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Fibersort

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RESOURCE AND
MATERIALS EFFICIENCY



PROJECT
AREA



**RECYCLED
POST-CONSUMER TEXTILES**
an industry perspective

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1. Introduction

In Europe we are facing a growing mountain of used textiles. Latest research shows that in North-West Europe (NWE) 4,700 kilo tonnes of post-consumer textile waste (PCT) is generated annually. Still, less than 1% of textiles produced are currently recycled into new ones, and around half of them are being downcycled, incinerated or landfilled¹.

Automated sorting technologies could enable the industry to turn non-rewearable textiles that currently have no other destination than downcycling, landfill or incineration into valuable feedstock for high-value recycling. One of these technologies is the Fibersort, a Near Infrared (NIR) based technology able to categorise textiles based on their fibre composition, structure and colour. While the technology is promising, identified socio-cultural, physical, economic and regulatory barriers must first be overcome to ensure its successful implementation. In May 2019, the Fibersort Interreg NWE project published an overview of these potential barriers for the implementation of Fibersort technology for collectors and sorters. This overview reflected macro trends in textiles, and identified their implications for the importance, fit and potential of the Fibersort technology.

While currently post-consumer textiles are struggling to successfully find textile-to-textile recycling end-markets, this report explores existing and potential end-markets for PCT, sorted according to their characteristics, and assesses the potential of different business models for brands and manufacturers to successfully integrate the recycled textiles. The research builds on publicly available data of recyclers, manufacturers and brands, as well as primary insights gathered through a survey, interviews with recyclers, manufacturers and brands, as well as industry and academic experts².

At the end of each chapter, recommendations are formulated for recyclers, manufacturers and brands to address the barriers for uptake of sorted textiles identified throughout this project:

- Making recycled the new norm: exploring socio-cultural barriers
- Creating new materials from post-consumer textiles: overcoming physical barriers
- Making recycling a sound business choice: reducing economic barriers

A table at the end of the report summarises key findings and recommendations emerging from this publication.

2. The current landscape: struggling end-markets for the growing mountain of used textiles

2.1 Availability of PCT in NWE

The global apparel and textile markets continue to grow yearly at a rate of around 3-4%³. Every year, over 86 million tonnes of yarns enter the market to be woven or knitted into new textiles⁴. This volume is the result of a tenfold increase in production since the 1950's. Synthetics, with polyester as its main representative dominate the market with a current share of 60%, while cotton follows the lead with a market share of 24.4%⁵. The last decades have also seen a major increase in the number textiles created from fibre blends, making polyester-cotton blended textiles a significantly available material in the market.

The accelerating consumption and disposal practices in NWE cause the textiles entering the market to reach their end-of-use rapidly. In the Netherlands, it is estimated that an average of 40 clothing items are annually disposed per person⁶. This growing mountain of PCT, has different potential to be reinserted into the market. In the best-case scenario, these textiles are collected separately and sold in the second-hand market both locally and internationally. In NWE this average of rewearable textiles is around 64% of collected textiles. This is in line with other European projects and organisations that usually refer to rewearable items fluctuating between 40-89%⁷. Nevertheless, a large portion of used textiles is currently being downcycled, incinerated or landfilled, while a minimal amount of textiles collected are currently recycled into new ones⁸. These are referred to as non-rewearable PCT. This consideration is either due to their unsuitability for the second-hand market (extensive use or damage, lack of quality, cleanliness) or due to market saturation that second-hand clothing is currently facing⁹. The accelerating consumption and disposal practices, coupled with lower quality clothes availability, leads this fraction of textiles to be in continuous growth¹⁰.

Collected textiles in NWE consist of different materials. Currently, the Fibersort is programmed to sort textiles made from cotton, polyester, acrylic, wool, viscose, polyamide as well as blended combinations of those materials. Previous research within the project shows that almost 75% of collected non-rewearable textiles are either cotton, polyester or polyester-cotton blends. Other materials are collected in smaller amounts. For example, collected non-rewearable pure acrylic textiles represent 1.7% of the total, pure wool and wool-rich blends represent 1.6%, and pure viscose textiles represent 0.9%¹¹.

2.2 Current recycling technologies

The current and potential end-markets to recycle these sorted textiles into new ones were mapped in the context of the project. A full overview of these end-markets is publicly available online¹² and will be continuously updated until the end of the project in March 2020. *Figure 1* illustrates the distribution of recycling technologies among material types.

While the number of potential recyclers for the Fibersort outputs is considerable, securing a demand for sorted materials remains a challenge. The market readiness and uptake of these materials as input for new textiles is dependent on their composition, the available textile-to-textile recycling technologies, the potential and incentives for further development of these technologies, as well as the market demand for materials containing recycled content. Currently most of them, 62% of the mapped recyclers, are using mechanical technologies and the remaining are developing chemical recycling technologies. Most chemical recycling still remains at pilot scale, with the exception of post-industrial textile waste for certain materials such as polyamide. Further, one third of the recyclers mapped can process more than one material composition.

RECYCLERS TURNING TEXTILE WASTE INTO NEW TEXTILES

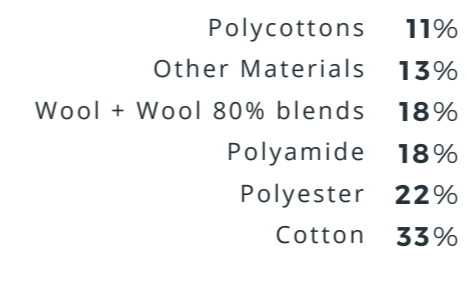


Figure 1. Textile-to-textile recyclers mapped per material they process

The most common material recycled by these organisations is cotton, followed by polyester, wool and polyamide (Figure 1.). These recyclers are currently present in the market at different scales, from lab research up to industrial scale. For materials such as wool, acrylic or their blends, which together represent 3.3% of the collected PCT in NWE, there is a mature mechanical recycling market, with technologies at scale. Wool has been recycled since the 1840's in the Italian region of Prato, a region which currently processes around 22,000 tonnes/year¹³. Further, wool PCT retain the highest prices in the recycling market (0.30 - 0.60 euro/kg)¹⁴. Hence, although the global market share of wool is relatively small, accounting for around 1% of global production¹⁵, when focusing on the textile recycling market, wool and wool blends become a largely important fibre to secure at its end-of-use.

In the chemical recycling landscape, a rising trend can be seen in solutions being developed over the last decade to recycle different materials, as can be observed in Figure 2. A growing number of recyclers are currently focusing on material separation, such as separating cellulose and PET from polyester-cotton blends. Further details and characteristics of the end-markets per material composition can be found in Annex 1.

TEXTILE-TO-TEXTILE RECYCLING TREND

■ Mechanical
■ Chemical

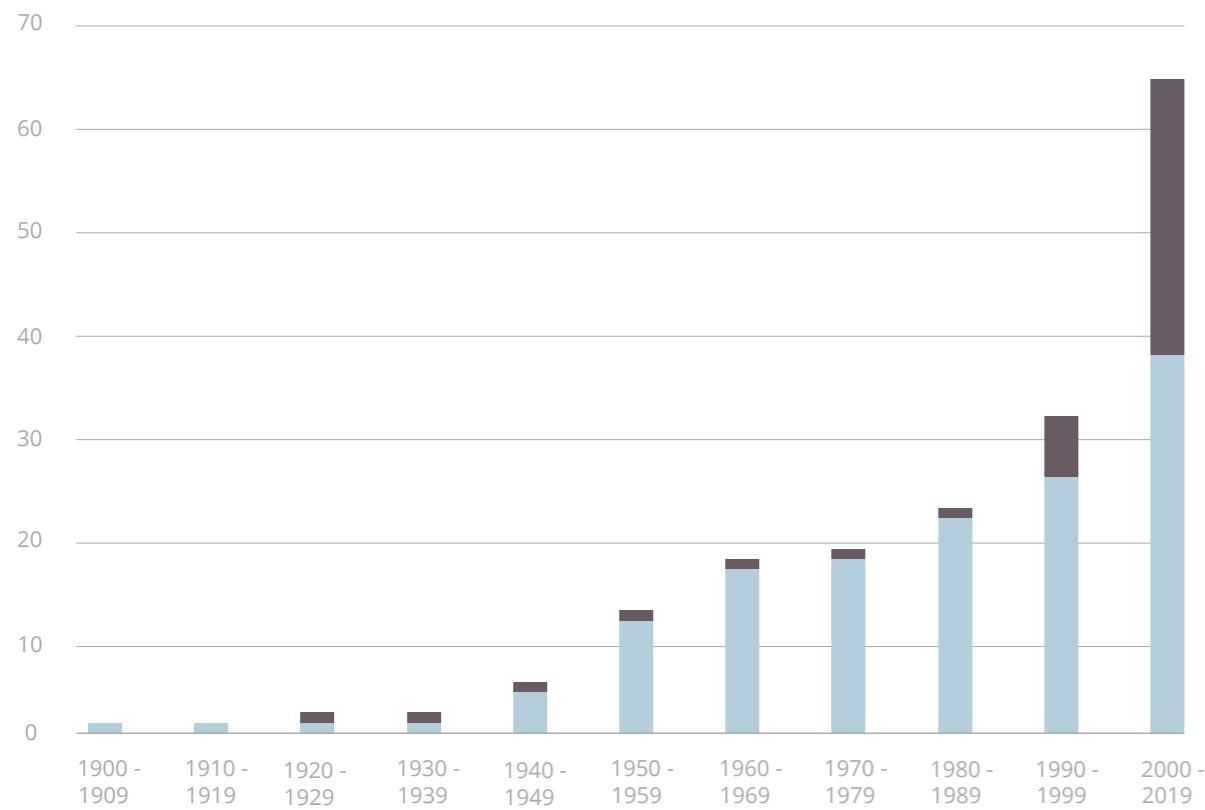


Figure 2. Number of recyclers mapped according to the years of active textile-to-textile recycling activities









2.3 Use of recycled textiles in fashion

There is a growing trend regarding target and commitment setting in order to undertake a change in businesses' strategy and operations. Commitments such as the Global Fashion Agenda 2020 Circularity Commitments¹⁶, Ellen MacArthur's Make Fashion Circular Commitments including their ongoing work on the Jeans Redesign Guidelines¹⁷ and other initiatives tackle issues related to changing design practices to facilitate cyclability, increase used textiles collection as well as the use of recycled content in apparel and textiles. Over the past years, a large variety of brands and manufacturers have signed these commitments, including 90 signatories to GFA commitments that represent 12.5% of the fashion industry, and more than 40 denim organisations committing to producing new jeans by May 2021 that follow the Jeans Redesign Guidelines. Nevertheless, the progress to achieve these commitments is slow. Commitment #4 of the GFA 2020 Circular Fashion System expects the increase in the share of garments and footwear made from recycled post-consumer textile fibres. However, from 47 targets set in 2017 by brands for 2020, merely 11% of them were achieved by July 2019¹⁸.

Despite the fact that there has been no quantifiable reporting on a significant increase in the percentage of textile-to-textile recycling, since the widely known figure estimated at below 1% by the Ellen MacArthur Foundation¹⁹, a surge in the number of recyclers processing different textile materials (Figure 2) as well as initiatives of brands and manufacturers integrating recycled content in their products can be acknowledged. Although most of them have been incorporating post-industrial textile waste, some have started testing in smaller amounts the use of post-consumer textiles.

Further, a nine fold increase between 2014 and 2019 in the number of facilities certified by the Recycled Claim Standard (RCS), as well as a 360% increase in those certified by Global Recycled Standard (GRS)²⁰ portrays that this surge is accompanied by manufacturers as well. In regards to the policy environment, the European Commission is required to consider by the end of 2024, whether targets for textile reuse and recycling should be introduced²¹.

In spite of initiatives being promising, sorted post-consumer textiles continue to struggle to find the end-markets that would enable their cyclability into new textiles. Hence, recyclers, brands and manufacturers have shared their perspective regarding the key requirements and circular strategies needed to introduce post-consumer recycled textiles in their production. While addressing the barriers previously identified by the Fibersort consortium, these strategies and requirements are laid out in the form of recommendations towards the relevant stakeholder groups in the next chapters.

PRODUCT CATEGORIES	EXAMPLES
Denim 	Initiatives: Denim Alliance (Post-Consumer Recycled Denim), Jeans Redesign Guidelines Brands: ASOS, GAP, JBC, Kings of Indigo, Kuyichi, Mud Jeans, Nudie Jeans Manufacturers: Artistic Milliners, Arvind, Bossa, Orta Anadalou
Heavy-weight Knits 	Brands: Fjällräven Re-Wool, Houdini, Loop.a.life, WE Fashion Manufacturers: Brightloops, Pure Waste
Socks 	Brands: EcoSox, Muji, Osombrand, Thunders Love, Solmate Socks Manufacturers: Osomtex
Home Textiles 	Brands: Alma Green Design, Blycolin Group Intl., Hammam Towels, Walra Manufacturers: Khaloom
Workwear 	Brands: HAVEP, Schjivens Corporate Fashion, TRICORP Workwear Manufacturers: Khaloom
Other 	Brands: Napapijri, Suit Supply (jackets), Beate Arens, Little Boomerang (accessories) Manufacturers: Circulose collection (re:newcell), Khaloom, Vivify Textiles, Rigenius.it



3. Making recycled the new norm: exploring socio-cultural barriers

When implementing new technologies, culture, whether organisational, national or community-driven, shapes individual perceptions towards these technologies. These in turn, impact consumer and industry practices.

3.1 Empower a thriving collecting and sorting industry

The growing mountain of PCT leads to an increase in the volume of clothing entering sorting facilities, of which a significant percentage is considered non-rewearable. These textiles have diverse potential to be reinserted into the market and hence, an effort to empower a thriving collecting and sorting industry needs to be undertaken by all industry actors.

PCT has the potential to be cycled back into the value chain if they are properly collected and sorted. From a brand's perspective, there are several ways to manage a take-back system. These should focus on increased product collection at end-of-use stages, while creating increased perceived value to consumers²². The perception of this value may differ depending on market segment and target audience. Currently, approximately one third of the interviewed brands have a takeback management scheme in place. Some of them are taking back only their own brand's products in the store, others are taking-back products from any brand. There are also other collaborations of brands with charities to reintroduce products into a reuse or recycling stream. Other brands are currently working in partnership with a private third-party collector. The interviewed brands with no take-back management scheme in place yet claimed to be waiting for recycling technologies to develop further or to find solutions to the issues arising from their international infrastructure and the shipping of waste across borders before putting such systems in place.

Take-back schemes relate directly to the quantity and quality of textiles collected in a region. Duly research remains to be conducted in regards to the availability of collected and sorted textiles in each local context. At the same time, the overall impact of brand take-back management (in-store drop-off, brand mail-back, etc) for municipal collection and sorting, such as street collection bins and containers, kerbside collection and/or home pick-up schemes, should be further assessed.

TYPE OF COLLECTION	DESCRIPTION	EXAMPLE
Independent	Brands manage their own textile collection and incentivise reuse, repair, remanufacturing or recycling initiatives with their own garments.	Eileen Fisher; Filippa K; Nudie Jeans; Schijvens.
Partnership with third-party collector	Brands implement a take-back management scheme with a third-party private partner.	H&M + I:Collect; North Face + The Renewal Workshop
Partnership with charity or not-for-profit organisation	Brands enter a donation partnership or a project-based collaboration with well-known local or international charity or not-for-profit organisations.	Inditex + Caritas; Kuyichi + Sympany M&S + Oxfam

RECYCLERS	MANUFACTURERS & BRANDS
<ul style="list-style-type: none"> Assess availability of collected sorted PCT in your local context. Partner with collectors/ sorters to test their materials and assess potential applications. 	<ul style="list-style-type: none"> Increase customer engagement by implementing take-back and/or repair schemes. Take-back garments once consumers no longer want to use them and partner with recyclers to high-value recycle these garments. Partner with or consult experienced players in textile collection to develop and implement these schemes.

3.2 Create market pull for recycled content

Several brands are already using recycled textiles on a small scale. However, the vast majority of them are not sourcing PCT. On the other end of the value chain, there does not seem to be a strong pull from consumers to drive the industry to use recycled content in their products either. The interrelationship between brand offer and consumer demand may be key to the success of recycled content integration.

Communication, provision of information and increased awareness are important activities to determine consumers' purchasing intentions²³. In the case of take-back schemes, these are usually accompanied by incentives such as discounts on future purchases, usually between 5\$ to <15% discounts. It is suggested to move away from incentivising more consumption through take-back schemes as this practice is not aligned to the waste hierarchy established in the EU Waste Framework Directive (2008/98/EC²⁴), whereas prevention of waste, namely through reduced consumption, is a first priority. Consumer education through marketing campaigns, increased amount of collection points and supporting policies such as EPR schemes may further support successful take-back schemes without incentivising further consumption. Examples of an educational campaign in this regard is the UK 'Love not Landfill' campaign²⁵.

Simultaneously, increased awareness and fluent communication within the entire value chain, including the end-of-life, can support a clear understanding of the materials that can be processed by recyclers, and therefore, inform brands and manufacturers on their strategies to design products that can be recycled. This initiative calls for existing value chains to further collaborate and work together to assess recyclability of products. Further, there is a potential for online marketplaces for secondary materials to inform industrial partners on material specifications and their application potential. Hence, the level of digital literacy within businesses, both suppliers and buyers, to implement and embed in their organisations these digital solutions will become of relevance.

RECYCLERS	MANUFACTURERS & BRANDS
<ul style="list-style-type: none"> Communicate recycling challenges to brands and manufacturers to foster design for recyclability. Set clear specifications on material grades suitable for your recycling process and make this available to collectors/sorters, manufacturers and brands. 	<ul style="list-style-type: none"> Communicate relevant information regarding environmental, social and ethical performance of materials, products and processes to inform consumers' purchasing intentions. Avoid financial incentives in take-back schemes that incentivise increased consumption. Uptake recycled content firstly focused on quantity of products, to later focus on increasing the quantity of recycled content per product. This may support consumers' mindset change regarding recycled content.

3.3 Assess and communicate the urgency of action

In order to gain momentum that drives significant investment in the collection, sorting and recycling practices of postconsumer textiles, urgency to further develop the end-of-use value chain needs to be established. Awareness raising coupled with goal-setting is still not big enough to drive a shift in consumption and production practices.

Several industry initiatives have been plotting out targets and commitments to implement action towards the development of the end-of-use value chain. We urge business to assess their potential and responsibilities to contribute to the development of these stages of the value chain. Following the relevant assessments, either by aligning industry-wide commitments or by setting strategic goals and priorities to address these issues, targets should be set. For brands and manufacturers that have already set targets, this time is perceived as the moment to focus on retraining their designers for circularity, including changing current practices to foster design for recyclability and assurance of material health to endure several lifecycles²⁶. Increasing internal capacity by retraining teams is also related to the strategy pointed out by certain brands to drive R&D internally through a brand and their supply chain partners to be able to increase the use of recycled textiles from post-consumer inputs in their products. Driving R&D will undoubtedly involve working together with recyclers and other supply chain partners to assess material choices as well as the potential of different PCT compositions and streams.

Increased awareness and information campaigns have an impact on the consumers' purchasing intention, although a study with UK consumers shows that it does not necessarily have an impact on changing consumers' purchasing behaviour²⁷. Hence, goal setting could also be implemented as a consumer-facing activity. Examples of consumer-setting goal campaigns are OXFAM's 'Second Hand September' or Fashion for Good's 'Good Fashion Action Plan' pledges²⁸.

RECYCLERS	MANUFACTURERS & BRANDS
<ul style="list-style-type: none"> Set your own or align to industry-wide targets and commitments to close the textiles loop. 	<ul style="list-style-type: none"> Set your own or align to industry-wide targets and commitments to close the textiles loop. Retrain internal teams on circularity, including but not limited to sourcing, design, marketing and management teams. Communicate your targets and goals to consumers and engage them in personal goal setting to translate purchasing intentions into changed purchasing behaviour.



4. Creating new materials from post-consumer textiles: overcoming physical barriers

Sorting by fibre composition through the updated NIR technology scanners at a significantly increased productivity rate, will result in reliable and consistent feedstock for textile-to-textile recyclers. Colour sorting will only enhance the potential the technology has to support a new circular textiles industry, especially for mechanical recyclers.

4.1 Maximize quality and consistency of inputs

Main reported physical concerns of PCT relate to the quality, consistency and availability of these materials. Nevertheless, several brands and manufacturers are already incorporating recycled content in their collections. Further, recycling technologies are seeing a surge both in amount of recyclers as well as the amount of materials processed.

It is extremely relevant for recyclers to receive PCT sorted by their fibre composition. Further, mechanical recyclers highlight the importance of colour sorting as well. Overall, one of the recurring challenges yet to be addressed is the viability of trim and hardware removal, as it is currently done mostly by hand, resulting in a low financial viability of mechanical recycling of PCT. Many of these recyclers have already developed business relationships with brands, the majority interviewed brands already report to be currently incorporating recycled content within their collections, the minority of the content being from post-consumer sources. The percentages of recycled content per garment vary according to the product category between 5-100%. Wool sweaters are the products with higher percentages of recycled content, with their recycled content reaching commonly up to 70%. Several brands are already sourcing recycled wool or experimenting with it through capsule collections. For example, loop.a.life is a Dutch-based brand that commercialises 100% recycled sweaters composed of 70% recycled wool and 30% recycled polyamide material. Further, major brands and retailers already source a percentage of their wool or wool-acrylic blends from recycled sources, including outdoor brands such as Patagonia, Houdini and Prana.

On the other hand, products such as jeans range in an average of recycled content between 15-40%. The denim industry has already incorporated both mechanically and chemically recycled post-consumer cotton yarns into their collections. The consistency of denim fabrics allows for less uncertainty in the feedstock of the recycling processes, although accurate sorting of the material remains key to identify high percentages of non-cotton materials such as elastane or polyester. A few examples of denim collaborations are Mud Jeans, Recovertext and Yousstex Intl.²⁹, Levi's and EVRNU³⁰ or G-Star and Artistic Milliners³¹. Other product applications where a finer yarn count is needed, such as t-shirts, have not yet proven the effectiveness of integrating mechanically recycled cotton³². This may be a potential space for chemical recycling technologies to introduce their products. Further the chemical decolourisation process for post-consumer cotton may still present a challenge for recycled fibres and therefore needs further piloting³³. In this regard, HKRITA and GAP have recently partnered to work with Arvind Limited to develop a physical method to decolour the denim.³⁴ Other product categories that brands and manufacturers deem suitable to incorporate recycled content and achieve performing products are socks and home textiles.

Certain recyclers and brands suggest that a potential way to increase the use of recycled content in brand's collections is to firstly increase the quantity of garments that contain recycled content and secondly work in collaboration with supply chain partners to increase the quantity of recycled content in each garment. Another opportunity highlighted is the possibility to blend post-consumer with post-industrial textile waste, as it has proven in some cases to achieve higher quality recycled materials while utilising resources that are currently identified as production waste. While challenges mentioned relate to Minimum Order Quantities (MOQs) per colour and its relation to possibilities to purchase a quantity of a certain material that is relatable to the size of their collections, or inconsistency of feedstock and lack of knowledge on its content. Regarding performance of recycled textiles, brands and manufacturers specify that this should be in accordance with the specifications required for the specific product category and application. Either quality should be comparable with its virgin alternative, or there should be an honest communication and a certain agreement with the client/consumer on the quality expectations of the product containing recycled content.

When discussing not only the use of recycled content, but the design of garments in accordance to recyclability parameters, a significant minority of the brands interviewed have already implemented such strategy within their products. Due attention is placed through this strategy in the health as well as the selection of these materials, prioritising the use of mono-materials that can currently be handled appropriately at their end-of-use. Reduction of fasteners and other hardware added to garments should be minimised as much as possible (e.g. zippers, buttons, rivets, paillettes). However, research participants mention that recurring times the desire to design for recyclability is hindered by the need to use fibre blends to achieve the desired quality in regard to durability, hand feel and/or performance.

RECYCLERS	MANUFACTURERS & BRANDS
<ul style="list-style-type: none"> • Source automated sorted textiles per material type to ensure reliable and accurate input to your processes. • For mechanical recycling, source colour sorted PCT as homogeneous as possible to avoid extra dyeing. PCT as homogeneous as possible to avoid extra dyeing. • Assess the potential of blending post-consumer with post-industrial textile waste. • Facilitate non-sensitive knowledge sharing as much as possible, to leverage the expertise in the recycling field and widespread the materials' potential and value. 	<ul style="list-style-type: none"> • Design garments that are durable (according to material health guidelines) and can be recycled (today or in the near future). • Avoid the presence of materials that cannot currently be handled appropriately at their end-of-use. • Facilitate and/or lead value chain collaboration, partner with collectors, recyclers and mills to high-value recycle these garments at their end-of-use.

4.2 Safeguard the value of sorted materials as recycled content

The lack of traceability of most textiles carries the risk of re-introducing textiles into the system which could pose a threat to product safety due to chemical contamination.

It is of primary importance that recycled textiles comply with brands and manufacturers restricted substance lists (RSLs), usually in line with REACH 2020 regulation (within the EU) and, more extensively with ZDHC RSL. Therefore, traceability of materials and components can be identified as a priority to enter the market. For the Fibersorted materials, and all PCT, this may present an additional challenge. The Fibersort provides information on material composition, colour and structure. The remaining challenge is linked to the chemical composition of textiles and the possibility of carrying and re-entering restricted substances into the market under current EU regulations. Tracking and tracing technologies such as RFID tags or yarns, QR or barcodes could support in addressing this issue.

This concern has previously arisen with several materials and is currently being tackled by several industry organisations such as The European Outdoor Group,³⁵ TEXAID and IKEA and H&M.³⁶ This research on the potential for chemical contamination in PCT needs to be continued and relevant results obtained should be made available to forward industry knowledge.

In regards to the presence of recycled content, voluntary certifications and standards (e.g. Global Recycled Standard, GRS; and Recycled Claim Standard, RCS; SCS Recycled Certification and Cradle2Cradle³⁷) may be a way of ensuring it. These do also increase operating costs for recyclers and manufacturers, and therefore, a cost/benefit analysis should be considered, as this may not be a viable solution for some SMEs. Further, the robustness of the assurance delivery systems they are based on needs to be assessed and

RECYCLERS	MANUFACTURERS & BRANDS
<ul style="list-style-type: none"> • Assess benefits and costs of certifying your recycled material with a (voluntary) certification and/or standard. • Build trusted relationships with partners and suppliers, while establishing clear agreements and expectations on the material supplied. 	<ul style="list-style-type: none"> • Assess the necessary requirements of the recycled PCT in your products and communicate to recyclers which certifications and/or standards cover these requirements. • Invest in further research into the actual impacts of recycled textiles including but not limited to chemical composition, environmental footprint, labour conditions. • Build trusted relationships with partners and suppliers, while establishing clear agreements and expectations on the material supplied.

5. Making recycling a sound business choice: reducing economic barriers

The conditions and context under which the Fibersort technology is implemented will either limit or boost its potential. Market demands, costing and pricing of sorted PCT are therefore key parameters to understand this context.

5.1 Accelerate the development and implementation of recycling technologies

The demand, size and pricing parameters for PCT end-markets still present major uncertainties. An overview of current available end-markets for sorted PCT can be found through the link in Annex 1. While volumes of collected textiles are growing, quality is decreasing and the market value remains low, especially for non-rewearable PCT. Few technologies for certain materials are at scale and the relative immaturity of most recycling technologies, as well as the lack of in-depth understanding of availability and potential of recycled fibres and fabrics made from PCT by brands and consumers, limits the certainty on the future of recycled textiles.

Certain mechanical recycling technologies already function at scale, and there is a mature recycling market for materials such as pure wool or cotton. For these technologies accurate sorting based on composition and colour is a key enabler for achieving higher quality products. Further, research and implementation of hardware and other non-compatible trim removal such as labels is still to be developed. For these recyclers, the potential of using textile production waste together with post-consumer textiles to reduce costs and manage resources more efficiently may be a relevant opportunity to ensure the business case.

On the other hand, chemical recycling technologies have the potential to process particular blended materials and address mechanical recycling limitations such as loss of fibre length. The potential of these technologies is expected to be considerable, though currently most of them are still at pilot scale. The implementation of these technologies needs considerable scaling. For such endeavour to take place, while considering the current investment landscape, these developments should be supported by policy instruments such as design guidelines, targets for recycled content Extended Producer Responsibility (EPR) schemes and tax incentives amongst others. All of these are addressed in our previous publication: *Recommendations for Policymakers - Towards a Zero Waste Textiles Industry*.

RECYCLERS	MANUFACTURERS & BRANDS
<ul style="list-style-type: none"> Invest and/or lead the development and scaling of recycling technologies for pure or blended materials by partnering with brands, manufacturers or other relevant organisations. Assess funding opportunities to innovate or implement existing hardware and non-compatible label removal solutions. 	<ul style="list-style-type: none"> Invest and/or participate in the development and scaling of recycling technologies for pure or blended materials by partnering with recyclers. Assess the potential to use recycled fibre collected from your own production waste together with post-consumer textiles to reduce costs and manage resources more efficiently.

5.2 Ensure price parity of recycled with virgin

To date, recycled fibre and fabrics made from post-consumer textiles are priced higher, which is intimately related to the higher costs required to process post-consumer textiles.

Nonetheless, few of the interviewed brands have mentioned this to constitute their main requirement, placing performance at a higher level of influence. As prices of virgin fibres are increasingly becoming unstable, this may present an interesting opportunity to further explore the potential of recycled textiles. This entails that brands need to conduct a long-term assessment of material pricing, considering valuation of natural capital, resource scarcity and price fluctuations within profit & loss statements. Examples of these types of valuations have already been published by, for example, Kering³⁸ and Hugo Boss³⁹ and are open for consultation.

Further, economies of scale should bring a reduction in prices of recycled textiles, meaning there has to be an increase in the uptake of these materials in order to reduce the gap between virgin and recycled prices. The lack of revenue streams in connection to the investment in increasing recycled content should be balanced through diverse value propositions for consumers and/or through policy support in material and process innovation. Recyclers should focus efforts in quality and performance validation for diverse product applications, while brands should assess diverse consumer value propositions to motivate change in consumer demand for recycled textiles. These new value propositions will differ depending on market segment, from a focus on extending utilisation periods through material quality and service-based offerings, to increasing recycled and recyclable materials within current product lines.

RECYCLERS	MANUFACTURERS & BRANDS
<ul style="list-style-type: none"> Validate quality and performance of recycled products for specific product applications 	<ul style="list-style-type: none"> Conduct a long-term assessment of material pricing, considering valuation of natural capital, resource scarcity and price fluctuations. Increase market offer of recycled content in final products, to reduce pricing due to scale.

6. Conclusions

The opportunities to scale the use of recycled textiles are increasingly under the radar of the textile and apparel industry, as can be observed in the surge of textile-to-textile recyclers and recycling technologies available, as well as the number of manufacturing facilities certified by standards proving recycled content, and the increasing amount of brands trying to integrate diverse types of recycled content into their, still niche, collections. Nevertheless, further research, development and piloting remains to be done in order to fully understand and solve the barriers that still remain regarding recycling post-consumer textiles. This report outlines the key requirements for recyclers, manufacturers and brands to integrate and scale the use of recycled content and further outlines action points for each stakeholder group to work actively towards this circular ambition.

As shown in the overview below, every industry partner has a stake in addressing socio-cultural, physical and economic barriers in order to successfully increase the use of recycled post-consumer textiles within the textiles and apparel industry. The Interreg NWE Fibersort will continue to investigate and illustrate the potential of automated sorting technologies and the prospects of a used textiles closed loop value chain in its final Case Study report, to be released by the end of this Interreg project in March 2020.

For more information on the project, go to: www.nweurope.eu/fibersort



	RECYCLERS	MANUFACTURERS & BRANDS
MAKING RECYCLED THE NEW NORM: EXPLORING SOCIO-CULTURAL BARRIERS	<ul style="list-style-type: none"> Assess the availability of collected sorted post-consumer textiles in your local context. Partner with collectors/sorters to test their materials and assess their potential uses and applications. Communicate recycling challenges to brands and manufacturers to foster design for recyclability. Set clear specifications on material grades suitable for your recycling process and make this available to collectors/sorters, manufacturers and brands. 	<ul style="list-style-type: none"> Increase customer engagement through new service value propositions by implementing take-back and/or repair schemes. Take-back garments once consumers do not longer want to use them and partner with collectors, recyclers and mills to high-value recycle these garments. Partner with or consult experienced players in textile collection to develop and implement these schemes. Communicate relevant information regarding environmental, social and ethical performance of materials, products and processes to inform consumers' purchasing intentions. Avoid financial incentives in take-back schemes that incentivise increased consumption. Uptake recycled content firstly focused on quantity of products, to later focus on increasing the quantity of recycled content per product. This may support consumers' mindset change regarding recycled content. Set your own or align to industry-wide targets and commitments to close the textiles loop. Retrain internal teams on circularity, including but not limited to sourcing, design, marketing and management teams. Communicate your targets and goals to consumers and engage them in personal goal setting to translate purchasing intentions into changed purchasing behaviour.
CREATING NEW MATERIALS FROM POST-CONSUMER TEXTILES: OVERCOMING PHYSICAL BARRIERS	<ul style="list-style-type: none"> Source automated sorted textiles per material type to ensure reliable and accurate input to your processes. For mechanical recycling, source colour sorted PCT as homogeneous as possible to avoid extra dyeing. Assess the potential of blending post-consumer with post-industrial textile waste. Facilitate non-sensitive knowledge sharing as much as possible, to leverage the expertise in the recycling field and widespread the materials' potential and value. Assess benefits and costs of certifying your recycled material with a (voluntary) certification and/or standard. Build trusted relationships with partners and suppliers, while establishing clear agreements and expectations on the material supplied. 	<ul style="list-style-type: none"> Design garments that are durable (according to material health guidelines) and can be recycled (today or in the near future). Avoid the presence of materials that cannot currently be handled appropriately at their end-of-use. Facilitate and/or lead value chain collaboration, partner with collectors, recyclers and mills to high-value recycle these garments at their end-of-use. Assess the necessary requirements of the recycled PCT in your products and communicate to recyclers which certifications and/or standards cover these requirements. Invest in further research into the actual impacts of recycled textiles including but not limited to chemical composition, environmental footprint, labour conditions. Build trusted relationships with partners and suppliers, while establishing clear agreements and expectations on the material supplied.
MAKING RECYCLING A SOUND BUSINESS CHOICE: REDUCING ECONOMIC BARRIERS	<ul style="list-style-type: none"> Invest in development and scaling of new technologies for pure or blended materials by partnering with brands, manufacturers or other relevant organisations. Assess funding opportunities to innovate or implement existing hardware and non-compatible label removal solutions Validate quality and performance of recycled products for specific product applications 	<ul style="list-style-type: none"> Invest in development and scaling of new technologies for pure or blended materials by partnering with recyclers. Assess the potential to use recycled fibre collected from your own production waste together with post-consumer textiles to reduce costs and manage resources more efficiently. Conduct a long-term assessment of material pricing, considering valuation of natural capital, resource scarcity and price fluctuations. Increase market offer of recycled content in final products, to reduce pricing due to scale.

7. Endnotes

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8. Annex: Factsheets per material type

The following factsheets present an overview of the main characteristics of the sorted PCT material fractions in NWE, as well as their current and potential end-markets. To access the full overview of end-markets for sorted PCT please refer to: <https://www.circle-economy.com/case/fibersort/>



COTTON

Collected PCT in NWE	49.5% (240,570 tonnes/year)
Fibersort Sorting Threshold	95% cotton
Fibersort Sorting Accuracy (testing 03-2019)	98.5% cotton

Recycling Technologies	
CHEMICAL	MECHANICAL
Pre-processing activities	
<ul style="list-style-type: none"> • Sorting based on fibre composition • Colour sorting to reduce decolourisation processes to a minimum. • Hardware removal 	<ul style="list-style-type: none"> • Sorting based on fibre composition • Colour sorting to ensure homogeneity and avoid extra dyeing steps to achieve the desired colour shade. • All hardware and non-compatible label removal
Relevant Characteristics	
<ul style="list-style-type: none"> • New cellulosic yarns obtained. • Can contain between 80 and 100% recycled content. • The presence of prints, permanent press or water-resistant finishing still presents a challenge to some of these technologies. 	<ul style="list-style-type: none"> • Mainly combined with open-end spinning. • Fibre shortening due to material opening. • Blending of final yarn usually with virgin cotton, virgin organic cotton, man-made cellulosic fibres, virgin polyester or recycled polyester from PET bottles depending on final product application. • Blending of post-consumer with post-industrial waste may secure a stronger yarn, while integrating a higher percentage of recycled content.

Product Categories	
<ul style="list-style-type: none"> • Denim • Heavy-weight Knits • Light-weight Knits 	<ul style="list-style-type: none"> • Denim • Heavy-weight Knits • Home Textiles • Socks
Some organisations in this space	
<ul style="list-style-type: none"> • EVRNU • Infinited Fiber • Refibra by Lenzing • Re:newcell 	<ul style="list-style-type: none"> • Artistic Milliners • Ecotec by Marchi&Fildi • Pure Waste Textiles • Recover by Hilaturas Ferré

re:newcell



Re:newcell is a Swedish company that has developed a polymer recycling technology for post-industrial or post-consumer cellulosic waste, including cotton or man-made cellulosic textiles. Based in Kristinehamn, their demo plant can currently produce 7,000 tonnes of Circulose pulp every year. In the next years they are planning on setting up industrial scale plants and expect to be recycling 1 billion garments by 2025. At the 2019 September edition of Premiere Vision in Paris, they have presented the first garments created from their Circulose pulp⁴⁰.

Recover is part of Hilaturas Ferre, a Spanish spinner located in Banyeres de Mariola. They mechanically recycle and spin yarns from textile waste of cotton or cotton-rich blends. Currently, Recover has a capacity between 120 and 150 tonnes of yarn a week and during 2019 has processed 2.7 million kgs of material coming from post-industrial and post-consumer sources. The resulting yarns are certified by GRS, OCS and OEKO-TEX 100, and may be used for a variety of applications, including clothing (weaving, including denim, circular and flat knitting), home textiles and upholstery⁴¹.

Collected PCT in NWE	6% (29,174 tonnes/year)
Fibersort Sorting Threshold	96% polyester
Fibersort Sorting Accuracy (testing 03-2019)	82% polyester

Recycling Technologies
CHEMICAL
Pre-processing activities
<ul style="list-style-type: none"> • Sorting based on fibre composition • Non-compatible hardware removal
Relevant Characteristics
<ul style="list-style-type: none"> • Current recycling technologies for polyester are limited, mostly focused on mechanically downcycling polyester fibre into other applications, for example, for use in the automotive industry or for filling for home textiles. • The current processing may pose a question of its contribution to microfibre release into the environment and wastewater⁴². • Chemical recycling technologies for polyester textiles are currently in the process of setting demonstration plants. • These technologies focus on extracting the polyester from the PCT and converting it into flakes or pellets for reuse in, potentially, the extrusion of new polyester fibres. • The percentage of polyester within the textiles that these technologies can extract varies between 40 and 100%, acknowledging that the larger the percentage of polyester in the feedstock, the larger the final volume of pellets or other outputs obtained.
Product Categories
<ul style="list-style-type: none"> • Outdoor Wear • Sportswear • Workwear
Product Categories
<ul style="list-style-type: none"> • Ambercycle • Jeplan • Worn Again

Technology developments can be found in the landscape of machinery producers. This is the case of the PureLoop machine, a sister company of the Erema Group, a globally recognised machine producer in the field of plastic recycling systems. PureLoop ISEC machines can convert synthetic input materials into synthetic pellets. This feature is possible due to the combination of shredding and extruding activities within one machine. Hence, polyester textiles could be fed into the machine, processed and transformed into recycled polyester pellets, ensuring high return rates and stable throughput. Depending on the type of machine purchased, the throughput can range from 70 to up to 1,500 kgs per hour. Certainly, the quality of these pellets will depend on the purity of the material feedstock. This means, a previous accurate sorting step by material composition would be crucial to guarantee the highest purity of recycled polyester pellets. Another challenge the machine presents for textiles is that metallic hardware has to be removed prior to feeding this material to the machine, as all inputs need to be synthetic⁴³.

Collected PCT in NWE	18.7% (90,927 tonnes/year)		
Fibersort Polyester-Cotton Fractions	C 65 / P 35	C 50 / P 50	C 35 / P 65
Fibersort Sorting Threshold	C>55% / P>20%	C>40% / P>40%	C>20% / P>55%
Fibersort Sorting Accuracy (testing 03-2019)	C 74% / P 26%	C 54% / P 46%	C 44% / P 56%

Recycling Technologies	
CHEMICAL	MECHANICAL
Pre-processing activities	
<ul style="list-style-type: none"> • Sorting based on fibre composition • Non-compatible hardware removal 	<ul style="list-style-type: none"> • Sorting based on fibre composition • Colour Sorting to ensure colour homogeneity and avoid extra dyeing steps to achieve a desired colour shade. • Hardware removal
Relevant Characteristics	
<ul style="list-style-type: none"> • Considering the possibility to process cotton, polyester as well as their blends, these technologies are able to recycle several PCT flows currently available. • Provide raw materials in the form of PET resin, pellets or polyester monomers (terephthalic acid and ethylene glycol), and cellulose pulp to reintroduce in new spinning processes. 	<ul style="list-style-type: none"> • Usually re spun in combination with virgin or post-industrial recycled cotton, virgin polyester or recycled PET from bottles.
Product Categories	
<ul style="list-style-type: none"> • Sportswear • Outdoor wear • Workwear • Home textiles • Heavy and light-weight knits 	<ul style="list-style-type: none"> • Workwear • Heavy and light-weight knitsT-Shirts • Blouses
Some organisations in this space	
<ul style="list-style-type: none"> • HKRITA • Tyton Biosciences • Worn Again 	<ul style="list-style-type: none"> • Filatures du Parc • Procotex • Wolkat

Worn Again⁴⁴ is a UK-based company that has developed a polymer recycling technology that is able to separate, decontaminate and extract PET polymers and cellulose (from cotton) from non-reusable textiles and PET bottles to be reintroduced into the value chain. It is their mission to eliminate waste by recapturing resources which are kept in constant circulation, driving positive economic, social and environmental benefits; competitively processing blended inputs and producing dual outputs, preserving resources within existing global supply chains. The Worn Again process expects a significant percentage of non-rewearable textiles to be suitable for their process as 'feedstock' materials, particularly pure polyester and polyester-cotton blends. It can also handle up to 10% of other fibre types, e.g. elastane, polyamide and wool.



Collected PCT in NWE	3.3% (16,038 tonnes/year)		
Fibersort Wool/Acrylic Fractions	Acrylic 100	W 50 / A 50	W 30 / A 70
Fibersort Sorting Threshold	95% acrylic	W>40% / A>40%	W>20% / A>60%
Fibersort Sorting Accuracy (testing 03-2019)	97% acrylic	W 42% / A 58%	W 27% / A 73%

Recycling Technologies

MECHANICAL

Pre-processing activities

- Sorting based on fibre composition
- Colour Sorting to avoid re-dyeing
- Hardware and non-compatible label removal

Relevant Characteristics

- The value for this recycled fraction depends highly on the homogeneity of the colour as well as the material composition⁴⁵.
- Final yarn will most likely be blended with virgin wool, which will compensate fibre length lost in the recycling process, as well as facilitate achieving specific colour shades.
- A Life Cycle Assessment (LCA) analysis conducted on Re.Verso wool, shows that for 1 tonne of this wool in comparison to virgin wool, the environmental savings are as follows: 76% in energy, 89% in water, 96% in CO₂ equivalent, 99% in SO₂, and 76% in chemicals and dyes⁴⁶.

Product Categories

- Heavy-weight knits

Some organisations in this space

- Cardato
- Procotex
- ReVerso



Procotex⁴⁷ is a Belgium-based mechanical recycler for a multiplicity of textile materials. The main markets for their recycled fibres are currently the automotive, mattress, geotextile, insulation, drainage, composite industries. Further, as a Fibersort project partner, they are currently developing expertise within the potential of their recycled fibres for the apparel and textile industry. In March 2019, they have opened Fibersorted material and sent it to a spinner in Spain in order to test the outputs. The material included a bale with 70% wool content and another one with 90% wool content. After a few months, the first spools of wool yarn, with up to 60% recycled post-consumer Fibersorted textiles returned to the company. The spinner has found that it is possible to ring spin the fibres into a new yarn and was also positive about the potential of the yarn to be commercialised. Hence, the next step for Procotex will be to assess the applications for that this yarn with two flat-knitting Belgian companies in order to create a jersey fabric and/or double-knitted fabrics.

<i>Collected PCT in NWE</i>	0.9% (4,374 tonnes/year)
<i>Fibersort Sorting Threshold</i>	95% viscose
<i>Fibersort Sorting Accuracy (testing 03-2019)</i>	90% viscose

Recycling Technologies

CHEMICAL

Pre-processing activities

- Sorting based on fibre composition
- Hardware removal

Relevant Characteristics

- The global market share for man-made cellulosic fibres continues to grow and is approximately 6-7%⁴⁸, hence this fraction will become larger in the coming years.
- Some chemical recycling technologies that can process cotton inputs can also recycle cellulosic man-made fibres, including those mentioned above processing cotton or polyester-cotton blends.
- Other recycled man-made cellulose derive from post-industrial cotton processing, such as Asahi Kasei's Bemberg fibre made from cotton linter⁴⁹.

Product Categories

- Denim
- Light-weight Knits

Some organisations in this space

- Infinited Fiber
- Ioncell
- Lenzing (Refibra™)
- Worn Again



Lenzing is an Austrian cellulosic fibre producer, with a large presence in the global market of these fibres. Refibra™ is their technology to upcycle used cellulose materials and create new virgin TENCEL™ Lyocell fibres with a percentage of recycled material. The fibre was launched in 2017, and currently up to 30% of its content comes from recycled inputs, while up to 10% of the recycled content can be from post-consumer cotton waste⁵⁰.

<i>Collected PCT in NWE</i>	0.5% (2,430 tonnes/year)
<i>Fibersort Sorting Threshold</i>	80% polyamide
<i>Fibersort Sorting Accuracy (testing 03-2019)</i>	61% polyamide

Recycling Technologies

Relevant Characteristics

- Technologies usually need a very high quantity of polyamide in a garment for it to be recycled.
- Polyamide represents 5.4% of the global fibre market. Nevertheless, post-consumer textiles with a high degree of polyamide fibre, more than 80%, are difficult to obtain, and are mainly present in swimwear, outdoor wear, fishing nets and other non-clothing applications. There are very limited amounts of these textiles that are mono-materials.
- The ample majority of feedstock for recycled polyamide is currently sourced from post-industrial waste.
- The recycling process can be either chemical or mechanical
- Main environmental benefits are related to the decreased use and dependency on fossil fuels.

Product Categories

- Outdoor Wear
- Swimwear

CHEMICAL

MECHANICAL

Some organisations in this space

- | | |
|---|--|
| <ul style="list-style-type: none"> • Fulgar (Q-Nova) • Kishco Group | <ul style="list-style-type: none"> • Aquafil (Econyl) • Nilit • Nurel |
|---|--|

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