white cycle

Driving circular innovations in technical textiles: Strengthening sustainable industrial value chain

Policy recommendations

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V1.3	Alexandra Poch Henri Sourgou Valeria J. Schwanitz, August Wierling Aurelie Gardarin Emmanuel PRETET Iris ELSER Carole Aubry Manoj Subedi Olivier Cardon	Written contribution of consortium members
V1.4	Clémentine Devarenne	Review and improvements of the document
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- Set stronger regulatory targets and enhanced full traceability to drive innovation and improve overall system performance
- Encourage the adoption of innovative models for conducting Life Cycle Assessments in closed-loop recycling systems to ensure that these systems are both environmentally and economically sustainable
- To enable a truly circular textile economy, the composition of products should be carefully managed from the design stage, supported by clear EU policies that also apply to products manufactured outside Europe, in order to prevent future recycling difficulties and associated costs

Economic

- Strengthening EU's market presence by fostering innovation and expanding infrastructure to enhance competitiveness
- Introduce stronger financial incentives to stimulate investment and accelerate the growth of textile recycling technologies

Societal

- Aligning development of recycled products with consumer preferences, fostering trust, and encouraging behaviors to support the use of products made of r-PET

End of life Tyres

Set EU-harmonised end-of-waste criteria **for secondary raw materials derived from end-of-life tyres** to ensure legal certainty and free circulation within the Single Market.

Developing and deploying traceability technologies for tracking **wastes and the recycled content in products.**

Promote policies that recognise the **added value of material recovery from end-of-life tyres** to deploy an economically **viable recycling value chain.**

Incentivise investments in end-of-life tyre recycling processes **to ensure their industrial scale-up.**

End of life Hoses

Introduce mandatory eco-design standards for textiles, with a strong focus on repairability, alongside requirements **for recycled content, durability, and recyclability**.

Establish labelling standards and a product passport indicating the percentage and type of textile reinforcement, polymer composition, and recycling instructions.

Provide subsidies **for textile manufacturers to adopt recycling technologies and offer tax incentives to companies** using recycled materials

Developing and deploying traceability technologies for tracking wastes and the recycled content in products

End of life garments

Introduce comprehensive financial support mechanisms. For example offering subsidies for textile manufacturers to invest in recycling technologies, and tax incentives for companies that use recycled content in their products

Establish clear and harmonised guidelines for eco-modulated fees, ensuring they are based on the environmental performance of products and fully aligned with Ecodesign requirements and enforcement mechanisms.

Include **environmental impact, recyclability, repairability, and supply chain data** in the DPP

white cycle

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Public summary and objectives of the deliverable

This policy brief, delivered at the mid-term stage of the WhiteCycle project, aims to provide policymakers with an overview of the challenges and key recommendations identified by the project consortium that are affecting the deployment and implementation of the projects related to complex and technical textiles circularity. It focuses on identifying critical enablers and barriers within the current and future policy landscape that influence the success and scalability of similar initiatives.

The brief will offer recommendations on how existing policies can be adapted, or new policies created, to support the rapid deployment of textiles circular projects. This document has been carefully structured to provide a clear and actionable understanding of the key challenges and recommendations related to technical textile waste management, recycling, and recovery. To ensure clarity and avoid a simple "list effect," we have grouped the content into three overarching categories: Governance, Economic, and Societal. This thematic organization makes it easier to identify where specific barriers lie and how they can be addressed effectively.

The challenges and recommendations included in the document are applicable across all types of technical textile waste studied which WhiteCycle: textile in tyres, hoses, and garments. By formulating cross-cutting insights, we aim to highlight the common needs shared by these sectors while enabling a unified approach.

To avoid overly generic recommendations, each challenge and recommendation is accompanied by a detailed table that breaks down the specific issues and proposed actions at each step of the project value chain, from collection and sorting to processing and final recovery. This ensures that our guidance remains practical and tailored, as the relevance and effectiveness of solutions can vary significantly depending on the stage in the chain.

Additionally, in recognition of the specificities of each waste type, the document provides targeted insights for each material stream (textile in tyres, hoses, and garments), complemented by a summary of the three priority recommendations for each category. This helps to quickly identify the key priorities and actionable strategies tailored to each waste stream.

This deliverable serves as a foundation for ongoing dialogue, offering valuable insights for future discussions with stakeholders, sister projects, and institutional actors. These early insights will serve as a basis for further discussion and refinement during the final project workshop. At this workshop, stakeholders, sister projects, and institutional representatives will be invited to contribute to refining the recommendations and exploring ways to create a more favourable environment for scaling similar projects across Europe.

Presentation of the project

PET is widely used in plastics and textiles leading to over 20 Mt/y of complex waste worldwide for which no closed-loop recycling is viable today. Most complex waste is landfilled or incinerated. There is an urgent need to develop a circular solution to convert complex PET wastes from plastics and textiles back into high-added value products.

WHITECYCLE unites 3 brand-owners, 1 PET converter, 2 waste managers, 1 digital deeptech for smart sorting, the world leading enzymatic recycling SME, 1 LCA company, 3 UNIs/RTOs, 1 cluster and 1 management firm.

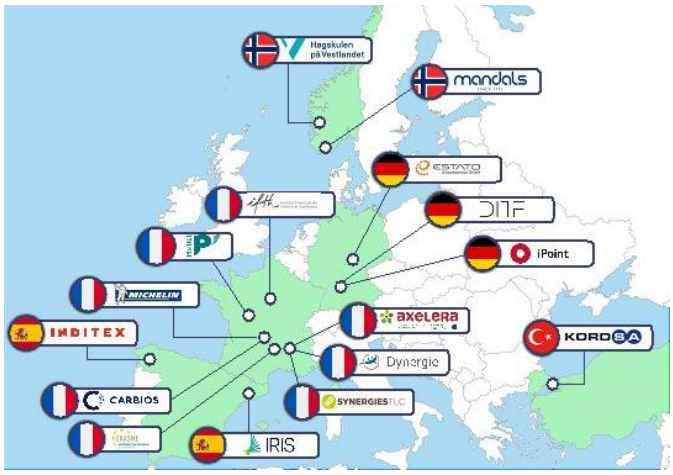

Figure 1: Mapping of partner locations in Europe

The consortium aims to demonstrate two new processes combining strong scientific and industrial know-how: (i) innovative identification, sorting and separation technologies that will dramatically increase the PET content of complex waste streams to 80%, and (ii) a disruptive enzymatic recycling process that is expected to yield pure PET monomers sustainably even for impure waste streams. PET monomers obtained will be repolymerised and recycled.

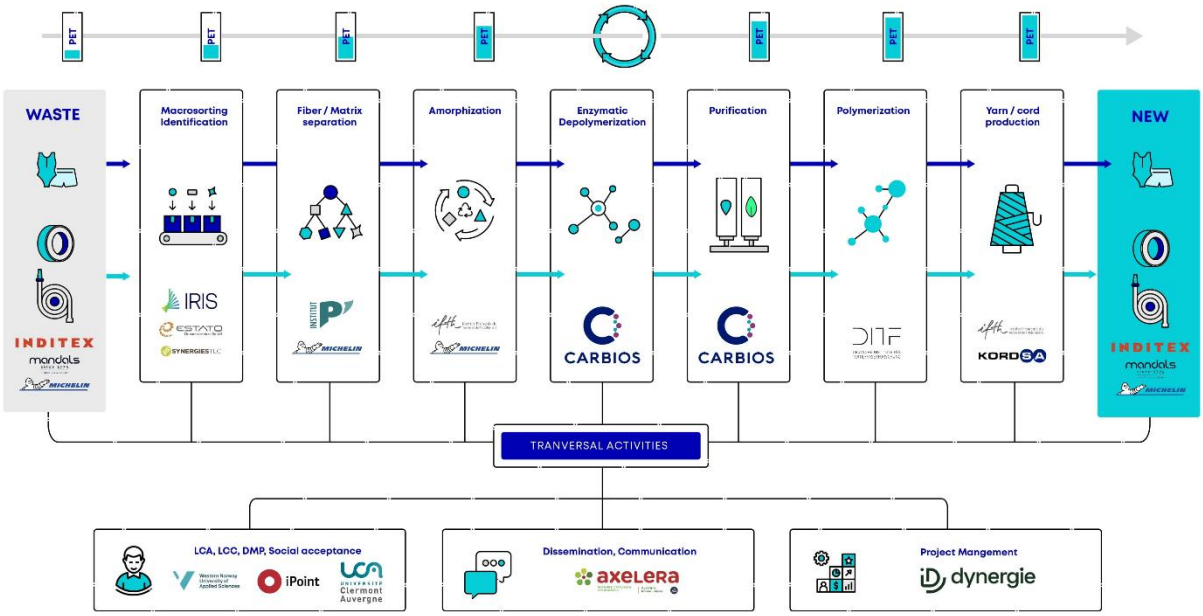

Figure 2: WhiteCycle key steps

Thus, 2 t of waste will be used to demonstrate 3 highly technical PET containing pilot series: 100 tyres, 1,500 m of lay-flat hoses and 400m2 of multicomponent fabric that will be coated and used to manufacture 4 lines of technical garments. Process design kits, LCA and production cost estimates will be provided to PET manufacturers and waste management companies for rapid deployment and assure social acceptance. First projections show that WHITECYCLE's recycled PET will be competitive to answer market demand. The project will conduct a full circle loop from real complex waste feedstock to

representative product of the 3 use-cases at TRL 5. Then, a strong upscale study will allow the process steps to reach TRL 6 to 8. By 2030, WHITECYCLE will enable the annual recycling of more than 2 Mt of PET, which corresponds to the amount of additional recycled PET needed to meet the EU's 2030 targets. This could reduce emissions by around 2 Mt CO2eq and avoid the landfilling and/or incineration of more than 2 Mt of PET.

The following diagram illustrates WhiteCycle's circular approach, and the key steps undertaken throughout the project.

Figure 3: WhiteCycle circular approach

Challenges identified by the consortium and associated recommendations

The deployment of technical textile recovery initiatives faces a range of challenges, many of which have been identified by the project consortium. These challenges might hinder the effective scaling and implementation of these initiatives, despite their potential to drive sustainability and innovation in the textile sector. The consortium has highlighted that these challenges manifest in various forms, creating complex obstacles to progress.

The challenges are multifaceted, cutting across various domains. The consortium has identified the following key dimensions to organise challenges:

1. governance,
2. economic, and
3. societal.

These diverse challenges require tailored solutions and addressing them will be key to enabling the broader adoption of circular technical textile recovery across Europe.

1. Governance challenges and recommendations

1.1 Challenge n°1: Lack of a harmonized regulatory framework in Europe for textile waste treatment and recovery

One of the key challenges facing the European textile industry is the lack of a harmonised regulatory framework for treating textile waste and recovering textiles. While some countries have made strides in establishing national regulations for textile waste management, these efforts remain fragmented across the EU. This lack of uniformity creates significant obstacles for both producers and consumers, hindering the efficient recycling and recovery of textile materials on a large scale.

Currently, EU member states are pursuing a range of divergent policies: while some prioritize textile waste collection and recycling, others lack comprehensive legislation altogether. This fragmented regulatory landscape creates uncertainty and hinders investment in recycling technologies.

At the European level, there is currently no clear and harmonized definition of what is encompassed by the term "textiles" within the regulatory framework. Textiles cover a wide range of products with highly diverse uses and compositions, including clothing, home textiles, car seat covers, and complex or technical textiles such as those used in tires. Each type of textile has specific characteristics in terms of both material composition and recovery potential, which implies different requirements for collection, sorting, and recycling. However, current regulations do not sufficiently reflect this diversity, thereby hindering the development of tailored recycling streams. It is therefore necessary to harmonize, at the European level, the structuring of textile waste management systems based on the specificities of each waste stream.

This challenge affects various stages of the WhiteCycle circular value chain in different ways (Figure 3). Table 1 below outlines the key challenges on each step, highlighting how varying levels of policy

implementation influence the effectiveness and development of the overall value chain. A challenge for all stages of the value chain is the low level of standardized and digitized data on processes, input, intermediate flows and final output. Well-organised and agreed-upon FAIR data flows are a prerequisite for optimal material flows within a circular economy.

Step N°	Name of the stage	Key challenges
1,2	Post consumer textile wastes	There is currently **significant confusion among consumers about how and where to dispose of textiles**, particularly complex or technical textiles. This confusion is reinforced by the fact that, in some countries like France, end-of-life textile management is organized not by material type but by finished product category. For example, professional clothing falls under the Extended Producer Responsibility (EPR) scheme for tools and gardening products, while clothing intended for the general public is managed by the EPR scheme for textiles, household linen, and footwear. This approach can be misleading, as similar-looking items such as two jackets may be managed by entirely different systems depending on their original intended use. The lack of clarity makes it difficult for citizens to properly sort their textiles and also complicates the coherent structuring of recycling systems at both national and European levels. In addition, in countries with established systems (e.g., France, Germany), consumers are more likely to recycle textiles. In contrast, **in regions with less infrastructure (e.g., Romania, Bulgaria), textiles are often discarded in general waste, contributing to higher landfill and incineration rates**.[1] Moreover, systems have to be expanded as one needs to separate between reusable clothes (as is), recyclable fabrics (incl. upcycling, downcycling, and repurposing), and end-of-life consumer textile waste.
3	Wastes collection	**Uneven textile waste collection practices across EU countries, limiting the volume and quality of recyclable materials**. In more than half of the EU-27 Member States, it is already mandatory to collect textiles separately, but this is mostly to capture reusable textiles. The average capture rate for textile waste in Europe is only 12 %, indicating that the rest ends up in mixed municipal waste and is consequently landfilled or incinerated. These data show significant room for improvement in separate collection systems for textiles. There is also a significant disparity between EU countries in terms of textile waste collection rates. For instance, Luxembourg collects about 50%, Romania around 2%, and Czechia reported a collection rate of 25% in 2020.[1]
4	Identification	**Lack of standardised and digitalized labelling requirements across the EU and inconsistent or inadequate garment labelling makes it difficult to accurately identify the material content (PET, PP)** of technical textiles because of additives for example coated fibres with PU, reducing sorting efficiency. This hampers material identification, making it harder to efficiently sort fabrics for recycling.
5	Sorting	The sorting of end-of-life garments faces several regulatory barriers that complicate the efficient scaling of identification and storing innovative technologies. **One major issue is the classification of used textiles as waste, which triggers strict handling and transport regulations**. While Extended Producer Responsibility (EPR) schemes encourage recycling, they can also introduce complex compliance requirements that burden sorting operations. Moreover, **variable infrastructure types and processes across countries leading to diverse sorting methods and quality, affecting recyclability.** In addition, **health and safety regulations further complicate the process,** as they are not consistently classified or applied across countries due to potential contamination

[1] *European Environment Agency - Management of used and waste textiles in Europe's circular economy, May 2024*

		risks in textiles. Lastly, the **lack of harmonized and digitalized standards across the EU exacerbates these challenges**, making it difficult to establish a unified approach to sorting and recycling.
6	Pre-treatment	The **high heterogeneity of post-consumer textiles**, particularly in the case of PET, **complicates the processing and pretreatment of this waste.** Indeed, these treatments are the first steps in the textile recycling value chain that involve large consolidated waste streams. The mixture of different textile qualities (such as the varying qualities of virgin PET fibers depending on their origin), combined with sometimes high levels of contamination and uncertainty about their exact composition, makes waste treatment complex. Moreover, **few facilities are currently equipped to carry out this operation,** as it requires upstream control of the waste streams and their quality. Product traceability is therefore crucial for implementing this stage on an industrial scale. The development of European standards to qualify raw materials for recycling would be beneficial for the sector.
7,8	Enzymatic depolymerisation, Monomers recovery,	The WhiteCycle value chain is centered on **post-consumer textile recycling**. However, **due to the complexity of these waste streams and the still-limited maturity of technologies for collection, sorting, preparation, pre-treatment, and recycling, a gradual approach is necessary**. This could involve the progressive incorporation of post-consumer textiles, initially blended with post-industrial textiles, whose composition and complexity are better understood and controlled.
9,10	Polymer production and chips production	PET is widely used across diverse textile types, often combined with various additives (e.g., colorants, flame-retardants, antioxidants) and blended with other polymers. These **complex formulations introduce a range of impurities that differ substantially from those encountered in more established recycling streams such as PET bottles or packaging.** While regulations exist for food-contact applications (e.g., bottle-grade PET), governed by the European Food Safety Authority (EFSA), no equivalent regulatory guidance is currently available for the use of recycled PET in textiles especially in high-performance or technical applications where safety standards may be required. **This regulatory gap leads to uncertainty regarding acceptable impurity levels, suitable processing methods** (such impurities can be removed at the monomer or polymer stage.), and the types of textile applications that can safely incorporate recycled PET. **There is a need to define both the safety requirements for such applications and the purification processes required to meet them**. Furthermore, it **may be necessary to categorize PET textile waste streams** to ensure that only suitable materials are used in the production of textiles with elevated safety demands.
11	Thread and yarn production	**Irregular quality and contamination levels** due to varying sorting standards **hinder the production of high-quality recycled yarns**.
12	Textile manufacturing	**Inconsistent environmental standards**, resulting in uneven implementation of sustainable practices and varying product quality.
13	Final products	**Fragmented standards hinder the development of high-quality recycled textile products for specialized applications like tires, technical textiles, and hoses** In addition, for continued recycling purposes as well as impact assessment, material and resource flows, together with responsibilities along the supply chain, have to be recorded. **Missing agreed-upon standards and the lack in digitisation efforts hinder seamless access to the necessary data.**

Table 1: Assessment of how regulatory fragmentation in Europe affects the WhiteCycle circular value chain

1.2 Recommendation n°1: Establishment of a unified EU policy framework to guide and support the transition to a circular textile economy, ensuring that policies are both effective and aligned across Member States

A harmonized regulatory framework at the EU level would help address these challenges by setting common standards for textile waste treatment and material recovery (incl. FAIR data standards). This could include establishing clear guidelines for the collection, sorting, and recycling of textiles, as well as creating a standardized system for tracking the recycled content in products. A unified framework would encourage the development of more efficient recycling infrastructures, increase market confidence in recycled materials, and create a more predictable regulatory environment for manufacturers operating across multiple European countries. All actors across the circular textile value chain need to discuss and agree upon FAIR data standards. However, it needs a central organisation to establish them among all industries (e.g., European Statistical Offices).

Moreover, to enhance Europe's environmental responsibility and strengthen its circular economy, it is crucial to implement legislation aimed at reducing the export of waste to non-EU countries. Currently, exporting waste, particularly textiles, to countries with weaker environmental regulations contributes to pollution and health risks, while undermining Europe's sustainability objectives. By addressing this issue, Europe can foster better waste management practices and significantly reduce the environmental impact of its waste exports.

First, limiting waste exports aligns with circular economy principles by ensuring that waste is processed, recycled, or repurposed locally rather than offshored. This would reduce the ecological burden on less-regulated countries, where improper waste handling can lead to pollution and health hazards. Additionally, it encourages investment in local recycling infrastructure, promoting innovation and creating green jobs within the EU.

In addition, reducing waste exports enhances the transparency and accountability of Europe's waste management systems. It ensures that waste handling follows stringent environmental standards, reducing the risk of improper disposal in countries with less oversight. This also minimizes Europe's reliance on external countries, whose waste management policies may change unpredictably, jeopardizing sustainable practices.

The following table 2 outlines the recommendations formulated by the consortium to address the challenges arising from the lack of harmonized regulations across the EU in the WhiteCycle circular value chain. The preliminary recommendations aim to induce and harmonize EU-level policies that can create a more cohesive and efficient framework, driving the transition towards a truly circular textile economy.

Step N°	Name of the stage	Recommendations
1,2	Post consumer textile wastes	• Launch EU-wide campaigns to educate consumers on proper textile waste disposal and the environmental benefits of recycling, especially in regions with low collection rates. • Introduce standardized labelling on textile products (including products containing technical textiles) to guide consumers on how to dispose of textiles responsibly, ensuring clarity across all EU countries. • Educate consumers on the environmental impact of textile waste and the importance of recycling, tailored to regional needs and behaviours.

3	Wastes collection	• Establish a binding EU-wide target for textile waste collection, ensuring all Member States implement standardized, high-coverage systems. • Expand policy focus to include non-reusable textile waste by introducing dedicated recycling streams alongside reuse initiatives. • Launch EU-funded campaigns to raise public awareness and incentivize separate textile disposal, especially in low-performing regions.
4	Identification	• Create a unified set of labelling standards across the EU to identify the material content (PET, PP) of technical textiles clearly and consistently, including information on coatings and additives. • Require that coatings (e.g., polyurethane (PU)) and additives be listed separately on labels, helping to distinguish base materials from applied chemicals. • Promote the use of advanced sorting technologies, such as near-infrared (NIR) spectroscopy or UFH-RFID, to better identify materials regardless of coatings or additives. • Establish a cooperative digital database where manufacturers can register the specific content of their products (including additives and coatings), accessible to recyclers and industry stakeholders.
5	Sorting	• Establish a common infrastructure framework to guide the development of recycling facilities, ensuring that key components, such as sorting methods, collection systems, and processing technologies, are harmonized across the EU. • Compile and disseminate a best practices guide on sorting and recycling processes, tailored to the different types of textiles, to improve the consistency of recycling efforts across countries. • Facilitate cross-border collaboration and knowledge-sharing between EU member states to exchange successful recycling strategies, overcome infrastructure challenges, and create more cohesive recycling networks.
6	Pre-treatment	• Standardize quality control measures of textiles after the sorting step
7,8	Enzymatic depolymerisation, Monomers recovery,	• Establish an EU-wide certification system for recycling facilities that meet uniform standards for sorting, processing, and quality control, ensuring that all facilities adhere to the same high recyclability standards.
9,10	Polymer production and chips production	• Standardize purification processes. • Standardize quality control measures at polymerization facilities, concerning defined impurities. • Foster information exchange on common impurities and influence on the safety of products (for example by providing funding for projects with publicly available results, creating data bases).
11	Thread and yarn production	• Standardize quality control measures at recycling facilities, including thorough checks for contamination levels at various stages of the recycling process to ensure that the final product meets the required standards. • Facilitate collaboration between recyclers, textile manufacturers, and quality control experts to refine sorting and contamination management practices, aiming to improve the overall output quality of recycled yarns.
12	Textile manufacturing	• Encourage member states to collaborate and share best practices in implementing sustainable practices to reduce disparities in environmental standards across different countries.
13	Final product	• Develop specific recycling standards for high-performance textile applications such as tires, technical textiles, and hoses. This would help meet the specialized requirements for durability, strength, and safety while promoting the use of recycled materials. • Establish common testing and quality assurance protocols for recycled materials used in specialized textile products. This would ensure that recycled inputs consistently meet the rigorous requirements of high-performance applications like tires and hoses

Table 2: Recommendations for inducing and harmonizing EU-level policies across each step of the WhiteCycle circular value chain

1.3 Challenge n°2: The absence of harmonized and clear EU-level targets undermines the efficiency and growth of the textile recycling value chain

The latest textile waste regulations in 2025 from the EU mark a significant step towards sustainability and circularity in the textile industry. These new rules were developed in the context of growing concerns about the environmental impact of textile waste and fast fashion, aiming to make textiles more durable, repairable, reusable, and recyclable. The legislative path included the European Commission's 2022 strategy[2] for sustainable textiles, which sought to reduce waste and stimulate innovation, and was shaped by discussions on producer responsibility, eco-design, consumer protection against greenwashing, and waste shipment controls.

Key elements of the 2025 regulations[3,4,5] include the requirement for EU countries to establish separate collection systems for textile waste, making it illegal to dispose of textiles with household waste. Extended Producer Responsibility (EPR) schemes are mandated, making producers financially responsible for the collection, sorting, and recycling of textile products, including those sold online or by producers outside the EU.

These schemes are set to be harmonized across member states, with fees based on the environmental impact of products (eco-modulation). The eco-design regulation enacted in 2024 introduces minimum standards for product durability and reparability and bans the destruction of unsold clothing from 2026. Consumer protection was enhanced through bans on unsubstantiated green claims.

The EPR framework applies to a broad range of textile categories, including clothing and accessories, hats, footwear, blankets, bed and kitchen linen, and curtains. However, technical textiles, such as those used in products like hoses, tyres, and other industrial applications, do not appear to be included under the current textile EPR scope. Lastly, several key elements of the EPR framework still require greater precision to ensure effective and harmonised implementation across the EU.

Moreover, the textile industry currently lacks specific targets for the incorporation of recycled content into textile products placed on the EU market. This absence of mandatory recycled content requirements creates uncertainty for manufacturers, hindering the adoption of sustainable practices and limiting demand for recycled textile fibers. In contrast, the EU Packaging and Packaging Waste Directive[6] has set clear recycling targets and mandatory recycled content quotas for packaging, incentivizing manufacturers to include more recycled materials in their products. This framework has been effective in increasing the use of recycled materials in packaging, highlighting the potential benefits of similar regulations in the textile sector.

The lack of enforceable recycled content targets in textiles, coupled with the absence of clear textile recycling targets, presents a significant barrier to scaling circular practices within the industry. The Ellen MacArthur Foundation (2021) [7] has emphasized that the textile sector remains largely unregulated

[2] *Fast fashion: EU laws for sustainable textile consumption – European Parliament, 2020*
[3] *Parliament adopts new EU rules to reduce textile and food waste – European Parliament, September 2025*
[4] *MEPs set to approve new rules to reduce textile and food waste – European Parliament, September 2025*
[5] *Textile waste directive & EPR, CENTEXBEL, 2025*
[6] *Directive (EU) 2019/904 on Single-Use Plastics European Commission.*
[7] *Ellen MacArthur Foundation (2021) – Circular Fibres Initiative: A New Textiles Economy Report.*

when it comes to recycled content, which hampers progress towards a more sustainable and circular industry. Without such regulations, manufacturers are under no obligation to incorporate recycled materials, ultimately reducing market demand for recycled textile fibers and prolonging the reliance on virgin materials.

In addition, the digitization of material flows is a key enabler for ensuring traceability and transparency in the textile value chain. At present, the lack of reliable systems to track and differentiate between virgin and recycled textile materials presents a major challenge. This lack of traceability not only impedes the setting and verification of recycled content targets but also undermines the credibility of recycling claims across the industry. For the EU to effectively address these challenges, it is essential to develop and implement robust traceability systems whether chemical, digital (e.g., product passports or blockchain technology), or hybrid solutions that allow for the clear identification and verification of recycled materials.

Furthermore, adapting the conditions for granting end-of-waste status to textile waste is a critical step. In the current regulatory environment, there are no standardized or widely accepted criteria for declaring textile waste as "non-waste" after recycling. This uncertainty creates additional regulatory barriers and limits the scale at which textiles can be recycled. A shift in the regulatory framework to grant end-of-waste status post-recycling, particularly for materials intended for reuse or recycling within the European Union, would provide the legal clarity and incentives needed to stimulate greater investment in recycling infrastructure and technology.

The absence of harmonized and clear EU-level targets undermines the efficiency and growth of the textile recycling value chain, creating varying challenges at each stage. These key challenges are outlined in Table 3 below.

<table>
<tr><th>Step N°</th><th>Name of the stage</th><th>Key challenges</th></tr>
<tr><td>1,2</td><td>Post consumer textile wastes</td><td>Different EU member States have vastly differing collection rates, limiting the quantity and quality of recyclables captured.</td></tr>
<tr><td>4</td><td>Identification</td><td rowspan="4">Without clear, enforceable collection and recycling targets, stakeholders are hesitant to invest in the critical infrastructure required to scale the textile recycling industry. Collection points, sorting facilities, and recycling plants need clear assurances that the volume and quality of recyclable materials will be consistent and sufficient, and that there will be strong demand for recycled materials within Europe. Without these targets, the market lacks the certainty needed to justify substantial investments in infrastructure.

Additionally, the absence of robust traceability systems, such as digital product passports or blockchain technology, exacerbates the challenge. Without reliable systems to track and access essential data on textile waste, such as material composition, origin, and processing history, it significantly complicates the identification and pre-treatment steps.

Moreover, to date, no standardized or analytical methods have been developed to reliably differentiate between virgin and recycled materials. This lack of transparency not only hinders the verification of recycled content but also undermines efforts to establish accurate and enforceable recycled content targets. As a result, it creates a significant barrier to the development of a fully circular textile economy, where verification, accountability, and effective recycling practices are essential for progress.</td></tr>
<tr><td>5</td><td>Sorting</td></tr>
<tr><td>6</td><td>Pre-treatment</td></tr>
<tr><td>7,8</td><td>Enzymatic depolymerisation, Monomers recovery,</td></tr>
<tr><td>9,10</td><td>Polymer production and chips production</td><td></td></tr>
</table>

11	Thread and yarn production	**The lack of mandates for recycled content in textile might slow the adoption of circular economy principles in industries.** For example, in automotive and more precisely tire production, where performance and safety are critical, recycled materials could greatly reduce environmental impact. However, additional R&D is necessary to validate the technical requirements for incorporating recycled content and scaling up closed-loop recycling processes, especially given the highly technical nature of textiles used in tires, which are challenging to recycle. Manufacturers may hesitate to invest in this research and development without clear legal mandates, as the lack of regulatory pressure diminishes the perceived return on investment and the incentive to innovate. Last but not least, the **digitization of material flows** along the entire value chain and across industrial stakeholders is a prerequisite for enabling efficient circular economy processes, including the **tracking of environmental and social impacts**.
12	Textile manufacturing	
13	Final product	

Table 3: Assessment of how the absence of harmonized and clear EU-level targets affects the WhiteCycle circular value chain

1.4 Recommendation n°2: Set stronger regulatory targets and enhanced full traceability to drive innovation and improve overall system performance

Despite the adoption of the latest EU regulations on textile waste, Extended Producer Responsibility (EPR), and the Waste Framework Directive (WFD), several key issues still require definition and clarification. Notably, there is an ongoing need to harmonize and operationalize EPR schemes across different Member States, including finalizing exact timelines for full implementation, with current proposals suggesting deadlines around late 2026 or early 2027.

Further clarity is needed on the scope of textile waste covered, particularly expanding definitions beyond household textiles to include commercial and institutional textile waste.
The role of social enterprises in collection, sorting, reuse, and recycling also requires formal recognition and support within the regulatory framework to ensure effective circular economy outcomes. Additionally, guidelines on eco-modulated fees based on the environmental performance of products need to be clearly aligned with ecodesign requirements and enforcement rules. Practical challenges around separate textile waste collection systems, improving sorting and recycling infrastructure, and preventing illegal exports of non-reusable textile waste remain critical areas for further regulatory support.
Finally, ensuring coherence between the Waste Framework Directive, EPR schemes, and other sustainability policies, like the ESPR and Digital Product Passport, is essential for a comprehensive and effective textile waste management system in the EU. These remaining issues highlight the evolving nature of EU textile waste legislation and the need for ongoing stakeholder engagement and regulatory refinement.

To ensure the effective implementation of the Ecodesign for Sustainable Products Regulation (ESPR), EU single market strategy and the Digital Product Passport (DPP), several critical areas require further clarification and development. Continued attention is needed to define the technical and organisational architecture, including data identifiers, data carriers such as QR codes or NFC, data formats, and storage methods. These elements are currently being developed by European standardisation bodies and are expected to be finalised by spring 2026, though they remain subject to revisions. Clarification is also

essential regarding the scope and content of the DPP specifically, what types of information it should include, such as environmental impact, recyclability, repairability, and supply chain data while balancing transparency, data privacy, and usability for companies. Implementation timelines must take into account sector-specific challenges, particularly for SMEs, with the textiles sector among those prioritised for early adoption around 2027.

Ensuring harmonised data standards and interoperability across industries and supply chains is another key issue, especially in supporting seamless data exchange and ensuring the durability of digital carriers throughout the product lifecycle. In relation to the circular economy, there is a need for clearer guidance on how the DPP will support traceability of textile waste, reuse, and recycling, along with more precise thresholds for recycled content, durability, and end-of-life documentation. Further work is also required to define how to manage damaged or non-standardised data, maintain long-term access to product information, and establish operational procedures for cross-sector data sharing, including supply chain responsibilities and enforcement mechanisms. Whietcycle project supports the ongoing discussions and recognises these as key topics that must still be addressed to ensure the DPP can effectively drive sustainability and circularity within the textiles sector and beyond.

Table 4 below presents the consortium's recommendations to support the development of clear, harmonised, and quantified objectives for the processes and products targeted by the WhiteCycle project.

Step N°	Name of the stage	Recommendations
3	Wastes collection	• Establish clear, quantified, time-bound, and enforceable targets for textile collection and sorting rates to meet the urgent need to scale up material flows and secure the textile recovery value chain across Europe. Higher recovery rates are essential to ensure a consistent supply of feedstock compatible with emerging recycling technologies. Setting such targets provides the necessary confidence for stakeholders to invest in key infrastructure including collection, sorting, and recycling by guaranteeing the volume and quality of input materials required for viable and efficient operations.
4	Identification	
5	Sorting	
6	Pre-treatment	
7,8	Enzymatic depolymerisation, Monomers recovery,	• It is essential to adapt the conditions for granting end-of-waste status to textiles wastes. A potential solution would be to assign end-of-waste status at the monomer recovery phase. This regulatory shift would provide greater flexibility to industry stakeholders, streamline logistical and administrative processes, and promote the development of local processing infrastructure. Moreover, it would ensure better quality control of the materials being prepared, while ensuring their traceability and adherence to environmental standards.
9,10	Polymer production and chips production	
11	Thread and yarn production	
12	Textile manufacturing	• The competitiveness of recycled PET versus virgin PET can only be achieved if (i) recycled PET can be clearly differentiated from virgin materials, and (ii) regulations for mandatory recycled content are established. These measures are essential to creating a level playing field and driving the widespread adoption of recycled textiles in the European market. In the initial phase, permit a portion of the recycled content (e.g., 20-50%), including both post-consumer and pre-consumer inputs. This approach acknowledges the current difficulties in sourcing post-consumer recycled materials while facilitating gradual market growth. • Set clear, quantified, time-bound, and enforceable targets for textile recycling rates. Consider implementing penalties for unrecycled volumes, similar to the system applied to plastics (currently €800 per ton of
13	Final product	

		unrecycled plastic charged to Member States), to incentivize compliance and drive progress in textile circularity.

Table 4: Recommendations for introducing enforceable targets on each step of Whitecycle circular value chain

1.5 Challenge n°3: Cost effective recycling is hindered by the lack of traceability of product composition and insufficient eco-design development

The development of cost-effective recycling in Europe is increasingly hindered by the lack of reliable traceability of product composition and by the insufficient integration of eco-design principles in products placed on the market. Ongoing 2025–2026 EU discussions on stronger circular-economy and product-policy frameworks underline that recyclers face higher operational costs and lower material yields when they process complex, multi-material and chemically heterogeneous products whose composition is not transparently disclosed along the value chain. Policymakers have noted that, in the absence of widely deployed digital product passports and harmonised rules on information transfer, recyclers cannot systematically identify polymers, additives or hazardous substances, which reduces process efficiency and limits the production of high-quality secondary raw materials that can compete with virgin inputs. At the same time, recent EU debates on updated eco-design requirements highlight that many products still enter the market with limited reparability, poor recyclability and unnecessary material complexity, so regulatory targets on recycled content and recovery risk remaining costly to achieve as long as design-for-recycling and design-for-disassembly are not mainstreamed across sectors.

1.6 Recommendation n°3: Establishing a comprehensive EU policy framework on traceability, sustainable product design, and global supplier compliance to ensure cost-effective recycling

Establishing a comprehensive EU policy framework on traceability, sustainable product design, and global supplier compliance is emerging as a central recommendation in current European circular-economy debates, because it directly conditions the feasibility of cost-effective recycling. Recent and upcoming instruments such as the Ecodesign for Sustainable Products Regulation (ESPR), the revised Construction Products Regulation, and the planned Circular Economy Act move product policy away from a narrow waste focus toward full life-cycle requirements, including recyclability, durability, reparability, and minimum recycled-content levels, which are meant to lower recycling costs by standardising and simplifying materials placed on the market[8,9]. A key element of this framework is the progressive roll-out of Digital Product Passports and related traceability tools, with a central EU registry and obligations for manufacturers and importers to upload composition, substance, and repair information; these measures are designed to give recyclers reliable data on product and material

[8] **EU rPET more positive in 2026: Petcore –** Argus Janury 2026

[9] **EU Commission fast-tracks support for plastics recyclers –** Resource recycling INC Janury 2026

composition, thereby improving sorting efficiency, process control, and the production of high-quality secondary raw materials that can compete with virgin inputs. At the same time, the EU's wider sustainability agenda including due-diligence rules and the forthcoming Circular Economy Act aims to extend these requirements to global suppliers, so that imported products comply with the same traceability and eco-design standards as EU-made goods, closing loopholes, supporting level-playing-field competition, and ensuring that investments in recycling infrastructure are economically viable under a unified, predictable regulatory framework.

1.7 Challenge n°4: Impacts assessment of large scale closed-loop recycling processes

Performing an impact assessment for large-scale closed-loop recycling processes presents several challenges. This is primarily due to the novelty of the technologies, the complexity of the systems involved, and the need for more comprehensive and dynamic evaluation methods.

Closed-loop recycling, particularly in the context of circular economy models, is still an emerging field and many open questions remain, such as where to draw assessment borders when it comes to multiple recycling steps. It adds to the difficulties that the technologies involved are often new, with limited or no previous data for comparison. Traditional impact assessment models, including Life Cycle Assessment (LCA), are still based on linear production and consumption models, which makes applying them to new technologies difficult. In closed-loop recycling, materials are reused multiple times, which introduces feedback loops and non-linear processes that LCA models are not always designed to handle. What is more is that existing reporting standards, certification routines, and related ISO norms, such as 14001, have to be revised. Currently, there is no clear benchmark or standard to compare the environmental or social impacts of these novel systems.

Another limitation of traditional impact assessments is their focus on CO2 emissions as the primary environmental indicator. While carbon emissions are undeniably important, they don't fully capture the complexity of environmental impacts in closed-loop recycling systems. Closed-loop systems may significantly reduce CO2 emissions, but they can still have substantial impacts in other areas, such as resource depletion, water usage, chemical toxicity, microplastic pollution, or biodiversity loss. A more holistic approach to impact assessment is needed. This means incorporating a wider range of environmental, social, and economic indicators. The following examples shed light on the avenue ahead.

Closed-loop recycling technologies are often in a state of flux, with innovations emerging rapidly and scaling at different rates depending on the region, industry, or type of material. This uncertainty can complicate the assessment process, as impacts may change quickly due to technological advances or shifts in economic conditions. For example, new recycling techniques may emerge that dramatically reduce energy consumption or improve material quality, which would significantly alter the impact profile of the process. Moreover, the composition of material flows creating the products is currently not known across the value chain, lacking on top standardization and digitization.

Furthermore, closed-loop recycling systems are inherently designed to minimize waste and keep materials in use for as long as possible. However, evaluating the long-term benefits of such systems requires a much longer time horizon than traditional assessments. Many closed-loop processes have slow-to-realize benefits that unfold over years or even decades, such as the gradual reduction of virgin material use or the cumulative environmental savings across multiple product lifecycles.

In addition, large-scale closed-loop recycling processes are typically part of complex, interconnected supply chains that involve multiple stakeholders, technologies, and stages. Assessing the impact of these

systems requires not just evaluating the individual steps in the recycling process but also how those steps interact with each other and the larger system. It is unclear where to draw the boundaries of the system that needs to be assessed and also to clarify responsibilities if multiple companies are involved in closed-loop production processes.

For instance, the efficiency of material collection, sorting, transportation, and processing can vary widely depending on infrastructure, location, and technological integration. Furthermore, the environmental impacts of closed-loop systems are influenced by external factors like energy grid composition, transportation networks, and market demand for recycled products. These factors can introduce significant variability, making it hard to generalize or standardize the assessment process.

To effectively manage the complexities of a closed-loop value chain, it is crucial to address the tracking of responsibilities across multiple companies involved. This requires incorporating new, yet-to-be-fully-understood impacts of material compounds, such as PFAS, microplastics, and other emerging contaminants, which complicate both recycling processes and consumer safety. For a truly circular economy to flourish, it will be essential to establish robust systems for data sharing, standardized material tracking, and clearer regulations that empower companies to make informed, sustainable decisions.

1.8 Recommendation n°4: Encourage the adoption of innovative models for conducting Life Cycle Assessments in closed-loop recycling systems to ensure that these systems are both environmentally and economically sustainable.

To effectively assess the impacts of large-scale closed-loop recycling systems, new models are needed to better capture the complexities of material reuse, energy consumption, and product lifespan. Current models often fail to account for the degradation of materials over multiple cycles and how these factors affect sustainability. Advanced models should track material flows, quality degradation, and product longevity over time, moving away from static lifecycle assessments to dynamic, adaptive evaluations.

These models must also emphasize the circularity of materials, how efficiently they return to the system and their environmental impact. In addition to environmental factors, assessments should include social and economic considerations, such as resource conservation, water usage, pollution, and the social implications of recycling, including job creation and community impacts.

A more long-term, systemic approach is necessary, focusing on the cumulative effects of material reuse and projections of future environmental and social changes. To support this shift, increased funding for research and development is crucial to create tools that can provide comprehensive, accurate assessments of large-scale recycling processes. This will ensure that recycling systems are both effective and sustainable in the long run.

The following recommendations are made:

- Supporting research of impact assessment to solve open questions on how to address closed-loops consistently and within defined borders.
- Supporting standardized documentation and digitization of material flows
- Supporting reporting standardized, including infrastructures so that targets groups have seamless access to the necessary information. This includes producers and consumers alike.
- Alignment of impact assessment efforts and revisions with ongoing initiatives that target reporting, including product passports.

- Addressing regulatory gaps from the handling of sensitive/competitive data to revising and extending current norms such as ISO 14001

2. Economic challenges and recommendations

2.1 Challenge n°1: Competition from non-European countries in technical textile recycling or recycled textile-based products

The European textile recycling sector faces significant economic challenges due to competition from non-European countries, particularly those with lower labor and operational costs. Many Asian nations, for example, can offer more affordable waste recovery and recycling services, making it difficult for European recyclers to compete on price[1,10.] As a result, a considerable volume of used textiles collected in Europe is exported for sorting, reuse, or recycling in these countries, where labor costs are significantly lower. According to the European Environment Agency (EEA), since 2000, the export of used textiles from the EU has nearly tripled, reaching 1.4 million tonnes in both 2019 and 2023[11, 12]. While these exports are intended for reuse or recycling, studies show that EU textile exports enter a complex trade pattern involving sorting, reuse, recycling, landfilling, and sometimes incineration, primarily across African and Asian countries.

Textile sorting and recycling are labor-intensive processes. In Western Europe, high labor costs make local sorting and recycling economically marginal, especially when compared to countries in Asia or Eastern Europe, where wages are much lower. Non-European countries often have less stringent environmental and labor regulations, reducing operational costs further. This allows them to process textiles more cheaply and offer competitive prices for recycled materials or waste recovery services.

The global price for recyclable textiles is currently at rock-bottom, further squeezing the margins for European recyclers. As the share of reusable textiles decreases, the price per kilogram falls sharply, making it even less viable for European operators to compete unless they receive subsidies or other forms of support.

Because of these economic pressures, much of Europe's collected textile waste is exported for sorting and recycling. This undermines efforts to develop a circular economy within Europe and creates a reliance on external markets that may not prioritize environmental or social standards. Addressing these challenges will require a combination of policy support, subsidies, and investment in advanced recycling technologies to level the playing field and retain value within Europe.

This economic challenge is having a significant impact across multiple stages of the project's value chain, as illustrated in Table 5. From waste sourcing and processing to end-product development and market competitiveness, various steps are affected, highlighting the need for strategic adjustments.

Step N°	Name of the stage	Key challenges
3	Wastes collection	**Competitive pressures may reduce investments in efficient and sustainable textile waste collection systems within Europe**. Non-European countries, often having centralized or more flexible collection mechanisms, can scale up their collection efforts more rapidly, potentially leading to the export of valuable waste streams from Europe, which weakens the local circular economy.

[10] *ECAP, Used textile collection in European cities, 2018*

[11] *European Environment Agency, Consumption of clothing, footwear, other textiles in the EU reaches new record high, March 2025*

[12] *European Environment Agency, Circularity of the EU textiles value chain in numbers, March 2025*

4	Identification,	**Advanced sorting technologies and expertise are crucial for efficient recycling, but non-European competitors may offer lower-cost manual sorting or automated solutions with different cost structures**. This affects European operators by pushing them to invest more heavily in innovation to maintain competitiveness, while also risking the loss of valuable sorted materials to overseas markets.
5	Sorting	
9,10	Polymer production and chips production	**Polymer production is already predominantly based in non-European countries**, driven by lower costs and less stringent safety regulation similar to many other stages of the value chain. However, recycling textiles within Europe can pave the way for greater independence in raw materials for polymer production. While oil, a key raw material for polymers, is sourced from outside Europe, waste as a raw material is abundant within the region. Therefore, **the development and implementation of innovative textile recycling processes in Europe is crucial for securing a sustainable supply of recycled materials.**
11	Thread and yarn production	**The competitiveness of non-European producers can result in lower-cost recycled threads flooding the market, putting pressure on European thread manufacturers to reduce costs or enhance quality and sustainability credentials.** This dynamic may stimulate innovation but can also strain margins and limit domestic production capacity.
12	Textile manufacturing	**European manufacturers face competition from countries with cheaper recycled raw materials and production costs**. This affects their ability to compete on price, potentially reducing the demand for locally manufactured textiles and **pressuring companies to focus on niche markets or high-value sustainable products.**
13	Final product	The final products made from recycled textiles in Europe compete with those from countries benefiting from lower production costs and potentially less stringent environmental regulations. **This can limit market share for European brands unless they leverage sustainability, quality, or innovation as differentiators.**

Table 5: The economic competitiveness challenge in textile recycling, implications for the WhiteCycle circular value chain

2.2 Recommendation n°1: Strengthening EU's market presence by fostering innovation and expanding infrastructure to enhance competitiveness.

The increasing competitiveness of non-European countries in textile recycling poses significant challenges for Europe's circular economy and textile industry. To strengthen Europe's position and ensure sustainable growth across the textile recycling value chain, a coordinated approach is essential.

It is important to highlight the structural differences between the textile and packaging sectors. While the value chain for packaging applications is largely established in Europe, the textile value chain is much more fragmented and predominantly located in Asia. This situation complicates the development of local recycling loops and hinders the creation of a robust European industrial ecosystem around recycled textiles. To strengthen, stimulate, and sustain the textile value chain in Europe, it is essential that all stakeholders from wastes collection to yarn production are present or have the opportunity to develop sustainably within Europe.

First, improving textile waste collection systems is crucial. Investments should focus on expanding and modernizing collection infrastructure, fostering cooperation between local authorities, retailers, and recycling companies. Raising public awareness will also encourage higher participation and better-quality post-consumer textile waste. Next, advancing sorting and identification technologies is key to

securing high-quality recycled materials. Innovations such as AI-driven automated sorting and near-infrared spectroscopy can significantly enhance sorting accuracy and efficiency, making European recycling operations more competitive on a global scale.

Investment in research and innovation should continue to drive improvements in recycling processes, especially for recovering fibers from mixed textiles. Collaborative pilot projects involving industry, academia, and technology developers can accelerate the adoption of new, cost-effective recycling methods.

In addition, the development and support of repolymerization and spinning stages in Europe are essential to strengthen industrial sovereignty and the sustainability of the recycled textile sector. By reestablishing these key steps locally, Europe can reduce its dependence on imports, ensure the quality of recycled materials, and promote a truly integrated circular economy. Moreover, having these stages within Europe creates jobs, fosters technological innovation, and guarantees stricter environmental control. Therefore, it is crucial to provide targeted financial and regulatory support to help stakeholders develop these strategic industrial capacities on European soil.

In parallel, prioritizing closed-loop projects and initiatives is key to giving value to waste. Emphasizing short supply chains and territorial approaches encourages industrial symbiosis, where local industries cooperate to share resources and reduce environmental impact, thereby strengthening regional circular economies. Strengthening local production capacities for recycled threads and textiles is equally important. Supportive measures and incentives can help European manufacturers scale up sustainable production, positioning European recycled products as premium offerings in the global market. Additionally, it is crucial to raise the regulatory requirements for textiles exported outside the EU, which are currently not classified as waste but as exports for reuse. This lack of oversight enables the export of large volumes of unsorted or non-reusable textiles without guarantees of actual reuse, weakening European recycling efforts and undermining circularity objectives.

Moreover, it is crucial to highlight the ecological and societal footprint of recycled materials produced in Europe. This transparency helps differentiate European recycled textiles in the marketplace and justifies potential price differences compared to lower-cost imports, reinforcing consumer trust and willingness to pay a premium for sustainable products.

Additionally, marketing efforts should emphasize the sustainability and quality of European recycled textiles. Certification, eco-labeling, and transparent communication can help brands differentiate their products and appeal to environmentally conscious consumers worldwide.

Lastly, by implementing the key strategic recommendations across each step of the value chain, as outlined in Table 6, Europe can overcome current competitiveness challenges, strengthen its textile recycling value chain, and secure a leading position in the global circular textile economy.

Step N°	Name of the stage	Recommendations
3	Wastes collection	• Invest in modern, efficient collection infrastructure. • Promote collaboration between local authorities, retailers, and recycling companies for better logistics.
4	Identification,	• Encourage the use of digital product passports for better tracking of textile content and recyclability. Invest in R&D for advanced sorting technologies tailored to European needs, with a focus on efficiency and scalability
5	Sorting	

9,10	Polymer production and chips production	• Introduce regulations that incentivize investment in local polymer production from recycled textiles.
11	Thread and yarn production	• Support European textile manufacturers in scaling up the production of recycled yarns and threads. • Promote the use of recycled fibers in high-performance textile products, emphasizing quality and sustainability
12	Textile manufacturing	• Encourage the use of sustainable, closed-loop textile production methods. • Offer incentives for brands that use a high percentage of recycled fibers in their manufacturing processes. • Promote eco-design principles to make textile products more easily recyclable.
13	Final product	• It is essential for European brands to commit to using recycled materials sourced within Europe. Without these commitments and consistent orders, activating industrial capabilities and fostering innovation becomes a significant challenge. In fact, the lack of stable demand for recycled materials in the EU not only undermines the profitability of recycling processes but also stifles the development of new, sustainable solutions. • Differentiate European products by emphasizing sustainability, quality, and innovation. • Create eco-certification programs for recycled textile products. And highlight the ecological and societal footprint of products to build consumer trust.

Table 6: The economic competitiveness challenge in textile recycling, recommendations for the WhiteCycle Circular Value Chain

2.3 Challenge n°2: Lack of financial Incentives for the establishment and deployment of the textile recycling value chain across Europe

A key barrier to the widespread adoption of recycled materials in textiles is the absence of strong financial incentives at the EU level. Unlike sectors such as packaging, where clear financial mechanisms (like subsidies or tax incentives) encourage the use of recycled materials, the textile industry has not received similar support to incentivize the integration of recycled plastics into fabric production. The current regulatory landscape lacks dedicated policies that would reduce the costs associated with using recycled materials or provide direct financial benefits for manufacturers investing in recycling infrastructure.

The European Commission's Circular Economy Action Plan has acknowledged the need for improved waste management and resource efficiency, but concrete measures specifically focused on the textile industry, especially concerning recycled plastics, remain limited. This lack of incentives is a critical barrier, as manufacturers face high costs for implementing recycling technologies and sorting systems. Additionally, without the financial motivation to use recycled materials or invest in advanced waste management solutions, companies often choose to continue using cheaper, virgin plastics, which are more readily available and easier to process.

Without a clear framework of incentives such as subsidies for recycling facilities, tax relief for incorporating recycled content, or even a cap-and-trade system for carbon emissions associated with textile waste companies are unlikely to prioritize the integration of recycled materials. As a result, the overall demand for recycled plastics in textiles remains low, and the industry struggles to scale sustainable practices.

In addition, the current market dynamics for PET yarn present a significant challenge to the uptake of recycled materials. Virgin PET remains widely available at a relatively low cost, driven by stable fossil

fuel supply chains and economies of scale in its production. In contrast, recycled PET (rPET) yarn often comes at a significantly higher price due to the complex and resource-intensive processes required to collect, sort, clean, and chemically or mechanically regenerate the material to meet quality standards suitable for textile applications. This cost disparity places recycled yarn at a competitive disadvantage, particularly in price-sensitive markets such as fast fashion or bulk textile manufacturing. As a result, despite increasing regulatory pressure and environmental awareness, the higher price point of rPET can hinder its broader market adoption. Without targeted support measures such as financial incentives for using secondary raw materials, the transition to recycled PET in yarn production may remain economically unviable for many manufacturers.

This challenge impacts various stages of the project value chain as outlined in Table 7 below.

Step N°	Name of the stage	Key challenges
4	Identification	Incentivizing the development of advanced identification technologies is critical to enhance the efficiency of sorting processes. **Without financial support or regulatory drivers, European companies may fall behind competitors from regions with lower development costs.** Reliable identification ensures high-quality material sorting, improving recycling rates and facilitating the verification of recycled content.
5	Sorting	Sorting is the backbone of efficient recycling systems. **Without financial support for innovation in sorting technologies (such as AI-based systems or robotic sorting), Europe risks falling behind in creating efficient sorting systems.** Financial incentives will foster technological advancements in sorting, improving material purity and increasing recycling efficiency, which is essential for a circular textile economy.
6	Pre-treatment	**Technical development of the pre-treatment of post-consumer textiles is crucial for the production of PET waste well adapted to enzymatic depolymerisation.** The purification, decontamination, shaping, and amorphization steps are key technical factors to optimize the textiles' quality for recycling. However, **without sufficient economic incentives, it will be challenging to invest in and advance this critical step**. Without financial support to incentivize innovation in pre-treatment technologies, the development of efficient and scalable solutions for textile recycling will remain stalled, hindering the broader transition to a circular textile economy.
7,8	Enzymatic depolymerisation Monomers recovery,	**Enzymatic depolymerization** offers a promising technology for recycling PET textiles, but it is still in early stages of development. **To scale up this technology significant investment is require**d. Without incentives or subsidies, the industry may struggle to meet the required scale. Incentivizing these technologies is essential for unlocking the potential of high-quality recycling in the textile sector.
9,10	Polymer production and chips production	**Without adequate incentives, Europe will remain dependent on virgin raw materials sourced from outside the region**. By providing economic incentives, the EU can stimulate investment in local polymer production, thus reducing dependency on fossil-based resources and enhancing Europe's self-sufficiency in recycled materials.
11	Thread and yarn production	As mentioned in Challenge 2.1 the competitiveness of non-European producers with lower costs presents a challenge for European thread and yarn manufacturers. Without strong financial incentives, **European companies may struggle to maintain competitive pricing and quality standards.**
12	Textile manufacturing	European textile manufacturers need financial support to incorporate recycled materials into their production lines. **Without this support, the cost differential between virgin and recycled materials will continue to make it difficult for manufacturers to adopt sustainable practices**. Economic incentives would help reduce the cost of using recycled content, creating a more level playing field for European manufacturers and encouraging the transition to sustainable production practices.
13	Final product	As mentioned in Challenge 2.1 the **market for recycled textile products in Europe faces competition from countries with cheaper production costs, which can hinder the market penetration of high-quality recycled products**. To overcome this, financial incentives (such as subsidies or tax credits) should be offered to European brands that produce and promote sustainable, recycled textile-based products. This will help maintain Europe's position as a leader in sustainable fashion and textile production.

Table 7: Evaluation of the impact of absence of financial incentives on the deployment of the Whitecycle circular value chain

2.4 Recommendation n°2: Introduce stronger financial incentives to stimulate investment and accelerate the growth of textile recycling technologies

To overcome the lack of incentives for using recycled plastics and drive the transition to a more sustainable textile industry, EU-level regulations should introduce comprehensive financial support mechanisms. This could include offering subsidies for textile manufacturers to invest in recycling technologies, and tax incentives for companies that use recycled content in their products. Furthermore, financial support schemes should be implemented to boost the incorporation of recycled textile materials across all textile sectors, using a system of bonus-malus similar to that already applied for recycled plastics (e.g., per-ton bonuses, with a preference for materials recycled in Europe).

Additionally, the introduction of a mandatory take-back program for textile waste across EU member states would help create a consistent flow of recycled materials into the market, reducing the dependency on virgin plastics and encouraging sustainable production. Finally, financial backing from eco-organisms should be directed toward industrial investments in infrastructure for collection, sorting, and recycling of textile waste, facilitating the scaling of recycling operations and improving the efficiency of textile waste management.

Within this framework, the introduction of targeted bonuses, financial incentives for producers who adopt closed-loop recycling processes holds significant potential to accelerate the transition to a circular economy. EPR schemes in France already use eco-modulation: producers pay lower fees if their products are more recyclable, contain recycled content, or are easier to process at end-of-life.[13] By expanding and increasing these bonuses specifically for closed-loop recycling where materials are recycled back into the same or similar products producers would have a clear economic motivation to design for recyclability and invest in recycling infrastructure.

Table 8 below presents the recommendations for each step of the value chain related to financial incentives.

Step N°	Name of the stage	Recommendations
4	Identification	• Provide incentives for manufacturers to use environmentally friendly coatings and additives that can be more easily sorted or recycled.
5	Sorting	• Encourage and subsidize investments in advanced sorting technologies (e.g., automated sorting, AI-based sorting systems) to improve the efficiency and accuracy of material separation, ensuring higher-quality recyclables. • Provide financial incentives, grants, or subsidies to local authorities and businesses that adopt standardized or advanced recycling systems that align with EU-wide goals, ensuring more uniform recycling practices. • Implement a traceability system for textile waste to track the flow of materials across borders, ensuring that textiles are processed correctly and according to consistent standards, regardless of the country of origin. • Invest in training programs for recycling operators across the EU to ensure they are well-versed in efficient sorting techniques and quality control practices, leading to higher-quality recyclables.
6	Pre-treatment	

[13] *Ecologic, Extended producer responsibility and ecomodulation of fees, 2021*

7,8	Enzymatic depolymerisation Monomers recovery,	• Provide financial incentives to support the scaling up of pre-treatment enzymatic depolymerization and monomer recovery processes. • Provide funding for the determination of common impurities, the determination of the effects of common impurities on certain products, for the development of standardized processes and similar approaches. • Allocate financial resources for the development of pre-treatment technologies
9,10	Polymer production and chips production	
11	Thread and yarn production	• Offering subsidies for textile manufacturers to invest in recycling technologies, and tax incentives for companies that use recycled content in their products.
12	Textile manufacturing	
13	Final product	

Table 8 Recommendations on incentives for each step of the project value chain

3. Societal challenges and recommendations

3.1 Challenge n°1: Consumer acceptance for products containing recycled PET.

Customers' choice to purchase recycled products is important for the existence of a circular economy, which aims to improve environmental quality and preserve natural resources through responsible production and consumption. This is a crucial step in the WhiteCycle circular value chain (Step 1, figure 1). This adoption is favourable if customers have a positive attitude towards recycled products, particularly with regard to the environmental benefits, resource conservation and support for the 3 Rs (recycling, reusing and reducing).

Secondly, their decision to purchase recycled products is not instantaneous; it depends on price perception, reliability and quality compared to conventional products. The choice to purchase a recycled product follows a sequential process, beginning with the consumer's exposure to the product. For example, an item made with recycled content which leads to awareness and recognition of the product's existence. Advertising campaigns and articles on recycled products could drive this exposure. This awareness is then followed by cognitive (intellectual, mental or rational) and affective (emotional or feeling) pathways. The cognitive pathway is characterised by acquiring and understanding the product's characteristics, while the affective pathway is characterised by emotional responses and developing positive or negative feelings. These concurrent cognitive and affective processes ultimately shape consumers' attitudes and preferences towards products made from recycled materials. In turn, these attitudes guide consumers' purchase intentions, i.e. their willingness to pay. Their willingness to pay can result in them purchasing the recycled product (purchase behaviour). However, these steps are influenced by individual differences, sociocultural factors, and demographics.

The University of Clermont Auvergne (UCA), a partner in the WhiteCycle project, has conducted a study on this topic aimed to understand the factors that could contribute to the success of the WHITECYCLE project[14]. Through a social acceptance survey, UCA found that the main barriers to purchasing a recycled product were the price, quality and traceability of the product. In addition, the survey also highlighted that lower prices, the sustainability credentials of these products, the guarantee of the same quality as conventional products, and product traceability are the most impactful motivators for purchasing products made from recycled PET.

[14] *Deliverable D6.11 Report on Social Impacts - Social Acceptance Process (task 6.4) – UCA – Status: sensitive*

3.2 Recommendation n°1: Aligning development of recycled products with consumer preferences, fostering trust, and encouraging behaviors to support the use of products made of r-PET

Based on the motivations and barriers identified by survey respondents, where high prices and insufficient information were cited as major obstacles to purchasing recycled products, textile recycling initiatives whether closed-loop or open-loop must find ways establish fair and competitive pricing for products containing recycled PET. It is essential that all stakeholders across the value chain collaborate to develop strategies for offering recycled PET products at fair, reasonable prices. Recommendations should focus on fostering partnerships, improving transparency, and driving innovation to make recycled PET more accessible and attractive to consumers.

Additionally, stakeholders need to provide clearer information about the quality and environmental benefits of these products. This is confirmed by the literature review and attested by the results of UCA analysis, which prove that the more environmental benefit information they give to the survey respondents, the more their willingness to pay for products made from recycled PET increases compared to when they don’t have any information. Furthermore, if this information is combined with a quality guarantee similar to that of conventional products, respondents' willingness to pay increases further. These results suggest that the success of textile recycling initiatives, such as the WHITECYCLE project, may be linked to offering fair prices alongside information on the sustainability benefits of these products and a guarantee of the same quality as conventional products, as this would serve as a powerful incentive for consumers to choose products containing recycled content.

Conclusion

This deliverable, presented at the mid-term stage of the WhiteCycle project, provides a thorough analysis of the challenges and recommendations identified by the consortium in relation to the circular textile economy. The project has uncovered a range of issues across governance, economics, societal concerns, and other areas that need to be addressed to accelerate the deployment of textile recycling technologies.

One of the primary governance challenges is the lack of a harmonized regulatory framework for textile waste treatment and recovery within Europe. This regulatory fragmentation is a significant barrier to scaling up recycling efforts. In response, the consortium recommends the establishment of a unified EU policy framework that can guide and support the transition to a circular textile economy, ensuring that policies are both effective and aligned across member states. Another governance-related challenge stems from the absence of clear and consistent EU-level targets, which undermines the efficiency of the textile recycling value chain. To address this, the consortium advocates for stronger regulatory targets and enhanced traceability to drive innovation and improve overall system performance.

Economically, the WhiteCycle project has identified intense competition from non-European countries in areas such as technical textile recycling and the production of recycled textile-based products. In order to position Europe as a leader in this field, the consortium recommends strengthening its market presence by fostering innovation and expanding infrastructure to enhance competitiveness. Another economic challenge highlighted is the lack of financial incentives, which hinders the scaling of complex recycling processes. The consortium calls for stronger financial incentives to stimulate investment and accelerate the growth of textile recycling technologies.

From a societal perspective, one of the key challenges lies in consumer acceptance of products made from recycled PET. Overcoming this barrier will require aligning the development of recycled products with consumer preferences, fostering trust, and encouraging behaviors that support the use of such products. Addressing this issue will be crucial for ensuring the success of the circular textile economy.

Finally, the project has also pointed to the need for better impact assessments of large-scale closed-loop recycling processes. To ensure that these systems are both environmentally and economically sustainable, the consortium recommends the adoption of innovative models for conducting Life Cycle Assessments (LCA) in closed-loop recycling systems. These assessments will be critical in measuring and optimizing the overall benefits of these systems.

It is important to note that this deliverable reflects the state of knowledge at the mid-term stage of the WhiteCycle project. Given the rapid pace of regulatory developments and technological advancements in the textile recycling sector, many of the challenges and recommendations presented here will continue to evolve. As such, this deliverable will be updated and amended in subsequent stages to incorporate new insights, regulatory changes, and any necessary adjustments to ensure continued progress toward a fully circular textile economy.

Glossary

Closed loop recycling	*Closed loop recycling is a process where products or materials are collected after use, recycled, and then used again to manufacture new products of the same type, with minimal loss of quality or properties throughout repeated cycles. This system effectively "closes the loop," meaning that materials are continuously recycled without introducing new raw materials, thereby minimizing waste and reducing environmental impact. Closed loop recycling is a cornerstone of a circular economy, ensuring that resources remain in use and out of landfills, and promoting sustainability by keeping products in a cycle of reuse rather than disposal.*
Complex textiles	*Complex textiles are fabric structures that incorporate additional sets of warp or weft yarns, coatings… to enhance performance.*
Complex waste	*Complex waste is defined as waste that is heterogeneous in composition, making it difficult to recycle. Due to this complexity, such waste is often either buried in landfills or incinerated. The complexity arises from the mixture of different materials within the waste, which may also sometimes result from manufacturing errors. Specialized processes, such as automatic or mechanical separation, are sometimes used to separate and recover recyclable materials from complex waste to enhance recycling efforts.*
Depolymerization	*Depolymerization is the process of breaking down a polymer into its monomeric units or smaller oligomers, effectively reversing polymerization. This involves cleavage of the chemical bonds that hold the polymer chains together to yield the original monomers or mixtures of monomers, which can then potentially be reused to make new polymers. Depolymerization can occur through various chemical, thermal, or biological methods, and it is important in recycling and sustainability as it allows recovery of monomers of high quality analogous to virgin materials.*
Garment	*A garment is a piece of clothing made from fabrics or textiles that is designed and sewn to be worn on the human body for protection, modesty, or adornment.*
High performance textile	*High-performance textiles are specially engineered fabrics designed to provide superior functionality, durability, and strength under demanding conditions. They are made from advanced fibers such as Kevlar, Dyneema, and carbon fibers that have exceptional strength-to-weight ratios, resistance to abrasion, thermal and chemical stability, and enhanced flexibility. These textiles are used in industries like aerospace, healthcare, automotive, defense, and sports, where they must withstand extreme environments and heavy wear while maintaining comfort and performance.*
Lay-flat hose	*A lay-flat hose is a flexible, lightweight hose usually made from PVC reinforced with woven polyester yarn, designed to be laid flat when not in use for easy storage and transportation.*
Multi-layer textile wastes	*Multi-layer textile wastes refer to textile items composed of several distinct layers, with each layer potentially containing different materials. To be classified as multilayer, an item must have at least two layers covering one-third or more of the item's surface area. These multilayered textiles often contain diverse materials, complicating recycling due to their composite nature.*

Multi-material textile wastes	*Multi-material textile wastes consist of discarded textile products or components made from two or more different material types bonded or mixed together. These materials are often blends of different fibers such as cotton and polyester, designed to combine the performance benefits of each fiber type, but this blending complicates recycling because the different fibers have distinct chemical and physical properties.*
Plastic waste	*Plastic waste refers to discarded plastic materials that no longer serve their original purpose. These plastic materials are synthetic or semi-synthetic polymers that have been used in various applications such as packaging, consumer goods, automotive parts, and construction.*
Post-consumer textile	*Post-consumer textile refers to garments, household textiles, and other textile products that have been used and discarded by consumers after serving their intended purpose. These textiles are collected for reuse, recycling, or disposal and represent the waste generated at the end of a product's life cycle following consumer use.*
Post-industrial textile	*Post-industrial textile refers to textile waste generated during the manufacturing process before the product reaches the consumer. This includes fibers, yarns, fabrics, and sometimes finished products that are excess, defective, or offcuts coming from textile production facilities.*
Repolymerization	*Repolymerization is a chemical process where monomers or smaller molecular units obtained from breaking down polymers (depolymerization) are chemically reassembled or polymerized again to form new polymer chains.*
Technical textile	*Technical textiles are textile products specifically engineered and manufactured for functional and performance purposes rather than aesthetic or decorative uses. Unlike conventional textiles used primarily for clothing or decoration, technical textiles are optimized to provide qualities such as strength, durability, flame resistance, chemical resistance, moisture management, and specialized functionalities.*
Technical garment	*A technical garment is an article of clothing specifically designed and engineered to provide advanced functional properties beyond basic aesthetics, such as breathability, water resistance, UV protection, insulation, flame resistance, and durability.*
Textile	*Textiles cover a wide range of products with highly diverse uses and compositions, including clothing, home textiles, car seat covers, and complex or technical textiles such as those used in tires. Each type of textile has specific characteristics in terms of both material composition and recovery potential, which implies different requirements for collection, sorting, and recycling.*