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Changemakers for a desirable future

MECHANICAL RECYCLING OF TEXTILES

April 2025

To promote circularity and minimize the impact of the Textile and Footwear sector, **recycling is a preferred route when repair or reuse are no longer feasible.** Mechanical recycling of textiles is the most utilized and the most mature route to date. It involves transforming textile materials through mechanical treatment without altering their chemical structure. Mechanical recycling technologies are well-established and capable of processing various blended textiles on an industrial scale, though some limitations remain in the treatment of post-consumer textiles.

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Sources

This summary note, written and published by Refashion, is part of the continuation of the webinar on mechanical recycling organized by Refashion and the European Center for Innovative Textiles (CETI), which is available for replay. Refashion sincerely thanks Manisha Marival, Head of Recycling and Circular Economy at CETI, for her contribution to the discussion. For the past 11 years, CETI has been a center for applied research and innovation, working alongside major companies in the textile industry to advance circularity within the sector.

The data on the composition of different textile materials in non-reusable waste from sorting centers is derived from the characterization study of incoming and outgoing streams from sorting facilities (Refashion, 2023).

Definitions & context

Legislative framework for recycling

Recycling offers a significant potential for sourcing new materials by reusing existing ones instead of disposing of them, thereby recovering recycled raw materials (RRM). In an era of climate change and resource scarcity, recycling is essential to improve our environmental footprint and preserve natural resources.

The Environmental Code positions recycling just below reuse in the waste treatment hierarchy . The EU's textile strategy, presented in April 2022[1], emphasizes the use of recycled and recyclable materials, encouraging industries to adopt more sustainable practices. Additionally, the 2018 revision of the EU Waste Framework Directive (2008/98/EC) requires all EU member states to establish systems for the separate collection of textiles, household linen and footwear as of January 1st, 2025. Since textile, household linen and footwear collection inevitably generates non-reusable textile flows, the framework directive reinforces the importance of recycling in waste management and the transition to a circular economy.

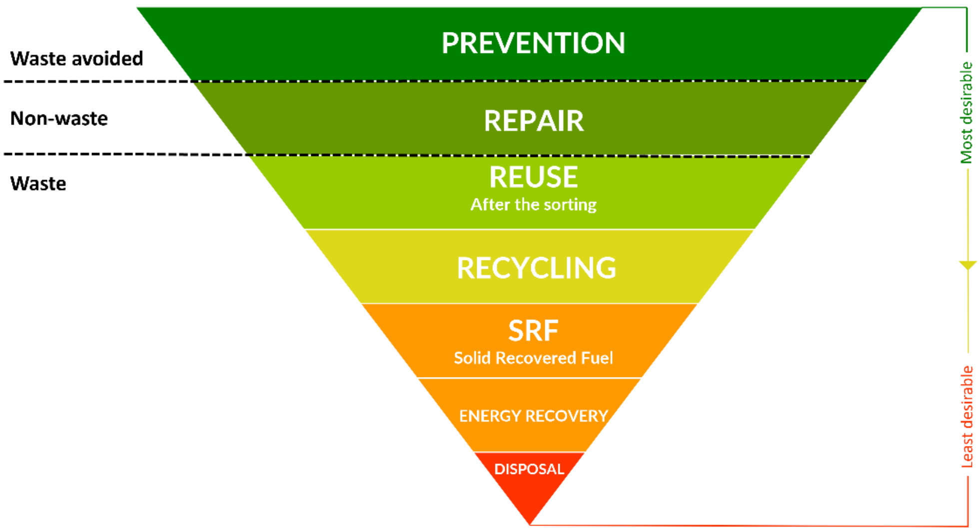

Figure 1 : Waste treatment hierarchy

In France, the [French law on fighting waste and on the circular economy]() of 2020 sets objectives and requirements in terms of recycling.

[1] https://ec.europa.eu/commission/presscorner/detail/en/ip_22_2013

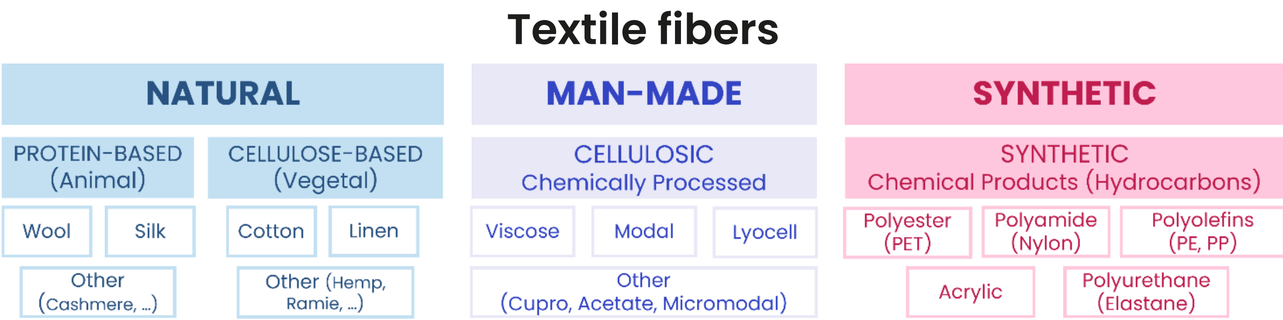

Figure 2 : Classification of fibers used in textiles

Various types of fibers are used for textiles (clothing, household linen manufacturing), and they are having an impact on possible recycling processes (Figure 2). **A distinction is made between natural fibers and man-made fibers, which can be derived either from natural resources (man-made cellulosic fibers) or from petrochemical sources (synthetic fibers).** These fibers are processed into yarn through spinning techniques, which vary depending on the fiber type, before being woven or knitted into textiles.

The three textile recycling pathways

Recycling, as defined by the European Commission in Directive 2008/98/EC, means « *any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes* ». This definition includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials intended to be used as fuels or for backfilling operations.

There are three main recycling pathways for textiles. These routes are complementary and help process a larger share of non-reusable textile waste:

Mechanical	**Thermomechanical**	**Chemical**
Encompasses all mechanical treatments (cutting, shredding, fiber recovery, and grinding) used to convert textile waste into new raw materials.	Designed for synthetic textiles made **from thermoplastics**, this process involves shredding, densifying, and extruding the material to produce new granules.	Involves breaking down textile materials into their **basic components** (monomers or polymers) using chemical processes such as dissolution or depolymerization. For more details, explore our report on chemical recycling.

For more details, explore our three webinars on each recycling pathway.

Mechanical recycling processes

Mechanical recycling is the oldest approach among existing textile recycling routes. It involves a series of mechanical processes such as cutting, unraveling, tearing/garnetting, and grinding to transform textile waste into recycled raw materials (RRM) in the form of shredded material, fibers, fabric scraps, clippings, or other outputs.

This recycling route is highly versatile and can process various textile compositions. However, knowing the fiber content of textiles before recycling is crucial, particularly the proportion of each material in blended fabrics. Some materials can pose challenges during processing (Table 1). Therefore, assessing the feasibility of the recycling process based on the specific material characteristics is essential.

Table 1: Classification of suitable and disruptive elements for mechanical recycling

Materials suitable for mechanical recycling	Disruptors[2]
Cotton Polyester Wool Nylon Acrylic Silk Cotton/Polyester Other blends	- Metallic-plastic yarn - Contaminants (dirt, moisture, odors) - Complex blends (more than two materials, any material <5%, elastane >5%) - Textured structures that are challenging or even impossible to tear (lace, embroidery, warp-knit fabrics, jacquard, dense fabrics with very fine threads) - Electronic and electrical components - Aesthetic elements (flocking/prints) - Hard thermoplastic and metallic components

*This list is **non-exhaustive**. The complete list of textile recycling facilitators and disruptors is detailed in the " Study on recycling disruptors and facilitators in Clothing, Household linen and Footwear " report published on the [Refashion website](#).*

The different mechanical recycling processes are outlined below. These may be used either as final recycling steps or as preparatory steps before chemical or thermomechanical recycling.

[2] Study on the factors disrupting and facilitating textile and household linen recycling, Refashion, 2014

Tearing/garnetting and unraveling

This process involves successive drawing of textiles to break them down and **recover fibers**. The textiles pass through a tearing machine equipped with multiple rotating cylinders fitted with spikes or needles.

Process primarily developed for textiles composed mainly of cotton, and wool/acrylic.

When this process is performed less aggressively to extract longer fibers suitable for yarn spinning, it is referred to as unraveling.

Applications:

- Fibers for yarn spinning ;
- Production of nonwovens (e.g. insulation) ;
- Composite materials production ;
- Padding and stuffing.

Preffered items:

- Knitted or woven articles made from natural fibers ;
- Knitted or woven fabrics containing synthetic fibers that do not risk melting under machine heat.

Limitations:

- **Elastic garments** with a high elastane content may stretch without breaking down properly. The elastane fraction may also melt, contaminating the resulting fiber stream ;
- **Non-shreddable fabrics** such as lace, warp knits, tulle ... ;
- **Metallic-plastic threads** (e.g., Lurex®) can create sparks, posing a fire hazard.

Non-exhaustive list of European tearing companies : Explore our list

Altex	Amarande	Buisson effilochage	Buitex	CETI
Coleo	Dagobaire	Delorge	Filatures du Parc	Frankenhuis

Hivesa Textil	L'Atelier des Matières	Minot Recyclage Textile	Ouateco	Robert Levy
Valérius360	Wolkat	Texcelis		

Cutting and Grinding

Cutting involves cutting textiles into pieces of varying sizes depending on the intended application. Small pieces are referred to as clippings, while larger pieces are called coupons or panels. This process can be performed manually using electric scissors or cutting machines or through automated cutters. It is widely used in the production of industrial wiping rags. Additionally, cutting helps prepare textiles for further recycling by fomatting them or removing trims such as buttons, zippers, labels, etc.

Grinding or **shredding** reduces textiles' size into clippings, granules, or fibers, ranging from a few centimeters to millimeters, depending on the desired output application.

Applications:

- Industrial wiping rags (primarily from cotton-based textiles) ;
- Padding and stuffing;
- Composites materials.

Preferred items:

All textiles can be cut or shredded (elastic fabrics require careful handling). However, not all of them have viable end-use applications. Cotton-based textiles are predominantly used for industrial wiping rags.

Limitations:

- **Metallic-plastic threads** (e.g., Lurex®) pose a fire hazard due to the risk of sparks.
- Cutting and grinding/shredding are often preprocessing stages before further recycling processes to transform textiles into new materials.

Applications of mechanical recycling

Mechanical recycling — through tearing/garnetting, cutting or shredding/grinding — offers a wide range of applications. These can be categorized into:

- **Closed-loop recycling**, where recycled raw materials are reincorporated into the textile and apparel industry.
- **Open-loop recycling**, where recovered materials are used in other industries such as **automotive, building, plastics manufacturing, etc.**

These applications complement each other, ensuring a broader and more efficient processing of non-reusable post-consumer textile waste.

Wiping rags

Open-loop recycling

In this process, textiles are **cut into panels** and repurposed as industrial wiping rags. This long-established recycling pathway is estimated to account for **20kt per year** across all textile types in Europe (not exclusively from the clothing, household linen, and footwear (CHF) sector). In terms of volumes, **wiping rags represent the second-largest textile recycling application after insulation**. However, the market for industrial wiping rags shows **limited growth potential**.

Primary textile feedstock: **Cotton-rich textiles**, preferably **knitted or terry fabrics**, due to their high absorbency.

Panels and Composite materials

Open-loop recycling

Textile materials recovered through cutting and tearing can be blended with other materials and combined with binding agents to produce composite panels or bricks. Currently, this recycling pathway accounts for less than 0.1kt per year[3], but projections suggest it could reach 1kt per year within the next 5 to 7 years.

Primary textile feedstock: Cotton textiles, synthetic textiles, cotton/polyester blends.

Non-exhaustive list of European companies:

Fabbrick   Maximum   Pierreplume

[3] Recycling potentials of non-reusable textiles, ADEME, September 2023

Yarn spinning

Closed-loop recycling

The goal of this process is to reincorporate fibers recovered from post-consumer textiles unraveling long enough to be spun. The resulting yarns can be used for new apparel manufacturing. Currently, this recycling pathway accounts for less than 1kt per year across all non-reusable textiles (not limited to the clothing, household linen, and footwear (CHF) sector), with projections up to 4–5kt per year within the next 5 to 7 years[4].

R&D

Developing a recycled yarn requires laboratory testing to assess the fiber quality after the unraveling process. Key factors include **fiber length** and fiber fineness. The quality of recovered fibers depends heavily on the quality of the input feedstock textiles.

Based on the quality test results, the target application of the yarn, and the spinning method, manufacturers may determine the percentage of recycled fibers that can be incorporated. This proportion rarely exceeds **30–40%.** To achieve the desired mechanical and aesthetic properties, recycled fibers **are blended with virgin fibers** (known as carrier fibers). This blending enables the production of recycled-content yarns with **technical properties equivalent** to those made from virgin materials.

When the recycled fibers are already dyed, there is no need for additional dyeing processes. However, due to color variations in post-consumer textile feedstock, the final yarns often exhibit a mottled appearance if the carrier fibers differ in color from the recycled fibers.

Production

Once the R&D phase is validated, recycled yarns can be produced using the same machinery as conventional yarns. The process includes the step of blending recycled fibers with virgin ones, then carding and finally yarn spinning.

Fiber opening ▶ **Blending** ▶ **Carding** ▶ **Yarn spinning** ▶ Woven/Knitted fabric

Figure 2 : The stages of yarn spinning

<u>Primary textile feedstock for this pathway:</u>

- Single-material cotton textiles ;
- Single-material wool and acrylic textiles.

Limitations:

- Higher costs of post-consumer recycled fibers compared to virgin fibers, mainly due to extensive sorting and preparation steps ;
- Lack of eco-design to enhance recyclability for this pathway ;
- Limited demand for post-consumer recycled yarns ;
- Distinct visual appearance.

Non-exhaustive list of European industry players:

European Spinning Group	Filatures du Parc	Hilaturas Ferre	Marchi & Fildi	Pages Valenti
R. Belda Llorens	Spinning Jenny	UTT Yarns	Vilarrasa	Valérius 360

[4] Recycling potentials of non-reusable textiles, ADEME, September 2023

Nonwovens

Open-loop recycling

Nonwovens are made from fiber webs bonded together by heating, using hot melt additives. They are widely used in thermal and/or acoustic insulation, padding, and technical components production. Currently, 21–26kt per year of nonwovens are produced from recycled fibers (not limited to post-consumer textiles) across Europe. This quantity could rise to 31–37kt per year within the next 5 to 7 years[5]. Nonwovens represent the largest recycling outlet for textiles and have the highest growth potential.

R&D

Depending on the intended application, nonwovens may require specific technical properties. Laboratory testing is conducted to determine the optimal fiber blend. To achieve the desired characteristics, recycled fibers are often mixed with virgin fibers, ensuring high-performance, value-added products.

For more insights on nonwovens and their applications, you may refer to [the article on the Nonwovens for the Transport Sector Working Group] led by Refashion.

Production

Once textiles are teared, fibers are precisely blended—sometimes with virgin fibers—to achieve the required nonwoven properties. A fiber web is then formed and consolidated using one of three bonding techniques:

- **Needle-Punching** (mechanical bonding): use of barbed needles to physically entangle fibers, strengthening the fabric;
- **Hydroentanglement** (water-jet bonding) : similar to needle-punching but uses high-pressure water jets instead of needles;
- **Thermal Bonding** : use of heat to melt thermoplastic binders (fibers or powders) within the mix, fusing the fibers together.

Figure 3 : The steps of nonwoven production

<u>Primary textile feedstock for this pathway [6]:</u>

- Single-material cotton textiles ;
- Cotton/polyester blends and acrylic blends.

Limitations:

- Certain applications (e.g., automotive, building) require strict product compliance with industry standards;
- Achieving specific technical performance in nonwovens requires precise identification of material composition within post-consumer textiles.

Non-exhaustive list of European industry stakeholders:

Buitex	I-Did	Le Relais Métisse	Ouateco	Pierreplume
Plusfelt	Vivaluz			

For more information on other recycling applications, we invite you to consult Refashion's mapping of products made from recycled textiles.

[5] Recycling potentials of non-reusable textiles, ADEME, September 2023
[6] Characterisation study of the incoming and outgoing streams from sorting facilities, Refashion, April 2023

Challenges of mechanical recycling

Despite its considerable potential, mechanical recycling faces several roadblocks.

1. **Economic challenges:**

The cost of post-consumer recycled fiber or yarn is often higher than that of virgin materials. This price difference is due to the complexity of sorting and preparation processes, which are still mostly manual, as well as the costs associated with recycling operations. Increasing processing volumes could help reduce these costs, but for now, the lack of price competitiveness limits demand compared to virgin materials. Additionally, building a strong recycling value chain in France and Europe remains a challenge. Most textile manufacturing and processing stages are still outsourced in Asia, making it difficult to incorporate post-consumer recycled fibers into local industrial processes.

2. **Technical challenges:**

Technical challenges persist, particularly in material identification for applications requiring precise composition. Clothing labels are sometimes missing, too worn out to read, or even inaccurate. Near-infrared spectroscopy (NIR) sorting technologies are advancing, and several sorting centers are beginning to implement them to improve material/color sorting efficiency. However, these technologies still cannot accurately identify all blended materials. Numerous projects are in progress to enhance these capabilities.

A similar issue arises in the trim removal process, which is still primarily performed manually.

3. **Lack of local and industrial-scale infrastructure:**

Mechanical recycling requires specialized infrastructure and large-scale processing capabilities. However, in many regions, these facilities are lacking, which limits the ability to effectively implement this type of recycling.

Among mechanical recycling technologies, tearing/garnetting is the most industrialized in France today. However, not all facilities accept post-consumer textile waste due to potential risks to machinery or a lack of viable applications/markets for the recovered fibers. Currently, nonwovens production is the primary industrialized pathway for processing fibers derived from tearing. Additionally, not all tearing facilities may be equipped to produce fibers suitable for yarn spinning.

Several yarn manufacturers offer product lines that incorporate fibers from post-consumer textiles. However, these recycled yarns typically account for only a small portion of their overall production. Should demand increase, these spinning mills could scale up the production of recycled yarns.

Ultimately, new incorporation pathways, such as panels and composite materials, are beginning to industrialize through the creation of small pilot plants.

4. **Lack of eco-design:**

Another major barrier is the absence of eco-design in textile products. Many items are designed and manufactured without considering their recyclability at the end of their lifecycle. The presence of numerous recycling disruptors and mixed materials complicates both the sorting for recycling and trim removal steps.

Summary

Mechanical recycling is currently the most industrialized textile recycling route and offers several advantages.

The outputs of mechanical recycling processes are varied and serve multiple industries: ready-to-wear fashion, furniture, building insulation, and decoration in the form of nonwovens, etc. By **combining closed-loop and open-loop recycling applications**, mechanical recycling can process a broader range of textiles and handle larger volumes. It is important to highlight that both recycling applications can generate high added-value products. However, despite these benefits, processing capacities remain **limited and still lack competitiveness** to recycle all non-reusable post-consumer textiles. To address this challenge, several R&D projects are ongoing to develop more efficient mechanical recycling solutions and overcome obstacles to its industrialization in France and across Europe.

Moreover, while current studies confirm that mechanical recycling[7] has a more favorable environmental footprint, **it is essential to recognize the complementarity of the three major recycling routes — mechanical, chemical and thermomechanical. All three pathways are necessary to strengthen textile resources circularity and maximize the volume of non-reusable textiles being recycled**. Achieving this goal requires close collaboration among stakeholders in the value chain. Manufacturers, suppliers, retailers, recyclers and consumers have to work together to optimize textile material flows and ensure the success of recycling initiatives.

Finally, eco-design plays a key role in the development of recycling. Designing products with their end-of-life in mind is crucial to improve their durability and recyclability. By adopting these principles and maintaining collective efforts, we can build a future where recycling becomes a fully integrated and sustainable practice, benefiting both the economy and the environment. For more information, you may refer to our best practice guide on textiles design for recycling.

Recycle Re_fashion

Refashion's Recycle platform aims to bring together players in the Textile and Footwear Sector to accelerate the industrialization of the recycling of non reusable textiles and footwear. Through the organization of workshops and webinars, Refashion builds bridges between companies offering materials and the manufacturers who will incorporate them into their production processes.

[7] Study on the technical, regulatory, economic and environmental effectiveness of textile fibres recycling – Final Report, European Commission, 2021