (ING, 2020). More in general, about one third (34 %) of the population is willing to pay more for sustainable products or services, and those willing to pay more would accept a 25 % premium on average (BusinessWire, 2021).

At the same time, there is also a need for policy enablers to successfully adopt recyclability and reuse business models. However, at the moment there are no **standards with regards to collection**, leaving it open to the collectors to what degree materials are separated for further processing (Hemkhaus et al., 2019). In addition, the EU classifies disposed textile products as 'waste' which means that strict rules for transport, storage and treatment apply, posing challenges for collection and recycling as the 'waste' is officially owned by the municipality (Elander and Ljungkvist, 2016). Movement across borders may also pose a potential barrier to broader implementation of textile recycling due to extra administrative burden and costs (Köhler et al., 2021).

Other identified areas of enabling policy support are related to **tax incentives** for textile products containing recycled content, tax penalties on conventional products internalizing the environmental costs of virgin fibres, or **eco-modulated extended producer responsibility systems.** These systems could be effective in creating an economic advantage for recycled fibres and material reuse and would incentivize manufacturers in applying design for recyclability into their design as it would be coupled with a bonus/malus system to reflect circular performances such as durability, repairability, recyclability and material use (ECOS, 2021; Köhler et al., 2021; ETC/WMGE, 2021a).

[35] The collection rate is defined as the total separate collection of used textiles divided by the total quantity of textiles placed on the market

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Annex 1: Definition of textile products

The following terminology is used in this report to describe the different groups of textile products.

Product type	
Textile products	included are CPA 2.1 Product groups 13.91, 13.92, 13.93, 13.94, 13.95, 13.96, 13.99, 14.11, 14.12, 14.13, 14.14, 14.19, 14.2, 14.31, 14.32 and 15.2 (footwear).
Carpets	refers to product group 13.93 'Carpets and rugs'
Household textiles	refers to product group 13.92 'Made-up textile articles, except apparel', which consists of blankets, including travelling rugs; bed, table, toilet or kitchen linen; quilts, eiderdowns, cushions, pouffes, pillows, sleeping bags etc.; curtains, valances, blinds, bedspreads, furniture or machine covers etc.; tarpaulins, tents, camping goods, sails, sunblinds, loose covers for cars, machines or furniture etc.; flags, banners, pennants etc.; dust cloths, dishcloths and similar articles, life jackets, parachutes etc. Note: facemasks and articles for face protection are also part of class 13.92.
Other textiles	refers to product groups 13.91 (knitted and crocheted fabrics), 13.94 (cordage, rope, twinage and netting), 13.95 (Non-wovens and articles made from non-wovens, except apparel), 13.96 (Other technical and industrial textiles) and 13.99 Other (textiles n.e.c.).
Clothing	refers to product groups 14.11 (Articles of fur); 14.2 (Leather clothes); 14.12 (Workwear), 14.13 (Other outerwear), 14.14 (Underwear), 14.19 (Other wearing apparel and accessories), 14.31 (Knitted and crocheted apparel), 14.32 (Other knitted and crocheted apparel)

Annex 2: Modelling methodology

The global distribution of pressures and effects related to final the consumption of textile products have been calculated using an extended multiregional input model based on EXIOBASE v.3.8.1[36] data (Stadler et al., 2018).. For this purpose, environmentally extended product-by-product tables were used. The calculation started from the following identities:

$$x = A \cdot x + y \quad (1)$$

where *x* is the total output vector, *A* the matrix of direct input coefficients (or matrix of technological coefficients), and *y* is the final demand vector. Solving the model for output gives (Miller and Blair, 2009)::

$$x = (I - A)^{-1} \cdot y = L \cdot y \quad (2)$$

where *I* is the identity matrix, and *L* the Leontief inverse also known as the multiplier matrix or matrix of direct and indirect output requirements per unit produced for final demand. The Leontief model implies the following assumptions: prices are fixed in the short term, input coefficients are constant regardless of output or final demand level changes, structure of the economy is taken to be constant, at least in the reported period.

The direct environmental effects of national production are the result of the sum of the direct effects associated with each unit produced in each industry:

$$e^T = \sum_1^n e_i = \sum_1^n e_i^{int} \cdot x_n = < e^{int} > \cdot x \quad (3)$$

By multiplying the environmental pressure per output unit (measured in physical units per Euro worth of output) by the total output of each industry (measured in Euro), defined by equation (2), an environmentally extended input-output model is created:

$$e^T = < e^{int} > \cdot x = < e^{int} > \cdot (I - A)^{-1} \cdot y \quad (3)$$

where e^T is the vector of total environmental pressures associated with the corresponding amounts of the products groups finally used (vector *y*) and e^{int} the environmental pressure intensity vector. Each element of e^{int} represents the amount of the environmental pressure directly caused by the production of a product group. Each element of e^{int} in Exiobase is allocated to a region, which allows to derive the EU-28 share of generated gross value added, employment, raw material use, water use, land use and greenhouse gas emissions in the total footprint.

In order to develop a realistic time-series dataset of environmental impacts, we adjusted the 2020 EXIOBASE consumption data with the already available 2020 household consumption data from Eurostat. This adjustment was required to include the COVID-19 crisis impacts into these results. The adjustments are based on the annual change 2019-2020 per consumption domain available from the final consumption expenditure of household by consumption purpose dataset [nama_10_co2_p3]. This change per consumption domain was applied to the EU27 final demand dataset in EXIOBASE to generate an adjusted 2020 final demand dataset.

[36] 10.5281/zenodo.3583070

Annex 3: An evolving role for product design in a transition towards a circular economy, applied to textile products

A few examples of existing initiatives illustrating the evolution of design for sustainability applied to textile products were compiled in the following table.

Approach	Example	Existing initiative, link
Green design	Substitution of (hazardous) substances at a specific process step (e.g. dyes, finishing agents)	• Phtalates, https://www.rewe-group.com/content/uploads/2020/12/FS-Phthalates.pdf • Perfluorinated Compounds (PFCs), https://hmgroup.com/wp-content/uploads/2020/10/HM_Case-Study-Phase-out-PFC.pdf
	Implemented wastewater treatment programmes	• Wastewater treatment, https://elib.uni-stuttgart.de/bitstream/11682/10847/1/Conference_Manual_Integrated Best Available Wastewater Management in the Textile Industry.pdf
Eco-design	Footwear using recycled content and/or locally sourced (bio-based) materials, efficient manufacturing processes, and recyclable materials	• Emma Safety Footwear, https://circulareconomy.europa.eu/platform/fr/good-practices/emma-safety-footwear-sustainable-safety-shoes
	Methods, tools and guidelines	• Ellen MacArthur Jeans redesign guidelines, https://www.commonobjective.co/article/ellen-macarthur-foundation-the-jeans-redesign-guidelines • Close the loop tool (FlandersDC), https://www.flandersdc.be/en • Higg-index, https://apparelcoalition.org/the-higg-index/ • etc…
	Digital technologies for more efficient production	• CETI On-demand for good, http://www.ceti.com/on-demand-for-good-2/2021/05/11627/ • Digital twins in textile design & development, https://blackswantextiles.com/digital-twin#:~:text=Black%20Swan%20Textiles%20drives%20a,other%20areas%20of%20product%20development.

Design for Behaviour Change	Emotionally durable design footwear	• Repair it Yourself, Customizing clothes and the concept of DIY can become a new form of personal expression and enable people/consumers to be creative and shape their world. These types of clothes (i.e customized, self-made) take up a whole new meaning for the people/consumers who have created and assembled them, https://designforlongevity.com/articles/emotional-durability, http://www.textiletoolbox.com/research-writing/design-reduce-the-need-consume-2/ https://futuremakers.artez.nl/project/emotional-durable-design/
	Digital technologies for sustainable behaviour change	• Re:Create - The behavioural implications of sustainable service design in the fashion industry: a digital wardrobe and peer-to-peer styling app. This service was designed by using an interdisciplinary method, combining service design with behavioural science (using the Behaviour Change Wheel approach). The behavioural science behind Re:Create focusses on the use of 'Persuasion', Modelling' and 'Training'. Furthermore, it taps into women's sense of identity and takes them on an emotional self-discovery journey that emphasises on the value of self-expression. The sustainability vision behind Re:Create is that women can 'shop in their own wardrobe' before purchasing something new; this stimulates product-life extension and the reduction of consumption. If 'new' garments are needed, Re:Create's second-hand webshop encourages re-using someone else's clothes as a means of collective product-life extension, https://repository.tudelft.nl/islandora/object/uuid%3A69021a50-6c9c-4ace-9d50-e82df13f2bb9
Product-Service Systems	Maintenance, reuse, refurbishment, recycling of jeans	• Nudie Jeans: manufactures different garments, jeans made out of 100% organic cotton constitute the core business. Nudie Jeans has established a return system, where customers receive a 20% discount off a new pair of jeans on return of an old pair in stores in London, Gothenburg and Stockholm. The returned jeans are washed, mended and subsequently put up for sale in the stores as second-hand jeans. If the jeans are worn out, and thus not possible to reuse, they are recycled instead. Nudie Jeans presents three such recycling initiatives on its website. In addition to the return system, the company offers free repairs of jeans in selected stores and sends repair kits free of charge to customers, who prefer to do repairs themselves or cannot visit the repair shops in the selected stores, https://www.researchgate.net/publication/321760260_Best_Practice_Examples_of_Circular_Business_Models
	Jeans as a service	• Mud Jeans: In the case of jeans, the customer pays a €25 member fee, in addition to a 12 month rent of €7,50. At the end of the 12-month lease, the customer has three choices: Keep the jeans, get a new pair of jeans in exchange for the old ones, or send the jeans back. When returning a pair of jeans, whether leased or purchased, the customer receives a €10 voucher for a later purchase at Mud Jeans. The system of lease and deposit ensures that a least part of the jeans are returned to Mud Jeans at the end of their useful life with the customers. Through this, the company can minimize consumption of virgin organic cotton for new jeans, and reduce material cost

		correspondingly, https://www.researchgate.net/publication/321760260_Best_Practice_Examples_of_Circular_Business_Models
Design for social innovation, for systems innovation and transitions	System Circularity and Innovative Recycling of Textiles	• SCIRT Horizon 2020, EU-funded project aims to accelerate the transition to a circular fashion system through technological innovation in textile-to-textile recycling. For that the project aims to demonstrate a complete textile-to-textile recycling system for discarded clothing—or post-consumer textiles—involving stakeholders throughout the value chain and focusing on the recycling of natural fibres, synthetic fibres and fibre blends. https://scirt-h2020.eu/

Annex 4: Identification of eco-principles from measures, criteria and requirements from existing Guidelines and Instruments

S*Sourcing, P*Production, UH*Use Health, UL* Use Lifetime extension, D*Disposal

Guidelines	**Measures, criteria and requirements**		**Potential environmental benefits**					**Comments**
Name	**Type**	**Description**	**S**	**P**	**U**		**D**	
					H	**L**		
The Jeans Redesign Guidelines	Be able to withstand a minimum of 30 home Laundries (durability)	• Jeans produced in accordance with the Guidelines will withstand a minimum of 30 home laundries, and afterwards retain their ability to meet the Participant's usual minimum durability requirements for jeans. Participants are requested to provide details of tests that will be used, e.g. abrasion resistance, dimensional change, etc. Further explanatory notes: • Examples of test methods available to test the above dimensions include, but are not limited to: ISO, AATCC, ASTM.				X		
	Provide information on how to care for jeans visibly on the garment (durability)	•Jeans produced in accordance with the Guidelines will include an easily accessible label that states: • Information on reducing washing frequency • Instructions to wash at low temperatures (30°C or below) • Instructions to avoid tumble drying •Further explanatory notes: • This information can be included as part of the legally required label or as an additional label. • Labels sewn into the jeans are included in the total fabric composition.				X		
	Source cellulose-based fibres from regenerative farming, organic or transitional methods	Further explanatory notes: • Cellulose-based fibres include, but are not limited to: cotton, hemp, lyocell, and viscose. • A regenerative agricultural system preserves the integrity of a farm's natural ecosystem, increasing its health, biodiversity, and resilience. Regenerative agriculture includes practices such as permaculture, no till, holistic grazing, and keyline land preparation. • To generate maximum soil regeneration, and therefore land productivity and farm profitability, several regenerative methods are often combined. • The longer-term aim is to source all cellulose-based fibres from regenerative sources. In this first version of the Guidelines, cellulose-based fibres from organic sources – which may or may not meet regenerative criteria – are used as a starting point. • 'In transition' or 'transitional' organic and regenerative methods are all included. Examples of methods that could be used to verify cellulosebased fibres from regenerative or organic farming methods include, but are not limited to: • Global Organic Textile Standard (GOTS): The aim of GOTS is to define worldwide recognised requirements that ensure organic status of textiles, from harvesting of the raw materials, through environmentally and socially responsible manufacturing up to labelling in order to provide credible assurance to the end-consumer. • Organic Content Standard (OCS): The goal of the OCS is to ensure trust in organic content claims. The OCS verifies the presence and amount of organic material in a final product. It provides a chain of custody system from the source of the organic raw material to the final product through certification	X	X				

Guidelines	Measures, criteria and requirements		Potential environmental benefits					Comments
Name	Type	Description	S	P	U		D	
					H	L		
	Jeans are made with chemicals that comply with Level 1, Zero Discharge of Hazardous Chemicals manufacturing restricted substance list as a minimum	•The Zero Discharge of Hazardous Chemicals (ZDHC) Manufacturing Restricted Substance List (MRSL) is a list of chemical substances banned from intentional use in facilities that process textile materials. This includes not only chemicals used specifically for production, but also cleaning supplies, machine cleaners, lubricants, etc. that are in use in the facility for maintenance and support. The ZDHC MRSL sets restrictions on trace concentrations for banned chemical substances that are not intentionally used but may be found as unintended contaminants within a commercial chemical formulation. •Companies may verify conformance with ZDHC requirements of at least level 1 through the ZDHC 'Gateway'.18 Examples of methods that could be used to verify safe chemistry beyond ZDHC Level 1 include, but are not limited to: Bluesign and C2C Certified™. While not thirdparty verification, tools such as ChemSec and Jeanologia can support self-assessment of chemical selection.		X				
	Use of the following chemicals or processes is prohibited	• Conventional electroplating. Electroplating is the process of coating with metal by means of an electric current. The major environmental issues associated with electroplating activities are the generation of hazardous wastes and effluent disposal as well as odour and noise • Stone finishing. The use of pumice stones has several damaging effects and negative factors, such as: decreasing fabric quality, damaging the washing machine, causing a build-up of sludge that needs to be disposed of in an appropriate manner, breaking down into smaller parts during washing that get caught in pockets and other parts meaning garments need to be washed several times to get rid of residue, and a large quantity of stones are needed for washing. • Potassium permanganate (PP). PP is a strong oxidising agent used to create different finishes on jeans. The use of PP decreases performance and durability and is thus counterproductive to the Project goal of increased durability. PP in contact with skin can cause irritation, burning, and pain; PP coming in contact with eyes carries the risk of a permanent loss of vision. PP is also an environmental hazard, especially for marine pollution and can bioaccumulate in the food chain. • Sand blasting. Sand blasting is a process used to create a distressed look on jeans. Sandblasting reduces the durability of the garment and is dangerous for workers' health, with risks such as the potential for serious damage to the respiratory passages.		X				
	Include a minimum of 98% cellulose-based fibres by weight in the total textile composition	To ensure materials used can be recycled at the highest quality and value, jeans produced to the Guidelines should not include more than 2% non-cellulose based fabric by weight. Further explanatory notes: • Cellulose-based fibres include, but are not limited to: cotton, hemp, lyocell, and viscose. • Non-cellulose based materials include all plastic-based fibres, for example, elastane, nylon, and polyester. • Any additional fibres containing tracking or tracing technology are included in the total textile composition and must not disrupt mechanical or chemical recycling processes. • Zipper tape is included in the total textile composition. • Thread used for seams is included in the total textile composition. • Interlinings are included in the total textile composition. • Labels are included in the total textile composition.					X	

Guidelines	Measures, criteria and requirements		Potential environmental benefits					Comments
Name	Type	Description	S	P	U		D	
					H	L		
		• Recycled content is included in the total textile composition						
	Optional: Include % [Please insert percentage here] post-consumer recycled content on average (by weight) of the total fabric composition	Post-consumer recycled content (PCRC) can potentially contain hazardous substances, depending upon the dyes or treatments that were applied when the garment was made. Since this can only be identified by rigorous chemicals testing, some certifications that specify strict material health guidelines, such as C2C Certified™, do not allow for such recycled content to be included. Therefore, to avoid excluding those Participants already working towards strict material health guidelines, PCRC is optional in this first iteration of the Guidelines. However, use of PCRC is strongly encouraged. Further explanatory notes: • PCRC refers to garment to garment recycling only. • Recycled plastic-based fibres from PET bottles or other industries are excluded. • PCRC does not need to be material that was originally produced using regenerative or organic farming methods. • Pre-consumer content can be added in addition to the elected PCRC. • PCRC is part of the overall fabric composition, and must meet criteria of section a of the recyclability guidelines. Examples of validation include, but are not limited to: • The Global Recycled Standard (GRS). A full product standard to verify and track recycled raw materials through the supply chain. It also includes processing criteria to prevent the use of potentially hazardous chemicals, and verifies positive social or environmental production at the facilities. The GRS uses the chain of custody requirements of the Content Claim Standard (CCS). • The Recycled Claim Standard (RCS). A chain of custody standard to verify and track recycled raw materials through the supply chain. It does not address the use of chemicals or any social or environmental aspects of production beyond the integrity of the recycled material. The RCS uses the chain of custody requirements of the Content Claim Standard (CCS).	X					
	Metal rivets are removed entirely or reduced to a minimum	Metal rivets are difficult to remove for recyclers. As a consequence, larger parts of the upper fabric of jeans are cut off and landfilled or incinerated. To maximise the amount of fabric that can be recycled, ideally metal rivets will not be used. If metal rivets are used, these must be kept to a minimum. Alternatives, such as the use of bar tacks, exist and are adopted in the industry today.					X	
	Enable easy disassembly of any additional material that is added to the fabric (accessories, metals, Radio-Frequency	Trims that cannot be easily disassembled for removal can cause additional waste fabric at the recycling stage as they are often removed by cutting. Any additional materials, including accessories, or digital technologies should be designed to be easily removed allowing for reuse and recycling at the end of use.					X	

Guidelines	Measures, criteria and requirements		Potential environmental benefits					Comments
Name	Type	Description	S	P	U		D	
					H	L		
	Identification, etc.)							
	Use Jeans Redesign Logo (traceability)	The following measures define the minimum standards of traceability that must be met: •To identify the jeans produced as part of the Project, the Jeans Redesign Logo will be made available to Participants meeting the Logo Terms and Conditions. The Jeans Redesign logo must be as durable as the redesigned jeans themselves, and align with the requirements for total textile composition. It may only be printed on the inside of the garment if it complies with the minimum requirements laid out in the Guidelines.					X	
	Optional: Use technology that enables sorting	All technology added to the jeans must not interfere with the recycling process and/or be easily removable, and be able to withstand washing, wear and tear, while retaining full functionality until the end-of-use.	X				X	
Sustainable Clothing Guide, WRAP https://wrap.org.uk/sites/default/files/2020-08/WRAP-Sustainable-Clothing-Guide-2017.pdf	Style and cut	• 'Classic' styles, tailored and semi-tailored garments last longer. • Think versatile, multi-functional, updateable styles.				X		
	Fit and size	• Comfort and fit are important, but needs differ between customers. • Adjustable fastenings allow for increased wearability.				X		
	Raw materials (Fibres, yarns and fabrics) selection	One way that designers and technologists can influence the durability of a garment is to identify key standards (specifications) the fabric must meet, and then task buyers to source fabrics that have been tested to meet those standards. It is also important to understand the durability of trimmings and components, which are used in clothing production, including zips, buttons and garment linings. For example, specifying collarbones that minimise abrasion and the use of woven rather than non-woven interlinings in a shirt, all increase its durability. • Processes, usage and care impact significantly on durability. • Identify key standards for the garment's main components (main fabric, trimmings and linings).				X		

Guidelines	Measures, criteria and requirements		Potential environmental benefits					Comments
Name	Type	Description	S	P	U		D	
					H	L		
	Colouration and dye selection	When customers choose new clothes, colour is one of the most important influences. It also plays a significant role in deciding when a garment has reached the end of its life. The choice of a cheap or unsuitable dye, or cutting corners in dye application, has a significant effect on the durability of a garment, so correctly specifying dye use and application should be a key part of product specification. • Retention of colour plays a significant role in deciding when a garment has reached the end of its life. • Dye selection and dyeing methods all have a huge impact on colour fastness and colour fading. • Minimising surface disruption is one way to reduce apparent fading and extend the life of products				X		
	Finishes	Many finishing treatments can affect performance and durability, or help extend the active use of a garment. Understanding likely impacts and giving clear instructions on where, and how, the final product will be used needs to be an integral part of an overall product specification. • Mechanical and chemical treatments produce a range of finishing effects. • How the product will be used impacts on the type of finishing that is needed. • Bio-polishing can reduce the abrasion that causes pilling, to extend the life of the product.				X		
	Manufacturing	Designers have numerous stitch types, sewing threads, machine models and settings to choose from, as well as an array of methods for garment construction. Each technique will be best suited to a particular fabric or garment type and can be exploited to achieve greater durability. For example, choosing the correct stitch density for seams will minimise fabric slippage and puckering, while making sure that the correct operating procedures are in place for the application of linings helps to avoid delamination. • A variety of sewing techniques can be used on particular fabrics to enhance durability. • Consider the way in which trimmings are attached.				X		
	Product testing	The use of clearly defined testing protocols for components and manufacturing elements can be built into product specifications to ensure consistency of quality. Industry standard tests cover physical testing, colour fastness, chemical testing and flammability, and can form part of a product specification. Standards may be British (BSI), European (CEN) or international (ISO), and even retailerspecific. Marks & Spencer, for example, led the development of clothing technology standards for the industry. • A number of industry standard tests now exist for fabrics and garments. • There is no absolute single standard for all products. • Each product specification should include clearly defined testing protocols. Main physical tests include: • seam rupture; • tear strength; • burst or tensile strength; • pilling; • abrasion; • elasticity; • stability to washing; and • seam slippage. Colour fastness tests include:				X		

Guidelines	Measures, criteria and requirements		Potential environmental benefits					Comments
Name	Type	Description	S	P	U		D	
					H	L		
		• domestic laundering; • commercial laundering and drycleaning; • rubbing (wet and dry); • chlorinated and sea water; • hydrophobicity (drop test); • phenolic yellowing; and • testing for print durability.						
	Extended wash tests and wearer trials	A good way to find out how suitable a fabric or trimmings may be for their intended use is through pre-production wearer trials. This method can be used to assess a range of issues that directly affect the durability of the garment, such as how well it withstands washing, its susceptibility to staining, the durability of fabric and trimmings, and understanding of care instructions. • Pre-production wearer trials can be used to fully assess fabric and trimmings suitability. • Issues can be identified from wash and wear trials and appropriate steps taken. • Ensure that garments used in wearer trials are manufactured from the production fabric				X		
	Customer education and messaging	Given a little direction, customers would be able to gauge the quality and potential durability of garments before they buy. Information could include advice on: • evaluating seams, including advice on looking for loose threads and broken stitches. Consumers could be made aware that a higher density of stitches per inch is generally better; that stitching should be relatively tight; and that serged seams or double straight seams are usually stronger and may last longer than an equivalent item with single straight seams; • examining garment linings and reinforcement. For example, looking at facing around zips, buttons, or other high-use areas; • understanding that fibre content will play a role in clothing durability. For example, natural fibres may last longer and launder more easily in some garment applications than synthetic alternatives; • reading care instructions, and ensuring that they are followed. For example, garments should be dry cleaned when necessary, cold washed and/or dried flat if appropriate; and • looking for stains, rips, and other obvious damage caused in store or in transit before sale.				X		
	Wash and wear guidance	Improving care information on labels, packaging, at point of purchase, or on supporting websites is a low cost way that could further decrease the carbon footprint, whilst increasing durability Advice might include: • washing coordinating products together (for example suits, twinsets or lingerie), and removing accessories before washing; • dry cleaning garments, when necessary; • considering steam clean options; • washing when necessary, rather than after each wear; • airing garments as a means of freshening; • not rubbing stains or marks, to avoid causing damage to the fabric; • avoiding the use of solvents for spot cleaning, as they can cause discolouration; • storing appropriately – for example on hangers – using any garment loops or other features provided; folding, and removing from sunlight when not in use;				X		

Guidelines	Measures, criteria and requirements		Potential environmental benefits					Comments
Name	Type	Description	S	P	U		D	
					H	L		
		• using moth balls when storing woollens; • using a specialist laundry bag for delicate items; and • washing and ironing garments at the right temperature, according to the care label, and reversing those with motifs to avoid damage.						
	Repair, alteration and re-use support	Repair and alterations Although most people are able to sew a button on, research suggests that fewer now have the skills to make more complicated repairs such as altering a hem or darning holes. Instead, people may store or discard items in disrepair or in need of alteration. At a national level, however, TV shows such as The Great British Sewing Bee have helped promote clothing repair and alteration as a hobby activity and lifestyle choice. This trend could be supported through the provision of basic repair kits – including threads or yarn, buttons and instructions – in garment packaging and/or on product labels. It can also be supported by factsheets offered in-store, online or in packaging. Some department stores with haberdasheries are promoting sewing materials and running open courses in stores. Where self-repair or alteration may not be appropriate, some brands and retailers are entering into national agreements with chains of tailors, or even offering this service themselves. Re-use support A number of brands and retailers have formed partnerships with charities to support and encourage consumer re-use by: • providing in-store take back options; • promoting the delivery of second hand clothing to charity shops; • incentivising re-use through the use of money off vouchers for new products; and • supporting workplace-based, used clothing amnesties and working with community-based organisations for re-use of specific clothing items such as sportswear. Research suggests that raising awareness of a number of re-use options increases collections of textiles across the board, rather than moving clothes from one re-use outlet (such as a charity shop) to another (such as a textile bring-bank). Promoting one or more options for re-use can therefore boost the active life of a wide range of clothing				X		
Circular Materials Guidelines 1.0	Feedstock content, Fiber content	1A - Recycled and/or reclaimed fiber content in material. This requirement is centered around incorporating recycled content in fibers. • Better: 5-74% of recycled material is incorporated into fiber/yarn contents and/or reclaimed material • Best: minimum of 75% of recycled material incorporated into fiber/yarn contents and incorporates post-consumer waste and/or reclaimed material Accepted Programs and Standards for Verification of Requirements: • Recycled Claim Standard • Global Recycle Standard • SCS Recycled content certification • UL Recycled Content Verification • Intertek's Green Leaf Mark • C2C Certified™ Silver (draft v4)	X					

Guidelines	Measures, criteria and requirements		Potential environmental benefits					Comments
Name	Type	Description	S	P	U		D	
					H	L		

	Feedstock content, Fiber content	1B - Renewable Sources
		When products are made partially from virgin cellulose and virgin protein-based materials the below is required
		• Remaining feedstock content from virgin natural sources align to organic or regenerative standards.
		  ○ Better: Certified organic or transitional organic fiber production
		  ○ Best: Principles for regenerative farming in place including:
		    ▪ Biodiversity & Soil health
		    ▪ Elimination of pesticides, synthetic fertilizers, and GMOs
		    ▪ Carbon sequestration
		    ▪ Water management: Maximize water use efficiency in rain-fed and irrigated systems.
		• Remaining feedstock content from virgin sources of manmade cellulosics (MMC)
		  ○ Better: The producer has completed the CanopyStyle audit and is ranked, at minimum, with a green shirt in Canopy's Hot Button Report.
		  ○ Best: The producer has completed the CanopyStyle audit confirming low risk of sourcing from Ancient and Endangered forests and is ranked with a darker shade green shirt in Canopy's Hot Button Report.
		
		Accepted Programs and Standards for Verification of Requirements:
		• Recycled Claim Standard
		• Global Organic Textile Standard
		• Organic Content Standard
		• Regenerative Organic Certification
		• Roundtable for Sustainable Biomaterials
		• Responsible Wool Standard
		• Responsible Down Standard
			X					

	Feedstock content, Fiber content	1C – Recycled and reclaimed content This requirement is centered around incorporating recycled or byproduct fibers/yarns into fabric • Better: at least 10% to 49% of final fabric is recycled (as defined in requirement 1A and associated certification/verifications) • Best: A minimum of 50% of final fabric is recycled and/or reclaimed fiber (as defined in requirement 1A and associated certification/verifications)	X					
	Feedstock content, Fiber recyclability potential	Recyclability potential We must ensure that all circular fibers are designed and developed to be recycled back into feedstock - not just theoretically (viscose is "theoretically" recyclable right now; but happens nowhere in the world. • Better: Technology is available through small production run or pilot to recycle fiber back into feedstock for industrial use, at end of useful life. • Best: Technology is available to run or pilot that recycles fiber back into feedstock for the fashion industry at end of useful life and is available to scale for industrial development and use This requirement is centered around blended fibers into fiber, yarn. Currently, there is no feasibility to separate blended protein or cellulose-based fibers with synthetic fabrications at scale. Regarding synthetic fibers, the aim is to eliminate the shedding of fiber fragments resulting in microplastics.					X	

Guidelines	Measures, criteria and requirements		Potential environmental benefits					Comments
Name	**Type**	**Description**	**S**	**P**	**U**		**D**	
					H	**L**		
		• Better: As a minimum, 95% of the total textile composition is protein or cellulose-based fiber, yarn. Remaining blended materials must account for recyclability. • Best: As a minimum, 98% of the total textile composition is protein or cellulose-based fiber, yarn. Remaining blended fibers must account for recyclability Accepted Programs and Standards: • 3rd party audited results within the last year						
	Chemistry, Managing Input Chemistry	Managing input chemistry MRSL compliant formulations are used to manufacture the Circular Material. Level 3 conformance was chosen because it includes a document review of the chemical formulation, formulation testing and a chemical supplier audit by a 3rd party. • Better: Implementation of the ZDHC MRSL at a level 2 conformance. • Best: Implementation of the ZDHC MRSL at a level 3 conformance. Accepted Programs and Standards for Verification of Requirements: • ZDHC Conformance Guidance • Bluesign OekoTex Eco-Passport ToxFMD Screened Chemistry® Scivera • Any ZDHC approved assessor at level 2 or 3		X				
	Chemistry, Transparency into Formulations	Transparency into forumulations: • Best: Facility uses chemical formulations that are fully assessed and certified through a hazard-based screening program. The facility must show an increase in the number of formulations year on year as a continuous improvement requirement. Accepted Programs and Standards for Verification of Requirements: • ToxFMD Screened Chemistry® • GreenScreen® Certified • SciVeraLENS Screened Chemistry		X	X			
	Chemistry, Non-petroleum Feedstock for Synthetic Alternatives	Non-petroleum feedstock for synthetic alternatives Our goal is to move toward non-edible non-petroleum resources meet guiding principles of the circular economy and the 12 principles green chemistry. • Best: Some chemical formulations contain over 50% content from non-petroleum-based feedstock. For example, agricultural waste, bacteria, algae, fermentation Accepted Programs and Standards for Verification of Requirements: • USDA Bioreferred® Program. The chemical formulation must be USDA bio based at a minimum of 50%						
	Water quality	1A - Water Quality. The water is treated prior to discharge to ensure it is returned in the same condition in which it was taken. • Better: Implementation of the ZDHC wastewater Guidelines at a Progressive level. Appendix A. And for MMCFs the ZDHC MMCF Interim Wastewater Guidelines Progressive level refer to Appendix A. • Best: Implementation of the ZDHC wastewater Guidelines at an Aspirational level. Appendix A. And for MMCFs the ZDHC MMCF Interim Wastewater Guidelines Aspirational level refer to Appendix A		X				

Guidelines	Measures, criteria and requirements		Potential environmental benefits					Comments
Name	**Type**	**Description**	**S**	**P**	**U**		**D**	
					H	**L**		
	Water recycling and reuse	1B - Recycled and reuse of Water. Zero discharge is aspirational and may be met by taking small steps, such as reusing and recycling process water and implementing waterfree technologies and processes. All of these actions meet the principles of designing waste and pollution out and striving for continuous improvement. • Better: Progressive level of ZDHC Guideline • Best: 90%+ of the facility's recaptured water is reused or recycled to produce less effluent. Per Aspirational level of ZDHC		X				

	Water conservation	1C - Water Conservation Zero discharge is aspirational and may be met by taking small steps, such as using chemicals that work in less water or using new technologies and equipment. All of these actions meet the principles of designing waste and pollution out and striving for continuous improvement.
		• Better: Reduction in water use year over year. Facility implements water-saving manufacturing techniques that may include closed loop processing and chemicals that work in less water.
		• Best: Maximum reduction in water use. Facility implements water-saving manufacturing techniques that are closed loop processing and chemicals that work in less water
		
		Accepted Programs and Standards for Verification of Requirements (also applies to 1A and 1B):
		• The following latest ZDHC wastewater guidelines should be met MMCF Wastewater Guidelines for MMCF fibers
		• Clean by Design (CBD) verified by a 3rd party audit
		• HIGG FEM Wastewater level 3 Answer Yes
		  ○ Verified by a third party
		  ○ Reuse and/or recycle process wastewater as process water (closed loop) to recycle 50% or more
		• STeP by OEKO-TEX
		• 3rd party audited results within the last year
		• Cradle to Cradle Certified™ (draft v4)
				X				

	Energy source and consumption	Decrease greenhouse gas emissions
		This requirement is centered around reduction of energy and sourcing renewable energy, both which result in lowering greenhouse gas emissions.
		• Better: Proven decrease in the use of energy in the facility that results in a reduction of greenhouse gas emissions within the last year; and year on year with a goal for transition to renewable sources within a specific timeline, maximum within 3 years.
		• Best: At least 20% of electricity used in the facility must come from a renewable source that emits no greenhouse gases, such as solar, steam, wind and/or geothermal. The energy can come from onsite or offsite resources, as long as it is verified through a Renewable Energy Certificate (REC) or STeP by OEKO-TEX certification or Cradle to Cradle v4 Silver level or above.
		
		Accepted Programs and Standards for Verification of Requirements:
		• Better:
		  ○ Facilities Environmental Module - 100 points in Energy Section (verified through 3rd party auditor)
		  ○ 3rd party audited results within the last year
		• Best:
				X				

Guidelines	Measures, criteria and requirements		Potential environmental benefits					Comments
Name	Type	Description	S	P	U		D	
					H	L		
		○ Renewable Energy Certificate (REC) or STeP by OEKO-TEX certification or C2C v4 Silver level or above certification ○ 3rd party audited results within the last year						
Instruments								
EU Ecolabel for textile products (https://ec.europa.eu/environment/ecolabel/documents/textile_factsheet.pdf)	Textile fibres	• Cotton and other natural cellulosic seed fibres: For T-shirts, woman's tops, casual shirts, jeans, pyjamas and underwear a minimum of 95 % organic cotton or 60% integrated pest management (IPM) cotton shall be used . In addition, in case of use of recycled cotton the above shares are respectively deducted . It shall be traceable from the point of verification of the production standard up until greige fabric production and the use of pesticides is restricted. • Wool (and other keratin fibres): See full criteria document for derogations and sum total limit vales for ectoparasiticide concentrations on raw wool prior to scouring. • Polyamide products(Nylon): Manufactured fibres shall include 20% recycled nylon. Exemptions apply if products comply with the related nylon emissions to air requirement. • Polyester: Staple fibres shall at least contain 50% recycled PET and at least 20% filament fibres. Products for sale to commercial or public sector can comply with this requirement or with the VOC requirement for polyester (in "emission to air"). • Polypropene : Lead based pigments shall not be used. • Man-made cellulose fibres (lyocell, modal and viscose): At least 25% of pulp fibres shall be manufactured from sustainable forestry management (UN FAO) wood- the remaning pulp shall come from legal forestry and plantations	X					
	Limitations on emissions to air	• See the full criteria document for specifications on emissions to air for acrylic, elastane, polyester (and its components), viscose and modal fibres, and nylon. • Total emission of organic compounds from textile printing and finishing production sites shall be < 100,0 mg C/Nm3. An emissions limit of 150,0 mg C/ NM3 applies If textile coating and drying processes allow the recovery and reuse of solvents.		X				
	Limitation of water pollution during fibre processing	• See the full criteria document for specifications on: –Water retting treatment flax and other bast fibres (e.g. wastewater treatment) shall reduce COD by 75% for hemp and 95% for flax – Man-made cellulose wood pulp specifications (e.g. chlorine used for bleaching) –Wool and other keratin fibre scouring operations shall minimise effluent COD. Limits of g COD/ kg greasy wool in the final discharge to the environment are 25 for coarse wool and 45 for fine wool. • For all weaving, dyeing, printing and finishing sites wastewater discharges to the environment shall be < 20g COD/kg textiles processed (measured downstream of on-site wastewater treatment plant and/or off-site wastewater treatment plant receiving wastewater from the processing sites). See full criteria document for requirements if effluent is treated on site and discharged directly to surface waters.		X				
	Limitation of toxic residues in fibres	• Manufactured Elastane shall not contain organotin compounds. • Cotton shall not contain > 0,5 ppm in total of specific substances listed in the full criteria document. • Polyester (and its components): Antimony shall be < 260 ppm (except for polyester fibres manufactured from recycled PET bottles) · The final product/production recipes shall not contain hazardous substances: Listed in the RSL (Appendix 1 in the full criteria document), that meet Article 57 criteria, or have been identified in Article 59(1) of Regulation (EC) No 1907/2006's described procedure.		X				

Guidelines	Measures, criteria and requirements		Potential environmental benefits					Comments
Name	Type	Description	S	P	U		D	
					H	L		
		• Refer to the full criteria document for derogations, restrictions on substances used during dyeing, printing and finishing. Classifications are based on the most recent classification rules.						
	Components and accessories	• Fillings shall comply with the textile fibres and the textile Restricted Substance List (RSL) biocides, formaldehyde, detergents, softeners and complexing agents, and auxiliary chemicals. Polymers shall comply with the relevant restrictions listed in the RSL • Metal and plastic components shall comply with RSL requirements for accessories		X				
	Energy used	• Energy used in washing, drying and curing steps shall be measured and benchmarked via an energy or carbon dioxide emissions management system. • These production sites shall also implement a minimum number of BAT energy efficiency techniques as, specified in Table 4 and Appendix 3 in the full criteria document.		X				
	Fitness for use	• Dimensional changes during washing and drying shall not exceed the values listed in the full criteria document. • Colour fastness shall achieve the values listed in the full criteria document. Some exceptions are also listed: –Washing and perspiration (acid, alkaline): Shall be at least level 3-4 (colour change and staining). For perspiration, level 3 is allowed when fabrics are dark coloured and made of regenerated wool. –Wet rubbing: Shall be at least level 2-3 (level 2 is allowed for indigo dyed denim). – Dry rubbing: At least level 4 (level 3-4 is allowed for indigo dyed denim). – Light: Furniture fabric shall be at least level 5. • See Tables 9 and 10 in the full criteria document for cleaning products' wash resistance and absorbency requirements. • Fabric shall resist pilling to a minimum of 3, apart from polyamide tights and leggings (minimum of 2). • Repellents shall retain a functionality of: 80/90 (for water), 3,5/4 (for oil), and 3/5 (for stains) after 20 domestic wash and tumble dry cycles at 40 °C, or after 10 industrial washing and drying cycles at a minimum of 75 °C. • Flame retardants on washable products shall retain their functionality after 50 industrial wash and tumble dry cycles at a minimum of 75 °C. Non-washable products shall retain their functionality after a soak test. • Natural fibre products with easy care properties (also referred to as non-crease or permanent press) shall achieve an SA-3 fabric smoothness grade and blended natural and synthetic fibre products an SA-4 fabric smoothness grade, both after 10 domestic wash and tumble drying cycles at 40 °C.				X		
	Information appearing on the EU Ecolabel	• The optional label next to the Eco-flower with text box shall may contain the following text: : – Less polluting production processes – More sustainable fibre production (or a text selected from Table 11 in the full criteria document). –Restrictions on hazardous substances – GMO-free and organic cotton cotton claim (if applicable) • The use of the optional label with the text box is explained in the "Guidelines for the use of the EU Ecolabel logo".			X			
Nordic Swan (Potential Ecodesign Requirements for Textiles and Furniture)	Declaration of, and/or minimum threshold for recycled content	•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 •Testing/documentation options: Global Recycle Standard and Recycled Claim standard	X					Under developme nt, exact informatio n and thresholds under

Guidelines	Measures, criteria and requirements		Potential environmental benefits					Comments
Name	Type	Description	S	P	U		D	
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								developme nt
	Durability of fasteners	Fasteners should be able to be fastened and unfastened X number of times without failure Testing/documentation options: D2061-03 ASTM international for zippers				X		
	Availability of spare parts (durability, repairability)	•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 (i.e. Extra buttons, thread of correct colour, replacement zips etc.) •Testing/documentation options: Proof of availability of parts				X		
	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 •Testing/documentation options: Standard for speed of disassembly would be difficult as may need to be manual test				X	X	
	Provision of detailed bill of materials	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 stamped with a "100% recyclable" stamp	X				X	
	Care and maintenance labelling	·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) ·Testing/documentation options: Standard for care labels already exist: ISO 3758:2012				X		
	Dimensional changes during washing and drying (Durability)	·Between minus x % and plus x % for woven products, and durable non-wovens, other knitted products ·Testing/documentation options: Standard ISO 5077				X		
	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 ·Testing/documentation options: Standard ISO 105 C06				X		

Guidelines	Measures, criteria and requirements		Potential environmental benefits					Comments
Name	Type	Description	S	P	U		D	
					H	L		
	Colour fastness to perspiration (acid, alkaline)	·Colour fastness must be at least x (test score for colour change and staining) ·Testing/documentation options: Standard ISO 105 E04				X		
	Colour fastness to wet rubbing	·Colour fastness to wet rubbing must be at least X (test score) ·Testing/documentation options: Standard ISO 105 X12				X		
	Colour fastness to dry rubbing	·Colour fastness to dry rubbing must be at least X (test score) ·Testing/documentation options: Standard ISO 105 B02				X		
	Colour fastness to light	·Colour fastness to light must be at least X (test score) ·Testing/documentation options: Standard ISO 105 B02				X		
	Fabric resistance to pilling and abrasion	·Fabrics shall resist pilling of a minimum of at least X (test score) ·Testing/documentation options: ISO 12945-1:2000(en) ISO 12945- 2:2000(en)				X		
	Chemical content – organic fluorine (Recyclability)	·The total content of organic fluorine must not exceed X µg F–/g garment ·Testing/document action options: Combustion Ion Chromatography of fluoride (CIC-F)					X	
Green Circle Certified, Product Certifications	Certified recycled content	Recycled content is comprised of pre-consumer and/or post-consumer material that is used as a raw material in the manufacturing of products.	X					Independent third-party certifications
	Certified closed loop product	Closed loop products have been designed utilizing life cycle thinking and intelligent environmental considerations for recycling at the end of life, typically into the same or equal quality product.	X	X	X	X	X	
	Certified energy savings	Products that provide energy savings compared to similar products are highly sought after as utility rates increase and consumers continue to focus on energy reduction.		X				
	Certified biobased content	A biobased resource can be defined as a commercial or industrial product (other than food or feed) that is composed of biological products, including renewable domestic agricultural materials and forestry materials.	X					

Guidelines	Measures, criteria and requirements		Potential environmental benefits					Comments
Name	Type	Description	S	P	U		D	
					H	L		
	Certified recyclable materials	Recyclable products can be diverted from the waste stream through available processes and programs and can be collected, processed, and returned to use in the form of raw materials or products at the end of life.					X	
	Certified Life Cycle Assessment optimised	GreenCircle will verify and certify claims that life cycle impacts of products were reduced as a result of implemented changes to the product based on previous LCA data.	X	X	X	X	X	
Cradle to Cradle (C2C)	Materials health	Chemicals and materials used in the product are selected to prioritize the protection of human health and the environment, generating a positive impact on the quality of materials available for future use and cycling. Bronze: • Product is in compliance with the Restricted Substances List. • Product does not contain organohalogen substances of special concern, or functionally-related, non-halogenated classes of equivalent concern, above relevant thresholds. • Product is 100% characterized by generic material. • Product is ≥ 75% assessed (complete formulation information collected for 100% of materials released directly into the biosphere). • Strategy developed to phase-out or optimize all x-assessed or grey-rated chemicals. Silver: • Product is ≥ 95% assessed (complete formulation information collected for 100% of materials released directly into the biosphere). • Product does not contain materials with > 1% carbon-bonded halogens by weight, or recognized PBTs or vPvBs. • Product does not contain EU CLP Cat.1 and 2 CMRs or substances causing an equivalent level of concern, or exposure is unlikely or expected to be negligible. • Product has low VOC emissions (required for products permanently installed in buildings). • Product complies with VOC content limits (required for liquid and aerosol consumer and construction products). Gold: • 100% of homogeneous materials subject to review are assessed (i.e., none have a grey rating due to insufficient data). • Product is optimized for material health (i.e., all x-assessed chemicals replaced or phased out). • Strategy developed to either increase the percentage of preferred (A/a and/or B/b assessed) • materials and chemicals in the product or optimize the chemistry in the supply chain. • Product has very low VOC emissions or is inherently non-emitting (required for products permanently installed in buildings). Platinum:	X		X		X	Independent third-party certifications. Four possible levels of achievement within each of the standard's five key requirement categories: Bronze, Silver, Gold, and Platinum. To reach a

Guidelines	Measures, criteria and requirements		Potential environmental benefits					Comments
Name	Type	Description	S	P	U		D	
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		• All product relevant process chemicals are assessed (i.e., none have a grey rating due to insufficient data) and no x-assessed chemicals are used. • > 50% of the product by weight is assessed as A/a or B/b. • ≥ 75% of the product's input materials or chemicals have a C2CPII Material Health Certificate at the Gold or Platinum level or ≥ 50% of the product's input materials or chemicals are Cradle to Cradle Certified at the Gold or Platinum level or equivalent. A strategy is developed to increase percentages over time. • OR Environmental health impact hotspot analysis based on life cycle assessment completed, emissions and resource use hotspots that impact human and environmental health are identified, and material health optimization strategy is developed based on the results.						desired achievement level within each category, the product must meet all of the requirements for that level, in addition to the requirements at all lower levels. Product standard, version 4.0 released on 16 March 2021, https://cdn.c2ccertified.org/res

Guidelines	Measures, criteria and requirements		Potential environmental benefits					Comments
Name	Type	Description	S	P	U		D	
					H	L		
								ources/certification/standard/STD_C2C_Certified_V4.0_FINAL_031621.pdf
	Product circularity	Products are intentionally designed for their next use and are actively cycled in their intended cycling pathway(s). Bronze: • Applicant is involved in a circularity education initiative to gain an understanding of relevant cycling infrastructure development. • Intended cycling pathway(s) for the product and its materials are defined. • A plan has been created to address challenges with the cycling infrastructure at the end of the product's first use; potential cycling partners have been identified. • Select product and material types contain cycled and/or renewable content. Alternative: • Limitations that prevent achievement of this requirement are publicly reported. • ≥ 50% of materials by weight are compatible with the intended cycling pathway(s) (i.e., recyclable, compostable, or biodegradable). • Circularity data and cycling instructions are publicly available Silver: • Partnerships for cycling (recovery and processing) of the product have been initiated. If the product is intended for cycling via municipal systems, materials are compatible with those systems. • Percentage of cycled and/or renewable content, by weight, is equal to or higher than industry averages and/or is consistent with common practice. Alternative: Limitations that prevent achievement of this requirement are publicly reported. • ≥ 70% of materials by weight are compatible with the intended cycling pathway(s) (i.e., recyclable, compostable, or biodegradable). • A strategy for improving product circularity is developed including plans for: ○ Increasing the amount of post-consumer recycled content and/or responsibly sourced renewable material, as relevant to the product type, ○ Implementing a circular opportunity or innovation, and ○ Improving the product's design for disassembly (if relevant). Gold:	X			X	X	

Guidelines	Measures, criteria and requirements		Potential environmental benefits					Comments
Name	Type	Description	S	P	U		D	
					H	L		
		• Percentage of cycled and/or renewable content, by weight, is consistent with values achieved by industry leaders for the product type. Alternative: Limitations that prevent achievement of this requirement are publicly reported. • ≥ 90% of materials by weight are compatible with the intended cycling pathway(s) (i.e., recyclable, compostable, or biodegradable) and support high-value cycling. This means that the materials are of high quality and are likely to retain their value for subsequent use. If relevant, parts containing these materials are designed for easy disassembly. • The strategy has been implemented including: o Increased use of post-consumer and/or responsibly sourced renewable material as relevant to the product type. Alternative: Limitations that prevent increased use are publicly reported. o A circular opportunity or innovation that increases product circularity. • The product is actively cycled (recovered and processed) and/or a program is implemented to increase the cycling rate or quality of the product's materials after use. (Both are required for short-use phase products; one is required for long-use phase products.) For select single-use plastic products, a minimum cycling rate of 50% is achieved. Platinum: • At least two intended cycling pathways are defined for the product and its materials. • Percentage of cycled and/or renewable content, by weight, has reached the technically feasible maximum. • ≥ 99% of materials by weight are compatible with the intended cycling pathway(s) (i.e., recyclable, compostable, or biodegradable). If relevant, parts containing these materials are designed for easy disassembly. • The product is actively cycled in an amount consistent with the product's use phase (the shorter the use phase, the higher the minimum percentage required) and a program is implemented to increase the cycling rate or quality of the product's materials after use. • Cycling rates and quality are monitored over time, and an increase in cumulative cycling rate or quality is demonstrated.						
	Clean air & climate protection	Product manufacturing results in a positive impact on air quality, the renewable energy supply, and the balance of climate changing greenhouse gases. Bronze: • Final manufacturing facilities comply with air emissions regulations or guidelines - i.e., permits, international guidelines, or industry best practice. • Annual electricity use and greenhouse gas emissions associated with the final manufacturing stage of the product have been quantified. • A strategy for increasing use and/or procurement of renewable electricity and addressing greenhouse gas emissions has been developed. The strategy includes near and mid-term targets. • 5% target(s)* for procuring or producing renewable electricity and/or addressing greenhouse gas emissions have been achieved. Applicable to final manufacturing stage electricity and emissions only. • Products that use energy during the use phase (e.g., appliances) or that greatly impact the energy efficiency of buildings (e.g., windows, insulation), are certified using a C2CPII-recognized energy efficiency standard or similar, if available.	X	X				

Guidelines	Measures, criteria and requirements		Potential environmental benefits					Comments
Name	**Type**	**Description**	**S**	**P**	**U**		**D**	
					H	**L**		
		• Greenhouse gas emissions data for the applicant company, for all final manufacturing stage facilities, or for the final manufacturing stage of the product are made available to stakeholders Silver: • For construction products and building materials used to construct primary building elements, the embodied emissions associated with the product from cradle to gate or through end of use have been quantified. • The renewable electricity and greenhouse gas reduction strategy includes long-term target(s) in addition to the near and mid-term targets. • 20% target(s)* for procuring or producing renewable electricity and/or addressing greenhouse gas emissions have been achieved. • Applicable to final manufacturing stage electricity and emissions only. • Alternative: 25% of the embodied emissions associated with the product from cradle to gate or through end of use are offset or otherwise addressed (e.g., through projects with suppliers, product redesign, savings during the use phase). Note: This is required at the Gold level in all cases. Gold: • For all product types, the embodied emissions associated with the product from cradle to gate or through end of use have been quantified. • For construction products and building materials used to construct primary building elements, a third-party critical review of the quantification of embodied greenhouse gas emissions is conducted, and an Environmental Product Declaration produced. For other product types, thirdparty verification or an internal review is conducted. • 50% target(s)* for procuring or producing renewable electricity and/or addressing greenhouse gas emissions have been achieved. Applicable to final manufacturing stage electricity and emissions only. • 50% of the renewable electricity (25% of total electricity used) is either produced on site or procured through long-term power purchase agreements supporting new renewable electricity installations. Alternative: Renewable electricity procurement matches 100% of electricity used at final manufacturing facilities. • Embodied greenhouse gas emissions data are made available to stakeholders. • Blowing agents used in the manufacture of the product's foam materials (any foam > 1% of product by weight) have low to no global warming potential and no ozone depletion potential. • 25% of the embodied emissions associated with the product from cradle to gate or through end of use are offset or otherwise addressed (e.g., through projects with suppliers, product redesign, savings during the use phase). Platinum: • For all product types, a third-party critical review of the quantification of embodied greenhouse gas emissions associated with the product from resource extraction through end of use is conducted, and an Environmental Product Declaration produced. • > 100% of electricity is renewably sourced. The electricity is produced on site or procured through long-term power purchase agreements supporting new renewable electricity installations. For other on-site energy demands (if any), eligible sources of bioenergy are used. • > 100% of any remaining greenhouse gas emissions are offset. Applicable to final manufacturing stage electricity and emissions only.						

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Name	**Type**	**Description**	**S**	**P**	**U**		**D**	
					H	**L**		
		• 100% of the embodied emissions associated with the product from cradle to gate or through end of use are offset or otherwise addressed (e.g., through projects with suppliers, product redesign, savings during the use phase).						

	Water & soil stewardship	Water and soil are treated as precious and shared resources. Watersheds and soil ecosystems are protected, and clean water and healthy soils are available to people and all other organisms.
		
		Bronze:
		• Local and product relevant water and soil issues are characterized. (Required for final manufacturing stage facilities and select tier 1 suppliers of key materials.)
		• Final manufacturing facilities comply with water quality regulations or guidelines (i.e., permits, international guidelines, or industry best practice).
		• Product relevant chemicals entering effluent or sludge comply with the relevant restrictions on the Core Restricted Substances List (RSL). (Required for final manufacturing stage.)
		• Water use at final manufacturing stage facilities is quantified.
		• Adequate drinking water, sanitation, and hygiene are provided (final manufacturing stage facilities only).
		• A strategy for achieving the Silver level water and soil conservation requirements has been developed. For facilities using high volumes of water in stressed locations, the strategy includes water use reduction targets. Progress is reported at recertification.
		Silver:
		• Manufacturing facilities of tier 1 suppliers comply with water quality regulations or guidelines (i.e., compliance with permits, international guidelines, or industry best practice). (Required for tier 1 suppliers of key materials associated with pollutant intense processes.)
		• The Bronze level water and soil conservation strategy has been implemented including:
		    ○ At least one conservation technology or best practice at facilities expected to have the greatest water- or soil-related impacts. (Required for final manufacturing facilities with high volume processes in stressed locations and facilities with pollutant intense processes.)
		    ○ One additional action to conserve water and/or soil either at final manufacturing facilities or in the supply chain. (Required when there are any facilities with high volume or pollutant intense processes and/or in stressed locations, or key materials in scope.)
		• Product relevant process chemicals entering effluent and sludge are defined and assessed.
		• Product relevant effluent and sludge does not contain recognized PBTs, vPvBs, or EU CLP Cat.1 and 2 CMRs, or substances causing an equivalent level of concern, or exposure via effluent and sludge is unlikely or expected to be negligible. (Required for final manufacturing stage.)
		• Water use data are made available to stakeholders.
		• A strategy for achieving the Gold level water and soil conservation requirements has been developed. Progress is reported at recertification.
		Gold:
		• The Silver level water and soil conservation strategy has been implemented including:
				X				

Guidelines	Measures, criteria and requirements		Potential environmental benefits					Comments
Name	Type	Description	S	P	U		D	
					H	L		
		○ Conservation technologies and best practices at facilities expected to have the greatest waterand/or soil-related impacts. (Required for all final manufacturing facilities with high volume or pollutant intense processes and/or in stressed locations.) ○ Actions to conserve water and/or soil in the supply chain, including the use of certified materials, working as part of multi-stakeholder group(s), and/or working directly with suppliers to implement water and soil stewardship requirements and address the processes of concern. (Required for key materials in scope.) • Product relevant chemicals in effluent and sludge are assessed and optimized (i.e., none are x-assessed or grey-rated). (Required for the final manufacturing stage and for key materials where pollutant intense processes occur at tier 1, or at any tier for leather, metal finishing, pulp/ paper and textiles.) • A positive impact project that addresses local and/or product relevant water and/or soil issues has been implemented. Platinum: • Water quality data are made available to stakeholders. • Impact of positive impact project demonstrated. • For final manufacturing stage facilities: ○ A comprehensive effluent and sludge quality management system has been established, and ○ Effluent and sludge produced as a result of all manufacturing processes used at the facility are optimized.						
	Social fairness	Companies are committed to upholding human rights and applying fair and equitable business practices. Bronze: • Human rights risks are assessed for the applicant company, final manufacturing stage, and direct suppliers to the final manufacturing stage (tier 1). Progress is made on assessing risks beyond tier 1 (i.e., tier 2 and beyond). • A human rights policy based on international human rights standards and an understanding of the company's risk areas is in place. • A strategy for implementing the human rights policy is developed. At recertification, progress toward achieving the strategy is measured. • For the applicant company and final manufacturing stage facilities, performance against the human rights policy is measured and corrective actions for select issues (e.g., child labor, forced labor) are complete. Corrective actions are planned for any other poor performance issues and, at recertification, progress is demonstrated. • Company executives demonstrate commitment and support for establishing, promoting, maintaining, and improving a culture of social fairness. Silver: • Social audit performance data are requested from tier 1 suppliers in high-risk locations. At recertification, progress is made on supply chain data collection and corrective actions, if needed. Corrective actions for select issues (e.g., child labor, forced labor) are complete. • Management systems support the implementation and oversight of the human rights policy within company operations.						Social aspects, potential environmental benefits not directly determined (copied for the sake of completeness).

Guidelines	Measures, criteria and requirements		Potential environmental benefits					Comments
Name	**Type**	**Description**	**S**	**P**	**U**		**D**	
					H	**L**		
		• A grievance mechanism permits company employees and other stakeholders to obtain redress for negative human rights impacts. • The company has implemented a positive social impact project that measurably improves the lives of employees, the local community, or a social aspect of the value chain. • The company uses open and transparent governance and reporting, making information on how human rights risks are managed and adverse impacts are addressed publicly available Gold: • Human rights risks are assessed for the product's components and raw materials (regardless of tier). • Materials associated with high risk of child or forced labor or support of conflict are certified to a C2CPII-recognized certification program or an equivalent alternative is in place. If a certification program is not available, a traceability exercise is conducted upon recertification. • Responsible sourcing management systems support the implementation and oversight of the policy within the product's supply chain. • A grievance mechanism permits contract manufacturer employees and other stakeholders to obtain redress for negative human rights impacts. • An assessment has been conducted to determine the impact of the positive impact project using quantitative metric(s). Measurable progress is demonstrated at recertification. • The company incorporates stakeholder engagement and feedback into human rights risk management. Stakeholder feedback informs strategy and operations. Platinum: • The company is collaborating to develop and scale solutions to an intractable social issue within the value chain of the product. • The company fosters a diverse, inclusive, and engaged work environment in which social fairness operates as a core part of recruitment, training, remuneration, performance evaluation, and incentive structures.						
The Blue Angel for textiles, German ecolabel	Textile fibres	• Requirements for the origin of natural fibres, cellulose and other plant-based raw materials • Compliance verification: https://produktinfo.blauer-engel.de/uploads/criteriafile/en/DE-UZ%20154-201707-en-Criteria-V1.8.pdf	X					Scope: Textile clothing and textile accessories, House and home textiles, Functional clothing, Technical

Guidelines	Measures, criteria and requirements		Potential environmental benefits					Comments
Name	**Type**	**Description**	**S**	**P**	**U**		**D**	
					H	**L**		
								textiles, Bed linen, Bedding (e.g. pillows and duvets), Cleaning textiles, Fibres, yarn, woven fabrics, knitted or crocheted fabrics

	Production process for fibres	• Requirement for recycled fibres
		• Production of flax and other bast fibres
		• Wool and other keratin fibres
		  ○ Requirements for waste water from wool scouring before mixing
		  ○ Requirements for waste water from wool scouring at the discharge point
		• Man-made cellulose fibres
		  ○ Halogen content
		  ○ Emissions to air
		  ○ Emissions to water in production of viscose fibres
		• Polyester fibres
		• Polyamide fibres
		• Polyacrylic fibres
		  ○ Acrylonitrile
		  ○ Acrylonitrile emissions
		• Elastance fibres
		  ○ Organotin compounds
		  ○ Aromatic diisocyanates
		• Polypropylene fibres
		• Elastolefin
			X					

Guidelines	Measures, criteria and requirements		Potential environmental benefits					Comments
Name	Type	Description	S	P	U		D	
					H	L		
		• Compliance verification: https://produktinfo.blauer-engel.de/uploads/criteriafile/en/DE-UZ%20154-201707-en-Criteria-V1.8.pdf						
	Biodegradability of auxiliaries and finishing agents for fibres and yarns	• Sizing • Spinning solution additives	X	X				
	Production process for laminates and membranes	•		X				
	For down and feathers from water fowl	• Requirements for waste water at the discharge point • Hygiene requirements		X				
	Fillings	• Latex • Polyurethane		X				
	General requirements	• General exclusion of substances with certain properties • Special substances requirements in finishing processes • Requirements for the degradability of textile auxiliaries • Requirements for waste water from the textile finishing process • Requirements for emissions to air in the textile finishing process • Requirements for specific substances and testing of the end product			X			
	Fitness for use	• Change in dimensions during washing and drying • Colour fastness to washing • Colour fastness to perspiration • Colour fastness to rubbing • Colour fastness to light • Colour fastness to saliva and perspiration • Fabric resistance to pilling and abrasion • Durability of function				X		
	Packaging	https://produktinfo.blauer-engel.de/uploads/criteriafile/en/DE-UZ%20154-201707-en-Criteria-V1.8.pdf						
	Consumer information	https://produktinfo.blauer-engel.de/uploads/criteriafile/en/DE-UZ%20154-201707-en-Criteria-V1.8.pdf						

Guidelines	Measures, criteria and requirements		Potential environmental benefits					Comments
Name	Type	Description	S	P	U		D	
					H	L		
	Working conditions	https://produktinfo.blauer-engel.de/uploads/criteriafile/en/DE-UZ%20154-201707-en-Criteria-V1.8.pdf						
	Restriction on the sandblasting of denim	https://produktinfo.blauer-engel.de/uploads/criteriafile/en/DE-UZ%20154-201707-en-Criteria-V1.8.pdf						
UPMADE® Certification	upcyling production, chemical toxicity, and social impact	• The products must be made from textile waste or leftovers: The share of waste in the base material must be 90-100%. Added components (like buttons, thread, zippers, fuse, etc.) may be new. The material used for upcycled products must be segregated and clearly marked to ensure traceability throughout the manufacturing process. There must be adequate storage conditions for materials in order to avoid deterioration of quality and safety. • The facilities must meet laws and standards regarding the working environment's safety and hygiene and fair pay for workers. The production facility for upcycling products must comply with the criteria drawn up by the Ethical Trading Initiative (ETI) and International Labour Organisation (ILO). • The upcycled products' material (i.e. waste and leftovers) and the production process must be fully documented. The production facility must have a documented quality management system (e.g. ISO9001), and the specific application of the UPMADE® system must be documented. • Upcycled products must not contain hazardous chemical substances restricted from the EU and US markets.	X	X	X			
Global recycled standard (GRS) https://textileexchange.org/wp-content/uploads/2017/06/Global-Recycled-Standard-v4.0.pdf	Recycled materials	Claimed Material accepted for the standard meets the established definition of Recycled Material. • Material Recycling requirements		X				Recycled Claim Standard (RCS) and GRS international, voluntary standards that set requirements for third-party certificatio

Guidelines	Measures, criteria and requirements		Potential environmental benefits					Comments
Name	Type	Description	S	P	U		D	
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								n of recycled input and chain of custody. The shared goal of the standards is to increase the use of recycled materials. The GRS includes additional criteria for social and environmental processing requirements and chemical restrictions.
	Supply chain	Claimed Recycled Material follows a complete, verified chain of custody from input to final product: • Application of Production Requirements • Production and Trade ○ All Recycled materials entering the supply chain shall have a valid Transaction Certificate (TC) issued by an approved CB.	X	X				

Guidelines	Measures, criteria and requirements		Potential environmental benefits					Comments
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					H	**L**		
		○ Pre-Consumer and Post-Consumer Material Content percentage shall be recorded separately for each batch at every certified site and recorded on the transaction certificate. ○ Traders with an annual turnover of less than $10,000 of GRS products, and retailers selling to end consumers only, are exempt from the certification obligation ○ In cases where there is the possibility of differential rates of production loss between Recycled and virgin inputs, Certified Organizations shall address this through their mass balance formula for each material to show that calculations were done to account for the differences. ○ Buyers of the GRS product will be responsible to set any further requirements on the specific standards or requirements to which the input material shall be certified. These additional requirements are separate from the GRS and its certification process.						
	Social	Workers employed at facilities involved in the production of GRS products are protected by strong social responsibility policy. • Social policy ○ Certified Organizations shall have a clear set of policies to ensure compliance with the social requirements of the GRS. ○ Record Keeping • Social requirements ○ Forced, bonded, indentured and prison labor ○ Child Labor ○ Freedom of association and effective recognition of the right to collective bargaining ○ Discrimination, harassment and abuse ○ Health and safety ○ Wages, benefits and terms of employment ○ Working Hours						
	Environmental	Facilities involved in the production of GRS products have strong environmental protections in place • Environmental Management System ○ Environmental Management System ○ Chemical Management System ○ Record Keeping • Environmental Requirements ○ Energy use ○ Water use ○ Wastewater/effluent ○ Emissions to air ○ Waste management		X				
	Chemical	Chemicals used in the production of GRS products do not introduce unnecessary harm to the environment or workers. • GRS Chemical Management ○ GRS Product Chemical Management ○ Record Keeping • Restricted Chemical Substances in GRS		X				

Guidelines	Measures, criteria and requirements		Potential environmental benefits					Comments
Name	Type	Description	S	P	U		D	
					H	L		
		○ Inherently problematic substances ○ Exclusion of substances and mixtures classified with particular hazard codes or risk phrases ○ Exclusion of substances that do not comply with the Manufacturer's Restricted Substance List (MRSL) from ZDHC.						
Reports, studies and other initiatives								
Guidance for fashion companies on design for recycling [(PDF) Guidance for fashion companies on design for recycling (researchgate.net)]	Recycled materials	Generic • Make use of recycled material, see to that it is certified recycled content (e.g. GRS5) to avoid green-washing. • In the dialogue with the supplier(s): ○ discuss the rationale behind choosing the specific quality, is it a suitable material for the application? ○ dialogue regarding chemicals content, compliance and suitability for the application. Polyester fibres • Make use of recycled polyester (chemical or mechanical recycling) Cotton fibres • Make use of recycled cotton (mechanical recycling) Nylon 6 • Make use of recycled nylon 6 (chemical or mechanical recycling) Nylon 6.6 • Make use of recycled nylon 6.6 (mechanical recycling) Trims • Use your own production's waste fibres for trims to your garments.	X					
	Recyclable	Generic • Avoid finishing with e.g. water repellent coatings and anti-bacterial treatment. • Create monomaterial design (unless this shortens life length of product): Polyester • Use 100% polyester (PET) in fabric, membranes, coatings and trims. • Collaborate with a polyester yarn producer: ○ check with producers of virgin fibre regarding which additives and dyestuffs may be present, to avoid a potential problem for the recycling process and ensure the recycler can use your products as input. ○ engage with one of the few polyester fibre-to-fibre recyclers that exist on an industrial scale, e.g. Teijin/Jiaren. Cotton • Use 100% cotton and/or regenerated cellulose in fabric and accessories					X	

Guidelines	Measures, criteria and requirements		Potential environmental benefits					Comments
Name	Type	Description	S	P	U		D	
					H	L		
		• Collaborate with a cotton yarn producer: o encourage the expansion of pilot plants that are available for postconsumer textiles, e.g. Re:newcell Nylon 6 • Use 100% Nylon 6 in fabric (other names are polyamide 6, PA 6) • Accessories should if possible also be made of nylon 6 – check all items on the request • Nylon 6.6 is NOT the same fibre, in terms of recycling it is rather a contamination. • Collaborate with a nylon 6 producer: o check with producers of virgin fibre regarding which additives and dyestuffs may be present, to avoid a potential problem for the recycling process. o Engage with one of the few nylon 6 fibre-to-fibre recyclers that exist on an industrial scale, e.g. Aquafil. Nylon 6.6 • Today, post-consumer nylon 6.6 (polyamide 6.6, PA 6.6) waste is not recyclable into textile fibres. Consider replacing this fibre until this situation changes.						
Ecodesign in the Textile sector, Ecodesign project http://www.ecosign-project.eu/wp-content/uploads/2018/09/TEXTILE_UNIT09_EN_lecture.pdf	Fibre and materials selection	Possible actions of interventions: • to prefer the use of certified cotton that meets environmental standards; • to prefer high quality cotton, which provides superior performance, in order to extend the useful life of the garment; • to ensure that the supply chain is in line with the best standards; • to evaluate alternative production technologies to traditional and low-impact ones, such as the use of transfer prints; • with reference to the recycling techniques seen, and to the indications given in Unit 08, try to optimise the possibility of recycling at the end of the product's life (for example, trying to keep the garment white or dye it with light colours); • where possible, assess the substitution with lower impacts fibres.	X	X		X	X	
	Efficient production	The Ecodesign principles aimed at optimizing production chains include: • maximizing energy efficiency • reducing production phases • reducing or eliminating surface treatments • reducing waste (see the example of "zero waste pattern cutting" within this unit) • adopting guidelines to improve waste recycling.		X				

Guidelines	Measures, criteria and requirements		Potential environmental benefits					Comments
Name	Type	Description	S	P	U		D	
					H	L		
	Increased functionality	Theoretically, a multifunctional garment is versatile, therefore, suitable for several uses, and so it minimize the need of complementary garments. The main strategies concern the transformability, intended as the ability to adapt to different settings thanks to a modular construction of the product.				X		
	Recyclability	The priority of preferences for maximizing recycling potential is to: • white fabrics which allow easy dyeing; • natural fibres that are easier to extract and are more versatile; • good quality fibres (length and fineness), which can be processed on faster machines • pure, unblended fibres that require less processing than fibre mixtures, guaranteeing reliable results and efficiency in the recycling process.					X	
	Design for longevity	Priority list of specifications to be considered for the design process: • fabric resistances to washing; • colour fastness under normal conditions of use; • resistance to abrasion and wear, resistance to the formation of pilling, resistance to tearing, and slippage of seams, and others; • ease of handling and following care instructions.				X		
Circular economy perspectives in the EU Textile sector, JRC Technical report [JRC Publications Repository - Circular Economy Perspectives in the EU Textile sector (europa.eu)]	Recycled content	Declaration of, and/or minimum threshold for recycled content (informative, threshold): • 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	X					List of potential ecodesign requirements for textiles based on a study from Bauer et al. 2018
	Durability of fasteners	Durability of fasteners (threshold): • Fasteners should be able to be fastened and unfastened X number of times without failure				X		

Guidelines	Measures, criteria and requirements		Potential environmental benefits					Comments
Name	**Type**	**Description**	**S**	**P**	**U**		**D**	
					H	**L**		
	Availability of spare parts	Durability, Repairability (other): • 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.).				X		
	Design for Disassembly	Durability, Reparability, Reusability, Recyclability (threshold): • 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.				X	X	
	Provision of BoM	Recyclability and recycled content (informative): • 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.	X				X	
	Care and maintenance labelling	Durability, Repairability (informative): • 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)				X		
	Dimensional changes during washing and drying	Durability (threshold): • Between minus X% and plus X% for woven products, and durable non-wovens, other knitted products				X		
	Colour fastness to washing	Durability (threshold): • Colour-fastness to washing must be at least X (test score) for colour change and at least X (test score) for staining				X		
	Colour fastness to perspiration (acid, alkaline)	Durability (threshold): • Colour-fastness must be at least X (test score for colour change and staining)				X		
	Colour fastness to wet rubbing	Durability (threshold): • Colour-fastness to wet rubbing must be at least X (test score)				X		
	Colour fastness to dry rubbing	Durability (threshold): • Colour-fastness to dry rubbing must be at least X (test score)				X		
	Colour fastness to light	Durability (threshold): • Colour-fastness to light must be at least X (test score)				X		

Guidelines	Measures, criteria and requirements		Potential environmental benefits					Comments
Name	Type	Description	S	P	U		D	
					H	L		
	Resistance to pilling and abrasion	Durability (threshold): • Fabrics shall resist pilling of a minimum of at least X (test score)				X		
	Chemical content – organic fluorine	Recyclability (threshold): • The total content of organic fluorine must not exceed X µg F/g garment					X	

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