73% of the textile waste is burned or dumped

Circular Economy in the Textile Sector

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Introduction

This publication is part of a European Interreg project. Under the name **Wanderful.stream** (2020- 2023) eight organisations in the Meuse-Rhine Euroregion are pooling their knowledge, strengths and resources to help small and medium-sized enterprises in the transition to a more circular economy. Wanderful.stream offers free guidance and support to the companies on how to **valorize waste and residual flows** and initiates and facilitates the **co-creation of circular prototypes**, together with technologists, designers and business developers.

With this publication we want to provide an overview of the current situation (problems, needs and opportunities) in the textile sector with regard to the circular economy. This is part of a series of thematic publications on the different SME waste streams in the Meuse-Rhine region. It also forms the basis for further workshops and master classes on the theme of textiles within the project, which will be offered to the SMEs.

Using current examples of textile related circular economy from the EMR region, we would like to highlight some possible solutions and opportunities within the sector. The intention is not to be all-embracing but to be a source of inspiration for all SMEs, designers, technologists and users with a heart for textiles.

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1
Fast Fashion

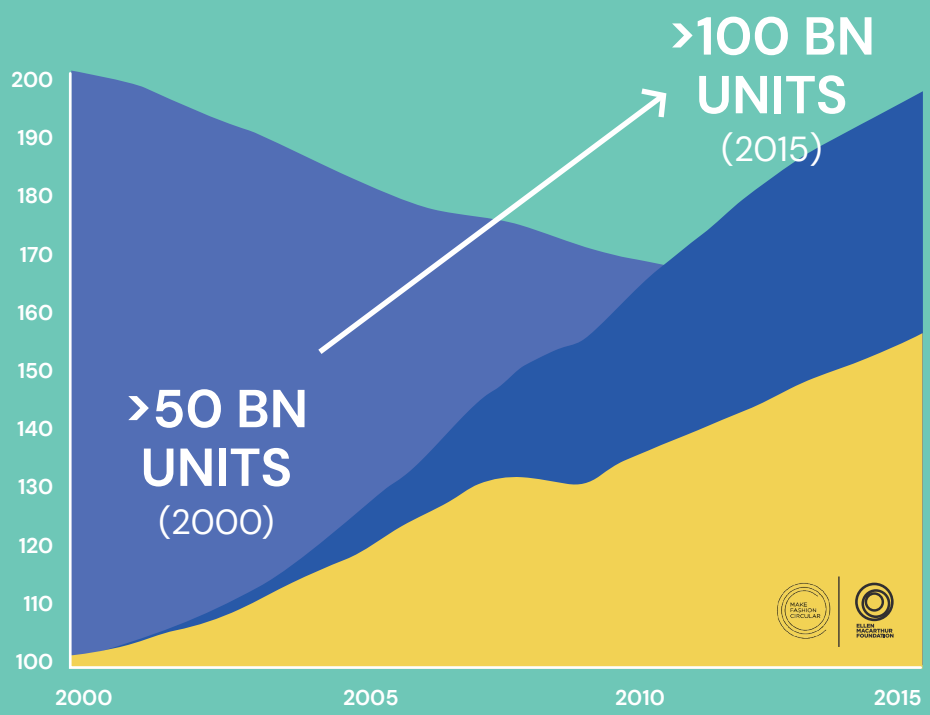
Nowadays the textile industry works mainly in a linear way. Non-renewable resources are used to produce garments that are often worn for only a short period of time after which they are usually taken to a landfill or incinerated.[1] Over the last two decades, both annual textile production and consumption have doubled (from 7 to 13 kg per person).[4] This increase is mainly due to the 'fast fashion' business model that emerged in the 1980s. Clothing companies reduced their costs, causing consumer prices to drop drastically, and increased the number of collections per year (2 collections per year in 2000 to about 5 per year in 2011). In response to these lower prices and greater variation in clothing, consumers started buying more items. The annual volume of clothes purchased increased by 40% between 1996 and 2018. 60% of German citizens indicate that they own more clothes than they need. [2] **Figure 1** shows that as a result of this 'fast fashion' phenomenon, clothing production doubled between 2000 and 2014. Due to the growing world population and middle class, this trend is likely to continue. [1]

People buy 40% more clothes than before

‘Fast Fashion’ phenomenon

Figure 1 Growth in clothing sales and decline in clothing use since 2000.
1 Average number of times a garment is worn before it is no longer used.

Source Euromonitor International Apparel & Footwear 2016 edition; World Bank, World development indicators – GD (2017)



Index 100 in 2000
- World GDP
- Clothing Sales

Number of times an item is worn
- Clothing Utilisation

2

Influence on Environment & Society

A natural consequence of the current linear model and consumption pattern in the textile sector, is an increased waste production and environmental impact. The textile industry is one of the largest, but also one of the most polluting sectors in the world.[2]

The textile industry processes 98 million tons of **non-renewable resources** annually, including oil for the production of synthetic fibers, fertilizers for cotton production and **chemicals** for textile treatment. Furthermore, textile production, including cotton cultivation, consumes about 93 billion cubic meters of **water** per year, contributing to an increasing water shortage in some regions. Greenhouse gas emissions from the textile sector amount to 1.2 billion tons per year, which is more than all international air and maritime traffic combined.[1] For example, the production of one pair of jeans results in a consumption of about 7000 liters of water and a **CO_2-emission** equivalent to a car journey of 110 km.[3] [4] Each year, the washing of synthetic textile products leads to the release billions of **microplastic fibers** that eventually end up in the oceans and our food chain.

Finally, the 'Fast Fashion' phenomenon saddles us with a mountain of **solid textile waste**. This includes not only textile waste from consumers, but also textile waste produced in industry (~12%) such as factory waste, clothing that is not sold, and so on. **Figure 2** shows textile waste per inhabitant and per EU country in 2012. The EU average is 6 kg of textile waste per inhabitant.

Only 13% of today's global textile waste is **recycled** in one way or another (**Figure 3**). Moreover, most of it is recycled into lower value applications in other industries such as insulation materials, dusters, mattress filling, etc. (**Figure 3**). Less than 1% of clothing textiles are recycled into new clothing, which represents an annual economic loss of 87 billion euros.[5] The remaining 73% of textile

73% of the textile waste is burned or dumped

waste is **incinerated or landfilled**, leading to a large loss of net energy and material.[1] Incineration also leads to greenhouse gas emissions. When dumped, potentially toxic chemicals such as certain dyes from clothing can leak into the environment. In addition, almost no textile item is currently fully biodegradable. Cellulose-based materials such as cotton are, but usually cotton garments contain parts such as buttons or stitching in another material that is not biodegradable.

In a circular textile economy it is therefore important to minimize the amount of waste on the one hand, and reducing the quantities that are incinerated or landfilled on the other.[2]

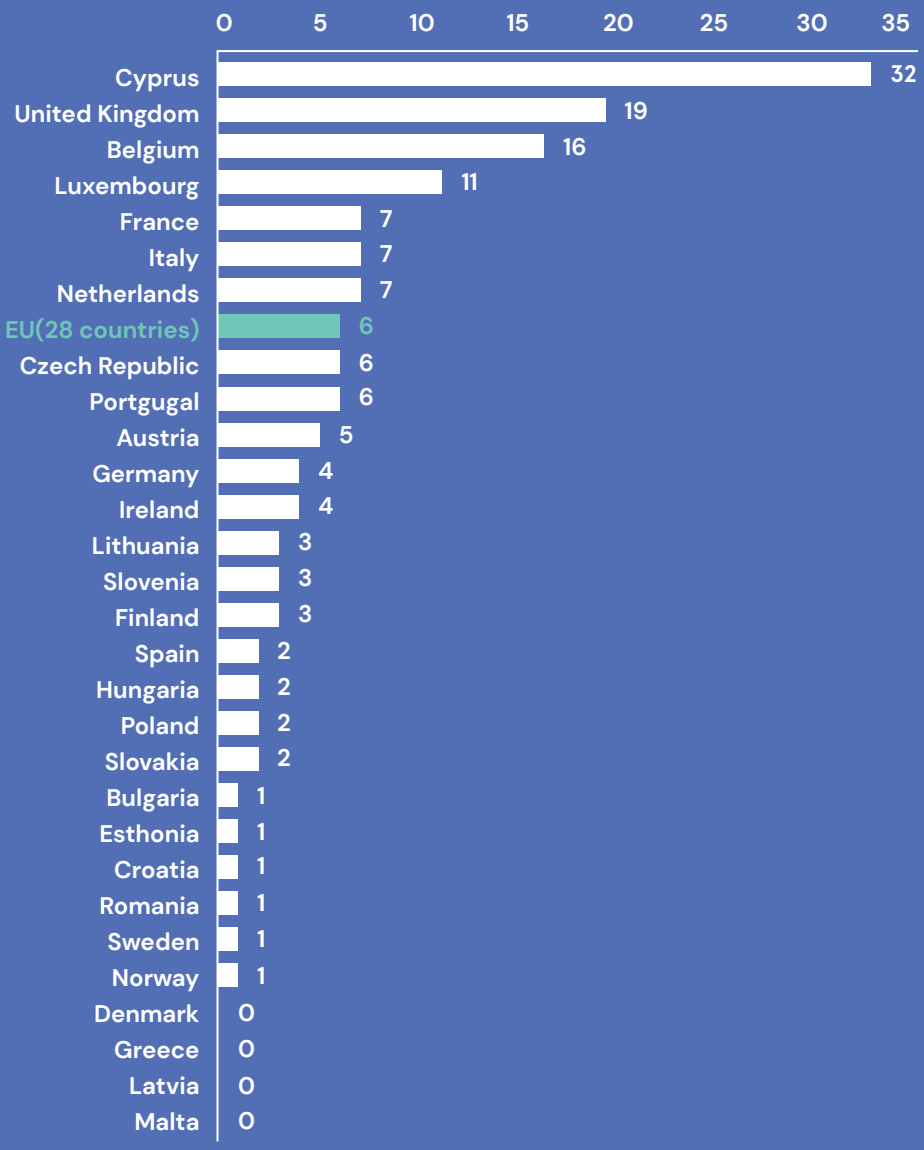
Finally, the traditional textile industry often has a negative impact on the environment as well as a negative **social impact**. Many textile workers work in an unsafe environment and are exposed to toxic chemicals. They are often poorly paid, work long hours and child labor still occurs.

A well-developed recycling process ensures that more waste can be reused for the production of new textiles

=

closed-loop recycling

Textile Waste in EU



Figuur 2 Textile waste (all NACE-activities + households) in EU countries in 2012, kg/per capita

Bron Based on Eurostat data

Worldwide Material Flows

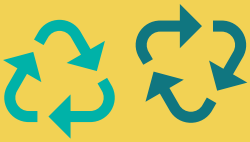
97%

Virgin Feedstock
63% Plastic
26% Cotton
11% Other

53 Million Tonnes

Annual Fibre Production for Clothing

2%



Recycled Feedstock from Other Industries

<1%

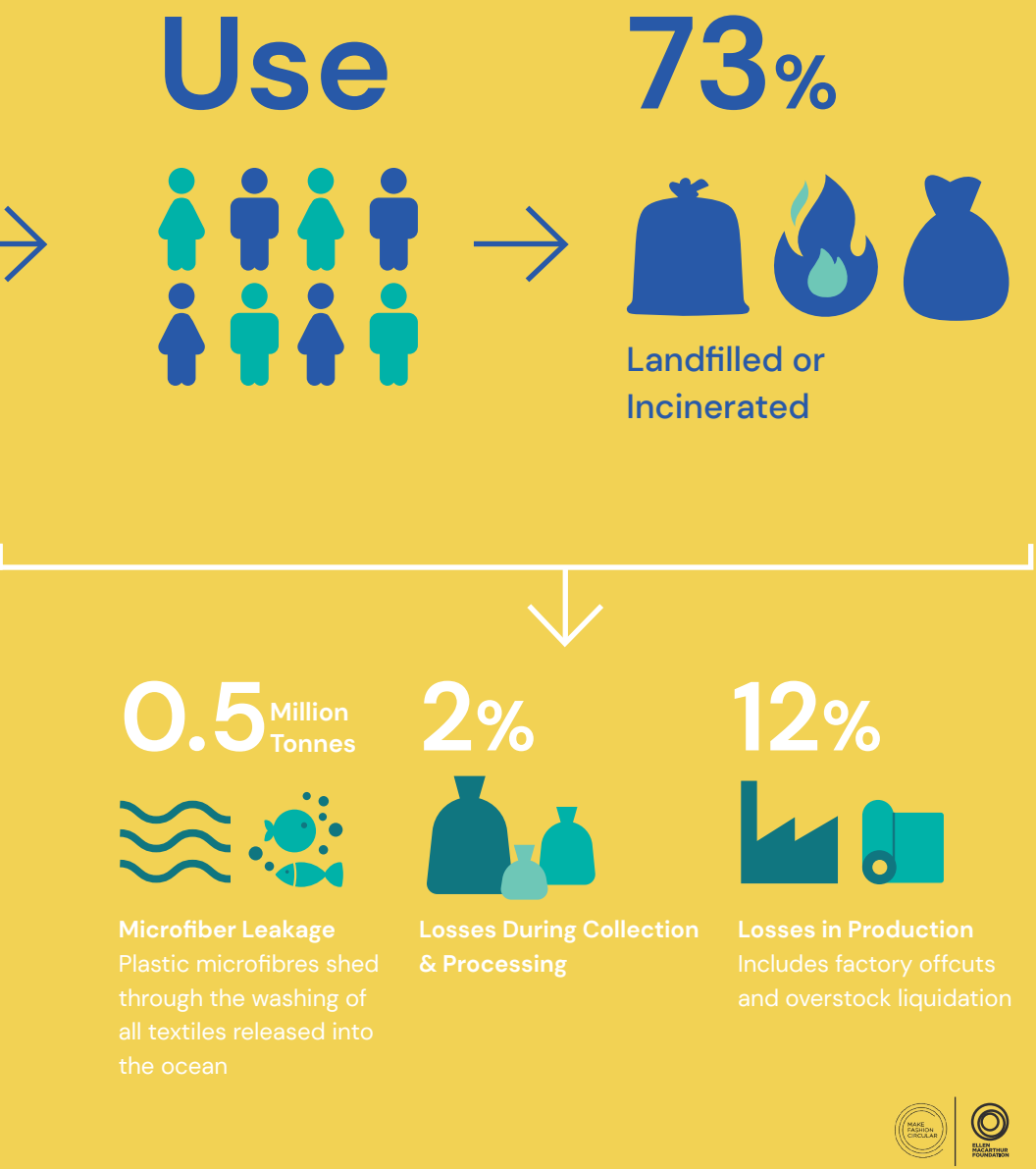
Closed-Loop Recycling
Recycling of clothing into the same or similar quality applications

12%

Cascaded Recycling
Recycling of clothing into other, lower-value applications such as insulation material, wiping cloths, or mattress stuffing

Figure 3 Global material flows for clothing in 2015.

Source Ellen MacArthur Foundation 2017a



The linear business model in the textile industry leads to overproduction, depletion of natural resources, pressure on ecosystems due to pollution, a negative social impact and an ever-increasing amount of waste.

3

Towards a Circular Textile Economy

The above shows that the linear business model in the textile industry leads to overproduction, depletion of natural resources, pressure on ecosystems due to pollution, a negative social impact and an ever-increasing amount of waste. Also, economic opportunities remain underused as only a small percentage of textile waste is recycled. A circular textile economy produces from non-polluting, biodegradable materials and uses energy and water-efficient production processes that are less harmful to the environment.

It also introduces earning models that counteract the current overproduction and consumption. Furthermore, a well-developed recycling process ensures that more waste is reused for the production of new textiles (closed-loop recycling).

In order to get an overview of the current possibilities, a literature study was carried out on companies active in the circular textile economy with a focus on the Euregion Meuse-Rhine.

4
Fibers

Polyester and other s**ynthetic fibers** such as **acrylic and nylon** currently make up 63% of the total textile fibers used. Their production requires large amounts of fossil fuels, consumes significant amounts of energy and emits large amounts of greenhouse gases. Some of the chemicals used in their production also end up in wastewater. When washed, these synthetics also emit microplastics, which accumulate in the oceans and our food chain. Moreover, these synthetic fibers are non-biodegradable. The ecological footprint of cotton, which accounts for 33% of total textile production, is also significant. It's cultivation consumes 10% of the total global pesticides, 25% of insecticides and 2.5% of the global water consumption. This causes water shortages in many areas, both for the local population and for nature. Toxic pesticides and insecticides are harmful to the workers who work with them, but also to the environment.

Cotton is a biodegradable fiber. However, chemicals used in e.g. coloring processes can potentially affect soil and water once released.[2]

In 2013, the European non-profit organization Made-By developed a classification for textile fibers based on the environmental impact taking into account 6 parameters: greenhouse gas emissions, toxicity to humans, toxicity to the environment, energy, water and land consumption. On this basis, fibers are classified as A (least environmental impact) to E. Some fibres could not be categorized due to insufficient available data. However, this classification only takes into account the first life stages of the substance. The spinning process, fabrication of the substance including dyeing and end of life were not taken into account (**Table 1**).

MADE-BY Environmental Benchmark for Fibres		
Class A	**Class B**	**Class C**
• Recycled Cotton • Mechanically Recycled Nylon • Mechanically Recycled Polyester • Recycled Wool • Organic Hamp • Organic Flax (Linen)	• Organic Cotton • Chemically Recyled Nylon • Chemically Recycled Polyester • Lyocell (TENCEL)	• Conventional Hemp • Conventional Flax (Linen) • Ramie • PLA
Class D	**Class E**	**Unclassed**
• Virgin Polyester • Poly-Acrylic • Generic Modal® (Viscose Product)	• Conventional Cotton • Virgin Nylon • Rayon • Cuprammonium Rayon • Bamboo Viscose • Wool	• Silk • Organic Wood • Leather • Elastane (Spandex) • Acetate • Kapok

Table 1 Classification of textile fibers according to environmental impact.

Source Made-By, (2013)

4.1
Recycled Fibers

Recycled fibers have a lower environmental impact than their corresponding new materials since no new input of materials is needed and energy consumption is much lower. Mechanical recycling techniques are less environmentally damaging than chemical methods. The recycling of fibers is further discussed in more detail (see 8.3.2).

4.2
Natural Cellulose-Based Fibers

Organic cotton is grown using organic pesticides and without the use of artificial fertilizer. The unsprayed cotton plants are picked manually and there is no chemical post-treatment (**Figure 4**). However, the high water consumption remains a problem with organic cotton and has resulted in these fibers being placed in a lower category by Made-By. Organic cotton is recognizable by means of an OCS (Organic Content Standard) or GOTS (Global Organic Textile Standard) certificate. A lot of companies already use organic cotton for their collection or for a part of it. C&A is the world's largest retailer of organic cotton. JBC (Houthalen-Helchteren, Belgium) has a baby collection of organic cotton. Other Belgian companies that have organic cotton in their range include Sambalou (Brussels, Belgium), Up-Rise (Leuven, Belgium) and Ink (Brussels). In the Netherlands, there are several brands that use organic cotton in their clothing, often combined with other organic or recycled materials. For example, Kuyichi, Pina Studio, A-dam, Unrobe, Unrecorded and Noumenon distinguish themselves from other brands in Amsterdam with their more sustainable clothing. In Zwolle J-lab3l is located and in Laren Mud Jeans also sells clothes made of organic cotton. Also in Germany there are numerous brands that design sustainable clothing by using organic cotton and other natural materials: Armedangels and Lanius in Cologne, Living Crafts in Selbitz, Mandala in Munich and the German brand Bleed in Helmbrechts.

However, there is still a wide range of alternatives to cotton. These fiber-

producing plants are less prone to diseases, so their cultivation requires less pesticides. Moreover, they consume less water and food and often grow faster. The most common fiber-producing plants are described here.

Hemp grows twice as fast as cotton and in many types of climates, purifies the groundwater and requires less pesticides during cultivation. Since the fibers are quite stiff, they are sometimes mixed with cotton to obtain a smoother fabric. Organically grown hemp does not use artificial fertilizer, but these fibers are 40% more expensive than conventional hemp. Stexfibers (Arnhem, the Netherlands) produces hemp fibres to replace cotton fibres. The clothing producers Ink (Brussels) and Up-Rise (Leuven) in Belgium use hemp in their clothing, as do Lanius (Cologne), Bleed (Helmbrechts) and HempTailor (Amsterdam).

Linen comes from the flax plant. Unlike cotton, flax cultivation requires no fertilizer and little or no pesticides. With organic linen, no chemicals are used for the growth of flax neither the processing of linen fibers. Examples of producers of flax fibres are Derotex (Wielsbeke, Belgium) and Procotex (Dottignies, Belgium). They also offer a wide range of other natural and recycled fibres. In Amsterdam, the Netherlands, Pina Studio produces jumpsuits exclusively made of organic linen and cotton. The flax is produced in France, Italy and Belgium and is then woven and dyed in Germany, without the use of harmful chemicals. Also Noumenon from Amsterdam, Ink (Brussels), Lanius (Cologne) and Living Crafts (Selbitz) from Germany, produce clothing with linen fibers.

Kapok is a cellulose fiber found in the fruit of the kapok tree (Timell, 1957). The kapok fiber is 100% biodegradable and 100% recyclable. The growth of kapok requires no pesticides (Ruby, 2014). However, because the kapok fiber is a rather short fiber, it must always be mixed with other fibers in order to be spun into yarn. The harvesting of kapok is also very labour intensive because the fiber-rich pods have to be beaten down high up in the tree and are also irritating to the lungs because of the seeds that spread through the wind. (Kapok - lightweight and water-resistant textile, 2018). Flocus in Enschede, the Netherlands, produces textile fibers and fabrics from kapok. J-Lab3l (Zwolle, the Netherlands) uses the kapok fibers from Flocus in their

Cotton Cycle

Cotton

Conventional

Cultivation with pesticides in monoculture

↓

Bleaching, spinning, dyeing with chemicals

↓

Strong cleaning necessary because of chemicals

↓

No control of working conditions

↓

Waste water regularly ends up in nature

Organic

Mixed Cultivation without agricultural toxins, such as pesticides

↓

Bleaching, spinning, dyeing in environmentally friendly manner

↓

No cleaning required

↓

Controlled socially responsible working conditions

↓

Waste water to treatment plant

Figure. 4 Cycle of conventional versus organically grown cotton.

Source Waschbär

clothing. Bleed (Helmbrechts) also uses kapok fibers in their clothing.

Ramee fibers originate from the 'Boehmeria' plant, which grows best in a (sub)tropical climate. The plant requires no pesticides, uses little water and can be harvested up to 6 times a year under good conditions. The plant is therefore renewable, biodegradable and above that the fibers are naturally white so they should not be bleached. Unfortunately, most productionplants use a chemical process to clean the fibers.

Bamboo grows fast, can be harvested indefinitely and needs little water. There are 2 methods to produce bamboo fibers: the chemical and the mechanical method. The chemical method uses strong chemicals to release the cellulose fibers from the bamboo. This leads to the production of bamboo viscose (see also 4.3). The mechanical method is a lot more durable. The 'woody' part of the bamboo plant is crushed and treated with natural enzymes. The obtained natural bamboo fibers are very rough like linen and more expensive than bamboo viscose. (Ali & Sarwar, 2010). This method of production only occurs on a small scale as it is a labor-intensive and costly process. Almost all bamboo clothing on the market is made from bamboo viscose. BAMBOO BELGIUM (Hechtel-Eksel, Belgium), Nooboo (Amsterdam, Netherlands) and Gesine Jost (Düsseldorf, Germany) make garments from bamboo viscose.

4.3 Synthetic Cellulose Fibers (Manmade Cellulose Fibers)

Synthetic cellulose fibers (Manmade cellulosic fiber, MMC) are produced from **wood** and are therefore biodegradable. During an energetically intensive production process, the wood pulp is dissolved in chemicals after which the fibers are spun into yarn. The "preferred MMC" label was created to identify MMCs that use renewable, certified wood and have a sustainable production process. Viscose, also known as rayon, is the most common MMC. Other synthetic cellulose fibers are Modal, Cupro and Lyocell. Modal fibers undergo a slightly different post-treatment than viscose, making them more wear-resistant. Cupro is made by treating (recycled) cotton cellulose with cuprammonium salt. Lyocell (TencelTM), produced by the Austrian manufacturer Lenzing (Lenzing), is the most sustainable

Figure 5 Chair made of seaweed yarn, naturally dyed with seaweed
Source Studio Nienke Hoogvliet

MMC as the production process uses a less toxic solvent in a closed-loop system where the chemicals are reused (Viscose fibres production - An assessment of sustainability issues, 2017). In Germany Living Crafts (Selbitz), Lanius (Cologne), Mandala (Munich) and Bleed (Helmbrechts) produce garments made out of lyocell fibers. Noumenon from Amsterdam uses lyocell in her clothing collection but also Cupro. Ink (Brussels) also designs clothing made out of lyocell. Wijld (Wuppertal) makes T-shirts out of lyocell and J-lab3l makes clothes out of FSC viscose.

Also from **seaweed** can cellulose be won. With this cellulose fabrics can be made such as viscose and modal. Smartfiber (Rudolstadt, Germany) makes Seacell, seaweed fibers. Dried seaweed is crushed, finely grounded and embedded in a lyocell cellulose wood fiber. Palgero (Vlotho, Germany) sells clothing from Seacell. Tjeerd Veenhoven (Groningen, Netherlands) is working on a research called ALGAEFABRICS, textile production from Cladophora, a seaweed species that exists out of 70% cellulose. Also in Studio Nienke Hoogvliet researched is being done to the production of textile from seaweed (**Figure 5**).

4.4
Bio Synthetic Fibers

Biosynthetic fibers consist of polymers made from renewable, biological sources such as agricultural crops, e.g. corn and reed or even better, waste products. The shift from synthetic fibers made from fossil fuels to bio-based fibers is only in its infancy. **PLA** (Polylactic Acid) fibers are considered a fully biobased and biodegradable alternative to polyester. PLA is produced from fermentable sugars, currently mainly from corn. Alternative sugar sources such as waste streams are being investigated. Sugar is fermented to lactic acid, which after further conversion can be polymerized to PLA. Finally, these PLA pellets are converted into textiles. The production process costs half of the energy needed to produce cotton. Nature Works LLC (Minnetonka, U.S.A.), one of the larger suppliers of biopolymers, sells PLA under the brand name Ingeo. In Belgium, Galactic (Celles) produces PLA from a variety of food crops.

Alternative biopolyesters are only partially bio-based and non-biodegradable such as PTT (Poly Trimethylene Teraphtalate) from DuPont™-Sorona® (Wilmington, U.S.A.) and bioPET (Polyethylene Terephtalate) from Toray (Tokyo, Japan).

Bio-based poly-amide (bioPA) (bio-based nylon) is a biopolymer made from castor oil (100% renewable source) but is not biodegradable. The main manufacturer of this polymer is the French company Arkema (Rilsan). Mandala (Munich, Germany) makes yoga clothing out of this material.

The Aachen-Maastricht Institute for Biobased Materials (AMIBM), MODINT (Zeist, the Netherlands) and CHILL work together on the project 'BioTex Fieldlab' with the aim to produce bio-based fibers. The partners in the **BioTex Fieldlab** work closely together with two Amsterdam-based industrial producers of biopolymers, Avantium and Corbion. Besides the biopolymers polyethylene furanoate from Avantium (Amsterdam) and PLA from Corbion, BioTex also focuses on other biopolymers, such as bioPET, bioPA and others, for the development of textile applications.

4.5
Protein Fibers

Protein fibers are usually of animal origin, such as wool and cashmere. These fibers are biodegradable, but their production is associated with the emission of animal greenhouse gases. Alternative protein fibers have recently been introduced on the market. **Casein fibers** are made from the casein protein in milk. Most casein fibers are produced by mixing the casein with acrylonitrile, thus depositing the casein on a synthetic acrylic fiber. As a result, the casein fiber is more likely to be considered a semi-synthetic product. The German Q-milk (Hannover), however, produces a textile fiber that consists 100% of casein and is therefore completely bio-based and biodegradable. Moreover, this casein is extracted from a waste product, i.e. cow's milk, which is no longer marketable. Qmilk fibers are used by, among others, the clothing brand Vaude.

Another protein fiber, on the market since 2015, is Biosteel fiber, produced by AMSilk (Planegg, Germany). It is a synthetic spider silk and therefore completely biodegradable. AMSilk ferments genetically modified E. coli bacteria that make the proteins from spider silk which can eventually be spun into a yarn.

Fruit waste, cow manure or mushrooms as a basis for the production of natural textile fibers

4.6

New Sources for Natural Textile Fibers

Numerous projects are currently underway in Belgium, the Netherlands and Germany to produce textiles from a diverse group of alternative, natural raw materials. These natural fibers are still in a research phase and are currently not commercially available.

"**Tomatentextiel**" in Rotterdam aims to produce textile from tomato stems. The tomato fiber is too short to be used as a natural fiber. Therefore the cellulose is first loosened and then polymerized into a filament that can be processed into yarn (MMC). Two projects use fibers from **fruit waste** as a basis for the production of a leather alternative. The aim of the APPEAL project is to convert fruit waste into a fully biodegradable biomaterial with different applications such as single-use plastics, agricultural foils, decoration and textiles (**Figure 6**). Fruitleather Rotterdam manufactures their fruit leather mainly from fruit waste from mangos.

Inspidere BV (Eindhoven, the Netherlands) produces bio-plastics such as cellulose acetate and viscose from **cow manure** containing up to 35% cellulose. The production method of these cellulose fibers consumes less energy and chemicals compared to the wood pulp industry.

Neffa /MycoTEX (Utrecht, the Netherlands) and Mylium (Wageningen, the Netherlands) produce a 100% biodegradable material based on mycelium, the "root" of mushrooms. When the material is fully grown (to the desired shape, thickness, ...) the material is baked so that the living mycelium cells die and the material dries.

Figuur 6 Handbag (prototype) made of apple leather

Bron Anouck Kuyckx & APPEAL

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5
Production Process

The production process of textiles has a significant ecological impact in terms of chemicals, energy and water consumption and also leads to the production of textile waste and microplastics. Here are some technological innovations from companies on the German-Dutch-Belgian territory to reduce this ecological footprint.

5.1
Chemicals

Many harmful **chemicals** such as solvents, dyes, heavy metals and surfactants are used in the production of textiles. These not only pose a threat to the health of textile workers and clothing wearers, but can also escape into the environment due to e.g. poor waste water treatment.(3)

The Dutch **ZDHC** (Zero Discharge of Hazardous Chemicals) unites textile brands in a collaboration to ban harmful chemicals. For this purpose they drew up the MRSL (Manufacturing Restricted Substances List) list of chemicals banned during the entire production process. The list includes products ranging from pesticides, dyes, detergents, coatings but also substances used during machine maintenance, waste water treatment, etc....

In Belgium, Buckman, a company that sells chemicals for tanning leather and Eurodye - CTC, which produces dyes, lubricants, detergents and softeners for textiles, support the ZDHC program. In the Netherlands, chemicals producers Smit & Zoon, Stahl and Tanatex chemicals are affiliated. Numerous German companies selling chemicals for the manufacture and finishing of textiles (including dyes, paints, pigments) also support the work of ZDHC: CHT; Dr. Petry; Lanxess; Pulcra Chemicals; Rudolf group and Trumpler. All these

companies are trying to contribute to the development of more sustainable textile chemicals.

When switching to more 'green' chemicals, many companies appear to focus on dyes. To dye clothing, traditional dyeing methods use dyes in excessive quantities where large quantities are discharged. Most of today's dyes are synthetic and are chemically made from petroleum, producing toxic waste. Dyes such as amine-containing azo dyes are often persistent, which is a desired property in fabric, but not in the environment. They sometimes also contain heavy metals such as lead or cadmium. Moreover, under certain circumstances, some dyes degrade to carcinogenic substances, while others cause allergic reactions.[1] A more sustainable textile sector therefore switches to **natural dyes**. These are extracted from natural materials such as plants and are also biodegradable. Designer Anke Van Asbroeck, among others, did research within Circle Sector (Genk) on how to make dyes from food waste under the name Re.Color. Natural dyes give a soft, pleasant color to the textile. However, synthetic dyes are cheaper and can achieve a wider and more intense color spectrum. However, research is being done into techniques that provide better coloring with natural dyes.

The Dutch Caffeink (Rotterdam) produces a dark ink based on coffee waste. Classically, the coffee grounds are burned, composted or fermented into biogas, resulting in the loss of valuable substances. Caffeink collects collected coffee waste, extracts a dark pigment from it and then sells it to ink producing companies. The coffee pigments can be used in paper, textiles, food and cosmetics. Knipidee (Almere) uses natural dyes to color their textiles. They extract these from plants and animals such as indigo, galnuts, pomegranates, rhubarb, etc. Natural fabrics such as cotton, silk,... absorb these dyes best. Synthetic fabrics, on the other hand, will usually get a lighter color. Nooboo (Amsterdam) released a collection that was colored completely natural with plants from Bali. They use the leaves of mango, tarum (indigo), mahogany and the bark of secang (sapan wood) to produce the 4 basic colors (green, blue, yellow and red). From these basic colors they make all other colors. Kuyichi (Utrecht) produces his jeans from 100% organic cotton, colored with the natural indigo. Ecological textiles (Roermond)

is a fabric distributor with a range of fabrics that are naturally dyed. Still garments (Berlin), Living Crafts (Selbitz) and An'tchi (Brussels) also color their clothing with natural dyes.

5.2 Processes with Less Energy or Water Consumption

Most textile production steps, such as sanding, washing, dyeing, bleaching and finishing, consume large amounts of water (Figure 7). In order to make the textile industry less environmentally damaging, at each of these steps an attempt can be made to save on energy and water consumption. DyeCoo (Weesp, the Netherlands) uses a CO_2 technology for dyeing textiles. The technique uses CO_2 under pressure in which dyes dissolve easily. Thanks to the high permeability of CO_2, dyes are transported deep into the fibers, creating vivid colors. CO_2 - dyeing thus requires no added process chemicals to dissolve dyes and is completely anhydrous.

The jeans manufacturer Kuyichi (Utrecht, the Netherlands) uses laser, ozone and E-flow as new washing techniques to minimize the waste of water, energy and chemicals. The **laser machine** is used to burn blurs in denim to replace sandpaper or chemicals. Their **ozone technology** is used for bleaching textiles instead of bleach, chemicals or stones. The machine sucks in atmospheric air and converts it into ozone, giving garments a natural, worn-out appearance. At the end of the cycle, the machine transforms the ozone back into air. Finally, there is the **E-Flow** machine, a technique that produces nanobubbles using water and an added product to treat the garment. These bubbles then transport this product into the garment. The process can be compared to a washing machine filled with steam instead of water. The technique can be used to soften or create 3D effects without using a lot of water and chemicals. So all these 3 techniques provide great water, chemicals and energy savings.

5.3 Processes with Less Textile Waste

Cutting patterns from fabrics invariably leads to cutting loss. These fabric residues can be recycled on the one hand (see further). However, some companies have

TO DYE OR NOT TO DYE?

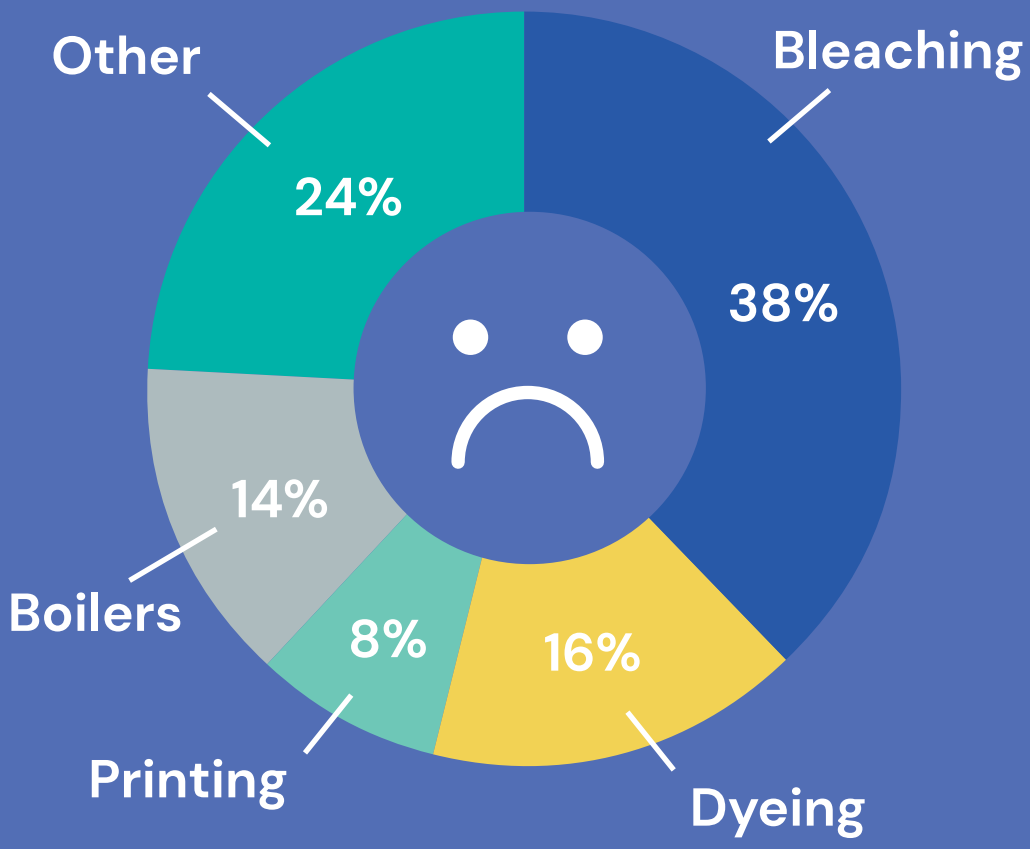


Figure 7 Conventional colouring processes – water consumption (%)

Source Biria Cellulose

developed techniques to reduce or even eliminate this cutting loss. For example, Vepa - the furniture factory (Hoogeveen, the Netherlands) upholsters furniture in which a CNC cutting machine calculates the most optimal way of cutting in order to minimize leftover material. Moreover, textile remnants are completely recycled into mats.

The classic way of producing clothing starts from a flat fabric that is cut into pieces, with the associated cutting loss, and then usually manually sewn together into a 3D piece. Fully fashion knitters, on the other hand, create less waste by knitting loose pan parts that are then linked together. To make a sweater, for example, a front panel, back panel and two sleeves are knitted into shape and then stitched together. By applying this method residual material is avoided. A workshop where machine-knitted articles are produced is “Breienbreien” (Dordrecht). They produce clothing through "full fashion" knitting and "knit and wear" knitting. "Knit and wear" knitting is the knitting of seamless articles that no longer need to be cut or stitched; the articles come out of the knitting machine completely in a 3D shape. The latter technique also avoids residual material, but it is a complicated, time-consuming and expensive technique and is therefore hardly used in the clothing industry. Another example is Knit-O-mat (Netherlands). They developed a 3D knitting process using state-of-heart knitting machines. The machines are capable of knitting entire garments or other forms, resulting in little or no waste.

A new seamless, three-dimensional textile design technology is used by UNSEAM (Amsterdam & Bloemendaal, the Netherlands). Through the use of digital techniques and special shrinking materials, 3D patterns are created in the clothing, which requires less labour-intensive actions and results in less cutting loss. This enables textile brands to produce their products to measure and on demand, closer to the end user, leading to a decrease in overproduction (**Figure 9**).

5.4
Reduction Plastic Micro Fibers

Every year, billions of microplastic fibers end up in the environment by washing plastic-based textiles such as polyester, acrylic and nylon. Textile production and use is thus responsible for 35% of all microplastics in the

oceans. These microfibers not only have a negative impact on maritime ecosystems, but also on human health via the food chain (**Figure 8**).[1] Alternative substances such as cotton do not secrete microplastics. There are also techniques to capture these microfibres during washing (use of special washing products or filters in the washing machine) or production techniques that reduce the release of microfibres.

The Swedish research program Mistra Future Fashion describes 3 possible ways to reduce the release of microplastics:

1 Reducing brushing (used to create fabrics such as fleece).
2 Replacing traditional cutting methods by ultrasound or laser cutting.
3 Removing microplastics in the production phase.

Another European project on this theme, Life - Mermaids (Italy), reports that treating the textile with certain excipients such as polysilk-CTE and chitosan reduces microfibre loss. They also described 4 polymer additives to be added to detergents that reduced fiber loss.

Every year,
billions of microplastic
fibers are released
into the environment by
washing plastic-based
textiles such as
polyester, acrylic
and nylon.

The Problem of Microplastics

Figure 8 The problem of microplastics

Source Life Mermaids

6

New Earning Models

Nowadays, the majority of the fashion offer consists of fast fashion products. In large retail chains, every six weeks new and inexpensive collections are available. On average, a garment is worn only 7 times. As fashion journalist Dana Thomas describes in her book Fashionopolis – The price of fast fashion and the future of clothes, "Our current consumption pattern and love of fast fashion is like a drug addiction. We've taken an overdose and need to rehabilitate". Clothing could be worn for a much longer period of time. Solutions for this are: renting and borrowing clothes or reselling the clothes after a first life (vintage clothes).

6.1 Rent Out

Closet in the Cloud and Tale Me in Belgium rent out clothing at reasonable prices.

Besides selling ecological denim, MUD JEANS (Laren, the Netherlands) also offers the rental service 'Lease a Jeans'. This service is completely focused on sustainability. You borrow a pair of jeans until it is completely worn out and then these jeans are processed into a new one.

Circos (Amsterdam, Netherlands) is a webshop that rents out clothing for children up to 3 years old. By renting / renting out less material is wasted so less new cotton has to be produced.

Many children's items are only used for a short period of time. Mic mac minuscule works with you to draw up the list of things you need for your baby on the way. You can buy these items at half the new price and if you take good care of them, you can bring them back into the Mic mac miniscule cycle.

STAY AWHILE (Germany) gives you two options to rent clothes: you can go for the self-selection box, with this you choose which clothes you rent. If you go for the self-selection box, they will put together an individual box with fresh looks for you.

Also at Myonbelle, Rent, Dresscoded, Kilenda, Kindoo and many others in Germany you can rent clothes.

6.2
Re-Sale

In the Netherlands, it is estimated that 55% of the textiles collected are suitable for reuse, 37% for recycling and 8% are waste. Of course, many second-hand clothing is also passed on directly from citizen to citizen, traded by them through the internet or offered to thrift stores. Many thrift stores also sell second-hand clothing in the EMR region: there are more than 6 thrift stores in Liège, 24 in Belgian Limburg, 77 in Dutch Limburg and 13 in the German part of the EMR region. Numerous other second-hand stores offer used clothes a new life. In the Limburg capital Hasselt sell Twenty Second Vintage, Hallelujah, Ladyland, Chou-Fleur kids, Cinderella and Streisant second hand clothing. In Liège are La Gerabotte, Le balon rouge, Les Petits Riens and Boutique Terre stores who sell second-hand clothing. In Maastricht there is also a secondhand store called Secondhand4All. In Aachen there are boutiques like Second Hand Korner, Großformat and Kinder Second Hand for money box that sell second hand clothing.

Second-hand clothing can be sold by the user on second-hand sites such as tweedehands.be, ebay, bobbo, marketplace or on Facebook. The disadvantage of this is that it is less safe than specialized websites or apps. United Wardrobe (Utrecht) and The Next Closet (Amsterdam) are platforms that focus on second hand clothing. Vinted is an online marketplace that originated in Lithuania and is active in more than ten countries, including Belgium and the Netherlands. United Wardrobe, The Next Closet and Vinted work both via website and app. On the app Swapp (Hoorn, the Netherlands) clothing, jewelry and accessories can be exchanged, bought or sold.

A cradle-to-cradle certified T-shirt can be fully composted or recycled when it cannot be worn again.

7

Textile Design

Currently, most textile companies have little alignment between the textile design and the recycling process needed afterwards. Often mixtures of different materials are used which are difficult to separate after use. Even when garments are labeled as 100% of a pure material, they can still contain small amounts of other materials, for example in the seams.[1] One of the prerequisites for a circular textile processing concept is the use of as pure textiles as possible. Separating textiles can be quite time consuming. Labels, zippers, buttons,... need to be removed completely.

Wear2go from Valkenswaard, the Netherlands uses a patented sewing thread in combination with microwave technology to completely disassemble garments. Resortecs (Waarschoot, Belgium) solves this problem by providing a thread "smart stitch" that easily dissolves at high temperature so that zippers and buttons can be easily removed.

C&A (Belgian-German-Dutch) developed a cradle-to-cradle certified T-shirt made entirely of organic cotton, including the stitching. The T-shirt was treated with safe chemicals and colored with non-toxic paint. All this ensures that the T-shirt can be fully composted when it cannot be worn again or recycled.

8

Recycling

In Belgium, the Netherlands and Germany there are numerous companies that contribute to the textile recycling chain including collection, sorting, recycling to the redevelopment of new products. After recycling, the textile pieces that are still usable end up on the second hand market. Other materials are reduced to dust, usually after fibrousification, from which new products are produced, such as new garments, or to lower value applications such as cleaning rags, bags, insulation materials... In Belgium, the Netherlands and Germany, for example, a large number of companies are involved in the collection, sorting and recycling of used textiles. Examples from the EMR region include Recytex Europe (Seraing) and Groupe Terre (Herstal), both active in the collection and triage of used textiles.

Recycling encompasses a whole chain of textile collection, sorting and a range of recycling technologies. A number of specific initiatives around these themes are described below.

Figure 9 UNSEAM Seamless design of the textile process by Bas Froon and Karin Vlug

Source Unseam

8.1
Textile Collection

Worldwide, about 20% of all textile waste is **collected** for reuse or recycling. However, there are large regional differences. In Germany, for example, 75% of discarded clothing is collected, while in the US and China it is only 10-15%. However, many of the garments collected in Western countries are exported to countries such as Asia and Africa, where they do not have their own collection infrastructure. In the end, therefore, these clothes often end up in landfills.

Textile collection is usually organized by a number of commercial and social organizations. However, more and more fashion chains are starting their own textile collection. For example, JBC (Houthalen-Helchteren, Belgium) offers a permanent collection of clothing in all stores. ⓘ Thanks to a collaboration with Wereld Missie Hulp (Boechout, Belgium) and Wolkat (Tilburg, the Netherlands), usable clothing is resold second hand and the rest is sold as raw material for new products. Previously, up to 35% of the collected clothing was a waste product, now this is reduced to 5 to 10%, which is also incinerated to generate energy. Moreover, the proceeds from the resale go to development projects all over the world. We see an analogous project in the 'WE TAKE IT BACK' ⓘ recycling programme of C&A (Dutch chain). For each bag a customer brings in, he receives a discount voucher of 15%. I:CO then collects and processes all collected clothing. If the clothes cannot be worn again, they can be given a new life in all kinds of other forms: from cleaning cloths to furniture,...

8.2
Textile Sorting

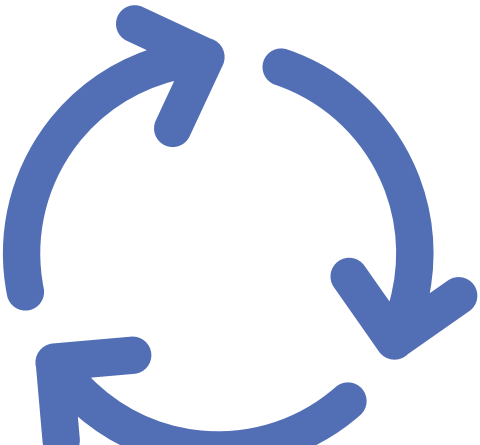
Once textile is collected, it must be **sorted** into separate material streams suitable for the various recycling techniques. Nowadays this sorting is mainly done manually. This process could be greatly facilitated by developing optical sorting technologies that increase the speed of the process.

Four European research projects have developed pilot facilities for recognition and sorting equipment based on near-infrared spectroscopy (NIR) and visual spectroscopy (VIS) for sorting textile waste by fiber type and color: SIPTex (i. s.m. a.o. Boer

group), Fibresort (with a.o. Valvan Baling Systems (Menen, Belgium) and Wieland Textiles (Wormerveer, the Netherlands), Identex by Textiles4Textiles (in collaboration with a.o. Wieland Textiles and the Laserzentrum Hannover) and Resyntex (Resyntex, 2019). These sorting devices detect and sort clothing by type and color of fiber using spectrography. Because each type of fiber shows a unique distribution of the color spectrum, the computer can make a quick analysis of the fabric in terms of composition, color and structure of the fibers used. The analysis is followed by transport by conveyor belt to the place intended for the group of garments in question. For the clothing industry, this precise and fast triage offers the perspective of a very large and consistent supply of high quality raw materials from discarded garments. The supply of the necessary technology for the transition to a circular textile economy is thus there. Once the old textiles have been sorted, they can easily be processed into new textiles.

8.3 Recycling Techniques

In order to be able to convert textile waste into recovered textiles, there are different types of recycling technologies. Some of these are already on a commercial level, other techniques are still under development or have difficulties to be cost competitive with newly produced textile material. Also, there is still only limited know-how on separating mixed textile materials. Recycling can take place at the level of fabric, yarn, fibers, polymers (mechanical or chemical) and monomers (**Figure 10**).



SMEs play a crucial role in the Euroregion and are the driving force behind a circular economy.

Routes for Re-use of Textile

Figure 10 Classification of textile reuse and recycling routes

Source Medium

- Closed Loop Recycle, Up-or Downcycling
- Energy Recovery
- Open-Loop Recycling, Downcycling
- Reuse

8.3.1
Recycling of fabrics

Recycling of fabrics uses intact pieces of fabric, from factory remnants or large pieces of fabric from used clothing, to create a new textile item. This type of recycling is currently only applicable on a small scale as it is a labor-intensive process and because of inconsistent supply. Many SMEs in the Netherlands, Belgium and Germany recycle used fabrics into new textile items.

In Belgium, Flagbag (Hasselt) makes shoulder bags, bicycle bags or toilet bags from discarded flags, pennants and sails. The clothing brand Paule Josephe (Ghent) produces women's and men's shirts from used men's shirts. In studio AMA (Ghent) they make clothes from post-production and post-consumer waste such as towels, old shirts, etc. TOP-studio (Zellik, Belgium) stimulates designers to work with recycled fabrics. In doing so, TOP-atelier tries to provide a continuous inflow of source material and focuses on innovative sorting systems and optimal cutting techniques to reduce cutting loss.

COFA (Sittard, the Netherlands) makes aprons and sports bags from used workwear from various industries. Pōur (Wijlre, the Netherlands) reuses workwear in all kinds of bags and backpacks. Also outside the EMR region, there are many companies in the Netherlands that do fabric recycling. In Amsterdam, companies such as Hacked by, Dom, Mon Sak and Makers Unite produce unique clothing or accessories made from residual textiles. Hacked By uses overstock clothing as a starting point for their new clothing. They used to work together with H&M. The sales items of H&M that were not sold were upcycled and sold in the H&M flagship stores. Dom and Mon Sak produce bags, respectively from old clothing remnants and from rejected leather. At Makers Unite, newcomers with a migration background make bags from old life jackets used during the migration. In Arnhem Fraenck, Schrav, Hul le kes and Wintervacht are upcycling used or discarded textiles. Fraenck uses cuttings from sailmakers and remnants of artificial leather in their handbags. Schrav and Hul le kes make clothes from textile leftovers. Winter coat makes jackets from old wool blankets. Also in other Dutch cities they work with residual textiles. Ressies Redesign from Haarlem makes surf clothing and accessories from old wind sails or wetsuits. From your old shirt you can have a boxershort

made at Vanhully (Groningen, The Netherlands). Indigo Ravens (Utrecht, The Netherlands) gives old clothing a second life by making new clothes out of it. HENK is a fashion label that makes clothes and bags out of fabrics from the 80's and 90's and Wear Patch makes clothes and pillowcases out of old clothes. Residual textiles are also used for the creation of tapestries (Studio Mieke Lucia) or panels to divide spaces (Simone Post). In Berlin (Germany), the Mimycri team makes rubber handbags from refugee boats left on the beach in Greece. Also Wiederbelebt from Stuttgart upcycled dust into clothing.

Getting started with residual textile

8.3.2
Mechanical fiber recycling

In mechanical fiber recycling, textiles are sorted according to material and color, after which they are torn to fiber level. The fibers of the fabrics are thus retained and reused. The largest Dutch fiber manufacturer is Frankenhuis (Haaksbergen) which fiberizes various textile streams including post-consumer clothing and industrial textiles. The two Belgian flax companies Derotex (Wielsbeke) and Procotex (Dottignies) extend their field of expertise to fiber recycling. Derotex recycles, among other things, jute and sisal by fiberization of used bags. Procotex recycles both natural and synthetic textile waste. RVN Faserproduktion (Neuenmarkt) uses both natural and synthetic fibers as raw materials for the production of new fibers. ℹ The fibers are used by their customers in acoustic parts of cars, mattresses, insulation panels,...

The disadvantage of mechanical fiberization is that fibers are shortened and weakened during grinding. As a result, fiberization often leads to applications with a lower value (so-called **downcycling**) such as use in insulation materials, car parts, carpets or mattresses. Vepa - the furniture factory (Hoogeveen, the Netherlands)

processes their cutting loss into a type of felt that they use as padding in their acoustic walls. VRK Insulation (Tilburg, the Netherlands) fiberizes unusable clothing into a high-quality insulation product consisting of 90% recycled cotton fibers. CEMBA (Leiden, the Netherlands) makes mattresses and blankets from recycled textile fibers from the garment industry in Bangladesh. In Belgium, Vanotex NV (Deinze) and Debeltex (Kortrijk) produce synthetic production waste for reuse in, among other things, felt, mattresses and fibers for the car industry.

Fibrous textiles can also be used for the manufacture of new garments (upcycling). As a result of the fiber weakening that occurs during the recycling process, yarn production always requires a combination with new, high quality fibers. Circular systems S.P.C. (Amsterdam, The Netherlands) produces Orbital hybrid yarns from organic cotton and mechanically recycled synthetic fibers through their Texloop recycling process. Circularity (Heusden, The Netherlands) makes new yarns from cutting waste and used clothing using the fibrization process to make new products such as T-shirts. Enschede Textielstad is a sustainable weaving mill that produces fabrics using natural and recycled fibers. I-did (Utrecht, the Netherlands) produces a high-quality design felt from mechanically recycled fibers from discarded textiles. Their goal is to create more valuable products such as interior products, bags and accessories.

For many companies, jeans textiles are the starting point for fiber recycling. DenimX (Maastricht) developed a composite material based on shredded jeans fibers and the bio-based plastic PLA. For production, DenimX can use textile waste streams from their customers as well as post-consumer waste. The material is suitable for the production of furniture, suitcases, helmets, etc. (Figure 11). An analogous process can be found at Rezign (Sliedrecht, the Netherlands). Old jeans are processed into yarn and combined with a bio-plastic to apply to a piece of furniture. Blue LOOP (Goor, Netherlands), MUD JEANS (Laren, Netherlands) and HNST (Antwerp, Belgium) unravel old jeans to fiber level to create new clothing or jeans. Blue LOOP mixes 30% recycled cotton fiber with 70% new fiber such as lyocell. The jeans from MUD JEANS consists of 40% recycled denim fiber and the jeans HNST consists of no less than half recycled denim fiber.

The open innovation center Texperium (Haaksbergen, the Netherlands) is specialized in consultancy in the field of mechanical textile recycling and the use of recycled materials in new applications. When developing projects, they form consortia and can make use of their pilot set-ups.

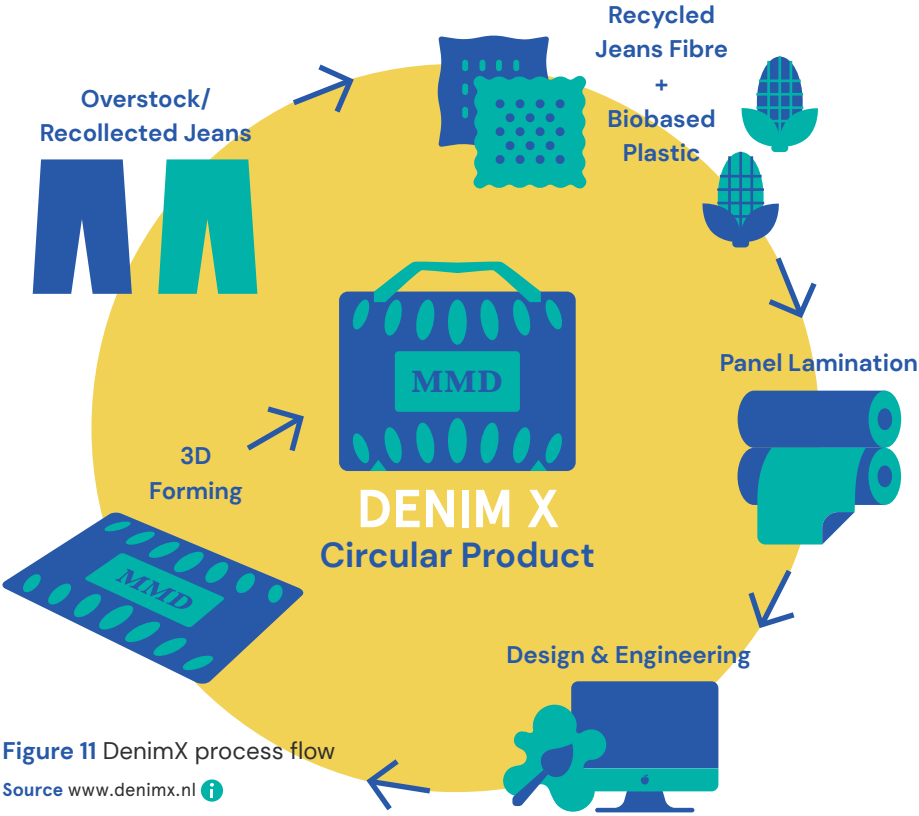


Figure 11 DenimX process flow

Source www.denimx.nl

8.3.3
Polymer recyclage

Polymer recycling destroys the fibers and converts them back to polymer level, leaving the chemical structure of the material intact. A distinction is made between mechanical and chemical techniques.

Mechanical polymer recycling is done by melting plastic-based textiles consisting of a single material. An example is PET that can be melted and spun into a new filament.

Waste 2 Wear is a project started by the Dutch textile engineer Monique Maissan. Plastic bottles are collected from the ocean and from the coast and mechanically recycled into yarn. Waste 2 Wear ⓘ further processes this yarn into fabrics for various applications.

The project Eigendraads (Rotterdam) converted the polyester from used marathon shirts of the Rotterdam 2019 marathon into new polyester yarn in collaboration with a recycler and a spinner.

Altena infra (Kampen, the Netherlands) produces the plastic Wootex ⓘ from old clothing and plastic bags. The old clothing and plastic bags are shredded and processed into granules. This granulate is extruded into different profiles. These profiles can be used for terraces, flower boxes, sound barriers, beams, etc. Wootex is as strong as wood and comparable in use but has the advantage that it does not splinter and is weather resistant. ⓘ

Pentatonic ⓘ (Berlin + London, Germany + UK) is a company that uses different waste streams with its technology and upgrades them in new products and applications. Their latest collection includes a series of furniture and objects made from recycled PET and from clothes thrown away in Europe.

ADVANSA (Hamm), in collaboration with the Canadian company Plastic Bank Aerelle Blue, produces a fiber made from recycled PET.

Chemical polymer recycling can be used for both synthetic and cotton fabrics. The substance is dissolved by means of solvents in order to come back to the polymer. An example is the recycling of cotton or cellulose based fibers to make a regenerated cellulose fiber by dissolving the cellulose in a solvent, followed by spinning of the solution.

SaXcell (Losser, the Netherlands) produces a chemically recycled textile fiber based on household cotton waste. First household cotton textile waste is sorted into as pure as possible waste stream. After sorting and removal of non-textile components such as zippers and buttons, the dry mixture is chemically decolorized and wet spun according to a process similar to the production of viscose or lyocell. The end product produces a regenerated pure cellulose fiber.

The starting project Upset Textiles (Rotterdam) wants to introduce an innovative recycling technology that makes it possible to convert 100% cotton textile waste into 100% recycled yarn.

From 100% cotton textile waste to 100% recycled yarn

Nowadays,
most recycled fibers
do not come from
old clothing but from
other plastic sources
such as PET bottles

8.3.4
Chemial Monomer Recycling

In chemical monomer recycling, the polymers are further broken down into individual monomers using chemicals from which new materials are then synthesized. An example of chemical recycling is the degradation of PET or nylon building blocks and polymerization of these molecules into a new molecule. This technology is about to be applied to plastic materials such as polyester and nylon, but is not yet widely applied to textiles due to lack of cost competitiveness compared to newly produced polyester fibers. Nowadays, most recycled fibers therefore do not come from old clothing but from other plastic sources such as PET bottles. For natural fibers such as cotton and wool, chemical monomer recycling is currently in an R&D phase.

22Paradise (Amsterdam, Netherlands) designs swimwear from Econyl , a regenerated nylon from Italy (Arco). Econyl , is produced from old carpets or fishing nets. After recovery of the nylon, the fabric is depolymerized and then regenerated into nylon of the same quality as new nylon.

Resyntex was a European research project with partners from 10 different EU countries in which an innovative pilot installation for textile recycling (in Slovenia) was developed. An automated sorting process based on infrared technology was linked to chemical and enzymatic processes that convert textile fibers into secondary raw materials and plastics.

8.4
Textile Manufacturers Based on Recycled Materials

Since recycled fibers are less harmful to the environment than the corresponding new materials, many designers and companies use them in their collections. For example, Postcouture (Antwerp + Rotterdam, Belgium + the Netherlands) and Loop a Life (Amsterdam, the Netherlands) make clothing using recycled fabrics. ReBlend (Hoorn) develops fabrics and textile products made from recycled fibers. Belle's club (Amsterdam) produces T-shirts from recycled cotton and PET fibers. Good Future (Giessendam) makes sustainable workwear from recycled and organic fibers. Juja Swimwear (Schiedam) produces UV resistant swimwear from recycled PET. Osier (Amsterdam) produces handbags from apple waste (apple leather) and recycled textiles and PET. The backpacks of UlStO (Dresden-Neustadt) consist of sustainable cork and felt from recycled PET. The backpacks of PinqPonq (Cologne) are made of 100% recycled PET. The Salvage brand of Continental Clothing Company (Berlin) consists of clothing and handbags made from recycled organic cotton and recycled PE.

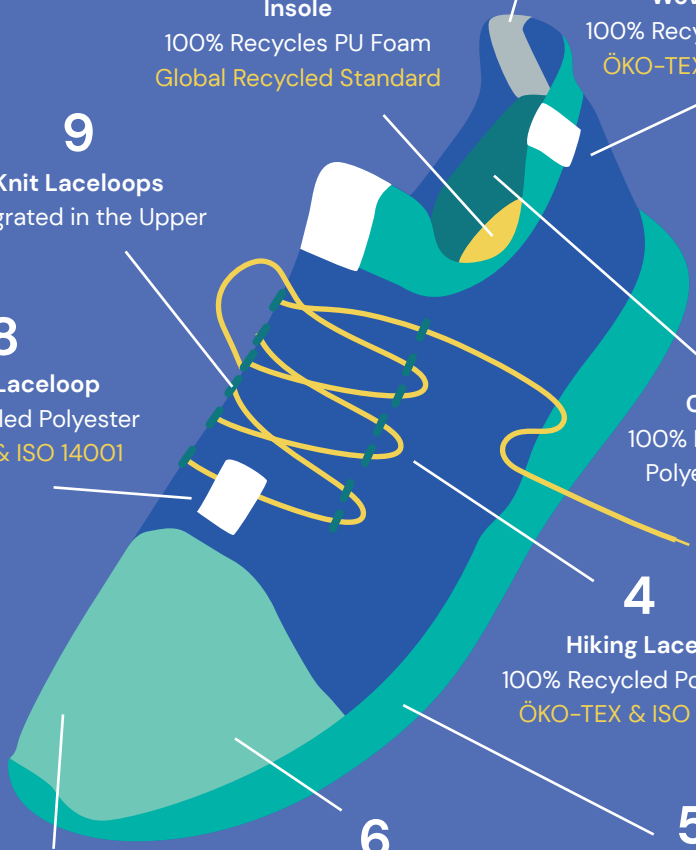
Recycled fabrics can also be used for the production of shoes. For example, the Custom Territory ⓘ project of Circle Sektor deals with the design of deconstructed sneakers. The Norm Shoe ⓘ (Brussels) consists for 90% of recycled materials, more specifically recycled PE and the soles consist for 75% of recycled rubber and 30% fair trade rubber). The fabric for the shoe was knitted as a whole by Knitwear Lab (Almere) without any loss of cut. The construction of the shoe is shown in **Figure 12**.

Another example of a circular shoe is Anna, created by a collaboration between European Spinning Group (ESG, Spiere-Helkijn, Belgium), CREAX (Kortrijk) and Knitwear Lab. The shoe was produced from yarn of recycled jeans in combination with lyocell and was knitted circularly by Knitwear Lab. Furthermore, the shoe is designed to be completely dismantled after use. ⓘ

Norm Shoe

Figure 12 The construction of the Norm Shoe

Source Metrotime



9
Conclusions

It is hard to imagine living in a world without textiles. Almost everyone, everywhere, comes into contact with them. The textile industry is also an important sector in the global economy, providing employment for hundreds of millions of people around the world. Despite these advantages, the way we design, produce and use clothing has drawbacks that are becoming increasingly apparent.

Over the past two decades, both annual textile production and consumption have doubled. This increase is mainly due to the 'fast fashion' business model that emerged in the 1980s. This linear business model in the textile industry leads to overproduction, depletion of natural resources, pressure on ecosystems due to pollution, a negative social impact and an ever-increasing amount of waste. Raw materials are becoming increasingly scarce and expensive and a growing environmental awareness among consumers and policy makers (stricter regulations) will only increase the demand for more sustainably produced and more circular textiles. In the long term, the current model is no longer sustainable and therefore a conversion in the textile sector is necessary.

SMEs play a crucial role in the Euroregion and are the driving force behind a circular economy. It is therefore mainly SMEs and designers who currently seem to be taking the lead in the conversion of the textile sector. They are the driving force behind this transition and can thus stimulate and inspire the larger players and policy makers in the sector to become part of it.

Although there are already steps in the right direction, there is still a long way to go. In order for this transition to be a sustainable success, it must encompass all aspects of the textile process;

- ✓ A **textile design** adapted to the recycling process afterwards
- ✓ A **production** that starts from non-polluting, biodegradable materials and uses energy and water-efficient processes that are less harmful to the environment.
- ✓ New **earning models** that counteract the current overproduction and consumption.
- ✓ New (recycling) **technologies** and a well-developed **recycling process** so that more textile waste can be reused for the production of new textiles (closed-loop recycling).

Only through collaboration, innovation and taking advantage of the new opportunities offered by this issue can companies, designers, technologists and users with a heart for textiles make a success of this vital transformation.

Note

Do you want to know more or do you want to get started but don't know how? Then surf to Close the Loop. ⓘ Here Flanders Circular and Flanders DC guide you through the principles of sustainable working in a circular fashion industry. On this site you can find a wide range of tips &tricks to pursue sustainability as a textile company or designer and a lot of inspiring examples from all over the world.

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- https://www.ecologicaltextiles.nl/index.html

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- http://www.pan-germany.org/download/katoen_klerenkast.pdf
- http://www.dyecoo.com/
- https://blog.kuyichi.com/2018/04/11/pure-denim-washing-techniques/
- http://www.chinawaterrisk.org/opinions/to-dye-or-not-to-dye/

5.3 Processes with Less Textile Waste

- https://vepa.nl/duurzaam/hergebruik-van-textiel/
- https://loopalife.com/
- http://www.knit-o-mat.com/
- https://www.unseam.nl/

5.4 Reduction Plastic Microfiber

- http://mistrafuturefashion.com/wp-content/uploads/2017/06/MFF-Report-Microplastics.pdf
- https://ec.europa.eu/growth/tools-databases/regional-innovation-monitor/organisation/swerea-ivf
- https://www.ri.se/en
- https://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=4973&docType=pdf

6. New Earning Models

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- https://www.parmentier.be/nl/nieuws/fast-fashion-een-drug-waarvan-de-wereld-moet-afkicken

6.1 Rent Out

- https://closetinthecloud.be/
- https://www.taleme-shop.com/
- https://www.mudjeans.eu/
- https://www.circos.co/
- https://www.micmacminuscule.be/
- https://stay-awhile.de/
- https://www.myonbelle.de/
- https://www.re-nt.com/
- https://dresscoded.com/
- https://www.kilenda.de/
- https://www.kindoo.de/

6.2 Re-Sale

- https://www.textielrecycling.nl/onze-branche/het-proces.html
- https://www.dekringwinkel.be/kringwinkelcentra-in-vlaanderen.html
- https://unitedwardrobe.com/en/home
- https://thenextcloset.com/en

Weblinks

- https://www.swapp.nl/

7 Textile Design

- https://wear2.com/
- https://resortecs.com/

8 Recycling

- https://www.unseam.nl/

8.1 Textile Collection

- https://blog.jbc.be/zo-jbc/duurzaamheid/tweede-leven-voor-ingezamelde-kleding/
- https://www.c-and-a.com/be/nl/corporate/company/duurzaamheid/wetakeitback/

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- https://www.nweurope.eu/media/9655/2020305-fibersort-51-final-case-studies-report.pdf
- https://www.wieland.nl/innovatie-fibersort/
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- http://mistrafuturefashion.com/wp-content/uploads/2019/10/M-Elander.-Automated-feeding-equipment-for-textile-waste.-Mistra-Future-Fashion-report.pdf

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- https://medium.com/@stonev/textile-waste-resource-or-trash-151114d1fcff

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- https://www.rvn-faserproduktion.com/en/products-and-raw-materials
- https://www.vrk-isolatie.nl/isolatie
- https://www.denimx.nl/

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- http://www.youtube.com/watch?v=I5UowEEKinE
- https://www.pentatonic.com/
- https://saxcell.nl/

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- www.youtube.com/watch?v=1UAofYqkdLs

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- https://fashionunited.be/nieuws/mode/norm-wil-s-werelds-meest-milieuvriendelijke-sneakermerk-zijn/2019050125611
- https://materialdistrict.com/article/circular-sneaker-disassembly/
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9 Conclusions

- https://www.close-the-loop.be/nl

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www.blog.jbc.be/zo-jbc/duurzaamheid/tweede-leven-voor-ingezamelde-kleding/

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2dehands

Bobbo

eBay

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Humana
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www.blog.jbc.be/zo-jbc/duurzaamheid/tweede-leven-voor-ingezamelde-kleding/

Wereld Missie Hulp
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Valvan Baling Systems
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Textiles4textiles

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1015 BX Amsterdam,
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Hullekes
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6828 ZN Arnhem,
The Netherlands
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about-hul-le-kes

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hello@henkmaaktdingen.nl
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Studio Mieke
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www.topatelier.be

Vanhully
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9727 AN Groningen,
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Wear Patch
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Mechanical Fiber Recycling

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www.users.skynet.be/fa678646/delbeltex/nl/default.htm

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Waste2Wear/ Vision Textiles Europe
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Loop a Life
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