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EU-wide end-of-waste criteria for recycling of textile and textile-related waste

JRC technical proposals

Egle, L., Pérez Arribas, Z., Saveyn, H., Pierri, E.

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Contact information
Name: European Commission – Joint Research Centre, Fair and Sustainable Economy, Circular Economy and Sustainable Industry
Address: Edificio EXPO, Calle Inca Garcilaso 3, 41092 Seville, Spain
Email: JRC-END-OF-WASTE@ec.europa.eu

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Contents

Abstract 5

Acknowledgements 6

Authors 7

Executive summary 8

Policy context 8

Related and future JRC work 9

Quick guide 9

JRC proposal for EU-wide end-of-waste criteria for recycling of textile and textile-related waste 10

1. Introduction 22

1.1. EU regulatory framework on textiles 22

1.2. EU regulatory framework on end-of-waste criteria 23

1.3. Scoping exercise to identify candidate streams 25

1.4. Objectives and possible impacts 27

1.5. Structure of this document 29

2. Methodology for the development of technical proposals 30

3. Background information on textile products 31

3.1. Textiles production 31

3.1.1. Textile fibres 31

3.1.2. Finished textile products 33

3.2. EU textiles market, use and trade flows 36

4. Background information on textile waste and used textiles 37

4.1. Classification of textile waste and suitability for recycling 37

4.1.1. Post-industrial textile waste 37

4.1.2. Pre-consumer textile waste 38

4.1.3. Post-consumer textile waste 39

4.2. Generation and management of textile waste and used textiles in the EU 40

4.2.1. Collection and preliminary sorting 41

4.2.2. Sorting 42

4.2.3. Pre-treatment for recycling 45

4.2.4. Recycling 45
5. Background information for the development of end-of-waste criteria 68
5.1. Market, demand and common applications 68
5.1.1. Market, demand and common applications for recycled textiles 70
5.2. Technical requirements and standards 70
5.2.1. Standards 70
5.2.2. Specifications and quality requirements for output materials of textile recycling 71
5.3. Legislative aspects 75
5.3.1. Relevant waste legislation 75
5.3.2. Relevant product legislation 77
5.4. Environmental and human health impacts 81
5.4.1. Chemicals of concern 82
5.5. Mapping existing end-of-waste criteria for textile recycling in Member States 85
6. End-of-waste criteria development for recycling of textile and textile-related waste 87
6.1. Scope and system boundaries 87
6.1.1. Textile sources within the scope 87
6.1.2. Textile fibres within the scope 91
6.1.3. Recycling technologies within the scope 94
6.1.4. Compliance with EoW criteria and system boundaries 98
6.2. Requirements on input materials (feedstock to recycling) 110
6.2.1. Criterion 1.1: Recognition of the waste hierarchy and compliance with the ESPR 110
6.2.2. Criterion 1.2: Minimum requirements and restriction of textile sources, categories and items 112
6.2.3. Criterion 1.3: Hazardous waste and waste containing substances classified as hazardous or other restricted substances 118
6.2.4. Criterion 1.4: Eligibility of input materials originating from waste streams partly made up of textiles 122
6.3. Requirements on processes and techniques (recycling processes) 124
6.3.1. Criterion 2.1: Storage of input and output materials 124
6.3.2. Criterion 2.2: Treatment steps 125
6.3.3. Criterion 2.3: Treatment of hazardous waste, waste containing substances classified as hazardous or other restricted substances and dilution 127

6.4. Requirements on product quality (output of recycling) 130
6.4.1. Criterion 3.1: Compliance with product legislation 130
6.4.2. Criterion 3.2: Compliance with legal requirements, standards or specifications 134
6.4.3. Minimum requirements for output materials of mechanical recycling 136
6.5. Requirements on quality assurance procedures 137
6.5.1. Criterion 4.1: Quality management system 137
6.6. Requirements on provision of information 142
6.6.1. Criterion 5.1: Statement of conformity 142
6.7. Comparison of JRC proposal for EU-wide EoW criteria for recycling with national EoW criteria 146
7. Conclusions and recommendations 148
References 150
List of abbreviations 158
List of boxes 161
List of figures 162
List of tables 164
Annexes 166
Annex 1: Destruction of unsold goods (ESPR) 166
Annex 2: List of textile fibre names in Annex I to Regulation (EU) No 1007/2011 on Textile Labelling 166
Annex 3: Limit values and typical analytical results for wood-based dissolving pulp 170
Annex 4: Parameters demanded by yarn spinning industry 170
Annex 5: Standard specifications of dissolving pulp from virgin sources for the production of MMC fibres 173
Annex 6: Technical specifications for man-made cellulosic fibres 174
Annex 7: Technical specifications for monomers 174
Annex 8: Technical specifications on polymers 177
Annex 9: Overview of national EoW criteria 178
Annex 10: Common third-party certifications for QMS in sorting facilities 182
Annex 11: Specifications of input materials for chemical recycling technologies 183
Annex 12: Overview of output materials from mechanical, thermo-mechanical, physical and chemical recycling processes 186

Annex 13: Glossary..... 189

Abstract

Textile waste was selected as a priority stream for EU-wide EoW criteria development following an earlier scoping study by the Joint Research Centre. The absence of an EU-wide harmonised legal framework for determining the end-of-waste (EoW) status of textile waste creates regulatory uncertainty for waste-management operators, recyclers and downstream users of recycled materials. Introducing EU-wide EoW criteria would resolve the current fragmentation among Member States and across the textile value chain, thereby fostering the market uptake of output materials of textile recycling.

The objective of this study was to develop a set of technical proposals for EU-wide EoW criteria for textile waste, in line with Article 6 of Directive 2008/98/EC. This report focuses on recycling operations and the proposed EoW criteria are applicable to mechanical, thermo-mechanical, physical and chemical recycling. In parallel, EoW criteria for preparing for re-use and remanufacturing of textile, textile-related and footwear waste have been developed. Those are outlined in a separate report.

This study provides a comprehensive overview of the textile sector, the composition and generation of textile waste, and the current and future recycling pathways. It further examines market-relevant aspects such as demand for recycled textiles and trade flows; technical requirements and existing standards; relevant EU and national legislation; and the environmental and human-health impacts, including chemicals of concern in the textile value chain. A comparative analysis of national EoW provisions for textile waste recycling across Member States is also presented.

Drawing on inputs from a broad spectrum of stakeholders and plant visits, the JRC has drafted technical proposals for EU-wide EoW criteria for recycling of textile and textile-related waste. The proposed criteria cover requirements for input materials, treatment processes and techniques, product quality, quality assurance and obligations for information provision.

The possible adoption of these EU-wide EoW criteria is expected to remove legal barriers, enhance market confidence and stimulate the circular use of textiles, thereby contributing to the EU's Green Deal objectives and the transition towards a sustainable textile economy.

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Authors

Egle, Lukas[1]

Pérez Arribas, Zahara[1]

Saveyn, Hans[1]

Pierri, Erika[1]

[1] European Commission, Joint Research Centre, Directorate B Fair and Sustainable Economy - Circular Economy and Sustainable Industry Unit (B5)

Executive summary

Policy context

One of the key objectives of setting end-of-waste (EoW) criteria is to make recycling and the use of secondary raw materials easier and more attractive, while safeguarding the environment, preserving natural resources and cutting the amount of waste sent for disposal. At present, recycling of several waste streams is impeded by a lack of certainty about when a material stops being waste and can be treated as a product that moves freely in the EU single market. A harmonised definition of that transition would remove these barriers and enable the material to circulate like any other commodity.

Article 6(1) of the Waste Framework Directive (WFD) 2008/98/EC lays down the conditions for a waste to cease to be waste after undergoing a recycling or other recovery operation, namely that:

> *"(a) the substance or object is to be used for specific purposes;*
> *(b) a market or demand exists for such a substance or object;*
> *(c) the substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products; and*
> *(d) the use of the substance or object will not lead to overall adverse environmental or human health impacts".*

Article 6(2) lists the detailed criteria to be considered when establishing EoW criteria, namely:

> *"(a) permissible waste input material for the recovery operation;*
> *(b) allowed treatment processes and techniques;*
> *(c) quality criteria for end-of-waste materials resulting from the recovery operation in line with the applicable product standards, including limit values for pollutants where necessary;*
> *(d) requirements for management systems to demonstrate compliance with the end-of-waste criteria, including for quality control and self-monitoring, and accreditation, where appropriate; and*
> *(e) a requirement for a statement of conformity."*

Building on its commitment to examine the feasibility of developing EU-wide end-of-waste or by-product criteria for selected waste streams[1], the Commission undertook a scoping study (Orveillon et al., 2022) to identify possible candidate streams. Textile waste was ranked as the second priority stream, after plastic waste, for the development of EU-wide EoW criteria.

The present study develops technical proposals for EU-wide EoW criteria for textile and textile-related waste, targeting the recycling operation. The recommendations set out herein are intended to form the technical proposals based on which the Commission may in the future develop a legal act laying down the Union-wide EoW criteria for textile and textile-related waste to be adopted according to Article 6(2) of the WFD.

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1 COM/2020/98 final: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1583933814386&uri=COM:2020:98:FIN

Related and future JRC work

EU-wide EoW criteria have already been successfully laid down for: iron, steel and aluminium scrap (Council Regulation (EU) 333/2011), based on the JRC proposals for aluminium and aluminium alloy scrap (Muchova & Eder, 2010) and for iron and steel scrap (Muchova & Eder, 2010) ; copper scrap (Commission Regulation (EU) 715/2013), based on the JRC proposals for copper and copper alloy scrap (Muchova et al., 2011); and glass cullet (Commission Regulation (EU) No 1179/2012), based on the related JRC proposals (Rodriguez Vieitez et al., 2011).

Furthermore, based on the JRC proposals for biodegradable waste subjected to biological treatment (Saveyn & Eder, 2014), the Commission adopted requirements for Component Material Categories (CMCs) that can cease to be waste pursuant to Article 19 of the Fertilising Products Regulation (EU) No 2019/1009, including requirements for: CMC 3 (compost) and CMC 5 (digestate other than fresh crop digestate) under Regulation (EU) No 2019/1009; CMC 12 (precipitated phosphate salts and derivates) under Commission Delegated Regulation (EU) No 2021/2086); CMC 13 (thermal oxidation materials and derivates) under Commission Delegated Regulation (EU) No 2021/2087; CMC 14 (pyrolysis and gasification materials) under Commission Delegated Regulation (EU) No 2021/2088 and CMC 15 (recovered high purity materials) under Commission Delegated Regulation (EU) No 2022/1171.

In parallel, the JRC is working on the development of technical proposals for EU-wide EoW criteria for preparing for re-use and remanufacturing of textiles (presented in Pérez Arribas et al. (2026)) as well as for recycling of construction and demolition waste.

Quick guide

This document presents a structured methodology for drafting EU-wide EoW criteria that target the recycling of textile and textile-related waste. It first outlines the textile value chain, from raw material production to waste generation, and reviews how textile waste is classified, the available management options, and market-related considerations. The report then details relevant information for formulating EoW criteria, including standards, waste and product legislation, and the environmental and human-health impacts. A comparative assessment of existing EoW criteria across Member States is also provided. Based on this background, the report proposes EoW criteria for recycling, organised by each category of requirement, and incorporates stakeholders' feedback and the accompanying assessment, while also acknowledging national EoW provisions.

JRC proposal for EU-wide end-of-waste criteria for recycling of textile and textile-related waste

As indicated above, this study was carried out by the JRC and aimed at supporting the Commission in the implementation of Article 6 of Directive (EC) No 2008/98, by developing technical proposals for **EU-wide end-of-waste (EoW) criteria for recycling of textile and textile-related waste** (see **Table 1**).

The scope encompasses:

- **post-industrial textile waste**[2];
- **pre-consumer**[3] and **separately collected post-consumer household**[4] and **commercial**[5] **textile waste** that have been deemed **not suitable for re-use** during pre-sorting, sorting for re-use or preparing for re-use operations, **nor suitable for remanufacturing** (if applicable);
- **textiles filtered out from wastes in which textiles are considered a misthrow** (e.g. mixed municipal solid waste);
- **textile fractions** separated from post-consumer household and post-consumer commercial waste streams that are **not primarily made up of textiles** (such as footwear, duvets, vehicle upholstery).

It is proposed to include all **natural and man-made textile fibres** and **mixtures thereof** within the scope. Mineral fibres are outside the scope.

The JRC proposes to include all **mechanical, thermo-mechanical, physical and chemical recycling technologies and combinations thereof within the scope**. Conversion technologies that partly convert the input materials to energy or recover output materials which may be partly or entirely used for the production of energy or fuels (such as syngas from gasification and pyrolysis oil from pyrolysis processes) are not within the scope.

Different conditions for achieving EoW status are proposed for different recycling technologies, namely the following:

(1) For mechanical recycling, EoW status shall be granted to output material that:

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2 Post-industrial textile waste is generated in the manufacturing of fabrics and textile products. It is generated as a result of technical features of the manufacturing process, inaccurate resource planning or production errors. Production scrap re-used within the production process or by-products are not within the scope.

3 Pre-consumer textile waste is generated at retail level, including excess stock, returns and discarded unsold goods.

4 Post-consumer household textile waste is generated at household level and can contain the following textile categories and items: clothing, clothing accessories, footwear, home/interior textiles, other items partially or fully made of textile materials.

5 Post-consumer commercial textile waste arises from any commercial or industrial activities such as hospitality, healthcare, agriculture, environmental, construction. Technical textiles also belong to this category (e.g. textiles for filtration, professional cleaning items, workwear with highly technical features, personal protective clothing and footwear).

— is either ready to be used for a specific material purpose or for the production of new products or items containing textile fibres within the scope; and

— complies with the full set of EoW criteria for recycling.

Considering that the shape or form of the incoming textile waste is modified based on the requirements for a specific material use or for the subsequent production processes, the compliance with the EoW status is not linked to a specific physical form (e.g. piece, fibre, powder).

It is pointed out that the user of the output material will have to handle it as waste if:

i. it is discarded; or

ii. it is used for any purpose other than for a specific material purpose or for the production of new products or items containing textile fibres within the scope, such as for energy recovery, for fuel production (e.g. solid recovered fuel), as feedstock for other recovery operations (e.g. thermo-mechanical, physical or chemical recycling), or for backfilling operations.

(2) For thermo-mechanical, physical and chemical recycling, EoW status shall be granted to output material that:

— is used for a specific material purpose; and

— complies with the full set of EoW criteria for recycling.

Any further treatment of output materials from thermo-mechanical, physical and chemical recycling processes for the purpose of transformation[6] into a new substance or material to be used for a specific material purpose is allowed, with the exception of production of energy or fuels. Common applications include re-polymerisation of monomers or oligomers into polymers or the production of man-made cellulose fibres from recycled dissolving textile pulp.

The user of the output material will have to handle it as waste if:

i. it is discarded; or

ii. it is not used for a specific material purpose, e.g. if it is used for energy recovery, fuel production or for backfilling operations.

Table 1. JRC proposal for EU-wide end-of-waste criteria for recycling and self-monitoring requirements

No	Proposed end-of-waste criteria	Proposed self-monitoring requirements
Requirements on input materials		
1.1	In compliance with Article 25[7] of Regulation (EU) No 2024/1781, pre-consumer textile waste shall not be used as input to any recycling process, unless it can be	When using pre-consumer textile waste as input, the operator of the recycling facility shall demonstrate the applicability of derogations.

6 Transformation is a process that changes the chemical structure of a substance, resulting in a new substance with different properties.

7 Destruction of unsold consumer products.

	demonstrated that one of the derogations set out in the Delegated Regulation[8] supplementing Regulation (EU) 2024/1781 applies.	This documentation shall be recorded in the quality management system.
1.2	Textile waste to be used as input to any recycling process shall fulfil the following minimum requirements: (a) it shall have undergone all necessary sorting and pre-treatment steps[9]; and (b) it shall be dry, unless recycling is demonstrably capable of treating wet input materials. Textile waste to be used as input to any recycling process may originate from any source of waste containing textiles or may be any textile item, with the exception of: (a) mixed municipal solid waste; (b) used healthcare textiles originating from healthcare facilities and laboratories (including laboratories dealing with biological, chemical or clinical research); and (c) used reusable absorbent hygiene products, unless proof of sanitation and/or decontamination by the previous holder or by the recycler can be provided.	The producer or another operator shall establish appropriate risk management measures to identify and remove, where needed, batches of ineligible input material. Quality control measures, in the form of a visual and olfactory inspection of all textile waste received and of an analysis of accompanying documentation, shall be carried out by qualified staff who are trained on how to recognise textile waste allowed but also restricted under this criterion. The staff shall be trained on potential types of contamination that may be associated with textile waste and on material components or features that allow recognition of the contaminants. Automated inspection systems that provide equivalent verification are also accepted. The procedure for recognising and removing contaminants to the extent needed and the results of the removal of contaminants shall be documented in the quality management system. The producer or another operator shall request the previous holder to provide documentation on sanitation and/or decontamination, where needed. The producer or another operator shall keep track of the eligible textile waste used as input material (date of receipt, supplier, origin, type and quantity of textile waste received) and the textile waste streams that have been rejected (date of rejection, supplier, origin, type, quantity of textile waste and reason for rejection). The

8 Commission Delegated Regulation setting out derogations from the prohibition of destruction of unsold consumer products: https://environment.ec.europa.eu/publications/commission-delegated-regulation-setting-out-derogations-prohibition-destruction-unsold-consumer_en

9 The requirements on the sorting and pre-treatment depend on the technical ability to carry out any pre-treatment steps as part of the recycling process (e.g. removal of hard parts). Sorting can be omitted if the input materials can be directly used without sorting. In the event that pre-treatment is an integral part of the recycling technology, pre-treatment can also be omitted.

		data shall be recorded in the quality management system.
1.3	Textile waste used as input to any recycling process may contain substances restricted under Regulation (EC) No 1907/2006, only if substances, on their own or in mixtures, that are present in the output material comply with that Regulation, including Article 56 setting out authorisation provisions for the use of substances listed in Annex XIV and for their placing on the market as well as the conditions laid down in Article 67 setting out the conditions for the manufacture, placing on the market and use of certain dangerous substances restricted in Annex XVII[10]. Textile waste used as input to any recycling process may contain POPs at concentrations above the limit values set out in Annex IV to Regulation (EU) 2019/1021[11] only if there is a (pre-)treatment step in place for textile waste that can result in an input fraction with POPs concentrations below the limit values set out in Annex IV to that Regulation. Textile waste used as input to thermo-mechanical, physical and chemical recycling may contain substances classified as hazardous pursuant to Article 3 of Regulation (EC) No 1272/2008, only if the output material resulting from recycling is classified and labelled according to that Regulation. Textile waste used as input to mechanical recycling shall not be classified as hazardous waste as defined in Article 3, point 2 of Directive (EC) No 2008/98 or it shall be possible to remove hazardous substances, on their own or in mixtures, from the textile waste before or during recycling, in compliance with Article 10(5) of Directive (EC) No 2008/98. Textile waste used as input to mechanical recycling may contain substances classified as hazardous pursuant to Article 3 of Regulation (EC) No 1272/2008 and Annex I to that Regulation, only if the output material resulting	An acceptance control, in the form of a visual inspection of all textile waste received and analysis of the accompanying documentation shall be carried out by qualified staff. The producer or another operator of the recycling facility shall apply appropriate control measures to detect hazardous waste as defined in Article 3(2) of Directive (EC) No 2008/98 and waste containing substances classified as hazardous according to Regulation (EC) No 1272/2008 or other substances restricted under Regulation (EC) No 1907/2006 and Regulation (EU) 2019/1021, paying particular attention to input material originating from waste sources which are more likely to contain such substances. The control measures and their results shall be documented in the quality management system. The (pre-)treatment steps to separate textile waste containing POPs and the results of the pre-treatment shall be documented in the quality management system.

[10] Including the latest amendment to Annex XVII (Regulation (EU) No 2023/923).

[11] Including the last amendment to Annexes IV and V (Regulation (EU) 2022/2400).

	from recycling does not contain substances, on its own or in mixtures, that would trigger its classification as hazardous according to Article 3 of and Annex I to Regulation (EC) No 1272/2008 (CLP).	
1.4	Waste streams that partly consist of textiles shall undergo a treatment step to separate textiles from non-textile parts provided that the separated textiles meet the specifications of the producer or another operator of a recycling facility.	An acceptance control, in the form of a visual inspection of all textile waste received and analysis of the accompanying documentation shall be carried out by qualified staff. This documentation shall be recorded in the quality management system.
Requirements on treatment processes and techniques		
2.1	Textile waste eligible to be used as input material to any recycling process shall: (a) be stored in a sheltered area to avoid damage and cross-contamination; and (b) be kept separately from ineligible input materials to avoid contamination. Output materials that comply with the end-of-waste criteria shall be kept separately from any output material that does not comply with those criteria.	The procedures carried out to fulfil the storage requirements laid down in this criterion shall be documented in the quality management system.
2.2	Mechanical recycling shall include all treatment steps needed to prepare the output material to be used for a specific material purpose[12] or for the production of products or articles containing textile fibres within the scope. Mechanical recycling shall not be limited to merely sorting or visually checking the waste. Thermo-mechanical, physical and chemical recycling shall include all treatment steps needed to prepare the output material to be used for a specific material purpose[13].	The sequence of treatment steps shall be documented in the quality management system.

[12] Depending on the quality, the recovered fraction may be used for different applications, e.g. cleaning, insulation or stuffing material.

[13] Common applications include re-polymerisation of monomers or oligomers into polymers or the production of man-made cellulose fibres from recycled dissolving textile pulp.

2.3	Eligible input materials to any recycling process shall be treated to the extent that the following conditions are fulfilled: (a) substances, on their own or in mixtures, that are present in the output material, comply with Regulation (EC) No 1907/2006, including Article 56 setting out authorisation provisions for the use of substances listed in Annex XIV and for their placing on the market as well as the conditions laid down in Article 67 for the manufacture, placing on the market and use of substances listed in Annex XVII; (b) substances, on their own or in mixtures, that are present in the output material, meet the provisions controlling the manufacturing, placing on the market and use of POPs pursuant to Article 3 of Regulation (EU) 2019/1021 and Annex I to that Regulation, regardless of whether a (pre-)treatment step for the textile waste is in place, as indicated in Criterion 1.3; and (c) substances, on their own or in mixtures, that are present in the output material, comply with Regulation (EU) No 528/2012. Eligible input materials to mechanical recycling shall be treated to the extent that the output material does not contain substances, on their own or in mixtures, in concentrations that would trigger the classification of the output material as hazardous according to Article 3 of and Annex I to Regulation (EC) No 1272/2008. Eligible hazardous textile waste to be used as input to any recycling process shall not be mixed or diluted with other waste, substances or materials, in accordance with Article 18(1) of Directive (EC) No 2008/98. The derogations set out in Article 18(2) shall apply. According to Article 7(2) of Regulation (EU) 2019/1021, waste consisting of, containing or contaminated by any substance listed in Annex IV of that Regulation, shall be disposed of or recovered to	Particular attention shall be paid to the processing of hazardous waste and textile waste that may contain substances classified as hazardous according to Regulation (EC) No 1272/2008, or other substances restricted under Regulations (EC) No 1907/2006, (EU) 2019/1021, or (EU) No 528/2012, as indicated in this criterion. The procedure and method used and compliance with the substance concentration requirements of Regulations (EC) No 1272/2008, (EC) No 1907/2006, (EU) 2019/1021, or (EU) No 528/2012, as applicable, shall be documented in the quality management system.

	ensure that the POP content is destroyed or irreversibly transformed.	
Requirements on product quality		
3.1	The following requirements shall apply to any recycling process: (a) substances, on their own or in mixtures, that are present in the output material, shall comply with Regulation (EC) No 1907/2006, including Article 56 setting out authorisation provisions for the use of substances listed in Annex XIV and for their placing on the market, and Article 67 setting out the conditions for the manufacture, placing on the market and use of substances restricted under Annex XVII[14]; (b) substances, on their own or in mixtures, that are present in the output material, shall meet the provisions controlling the manufacturing, placing on the market and use of POPs pursuant to Article 3 of and Annex I to Regulation (EU) 2019/1021; and (c) substances, on their own or in mixtures, that are present in the output material, shall comply with Regulation (EU) No 528/2012. The output material from thermo-mechanical, physical and chemical recycling shall be classified and labelled according to Regulation (EC) No 1272/2008. The output material from mechanical recycling shall not contain substances, on their own or in mixtures, in concentrations that would trigger its classification as hazardous according to Article 3 of Regulation (EC) No 1272/2008.	The assessment of compliance with Regulations (EC) No 1907/2006, (EU) No 2019/1021, (EU) No 528/2012 and Regulation (EC) No 1272/2008, as applicable shall be concluded based on a qualitative and quantitative characterisation of the output material. The exemptions laid down in those Regulations shall apply, including in Article 2(7) of Regulation No 1907/2006, Article 4 of (EU) 2019/1021 and Article 29 of Regulation (EC) No 1272/2008. To this end, representative samples of the output material shall be analysed to measure the concentration and nature of hazardous substances. These representative samples shall be taken at appropriate intervals determined on a risk-based approach that considers the following factors: (1) the expected pattern of variability of the output material composition (for example as shown by historical results); (2) the inherent risk of variability in the quality of the waste used as input for the recycling operation and any subsequent processing, for instance a higher average content of waste containing substances classified as hazardous according to Regulation (EC) No 1272/2008 and substances restricted under Regulations (EC) No 1907/2006, (EU) 2019/1021 and (EU) No 528/2012; (3) the inherent precision of the monitoring method; and (4) the proximity of results to the concentration thresholds that render the material hazardous or restrict its commercialisation. The frequency of monitoring by sampling shall occur at least once every six months and shall

[14] Including the latest amendment to Annex XVII (Regulation (EU) No 2023/923).

		be adjusted to ensure that trends or other changes in the input materials can be detected. The process for determining the monitoring frequency and the results of the monitoring shall be documented as part of the quality management system.
3.2	The output material from mechanical recycling shall comply with Union product legislation requirements, industry specifications or standards for the use of the output material for a specific material purpose[15] or for the production of new products or items containing textile fibres within the scope. The output material from thermo-mechanical, physical or chemical recycling processes shall comply with Union product legislation requirements, industry specifications or standards for the use of the output material for a specific material purpose[16].	Qualified staff shall verify that each batch in the consignment complies with the legal requirements and appropriate standards and product specifications, including customer requirements. To monitor compliance, representative samples of the output material shall be taken and analysed at appropriate intervals determined on a risk-based approach, considering the intended specific use of recycled material. Automated inspection systems that provide equivalent verification are also accepted. The frequency of verification shall be defined in accordance with the characteristics of the textile waste stream treated. The process for determining the monitoring frequency and the results of the monitoring shall be documented in the quality management system.
Requirements on quality assurance procedures		
4.1	1. The producer shall implement a quality management system that allows it to demonstrate compliance with the end-of-waste criteria. 2. The quality management system shall include a set of documented procedures concerning each of the following aspects: (a) monitoring of textile waste used as input material for recycling including quality control measures and risk management measures; (b) monitoring of the treatment processes and techniques; (c) monitoring of the quality of output material resulting from recycling, including instructions for sampling and analysis and their frequency; (d) record-keeping of the results of monitoring conducted under points (a), (b) and (c);	

[15] Depending on the quality, the recovered fraction may be used for different applications, e.g. cleaning, insulation or stuffing material.

[16] Common applications include re-polymerisation of monomers or oligomers into polymers or the production of man-made cellulose fibres from recycled dissolving textile pulp.

	(e) record-keeping of feedback from customers concerning the quality of the output material; (f) record-keeping of the actions taken to improve the performance of recycling, in order to assess non-compliance with the end-of-waste criteria; (g) review and improvement of the quality management system; and (h) training of staff. 3. The quality management system shall cover all the specific self-monitoring requirements set out for each end-of-waste criterion and the statement of conformity. 4. The quality management system shall be assessed by one of the following bodies: (a) a conformity assessment body; or (b) an environmental verifier. 5. The bodies referred to in point 4 shall verify that the quality management system fulfils the requirements on procedures referred to in point 2. The verification shall be carried out every three years. 6. Environmental verifiers, referred to in point 4 (b), shall be permitted to perform the verification referred to in point 5 only if such bodies have obtained an accreditation or licence with a scope covering at least one of the following NACE codes specified in Regulation (EC) No 1893/2006 of the European Parliament and of the Council[17]: – NACE Code 13 (Manufacture of textiles); or – NACE Code 14 (Manufacture of wearing apparel); or – NACE Code 15 (Manufacture of leather and related products); or – NACE Code 20 (Manufacture of chemicals and chemical products); or – NACE Code 22 (Manufacture of rubber and plastic products); or – NACE Code 38 (Waste collection, treatment and disposal activities; material recovery). 7. The producer shall give enforcement authorities, as defined in Article 2, point (26), of Regulation (EC) No 1221/2009, access to the quality management system upon request and make the records referred to in point 2 (d), (e), and (f) of this criterion electronically available to the relevant national authorities upon request, for at least five years after the date of recording. 8. To be allowed to place output materials on the Union market, the importer of such output materials from recycling facilities located in a third country shall require third-country suppliers to implement a quality management system which complies with the requirements set out in points 1, 2 and 3 of this criterion. This quality management system shall be verified by one of the bodies referred to in point 4, which is accredited or licensed in a Member State to perform verification and validation activities for an organisation located in a third country, in accordance with the

[17] Regulation (EC) No 1893/2006 of the European Parliament and of the Council of 20 December 2006 establishing the statistical classification of economic activities NACE Revision 2 and amending Council Regulation (EEC) No 3037/90 as well as certain EC Regulations on specific statistical domains (OJ L 393, 30.12.2006, p. 1, ELI: http://data.europa.eu/eli/reg/2006/1893/oj).

	specifications laid down in Regulation (EC) No 765/2008 or in Regulation (EC) No 1221/2009 in conjunction with Commission Decision 2011/832/EU[18]. 9. If the importer of output material from recycling facilities located in a third country fails to meet the requirements laid down in point 8, the output material to be imported shall be considered waste and, therefore, shall comply with Regulation (EU) No 2024/1157.
Requirements on provision of information	
5.1	The producer or the importer shall issue, for each consignment[19] of output material that complies with end-of-waste criteria, a statement of conformity in agreement with the model set out in the template. The producer or the importer shall transmit the statement of conformity to the next holder of the consignment. The producer or importer shall retain a copy of the statement of conformity for at least three years after its date of issue and shall make it available to relevant national authorities upon request. The statement of conformity may be in electronic form.

Source: own elaboration

Table 2 contains the proposal for the statement of conformity to be used by the producer/importer of the output material fulfilling the EoW criteria for recycling.

Table 2. JRC technical proposal for the statement of conformity

1.	Unique identification code of the consignment: Producer/importer of the output material (location of the installation in which the recycling of this consignment was carried out): Name: European Unique Identifier (EUID) (optional, alternative to the name): Address: Contact person: Tel.: E-mail:
2.	Quantity of the consignment in tonnes:
3.	Characteristics and intended use of the output material:

[18] Commission Decision 2011/832/EU of 7 December 2011 concerning a guide on EU corporate registration, third country and global registration under Regulation (EC) No 1221/2009 of the European Parliament and of the Council on the voluntary participation by organisations in a Community eco-management and audit scheme (EMAS) (OJ L 330, 14.12.2011, p. 25, ELI: http://data.europa.eu/eli/dec/2011/832/oj).

[19] Consignment: a batch of EoW textiles which is intended for delivery from a producer to another holder and may be contained in either one or several transport units, such as containers.

	a) Name or code that identifies the output material, in accordance with Union product legislation, standards or product specifications, including customer requirements: b) Main technical characteristics of the output material, in accordance with Union product legislation, standards or product specifications, including customer requirements:
4.	The output material in this consignment complies with a customer requirement, industry specification or a standard referred to in point 3.
5.	The textile recycling consignment meets the criteria on input materials (1.1, 1.2, 1.3 and 1.4), on treatment processes and techniques (2.1, 2.2 and 2.3), and on product quality (3.1, 3.2 and 3.3).
6.	**For output materials resulting from mechanical recycling** Substances, on their own or in mixtures, that are present in the output material, comply with Regulation (EC) No 1907/2006, including Article 56 setting out authorisation provisions for the use of substances listed in Annex XIV and for their placing on the market, and Article 67 setting out the conditions for the manufacture, placing on the market and use of substances restricted under Annex XVII. Substances, on their own or in mixtures, that are present in the output material, meet the provisions controlling the manufacturing, placing on the market and use of POPs pursuant to Article 3 of and Annex I to Regulation (EU) 2019/1021, regardless of whether a (pre-)treatment step for the textile waste is in place, as indicated in Criterion 1.3. Substances, on their own or in mixtures, that are present in the output material, meet the relevant provisions laid down in Regulation (EU) No 528/2012. The output material does not contain substances, on their own or in mixtures, in concentrations that would trigger its classification as hazardous according to Article 3 of Regulation (EC) No 1272/2008. **For output materials resulting from thermo-mechanical, physical and chemical recycling** Substances on their own or in mixtures, that are present in the output material, comply with Regulation (EC) No 1907/2006, including Article 56 setting out authorisation provisions for the use of substances listed in Annex XIV and for their placing on the market, and Article 67 setting out the conditions for the manufacture, placing on the market and use of substances restricted under Annex XVII. Substances on their own or in mixtures, that are present in the output material, meet the provisions controlling the manufacturing, placing on the market and use of POPs pursuant to Article 3 of and Annex I to Regulation (EU) 2019/1021, regardless of whether a (pre-)treatment step for the textile waste is in place, as indicated in Criterion 1.3. Substances on their own or in mixtures, that are present in the output material, meet the relevant provisions laid down in Regulation (EU) No 528/2012. The output material is classified and labelled according to Regulation (EC) No 1272/2008.
7.	The producer of the output material applies a quality management system assessed by an accredited conformity assessment body, which is accredited by a national accreditation body, or by an environmental verifier as defined in Article 2, point (20)(b), of Regulation (EC) No 1221/2009. Where output items which have ceased to be waste are imported into the customs territory of the Union, the quality management system shall be verified by an accredited conformity assessment body, which is accredited by a national accreditation body, or by an environmental verifier, who has obtained a specific accreditation or licence to operate in a third country, in accordance with the

	specifications laid down in Regulation (EC) No 765/2008 or in Regulation (EC) No 1221/2009 in conjunction with Commission Decision (EU) No 2011/832.
8.	**For output materials resulting from mechanical recycling** The output material in this consignment is intended to be either ready to be used for a specific material purpose or for the production of new products or items containing textile fibres within the scope. It must not be used for energy recovery, for fuel production (e.g. solid recovered fuel), as feedstock for other recovery operations (e.g. thermo-mechanical, physical and chemical recycling), or for backfilling operations. Where these conditions are not met, the user of the output material shall handle it as waste and shall inform the producer, for the purpose of accurately reporting the weight of textiles that has achieved end-of-waste status. **For output materials resulting from thermo-mechanical, physical and chemical recycling** The output material in this consignment is intended to be used for a specific material purpose. It must not be used for energy recovery, fuel production or for backfilling operations. Where these conditions are not met, the user of the output material shall handle it as waste and shall inform the producer, for the purpose of accurately recording the weight of the output material that has achieved end-of-waste status.
9.	Declaration of the producer/importer of the output material: I certify that the above information is complete and correct to the best of my knowledge: Name: Date: Signature:

Source: own elaboration

1. Introduction

1.1. EU regulatory framework on textiles

In March 2022 the Commission launched the **EU Strategy for Sustainable and Circular Textiles**[20], aiming at creating a greener and more competitive sector for textiles. A core objective of the strategy is to enhance recyclability of textiles placed on the EU market, alongside promoting durability and reparability. It emphasises scaling up recycling capacity to increase the share of recycled fibres, thereby reducing reliance on virgin materials and minimising the sector's environmental footprint. The strategy aligns with the broader European Green Deal and Circular Economy Action Plan (CEAP), positioning textile recycling as a priority for sustainable growth.

The minimisation of environmental impacts of textile manufacturing processes at large EU textile production plants is addressed in the Best Available Techniques (BAT) **Reference Document (BREF) for the Textiles Industry**[21] as a part of the revision of the Industrial Emissions Directive (2010/75/EU).

To address the environmental impacts linked to production and waste management of textiles, the **Eco-design for Sustainable Products Regulation** (ESPR) ((EU) No 2024/1781), adopted in June 2024, sets in Article 25(1) a ban on the destruction of unsold consumer products listed in Annex VII to the Regulation (reported in **Annex 1** of this document). The ban covers unsold products intended for consumers (e.g. overstock) or those returned by consumers. Recycling, other recovery and disposal are considered destruction. Under the ESPR, large enterprises in the EU are prohibited from destroying unsold clothes, clothing accessories (e.g. belts, hats) and footwear from July 2026 and medium-sized enterprises from July 2030.

In late 2024, the Commission adopted delegated acts under Article 4 of the ESPR, introducing **mandatory fibre labelling** (e.g. 100% recycled cotton) and **design for disassembly** requirements for textiles. These aim to improve recyclability and consumer transparency.

Article 4 of the ESPR empowers the Commission to adopt delegated acts to set **ecodesign requirements** for specific product groups, with the goal of increasing their environmental sustainability. To support the prioritisation of products, the JRC launched a preparatory study on new product priorities[22]. Textiles and footwear have been shortlisted as priorities along with 18 other product groups.

Voluntary schemes, such as the **EU Ecolabel criteria** for textile products[23] and the **EU Green Public Procurement criteria** for textiles products and services[24] already include requirements on

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20 EU Strategy for Sustainable and Circular Textiles: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022DC0141

21 BREF Document for the Textile Industry: https://eippcb.jrc.ec.europa.eu/reference/textiles-industry

22 'Ecodesign for Sustainable Products Regulation - preliminary study on new product priorities', available at https://susproc.jrc.ec.europa.eu/product-bureau/product-groups/635/documents

23 Commission Decision 2014/350/EU of 5 June 2014 establishing the ecological criteria for the award of the EU Ecolabel for textile products (OJ L 174, 13.6.2014, p. 45–83).

24 EU green public procurement criteria for textiles products and services, SWD (2017) 231 final.

the durability of textile products and criteria restricting hazardous chemicals in ecolabelled products or green public procurement products and services.

Regulation (EC) No 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (**REACH**) sets regulatory requirements for chemicals, which also concern textile products. These include restrictions on manufacturing, placing on the market and use of certain chemical substances on their own, in mixtures and articles (as regulated in its Annex XVII). The REACH Regulation (EC) No 1907/2006 was updated in 2024 to restrict persistent, bio-accumulative and toxic (PBT) chemicals in textiles, ensuring they do not compromise recycling processes. This aligns with the EU Strategy's goal of creating a toxics-free textiles supply chain.

The **Waste Framework Directive** (WFD) (2008/98/EC) lays down a separate collection obligation for textiles (Article 11 (1)), which applies from 1 January 2025, requiring all EU Member States to set up separate collection systems for textiles. The targeted revision of the WFD, which entered into force in October 2025, focused on used textiles and textile waste (in line with the EU strategy for sustainable and circular textiles) and on food waste (to support the Farm to Fork Strategy25). Conforming to the polluter pays principle26, Article 22a of the amended WFD mandates Member States to establish **extended producer responsibility** (EPR) obligations for textile, textile-related and footwear products, listed in its Annex IVc.

1.2. EU regulatory framework on end-of-waste criteria

The WFD defines in Article 6(1) the general conditions that a waste material has to fulfil to cease to be waste: *"Member States shall take appropriate measures to ensure that waste which has undergone a recycling or other recovery operation is considered to have ceased to be waste if it complies with the following conditions:*

(a) the substance or object is to be used for specific purposes;
(b) a market or demand exists for such a substance or object;
(c) the substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products; and
(d) the use of the substance or object will not lead to overall adverse environmental or human health impacts."

In 2009, the Joint Research Centre (JRC) published a general methodology analysing the principles according to which the criteria should be set up and providing the related methodological framework required to determine EoW criteria (Delgado et al., 2009). This methodology was incorporated into the WFD Article 6 (2) in the following terms:

"The Commission shall monitor the development of national EoW criteria in Member States, and assess the need to develop Union-wide criteria on this basis. To that end, and where appropriate, the Commission shall adopt implementing acts in order to establish detailed criteria on the uniform application of the conditions laid down in paragraph 1 to certain types of waste.

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25 Farm to Fork Strategy: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0381

26 As referred to in Article 191(2) of the Treaty on the Functioning of the European Union (TFEU).

Those detailed criteria shall ensure a high level of protection of the environment and human health and facilitate the prudent and rational utilisation of natural resources. They shall include:

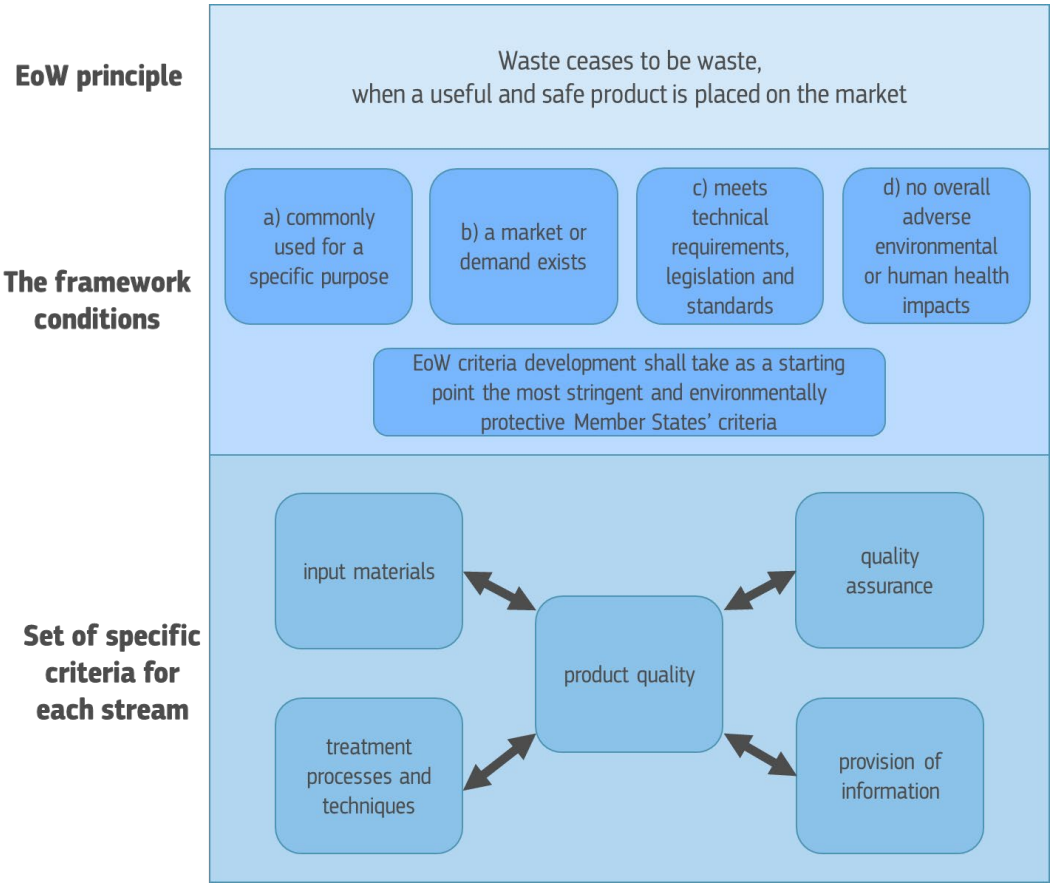
(a) permissible waste input material for the recovery operation;
(b) allowed treatment processes and techniques;
(c) quality criteria for end-of-waste materials resulting from the recovery operation in line with the applicable product standards, including limit values for pollutants where necessary;
(d) requirements for management systems to demonstrate compliance with the end-of-waste criteria, including for quality control and self-monitoring, and accreditation, where appropriate; and
(e) a requirement for a statement of conformity."

Additionally, the Commission shall take as a starting point the most stringent and environmentally protective EoW criteria established in Member States:

"When adopting those implementing acts, the Commission shall take account of the relevant criteria established by Member States in accordance with paragraph 3 and shall take as a starting point the most stringent and environmentally protective of those criteria".

Figure 1 shows the conceptual approach and framework conditions for the development of EoW criteria, taking into account the JRC methodology.

Figure 1. Conceptual approach of the EoW mechanism, framework conditions and elements of EoW criteria



Source: own elaboration

EoW criteria have been already successfully laid down for:

— iron, steel and aluminium scrap (Regulation 333/2011/EU);

— glass cullet (Regulation 1179/2012/EU);

— copper scrap (Regulation 715/2013/EU).

In addition to the EoW criteria listed above, the Commission adopted requirements for Component Material Categories (CMCs) that can cease to be waste pursuant to Article 19 of the Fertilising Products Regulation (EU) 2019/1009[27]. They include requirements for:

— CMC 3 (Compost) and CMC 5 (Digestate other than fresh crop digestate) under Regulation (EU) 2019/1009;

— CMC 10 (Processed manure) under Commission Delegated Regulation (EU) 2024/1682

— CMC 12 (Precipitated phosphate salts and derivates) under Commission Delegated Regulation (EU) 2021/2086);

— CMC 13 (Thermal oxidation materials and derivates) under Commission Delegated Regulation (EU) 2021/2087;

— CMC 14 (Pyrolysis and gasification materials) under Commission Delegated Regulation (EU) 2021/2088;

— CMC 15 (Recovered high purity materials) under Commission Delegated Regulation (EU) 2022/1171.

The implementation of EoW criteria for plastic waste is currently under way.

1.3. Scoping exercise to identify candidate streams

Further to the commitment to assess the scope to develop EU-wide EoW or by-product criteria for certain waste streams[28], the Commission carried out a scoping exercise in 2021 to identify candidate streams (Orveillon et al., 2022).

The potential for the development of EU-wide EoW or by-product criteria was appraised for 11 categories of waste and by-products using the following ranking criteria:

— level of support from stakeholders to develop further EU-wide EoW or by-product criteria;

— current collection and material re-use/recycling rates;

— identified uses, types of uses (recycling versus other recovery operations) and impacted economic sectors;

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27 Regulation (EU) 2019/1009: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02019R1009-20230316#M2-2

28 COM/2020/98 final: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1583933814386&uri=COM:2020:98:FIN

— estimated EU market value;

— intra- and extra-EU shipments;

— purity/composition of recovered materials and possibility to recover critical raw materials;

— evidence of demand;

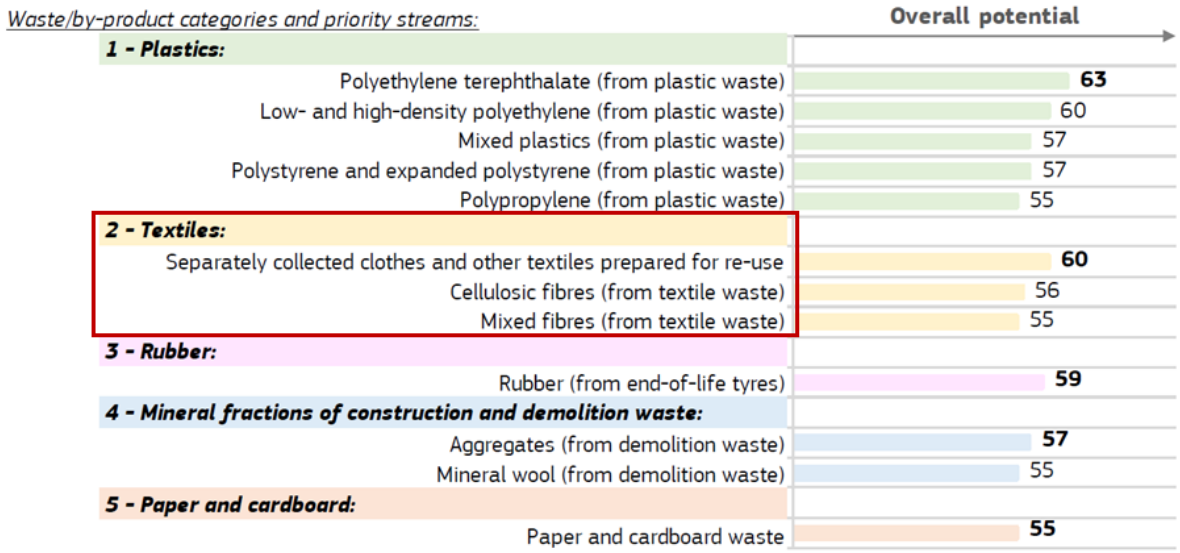
— existence of relevant international or national product standards;

— existence of national or regional EoW or by-product criteria;

— expected environmental and human health impacts.

Figure 2 presents the results of the scoping study, grouped by category of waste/by-product. **Textile waste** was ranked as the **second priority stream** for the development of **EoW criteria**, after plastic waste. The JRC recently released a report on technical proposals for EU-wide EoW criteria for plastic waste (see Pierri et al. (2024b)).

Figure 2. List of priority streams grouped by category, and ranked based on their overall potential, according to the scoring system



Source: Orveillon et al., 2022

Figure 3 presents the final ranking of the streams that were scored as top candidates for the development of EoW or by-product criteria.

Three main textile waste streams (highlighted in green in **Figure 3**) were included on the priority list:

— separately collected clothes and other textiles prepared for re-use;

— cellulosic fibres (from textile waste);

— mixed fibres (from textile waste).

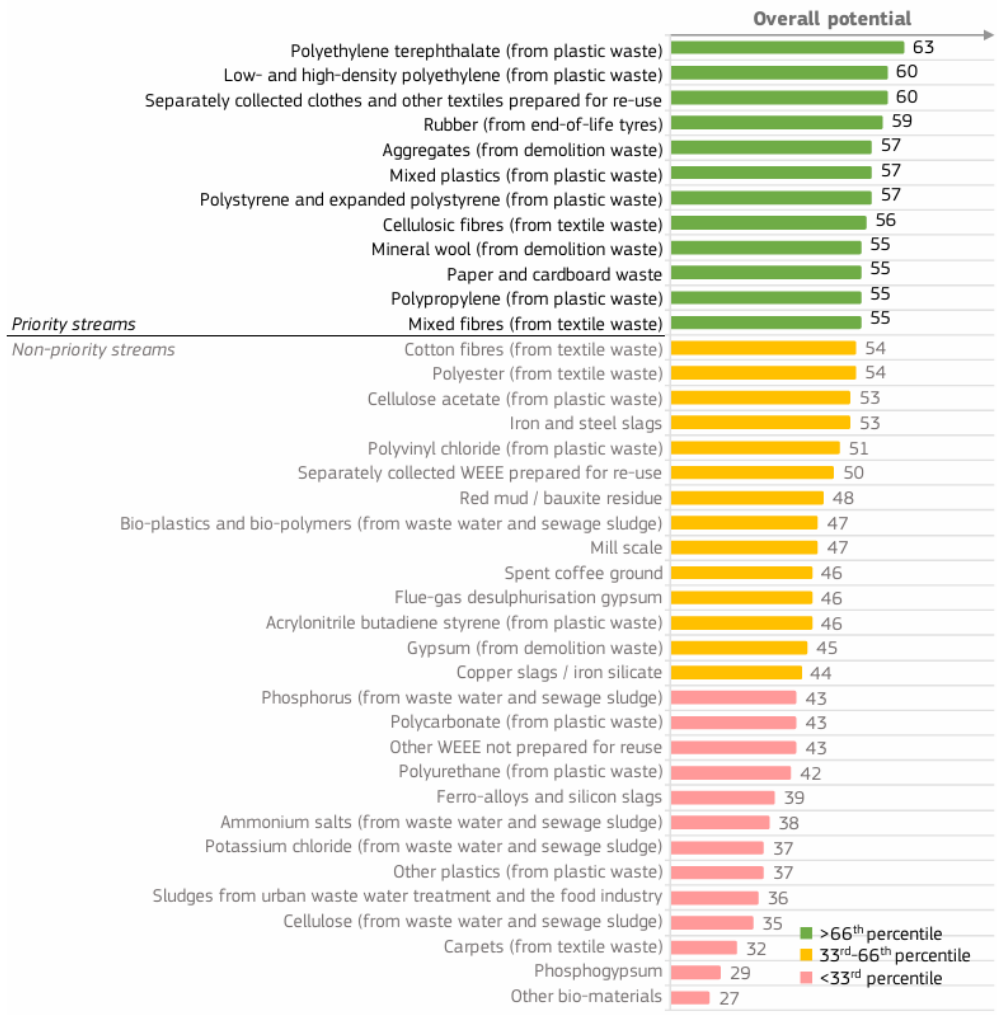
Two textile waste streams (highlighted in yellow in **Figure 3**) are just below the cut-off line of priority streams:

— cotton fibres (from textile waste);

— polyester fibres (from textile waste).

The waste stream *carpets (from textile waste)* is at the bottom of the ranking (highlighted in red in **Figure 3**).

Figure 3. Final ranking of the candidate streams for which to develop further EU-wide EoW or by-product criteria based on their overall potential



Source: Orveillon et al., 2022

1.4. Objectives and possible impacts

This study aims to deliver **technical proposals for EU-wide EoW criteria for textile and textile-related waste**. In particular, the proposals focus on **recycling** (see definition in Article 3(17) of the WFD and Section 4.2.4 of this report).

Possible impacts of the implementation of EU-wide EoW criteria for recycling of textile and textile-related waste are as follows:

— **Environmental and human health impacts**:

- By promoting recycling, EoW criteria contribute to diverting textiles from landfills and incineration, therefore reducing greenhouse gas emissions.
- By extending the life cycle of textile fibres, EoW criteria contribute to reducing the demand for virgin materials, possibly resulting in energy and materials savings.
- Through the identification of contaminated textiles, EoW criteria prevent the release of harmful chemicals into the environment. They also contribute to pushing manufacturers to phase out chemicals upstream.
- By better defining sorting operations, EoW criteria improve the purity of waste streams sent to recycling, enhancing the efficiency and quality of recycled materials.

— **Economic/market impacts**:

- By facilitating cross-border trade of recycled materials, EoW criteria contribute to the transition to a circular economy market in the EU and globally.
- The implementation of EU-wide EoW criteria is expected to provide support to recycling markets. By granting secondary materials a clear legal status as products, administrative costs associated with waste shipments are reduced. Transporting materials recognised as products is less burdensome than shipping waste under stricter regulatory frameworks and to a limited number of licensed facilities.
- EU-wide EoW criteria simplify compliance across Member States, reducing administrative burdens and fostering a level playing field.
- Despite having to face higher compliance costs, recyclates may be sold at higher prices, as product status adds market value.
- EoW criteria for recycling contribute to increase the quality of recycled materials. High-quality recycled materials produced in the EU might become competitive in international markets.
- By providing clarity about the legal status of output materials of recycling, EoW criteria incentivise the development of a well-established EU textile recycling market. They could create a clearer pathway for investments in textile recycling.

— **Legal impacts**:

- A harmonised definition of EoW status reduces the risk of facing divergent national interpretations.
- The criteria support the implementation of Article 22a, 22c and 22d of the WFD concerning EPR for textiles and management of used textiles and textile waste.
- The EoW criteria support the Circular Economy Action Plan and the EU Strategy for Textiles by promoting high-quality recycling.

1.5. Structure of this document

This document is structured as follows:

— Chapter 2 provides a brief overview of the textiles value chain and includes relevant definitions;

— Chapter 3 presents an overview of textile production and the EU textile market;

— Chapter 4 contains relevant background information on textile waste, including definitions and a detailed overview of the textile waste management chain;

— Chapter 5 contains additional information that is key for the development of EoW criteria, namely market-related aspects, standards and relevant legislative aspects, environmental and human health impacts, complemented by a mapping of existing EoW criteria in Member States;

— Chapter 6 presents the draft proposals for EU-wide EoW criteria for recycling;

— Chapter 7 presents the conclusions of this work.

2. Methodology for the development of technical proposals

The project was launched on 19 April 2023 with a kick-off meeting hosted by the Joint Research Centre (JRC). The scope of the meeting was to present the initial scope for the development of EoW criteria for textile waste and to present preliminary data gathered through a short stakeholder survey.

The work was initially focused on preparing for re-use and recycling.

A second workshop was held on 25 October 2023, to present the consolidated scope and preliminary findings and to launch the first consultation phase.

The first consultation round (October 2023 to January 2024) aimed at gathering data on collection, sorting and recycling practices as well as opinions about possible requirements on the five main pillars of EoW criteria, i.e. input materials, processes and techniques, output materials, quality management system and provision of information.

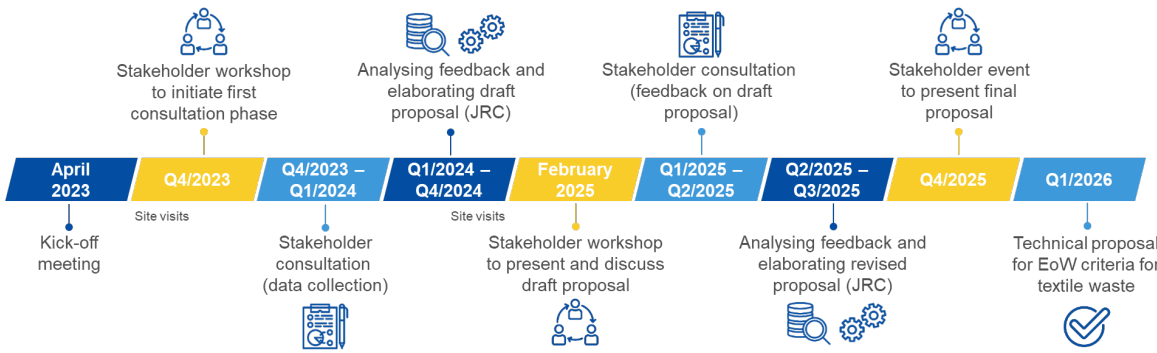
The preliminary proposals were presented to stakeholders on 17 and 18 February 2025, when the second consultation round (February to April 2025) was launched. Stakeholders were asked to fill in an extensive questionnaire with targeted questions and to provide arguments in favour of or against the draft proposals for EoW criteria for preparing for re-use and for recycling. They were also asked to provide additional evidence to support the finalisation of the work.

It is noteworthy that, in the project's latest phase, the criteria for preparing for re-use were extended with dedicated requirements for remanufacturing, an addition that aligns with the proposed amendment to the WFD, which gives remanufacturing priority over recycling.

After a thorough analysis of the feedback received, complemented by site visits, bilateral meetings and in-house research, the JRC drafted the technical recommendations outlined in this report that were presented at the final stakeholder events on 3 and 4 December 2025. These consist of two sets of criteria: one for preparing for re-use and remanufacturing (outlined in Pérez Arribas et al. (2026)) and one for recycling (outlined in this report).

Figure 4 provides an overview of the project timeline and methodology.

Figure 4. Project timeline and methodology



Source: own elaboration

3. Background information on textile products

This chapter provides a brief description of textile production, from the harvesting and production of fibres up to the finished textile product and the relevant definitions. An overview of the market, trade flows and use of textile products in the EU is also given.

3.1. Textiles production

3.1.1. Textile fibres

The textile value chain starts with the harvesting and production of raw fibres (see **Figure 5**).

Natural fibres are categorised into (Roth et al., 2023; Sajn, 2019; Textile_Exchange, 2022):

— animal origin (protein such as wool, hair, silk fibres);

— vegetable origin (cellulose such as bast, leaf and seed fibres);

— mineral origin fibres (e.g. asbestos).

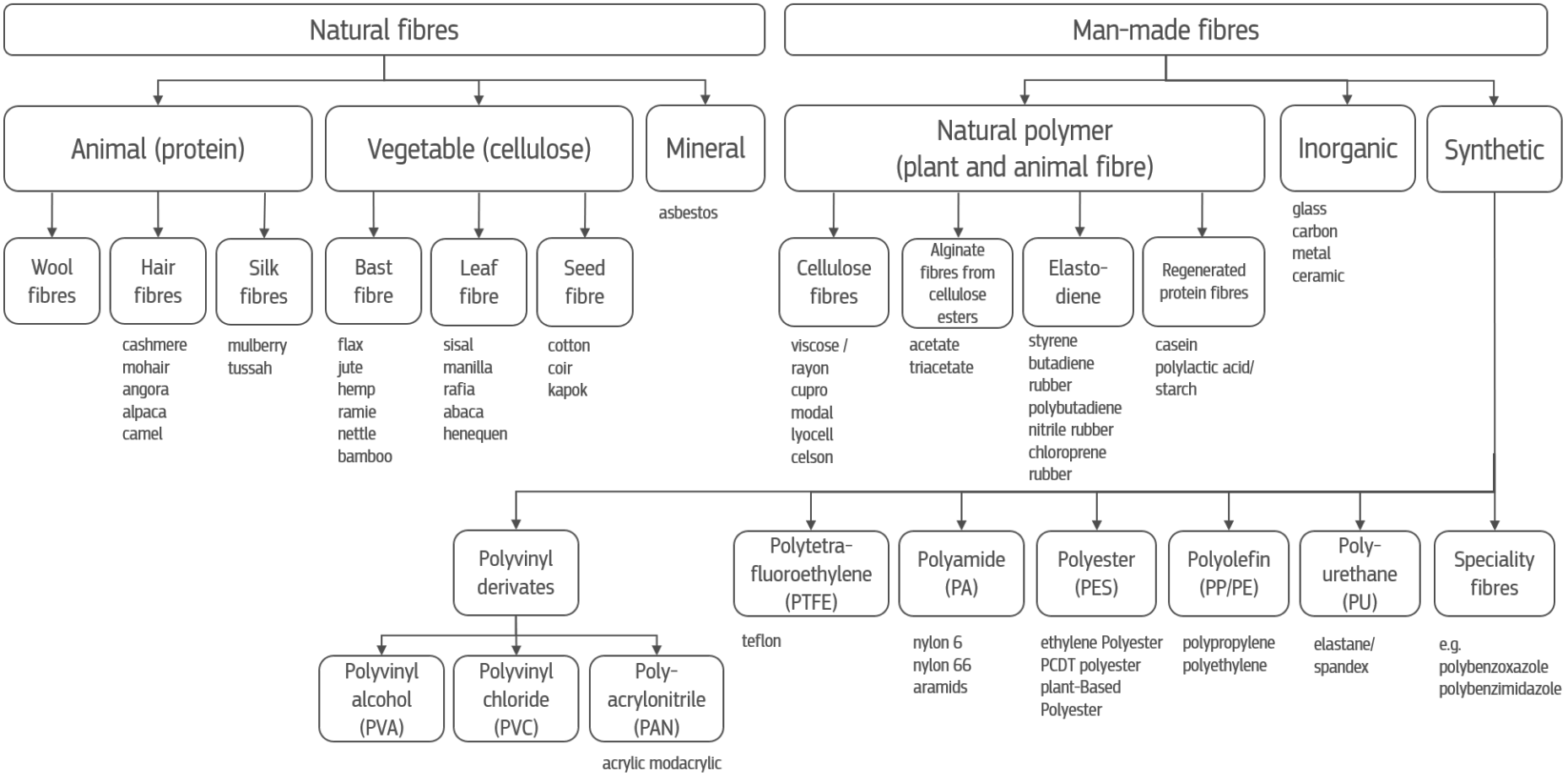
Man-made fibres include (Roth et al., 2023; Sajn, 2019):

— natural polymer origin (plant and animal fibre such as cellulose, alginate, elastodiene and regenerated protein fibres);

— inorganic origin (e.g. glass, carbon, metal, ceramic, as well as fibreglass and gold fibre);

— synthetic origin (petrochemical) (e.g. polyurethane, polyolefin, polyester, polyamide).

Figure 5. Overview of textile fibres



Source: own elaboration, based on Mather et al., 2023; Roth et al., 2023; Sajn, 2019; Textile_Exchange, 2022; Tobler-Rohr, 2011

In Regulation (EU) No 1007/2011 on textile fibre names and related labelling and marking of the fibre composition of textile products, known as the **Textile Labelling Regulation**, "*textile fibre means either of the following:*

(i) a unit of matter characterised by its flexibility, fineness and high ratio of length to maximum transverse dimension, which render it suitable for textile applications;

(ii) a flexible strip or tube, of which the apparent width does not exceed 5 mm, including strips cut from wider strips or films, produced from the substances used for the manufacture of the fibres listed in Table 2 of Annex I and suitable for textile applications."

In Annex I to the Textile Labelling Regulation a detailed list of textile fibre names is given (50 in total) (see **Annex 2** of this document).

As stated by Textile Exchange (2023), polyester holds the top position in worldwide fibre production (54%), with cotton coming in second (27%) and cellulosic fibres accounting for a smaller share (7.3%). Fibre blends, such as poly-cotton or elastane combinations, which are popular in the apparel industry, pose challenges for recycling.

3.1.2. Finished textile products

Fibres are prepared for the **manufacturing of yarns** which are produced through spinning. **Production of fabric** consists of different methods, e.g. weaving, knitting and non-weaving. Finishing steps include dyeing, printing and coating, among others. Fabric is then converted into the **finished textile product** (e.g. clothing) (Roth et al., 2023).

In the **Textile Labelling Regulation** textile products are defined as "*any raw, semi-worked, worked, semi-manufactured, manufactured, semi-made-up or made-up product which is exclusively composed of textile fibres, regardless of the mixing or assembly process employed*". The Regulation also specifies that "*the following products shall be treated in the same way as textile products:*

(a) products containing at least 80% by weight of textile fibres;

(b) furniture, umbrella and sunshade coverings containing at least 80% by weight of textile components;

(c) the textile components of:

(i) the upper layer of multi-layer floor coverings;

(ii) mattress coverings;

(iii) coverings of camping goods;

provided such textile components constitute at least 80 % by weight of such upper layers or coverings;

(d) textiles incorporated in other products and forming an integral part thereof, where their composition is specified".

Textile products can also contain *non-textile parts of animal origin*, such as down, feathers, leather and bones.

Textile products can be classified into **five main categories**:

— **Clothing** (also known as garments): designed to be worn on the body for different purposes (e.g. covering, protecting, or decorating the body).

— **Footwear**: all articles with applied soles designed to protect or cover the foot, including parts marketed separately, as defined in the EU Directive on Footwear Labelling (94/11/EC)[29]. Protective footwear belongs to the technical textiles/footwear category as per Regulation 2016/425/EU[30].

— **Clothing accessories**: items made of textiles or non-textile materials used to fulfil different practical or decorative functions.

— **Home/interior textiles**: textiles used in households for home furnishing as well as in accommodation services.

— **Technical textiles**: engineered fabrics that prioritise function over aesthetics, meeting strict technical and quality standards for specialised uses. They span many sectors and are grouped into subcategories such as:

- AgroTech or Agro Textiles – used in agriculture, aquaculture, horticulture and forestry (e.g. crop protection nets);
- BuildTech – used in building and construction (e.g. architectural membranes);
- Geotech or Geotextiles – used for soil and civil engineering applications (e.g. separation layers, filters);
- InduTech or Industrial Textiles – used in manufacturing sectors for specific purposes (e.g. filtration, cleaning);
- MobilTech – used in automobiles, railways, aerospace, etc. (e.g. seat upholstery, seatbelt, carpets, airbags);
- EcoTech – used for environmental protection (e.g. landfill waste management).

Personal Protective Equipment (PPE) is included in the technical textiles category and encompasses products specifically designed and certified to protect the wearer against identifiable occupational health and safety risks and is regulated under Regulation (EU) 2016/425. **Protective footwear** is considered PPE according to Regulation (EU) 2016/425.

Workwear with advanced technical features, while not always certified as PPE, is also classified as a technical textile because it is designed for demanding professional conditions and incorporates functional features such as weather-resistant or water-repellent coatings, thermal

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29 Directive 94/11/EC of European Parliament and Council of 23 March 1994 on the approximation of the laws, regulations and administrative provisions of the Member States relating to labelling of the materials used in the main components of footwear for sale to the consumer (OJ L 100 19.4.1994, p. 37): http://data.europa.eu/eli/dir/1994/11/2013-07-01

30 Regulation (EU) 2016/425 of the European Parliament and of the Council of 9 March 2016 on personal protective equipment and repealing Council Directive 89/686/EEC (OJ L 81, 31.3.2016, pp. 51–98): http://data.europa.eu/eli/reg/2016/425/oj

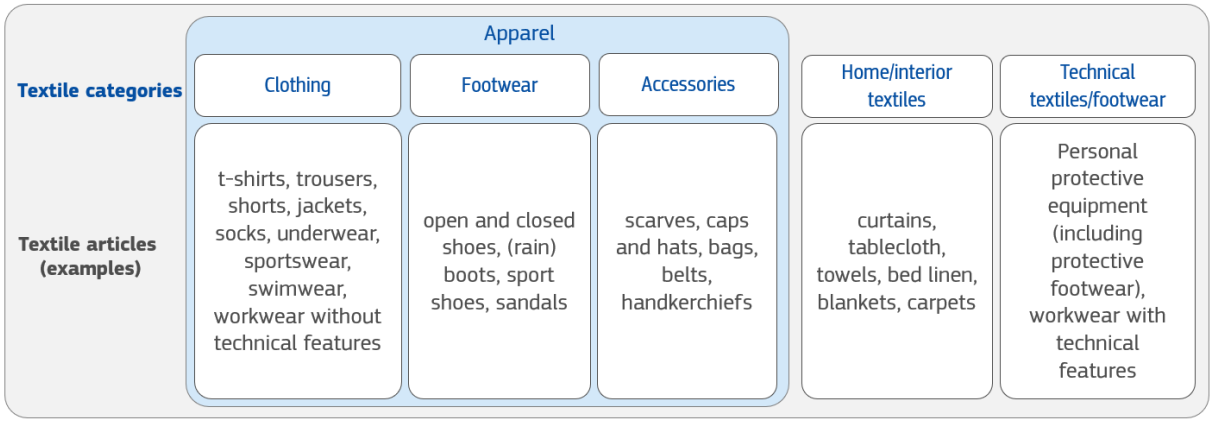
insulation, anti-static or flame-retardant treatments, abrasion-resistant reinforcements, chemical-resistant finishes. These features may be identified by visible cues (reinforced elbows/knees, special textures, ventilation panels) or by product documentation (specifications, care labels, certifications). In contrast, standard uniforms or basic workwear lack measurable performance specifications and provide only basic coverage or durability.

Certain textile products cannot be classified solely by end use; their classification depends on design intent and functional performance:

- **Workwear without advanced technical features** (standard uniforms, basic service clothing) is considered regular apparel because it provides only basic protection and comfort, without task-specific performance metrics.
- **Raincoats** and **sportswear** are not technical textiles despite functional finishes; they are intended for consumer comfort and recreation, not for defined professional or industrial roles.

Thus, technical textiles are distinguished by purpose-driven design and verified performance for specific operational contexts, whereas conventional apparel and recreational garments prioritise comfort and aesthetics.

Figure 6. Textile categories and exemplary articles



Source: own elaboration

An extensive list of textile items is given in the Eurostat Prodcom database (statistics on the production of manufactured goods)[31] NACE Rev. 2 sector 13 (Manufacture of textiles), sector 14 (Manufacture of wearing apparel) and sector 15 (Manufacture of leather and related products).

31 EUROSTAT - Statistics on the production of manufactured goods: https://ec.europa.eu/eurostat/cache/metadata/en/prom_esms.htm

3.2. EU textiles market, use and trade flows

The EU plays an important role in the global textiles industry, in terms of import as well as production and export of textile fractions and final products (Köhler et al., 2021).

Huygens et al. (2023) estimated that **12 Mt/year** of textiles are **placed on the EU market**. Around 3 Mt/year are produced in the EU. The production of clothing and accessories made of textiles is predominant in the EU textiles manufacturing industry. Footwear is the second largest subsector in terms of production (EC, 2021). The share of technical textiles is rapidly increasing, due to growing demand for industrial applications, such as healthcare and automotive (EURATEX, 2022). The production of household textiles is also growing (EC, 2021).

According to Huygens et al. (2023), **13.5 Mt/year** of fibres, yarns, fabrics and finished products are **imported into the EU**. One third of the imported textile products originates from China. Other relevant suppliers are Bangladesh, Turkey and India (EURATEX, 2022). The EU is the second biggest exporter of textiles[32] after China, with a market share of 27.5% in 2021 (Statista, 2022). Textile products manufactured in the EU are exported mostly to Switzerland, the United Kingdom and the United States, followed by China, Russia and Turkey (EURATEX, 2022).

EEA (2023b) reports **14.9 kg/capita** of **textile consumption**, including clothing, household textiles and footwear.

Private households are the main consumers of clothing and household textiles. A smaller share of the apparent consumption[33] of textiles is attributed to government and businesses (e.g. workwear, uniforms for employees, bed linen for hospitals and hotels etc.) (Köhler et al., 2021).

Köhler et al. (2021) estimated that in 2020 the apparent consumption of clothing and household textiles in the EU-27 was equal to 9.92 kg/capita and 2.36 kg/capita, respectively.

[32] Including precursors (e.g. fibres, yarns, fabric), textile items and used clothing.

[33] Apparent consumption means domestic retail and textiles placed on the market for business-to-business applications. It is calculated as the sum of EU production plus imports minus exports of finished textiles.

4. Background information on textile waste and used textiles

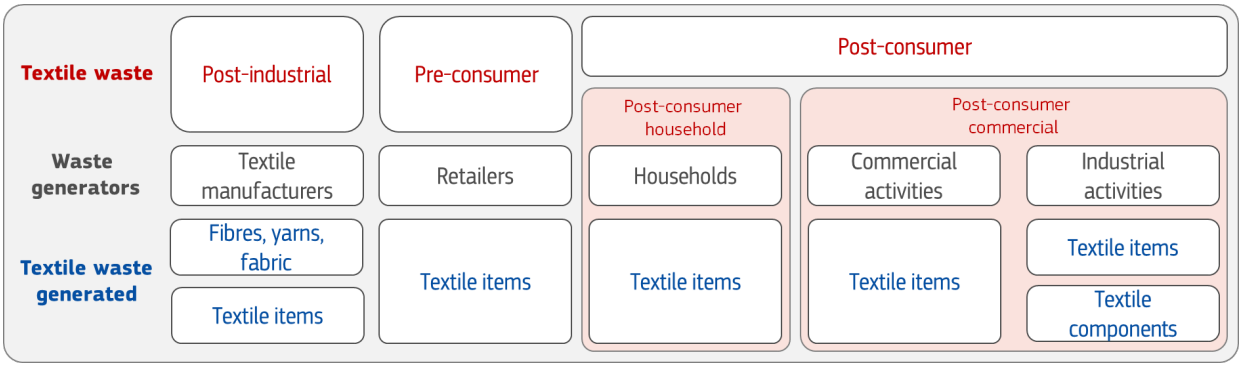
This chapter provides in-depth background information on textile waste, including classification, composition and suitability for recycling. The different phases of the textile waste value chain, with the relevant definitions, are presented.

The findings presented in this section come from a literature review carried out in-house by the JRC, complemented by information provided by stakeholders.

4.1. Classification of textile waste and suitability for recycling

Textile waste[34] can be classified into post-industrial, pre-consumer and post-consumer textile waste (see **Figure 7**).

Figure 7. Classification and sources of textile waste – including textile, textile-related and footwear products



Source: own elaboration

A more detailed description of the origin, composition and suitability of those waste types for recycling is given in the following sections.

4.1.1. Post-industrial textile waste

Post-industrial textile waste is generated in the manufacturing of fabrics and textile products (see **Table 3**). It is generated as a result of technical features of the manufacturing process (e.g. cutting, roll ends), inaccurate resource planning (e.g. excess fabric) or production errors (e.g. defective or damaged fabric) (Aus et al., 2021).

This constitutes the **preferred feedstock for mechanical recycling**, given its characteristics (clean) and known chemical composition (Huygens et al., 2023).

[34] Textile waste includes **textile, textile-related and footwear products**, as defined in the proposal for a targeted amendment of the WFD: https://environment.ec.europa.eu/publications/proposal-targeted-revision-waste-framework-directive_en

Table 3. Overview of post-industrial textile waste from different stages of manufacturing

Industry	Input Materials	Types of Waste
Ganning	Cotton crops	Cotton lint
Spinning	Cotton and other natural fibres, synthetic fibres	Cotton lint, damaged yarn, unfinished cones, pneumafil
Knitting/weaving	Natural and synthetic yarn	Fly fibre, scrap yarn, unfinished fabric
Wet processing	Greige/unfinished fabric	Rejected coloured fabric, excess finished fabric
Apparel	Finished fabric	Fabric cut pieces (cut-offs), excess development samples, excess apparel, defected textile items or rejects

Source: own elaboration, based on Khairul Akter et al., 2022

4.1.2. Pre-consumer textile waste

Pre-consumer textile waste is generated at retail level, including excess stock, returns and unsold goods (Huygens et al., 2023). According to recital 37 of Regulation (EU) 2024/1781 on Ecodesign for Sustainable Products (ESPR), unsold consumer product means any consumer product that **has not been sold including surplus stock, excess inventory and deadstock and products returned by a consumer** on the basis of its right of withdrawal in accordance with Article 9 of Directive 2011/83/EU or, where applicable, during any longer withdrawal period provided by the trader.

Returned and unsold products that are still functional may be redirected to discounts/outlet shops or jobbers[35] or may be donated. Damaged and defective products are typically discarded (Tom Duhoux et al., 2024).

As reported by Tom Duhoux et al. (2024), return rates for fashion and lifestyle products are higher than those of other product categories, due to the fact that relevant parameters cannot be evaluated when purchasing products online (e.g. general appearance, fit and size). Once the item is returned, it is checked in return centres, and it can be restocked at full price (if it is fully functional and not faulty) or at a reduced price (if minor repairs or cleaning were necessary or if it is obsolete). If the product is faulty but still sellable it may be redirected to the secondary market (charity or jobbers), while if it is not sellable it may be discarded of (Tom Duhoux et al., 2024).

As mentioned in Section 1.1, Article 25(1) of the ESPR prohibits the **destruction of unsold consumer goods**, including apparel, clothing accessories and footwear (see **Annex 1**). The ban is meant to reduce the environmental impact of textiles by reducing the generation of waste and disincentivising overproduction.

Destruction is defined in Article 2(34) of the ESPR as "*the intentional damaging or discarding of a product as waste with the exception of discarding for the sole purpose of delivering the discarded*

[35] Jobbers are companies that deal in clothes and textiles but not necessarily for sale to consumers.

product for preparing for re-use, including refurbishment or remanufacturing operations". Thus, destruction covers recycling, other recovery or disposal, while preparing for re-use, including refurbishment and remanufacturing, is not considered destruction.

Article 25(5) of the ESPR empowers the Commission to adopt delegated acts to set out derogations for products listed in Annex VII to the Regulation, when it can be justified for the following reasons:

> *"(a) health, hygiene and safety reasons;*
> *(b) damage caused to products as a result of their handling, or detected after products have been returned, which cannot be repaired in a cost-effective manner;*
> *(c) unfitness of products for the purpose for which they are intended, taking into account, where applicable, Union and national law and technical standards;*
> *(d) non-acceptance of products offered for donation;*
> *(e) unsuitability of products for preparing for reuse or for remanufacturing;*
> *(f) unsaleability of products due to infringement of intellectual property rights, including counterfeit products;*
> *(g) destruction is the option with the least negative environmental impacts."*

Additional details on the derogations may be found in Article 2 of the Delegated Act setting out derogations from the prohibition of destruction of unsold consumer products[36].

Hence, unsold goods and returns should not be destined directly to recycling. However, **recycling could represent a viable alternative if the items are deemed unsuitable for preparing for re-use or remanufacturing.**

4.1.3. Post-consumer textile waste

Post-consumer waste is generated by end-consumers of a material stream. It consists of textile, textile-related and footwear waste disposed of by **households**, **commercial** and **industrial** activities. It is therefore classified into post-consumer household textile waste, post-consumer commercial textile waste and post-consumer industrial textile waste.

Post-consumer household textile waste is generated at household level and can contain the following textile categories and items:

- clothing (e.g. t-shirts, trousers, underwear, sportswear);
- clothing accessories (e.g. scarves, caps, bags);
- footwear (e.g. boots, sport shoes, sandals);
- home/interior textiles (e.g. household cleaning items, household carpets, bedding, toilet and kitchen linen and towels, curtains, soft toys);
- other: items partially or fully made of textile materials, not classified under any of the categories above (e.g. packaging - nonwoven fabrics, bags, sacks).

36 EUR-Lex - Ares(2025)5207942 - EN - EUR-Lex

These fractions are collected through collection schemes set up by municipalities, charity organisations, waste management organisations, second-hand shops and retailers (Huygens et al., 2023).

Post-consumer commercial textile waste is textile, textile-related and footwear waste that arises from any **commercial or industrial activities** such as hospitality (accommodation and food service activity), healthcare (human health services and residential care activities), agriculture (e.g. crop protection, greenhouse covers, shade nets, and anti-hail nets, crop storage, and silage wraps), environmental (production of filters, membranes, barriers for water treatment, air purification, waste management), and construction (e.g. isolation, geotextiles for erosion control, drainage, soil reinforcement, tensioned fabric structures such as tensile roofs, membrane structures, and canopies). Technical textiles also belong to this category (e.g. textiles for filtration, professional cleaning items, workwear with highly technical features, personal protective clothing and footwear).

Textile waste from accommodation and food services (interior textiles, e.g. bed linen, curtains, tablecloths) is similar to textile waste generated by households but is often provided in larger and more homogeneous volumes, which can make it suitable for recycling when re-use is no longer possible.

For certain post-consumer household and post-consumer commercial waste streams, textiles do not constitute the primary components. We refer to these waste streams as '**textile fractions** separated from post-consumer household and post-consumer commercial waste streams that are **not primarily made up of textiles**'. Typical examples of these waste streams include footwear, vehicles and other transportation systems (seat covers, carpets, floor mats, headrest covers, upholstery, filling/stuffing, airbags, safety belts, sound insulation) or construction and demolition waste. To render these waste streams suitable for recycling, a pre-treatment process must be employed to separate the textiles from the other waste materials.

Post-consumer textile waste **may qualify for recycling**, depending on its quality and fibre composition. The fibres that are most commonly found in post-consumer textile waste are cotton, polyester and polyamide, making up 70% of the composition. Other fibres with a smaller share in the composition are wool, viscose, polypropylene and acrylic fibres, among others. In total, 11% of the textile waste mass is represented by non-textile materials (e.g. leather and metals in zippers) (Huygens et al., 2023).

4.2. Generation and management of textile waste and used textiles in the EU

Estimates on the amount of textile waste generated vary significantly depending on the scope and the selected system boundary of the study.

Huygens et al. (2023) report that the amount of **textile waste in the EU market** is estimated to be around **12 Mt/year**. The study covers post-consumer waste (10.9 Mt/year), post-industrial waste (1.34 Mt/year) and pre-consumer waste (0.33 Mt/year).

Separate collection of **post-consumer textile waste** accounts for approximately **2.4 Mt/year**, as estimated by Huygens et al. (2023). Clothing, accessories, footwear and home/interior textiles, in

total covering 57% of post-consumer textile waste, are the dominant fractions of the separately collected post-consumer waste.

About **0.33 Mt/year** of separately collected textile waste is **imported** into the EU. Based on the data from Huygens et al. (2023), a **separate collection rate**, relative to the total textile waste generation including commercial and bulky textile waste, of around **20%** is calculated.

Moreover, of the amount of separately collected textiles, **1.77 Mt/year** are **sorted**. Existing sorting capacities in Europe are likely below the required capacities to sort this amount (Huygens et al., 2023). According to Dahlbom et al. (2023), the textile sorting capacity in the EU is 560 000 tonnes/year. A large amount of collected textiles is exported and sorted in third countries (van Duijn et al., 2022).

Separately collected textile waste is sorted and then redirected to re-use (after preparing for re-use) or recycling, either within or outside the EU. Innovative approaches can sort textiles present in mixed municipal solid waste, to be recycled after a cleaning step. Textile fractions that are neither suitable for re-use nor for recycling may be diverted to landfills or incineration.

Huygens et al. (2023) report that the **recycling capacity** for the reference year 2019 **in the EU** was **0.75-0.80 Mt/year** (considering only post-consumer textile waste). Only around 6% of generated textile waste is recycled in the EU. Closed loop **fibre-to-fibre recycling** covers less than **0.07 Mt/year** (or 0.56% of textile waste) (Janmark et al., 2022).

A brief overview of the management chain for used textiles and textile waste is provided in the following sections, with a focus on collection, sorting and recycling. While some practices described may be common in certain countries, they should not be taken as representative of procedures across the entire EU.

4.2.1. Collection and preliminary sorting

As per the definition in Article 3(10) of the WFD, '**collection**' *means the gathering of waste, including the* ***preliminary sorting*** *and* ***preliminary storage of waste*** *for the purposes of transport to a waste treatment facility*.

Furthermore, according to Article 22d of the WFD: '*Separately collected used and waste textile shall be subject to a* ***professional screening*** *at the* ***separate collection point or the sorting facility*** *to identify and remove non-target items or materials or substances that are potential sources of contamination*.'

This **preliminary sorting** during collection serves as a filter, ensuring that only suitable textile items are accepted as feedstock for the subsequent sorting process. The preliminary sorting takes place at collection points, where drivers manually empty containers into trucks. At this stage, drivers pack clothes in plastic bags to preserve their potential reusability and carry out a basic visual check, rejecting clearly non-reusable materials. This process also allows heavily soiled items, which may be directed to recycling or energy recovery, to be identified, while non-textile items such as toys, packaging or electronic devices are separated.

Article 3(11) of the WFD defines '**Separate collection**' as *the collection where a waste stream is kept separately by type and nature so as to facilitate a specific treatment.*

Separate collection of textile waste is already in place in most Member States. However, some countries have a more established history of separate collection than others, as shown in EEA (2024c) where around 10 countries already had mandatory separate collection before the EU-wide obligation set by the WFD. Waste collection competencies are regionalised in some countries meaning that the textile items that are collected could be for re-use purposes, for recycling or for both, depending on the region or municipality in which the collection takes place. Additionally, within the same country, waste collection may differ in smaller urban settlements compared to more populated areas.

With the obligation for Member States to set up separate collection systems for textile waste as of 1 January 2025 established in the WFD, the markets for textiles prepared for re-use and for recycled textiles will be stimulated and an increased amount of textile waste available for re-use or recycling, particularly textile waste from households, is expected.

EPR schemes

Some Member States such as France, the Netherlands and Hungary already have in place mandatory Extended Producer Responsibility (EPR) schemes for textiles. In the case of France, accessories and technical textiles for instance are allowed to be accepted as feedstock in the sorting facility. However, sorters do not receive any support from the EPR scheme to sort these types of textiles. Nevertheless, it should be noted that the EPR scheme does not set restrictions on sorting of products in sorting facilities. It is also worth noting that the EPR established in France is not fully aligned with the new provisions laid down in the amended WFD, as it was established before those new provisions entered into force.

As mentioned above, Article 22a of the amended WFD lays down the mandatory EPR obligations for certain textile, textile-related and footwear products (specified in Annex IVc) to be established in Member States. The provisions apply to economic operators (EPR producers) making products available on the market of a Member State, including manufacturers, distributors, importers and online sellers. EPR for textiles makes it mandatory for producer organisations to implement extended producer responsibility obligations. The WFD clarifies that all relevant stakeholders, e.g. private or public waste operators, local authorities, re-use and preparing for re-use operators, social economy entities including local social enterprises, should be involved in the implementation of EPR. EPR shall cover the costs of i) collection and subsequent waste management operations; ii) a compositional survey of collected mixed municipal waste; iii) provision of information on sustainable consumption, waste prevention, re-use, preparing for re-use, recycling, other recovery and disposal; iv) data gathering and reporting to competent authorities; v) support to research and development to improve sorting and recycling.

4.2.2. Sorting

There is no legal definition for sorting in the WFD. However, in point 5 of Article 22(d) there are minimum criteria for sorting of used and waste textile, textile-related and footwear products.

Textiles sorting is a complex, multi-stage process that is mostly manual and not widely automated, as per the current state of the art. There are no established industry-wide sorting criteria or standards for uniform sorting fractions across Member States. Sorting is highly influenced by market demand and varies almost constantly.

Sorting can be classified into sorting for re-use operations, sorting for remanufacturing and sorting for recycling. In the following subsection sorting for recycling is described in more depth.

4.2.2.1. Sorting for recycling

There is no legal definition for sorting for recycling in the WFD. Sorting for recycling consists of the categorisation of textile items, based on material composition and/or colour, to create feedstock for recycling facilities. Sorting for recycling is performed to a great extent manually in countries where labour and warehousing costs are lower than in Europe (in particular Bangladesh, India and Pakistan). Automated technologies, such as optical sorting and fibre sorting, are being explored to improve efficiency and accuracy in this process.

Overall, the sorting process for textiles for recycling is highly dependent on the requirements of the subsequent recycling process. Most recyclers have specific input requirements in terms of fibre composition, sizing, colour (light or dark), contaminants, and disruptors, which are sometimes difficult to identify through manual sorting. Manual sorting is highly time-consuming and distinguishing between different fibres or fibre blends by visual inspection is very difficult or impossible, not least because labels indicating the fibre types are often missing.

An important challenge is also related to design aspects, as for mechanical recycling or other recycling technologies the fibres should be mono-fibre or rich in the defined targeted fibre (e.g. cotton, polyester, poly-cotton, nylon). Depending on the recycling process, non-textile materials such as metallic yarns, coatings, large rubber trims, foil-based prints and embroidery are removed. Textile recycling at large scale needs consistent quality and large volumes. Manual sorting of textiles cannot meet the market's need for quality-assured products (EU, 2024).

In recent years, **automated sorting** technologies have become available to the market and, according to Lanz et al. (2024), the automated process has the potential to provide cost-effective and accurate sorting of textile waste by material composition. The most promising automatic sorting technologies are:

- near-infrared spectroscopy (NIR) (with a technology readiness level (TRL) 9);
- visual spectroscopy (VIS);
- radio-frequency identification (RFID).

With NIR spectroscopy the material composition is analysed via interactions between electromagnetic waves and chemical structures of the textiles. NIR is the most common spectroscopic approach for automated textile sorting (Dahlbom et al., 2023). Knowledge of the fibre composition is crucial, especially for textiles destined for recycling, since there are requirements and limitations regarding the fibre composition of the recycling feedstock. Automated sorting enables categories to be discerned based on the composition: one single fibre (e.g. ~100% cotton or PES, with a certain tolerance for other fibres) or a mix of fibres (various ranges of blends such as 40% cotton / 60% polyester) (Cura et al., 2021; Dahlbom et al., 2023; Fibersort, 2024). Besides composition, the construction of a garment (lining fabric or certain finish) and production technique (knitted, woven, nonwoven) are also of importance.

To distinguish between colours, which is of importance for certain recycling processes, visual spectroscopy (VIS) is applied. With the combination of NIR and VIS technologies, an even more

precise and efficient sorting process is possible. This dual approach ensures that the sorted textile fractions meet the specific requirements for various recycling processes, enhancing the overall efficiency and quality of textile recycling.

RFID uses electromagnetic fields to automatically identify and track tags attached to textile waste containing information about their composition (Pagoropoulos et al., 2017). In comparison to the spectroscopy-based technologies, a RFID tag containing all relevant information has to be applied by the manufacturer at the production stage and needs to accompany the textile until its end-of-life phase (Pagoropoulos et al., 2017). An advantage of RFID compared, for example, to other recognition systems mentioned above, but also to a barcode or QR code, is that during reading, the tag can be in the middle of the garment and covered with various layers of fabric without affecting the quality of the reading.

The world's first full-scale automated textile sorting plant (Siptex (EU, 2024)) sorts materials including cotton, wool, polyester, viscose, polyamide, acrylic and customised products tailored to specific customer requirements. The textile recycling industry is currently seeking to process high-value fractions of textiles that meet specific compositional requirements and therefore asks mainly for cotton-rich textile fractions (up to 95% cotton content) and polyester-rich textile fractions (greater than 70% polyester content).

The main challenges for automated textile sorting are related to the following factors (Cura et al., 2021; SOEX, 2020):

— Material:

  - heterogeneity of the material flow and sizes coming from post-consumer textile waste;
  - carbon-containing pigments make the NIR detection of material composition impossible;
  - multi-layer textiles cannot be detected, as only the surface is scanned (e.g. outer layer is cotton and lining is polyester);
  - elastane is only detectable if the content is > 3-5%; at the same time elastane is a problematic polymer for recycling processes;
  - certain fibres cannot be differentiated (e.g. linen from cotton (both cellulose) or PA 6 from PA 6.6);
  - separation by colour only works for single-coloured textiles;
  - NIR penetrates the fabric when the fabric is too thin and results in a lack of recognition.

— Output quality:

  - a small percentage of impurities due to prints, labels, seams, pocket linings, etc. is unavoidable;
  - meeting the needs of chemical recyclers (high purity, light colours) is very challenging;
  - the post-consumer input "purity" is insufficient for some chemical recyclers' requirements.

— Technique:

  - heavy textiles cannot be handled by the picker or blowout system;
  - very small pieces are difficult to remove;
  - wet textiles will not be accurately scanned, as liquids interfere with the spectrum analysis;
  - textiles become entangled in containers and form a bundle after being tipped out onto the conveyor belt and thus complicate sorting.

4.2.3. Pre-treatment for recycling

There is no legal definition for 'pre-treatment for recycling' in the WFD.

Pre-treatment for textile recycling can be undertaken by various parties, including the sorter, specialised companies, or the recycler itself before the textile waste enters a recycling process. In reality, the different processing steps are often distributed among the various actors along the textile value chain. The specific pre-treatment steps are typically dictated by the requirements of the recyclers and may include:

— removal of non-textile parts (e.g. zippers, buttons, labels);

— removal of textiles with excess print or sequins;

— removal of process-interfering fibre types within a textile (e.g. elastane);

— disassembly;

— cutting to various sizes;

— shredding and tearing;

— washing to remove contaminants like dirt, oil or stains;

— compacting/densification (e.g. to textile pellets);

— extrusion (to increase the surface area of textile pellets);

— decolouring;

— drying.

It is worth noting that the list of pre-treatment steps is not exhaustive and they can be performed in varying sequences, depending on the specific requirements of the recycling process. The following sections make it clear that pre-treatment steps can also be carried out within the recycling process itself.

4.2.4. Recycling

A material classified as waste can only cease to be waste after it has undergone a recycling or other recovery operation, provided it fulfils the requirements of Article 6(1) of the WFD.

As per the definition in Article 3(17) of the WFD, *"'Recycling' means any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations".*

Mechanical recycling is identified as the main textile recycling technology applied to date for fibre-to-fibre recycling. Thermo-mechanical, physical and chemical recycling approaches are starting to emerge (Duhoux et al., 2021). Combined recycling technologies, in which for example mechanical recycling is a preparatory process for thermo-mechanical, physical or chemical recycling, are also emerging.

Recycling technologies require certain upstream processing such as sorting for recycling and pre-treatment to fulfil the requirements for the input material. For example, for mechanical recycling a manual sorting step with subsequent removal of non-textile materials (e.g. zippers and buttons made out of metals or hard plastics) could be sufficient. More complex recycling technologies, such as chemical recycling technologies, have been developed to recycle one specific type of fibres, only one polymer type or compatible polymer types, and in some cases specific blended fibres, such as poly-cotton.

Janmark et al. (2022) estimate that the recycling rate for textile waste could increase from around 10% in 2020 to 33% in 2030. This improvement could be achieved with the increasing amount of separately collected textiles, advanced and more accurate automated fibre sorting and the further development and upscaling of new recycling technologies.

The following sections provide an in-depth overview of mechanical, thermo-mechanical, physical and chemical recycling technologies, offering a comprehensive understanding of the processes, applications and limitations. This information is based on a thorough review of existing literature, supplemented by valuable insights and expertise shared by stakeholders during consultations and site visits.

4.2.4.1. Mechanical recycling

4.2.4.1.1. Cutting

One of the simplest material recycling processes involves removing any hard components and cutting textile waste with high liquid absorption capacities, such as cotton or cotton-blend fabrics (including those mixed with wool), into smaller pieces. New technologies cut the textiles to certain sizes and simultaneously remove zippers, buttons, collars, cuffs and other hard parts. These pieces can then be repurposed as cleaning rags or cloths, or even used to create cleaning mops (

Figure 8). To ensure the absence of elements that can scratch the surfaces to be cleaned, the cleaning rags can also pass through a metal detector. The recycled cleaning rags are utilised in many sectors including the automotive and mechanical engineering industry. For the production of cleaning rags, a standard exists (DIN 61650: 2005-04, see **Table 5**).

4.2.4.1.2. Mechanical transformation to pieces, shredded textiles, fibres, fluff and powder

With mechanical recycling the overall fibre properties, including material composition and colour, are usually retained[37], except for the fibre length and strength. Pre-treatment of sorted textile waste is the first crucial step and includes the removal of non-textile or heterogeneous components, such as zippers, buttons or labels (which represent 'disruptors' for recycling) and cutting into smaller pieces. These operations may represent ordinary industrial practices, thus not always being part of the recycling process. The main mechanical recycling process may include cutting, shredding and fraying to transform the textile waste into pieces, shredded textiles, fibres, fluff or even powder.

The recycling of fibres for yarn production can be considered a high-quality closed-loop recycling process as the yarn can be used for the production of the same type of items as those in which it originated.

However, mechanical recycling may lead to some damage to the fibres and to a reduction of the fibre length, staple length, yarn count or strength, depending on the technology used. To avoid this, shredding and fraying can be performed under wet conditions. Water or, in some cases, specific chemicals are used to soften the textile material in order to control fibre length and reduce the number of unopened fibres.

In the case of natural fibres, the fraction of spinnable fibres to be respun into yarn is 5-20%; for poly-cotton or polyester, the fraction of spinnable fibres is 25-55% related to the input textile waste. Polyamide for example is not recyclable at present through mechanical recycling processes (Duhoux et al., 2021). To overcome this issue, novel chemical treatment can be applied. This makes the fibres more resistant to the stresses applied during mechanical recycling and enables the recycler to obtain fibres with a length comparable to virgin fibres (Duhoux et al., 2021).

Further aspects that hamper the recycling of one woven product to another woven textile product is the widespread use of woven textiles with a wide variety of fibre compositions, and the inclusion of non-recyclable materials (such as elastane), dyes and other finishes which are not compatible with recycling.

Due to the challenges described above and to the inherent characteristics of the recycled fibres, blending with virgin fibres is often necessary to achieve the targeted strength and durability (Roos et al., 2019). For cotton for example, any amount of recycled cotton will impact the yarn and fabric properties such as evenness, strength and uniformity and the content of recycled fibres will depend on the end-use (Cottonworks, 2024).

[37] It is to be noted that currently mechanical recyclers lean towards using post-industrial textile waste as input for mechanical recycling, which is a relatively homogeneous feedstock, in terms of fibre composition and colour. The situation may change if more heterogeneous materials originating from post-consumer textile waste for example are used as feedstock.

During the mechanical recycling process, small particles of lower quality than fibres can be generated (the so-called fluff), in cases when the fibre shape is drastically altered (Roos et al., 2019). Fluff can be used, along with textile pieces and shredded textiles, as a raw material for the nonwoven industry for the production of different items, such as cleaning material (e.g. cleaning wool), loose or compacted insulation materials[38], stuffing, as well as objects with various shapes after pelletising and pressing.

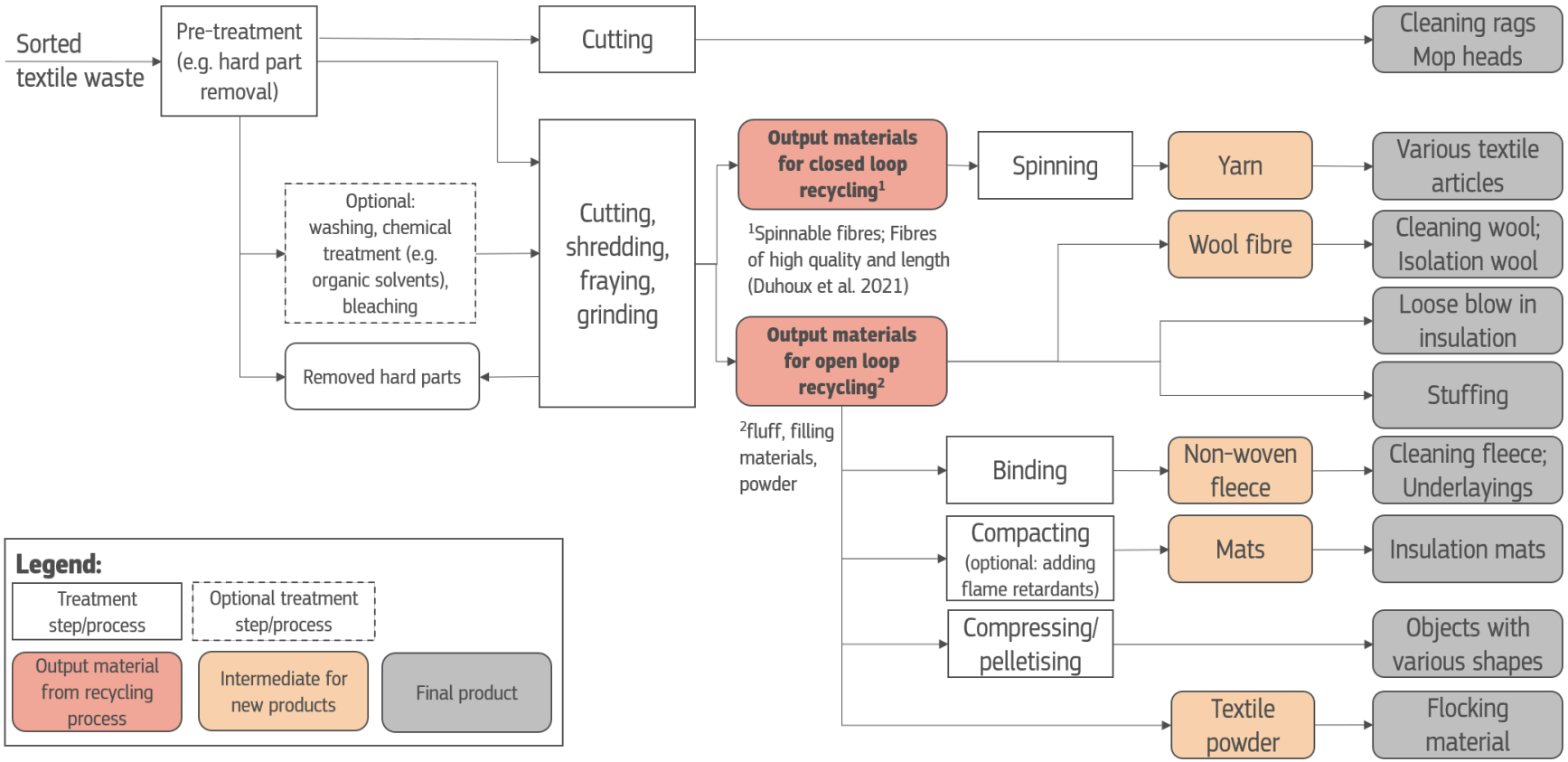
4.2.4.1.3. Advanced mechanical recycling

There is no legal definition for advanced mechanical recycling, but this terminology is used in this report. In addition to the -purely mechanical treatment steps described above, newer recycling approaches also expose the fibres under wet conditions to higher temperatures and various substances, in order to clean or even bleach the fibres. It is important to note that the applied temperatures and substances do not alter the fibre characteristics unlike thermo-mechanical, physical or chemical recycling technologies, which do (see the following subsections).

Figure 8 provides an exemplary process scheme for mechanical textile recycling, downstream processes and examples of final products based on recycled textiles.

[38] In the case of insulation mats, the fibres are compacted and treated for example with flame retardants to fulfil the criteria for fire prevention.

Figure 8. Exemplary process scheme for mechanical textile recycling, downstream processes and examples of final products based on recycled textiles (non-exhaustive)



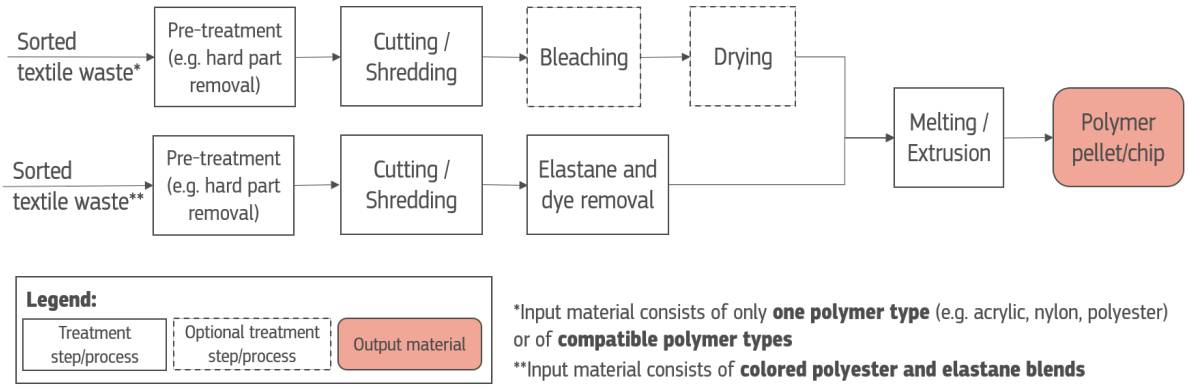
Source: own elaboration

4.2.4.2. Thermo-mechanical recycling

Thermo-mechanical recycling processes use heat to melt thermoplastic textile waste and recover polymers in the form of pellets or chips that can then be eventually further processed into fibres (see **Figure 9**). If needed, the textile waste is bleached before melting and extrusion to remove colours. Some of these recycling processes are not capable of removing unwanted substances or unwanted fibres, thus it is crucial that the input textile waste consists only of one polymer type (e.g. acrylic, nylon, polyester) or of compatible polymer types, to avoid issues during processing and to recover a polymer suitable for further processing.

Certain technologies even allow the input of dyed polyester-elastane blends. In this case a polyester purification step (i.e. elastane and dye removal step is applied to remove colour and elastane from the polyester prior to the melting and extrusion step (see **Figure 9**).

Figure 9. Exemplary process schemes for thermo-mechanical textile recycling



Source: own elaboration

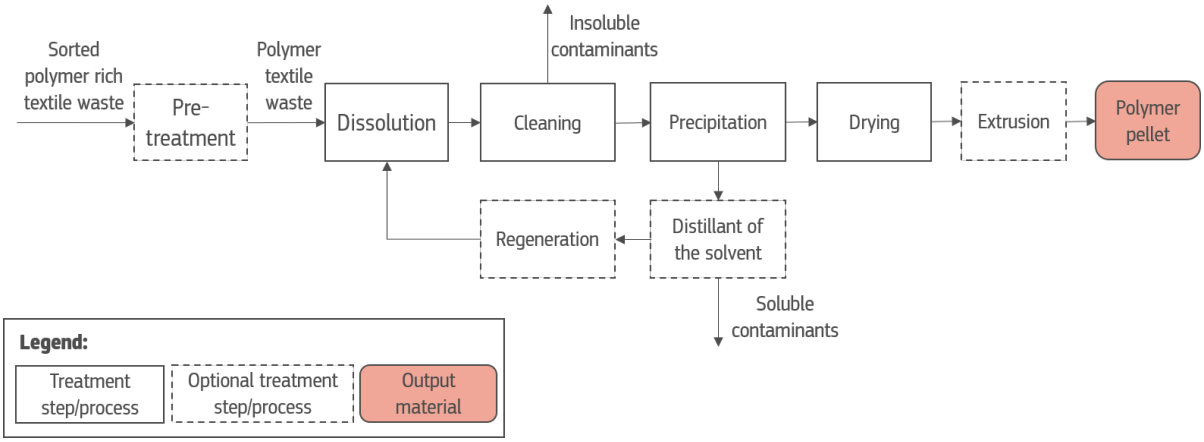
4.2.4.3. Physical recycling

Thermo-mechanical and physical recycling processes usually preserve the chemical structure of thermoplastic textile waste, allowing the recovered polymers to be used for new or similar applications. The most common physical recycling approach is so-called solvent-based recycling, also called dissolution recycling. Solvent-based processes have been developed, or are still under development, for the recovery of polymer-based textile waste (Klotz et al., 2024). These technologies are considered to be an effective way to recycle complex polymer-based textile waste that is difficult to recycle using traditional mechanical and thermo-mechanical recycling methods.

After pre-treatment of the input material, different technological approaches may be applied to change the material's physical state (Xu et al., 2025). Based on their polarity, the solvent molecules interact with the polymer macromolecules to form a polymer solution (Martinez Sanz et al., 2022). This allows an intensive purification of the polymer solution at the molecular level. This purification step is followed by precipitation and heating, to remove the solvent and return the entire polymer to the loop. Contaminants can be removed either at the cleaning step (insoluble contaminants) or after the distillation of the solvent for regeneration purposes (soluble contaminants). If no polymer degradation has taken place during the plastic's life, the recovered polymers may have properties

similar to virgin polymer materials. **Figure 10** gives an exemplary process scheme for physical recycling.

Figure 10. Exemplary process scheme for physical recycling of polymer-rich textile waste



Source: own elaboration

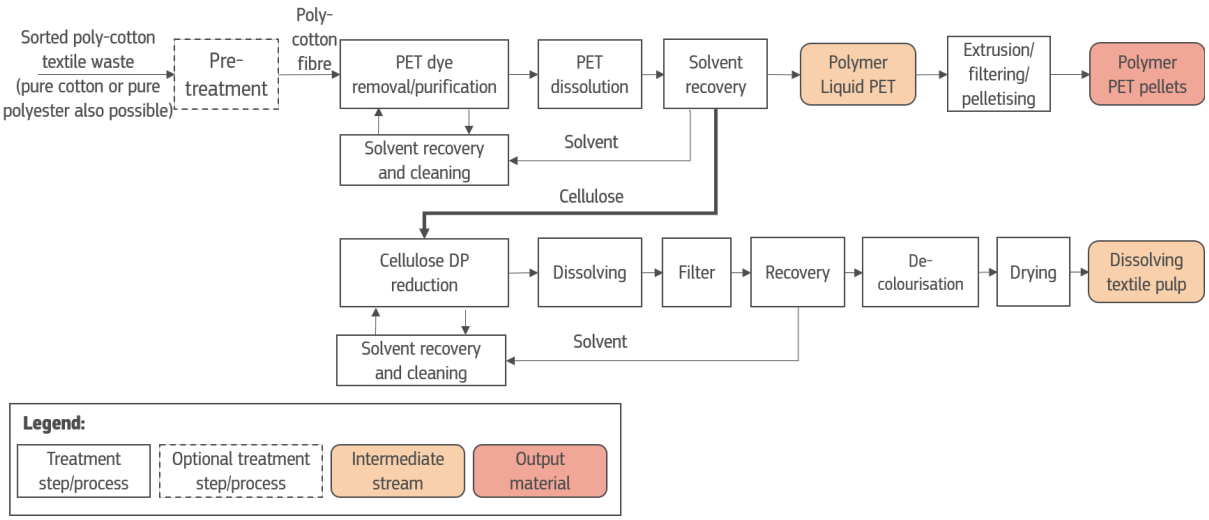
Physical recycling can also be a part of a more complex recycling process in the event that poly-cotton textile waste is used as input. In this case, the first step could be industrial washing with chemicals to remove contaminants and prepare the polyester and cotton for dissolution. Already this step is able to remove some colourants from the textile. The next step is dye removal using chemical solvents. After this step, the fabric is effectively decoloured (apart from pigments which are removed later). The next step is multistage sequential dissolution of polyester and cotton using a series of chemical solvents. The liquid polyester is processed via the polyester line (1) and the dissolved cotton ('cellulose dope') is processed via the cellulose line (2) (**Figure 11**):

(1) In the polyester line, the first step is filtration to remove any entrained undissolved components (e.g. carbon black) and selectively remove TiO_2 and catalyst. The liquid is transported into a solvent recovery unit where more than 95% of the chemical solvent is recovered and reused in the system. The **liquid PET** is upgraded to pre-spinning grade using a homogeniser. Finally, the hot liquid is extruded into a cold-water bath and pelletised for shipping. The PET pellets are a virgin-equivalent product which is ideally suited for the extrusion market.

(2) In the cellulose line, a filtration unit captures entrained undissolved components (e.g. elastane, PU). This is followed by precipitation and washing stages to recover more than 95% of the chemical solvent. The solvent is reused into the process. Following washing, the dissolving textile pulp is dried and bagged in powdered form. The dissolving textile pulp may be used for fibre spinning, cellulose derivatives (such as additives in construction/paint), and packaging.

The recovered dissolving textile pulp can be applied in a typical pulping and wet spinning process, while the PET polymers remain largely intact.

Figure 11. Exemplary process scheme for physical recycling as an integral part of poly-cotton-rich textile waste recycling



Source: own elaboration

4.2.4.4. Chemical recycling

Different chemical recycling approaches exist or are under development for different types of textile waste, as described in the following paragraphs. It should be noted that some of the processes described as chemical recycling are in effect a combination of recovery and recycling operations, as they may convert part of the input textile waste directly or indirectly to energy, e.g. via the production of fuels. In this report, we further divide chemical recycling into thermo-chemical and (bio-)chemical recycling.

4.2.4.4.1. Thermo-chemical recycling of various fibre types

A wide range of waste types can be used as feedstock for gasification and pyrolysis, as long as the waste consists of organic/carbon-based material. The principle is to produce a syngas or pyrolysis oil at high temperature in an environment depleted of oxygen.

Gasification to produce syngas

In this process, the textile waste is heated (700–900 °C) in a low-oxygen environment, causing it to break down into its basic chemical components (Saebea et al., 2020). Unlike natural gas, which is mainly composed of methane, syngas is a blend of gaseous components, potentially including carbon monoxide (CO), hydrogen (H_2), methane (CH_4), carbon dioxide (CO_2), steam (H_2O) and in lower amounts C_nH_m (ethylene (C_2H_4), ethane (C_2H_6), acetylene (C_2H_2), propane (C_3H_8)) (Khlifi et al., 2024; Lopez et al., 2018). Moreover, syngas also comprises impurities, including sulphur compounds, hydrogen chloride (HCl), volatile particles, alkali compounds and heavy metals, depending on the quality of input materials (Khlifi et al., 2024). These impurities are removed through a series of cleaning processes (e.g. filtration, scrubbing, and catalytic conversion). If burned, the syngas can be used to produce electricity and heat but is also a foundational element for the chemical synthesis of a variety of products such as hydrogen, methanol, dimethyl ether, jet fuels and alkenes, among others (Bolívar Caballero et al., 2022).

The first step to produce a textile from syngas is the conversion to methanol in a methanol synthesis reactor. From methanol, intermediates such as dimethyl terephthalate (DMT), acrylonitrile, adipic acid or polytetramethylene ether glycol (PTMEG), are produced for further transformation into different types of polymers for polymer fibre production. The following list provides examples of polymers that can be produced from the methanol-derived intermediates:

- Methanol → Dimethyl terephthalate (DMT): intermediate for production of polyester fibres;
- Methanol → Acrylonitrile: key monomer to produce acrylic fibres;
- Methanol → Adipic acid: key intermediate in the production of polyamide fibres (nylon);
- Methanol → Polytetramethylene ether glycol (PTMEG): key intermediate in the production of spandex fibres (elastane/Lycra).

Another option is to feed cleaned syngas into a Fischer-Tropsch process, where it undergoes a catalysed reaction to produce long-chain hydrocarbons, such as paraffins and olefins. These hydrocarbons serve as the foundation for the production of monomers, which are then utilised in subsequent re-polymerisation processes to generate new polymers.

As in the case of pyrolysis (see below), the gasification process and downstream processes generally see considerable fractions of the input material being converted directly or indirectly to energy, e.g. as process heat or through the production of (gaseous) fuels. For this reason, gasification of textile waste should also be seen as a step in a textile waste treatment process that typically combines elements of recycling and energy recovery to varying degrees (dual use).

Pyrolysis to produce pyrolysis oil

Pyrolysis is a process that involves breaking down organic compounds at high temperatures in the absence of oxygen, resulting in the production of liquid and gaseous fuels, as well as a solid residue (carbon black or activated carbon) (Anuar Sharuddin et al., 2016; Kunwar et al., 2016). The liquid pyrolysis oil is a complex mixture of various compounds. The composition can vary depending on the input material (e.g. organic fibres or polymer fibres), as well as the pyrolysis conditions, such as temperature, residence time and catalysts used. Thus, pyrolysis oil can contain phenolics, formed from the decomposition of cellulose and hemicellulose, ketones, esters or hydrocarbons such as aliphatic or aromatic hydrocarbons and various oxygen-, nitrogen- and sulphur-containing compounds.

After oil fractionation and/or purification steps, lighter pyrolysis oil fractions are sent to a steam cracking process where the oil is broken down into smaller molecules, including various olefins and aromatics (Shah et al., 2023).

To produce new polymers, the smaller molecules from the cracker serve as the building blocks for the production of monomers (e.g. ethylene, propylene) and subsequently for polymers. In many cases, however, pyrolysis oil is not specifically used to produce raw materials for the production of textiles or polymers but is mixed in existing refineries with virgin petroleum feedstock. The output from these petrochemical installations typically comprises a wide spectrum of chemicals, including precursors to other fine chemicals. Moreover, the pyrolysis process and downstream processes generally see some of the input material being converted directly or indirectly to energy, e.g. as process heat or through the production of fuels. Similar to gasification, pyrolysis of textile waste

should be seen as a step in a textile waste treatment process that typically combines elements of recycling and energy recovery to varying degrees (dual use).

4.2.4.4.2. Thermo-chemical recycling of polycotton fibres

Hydrothermal recycling

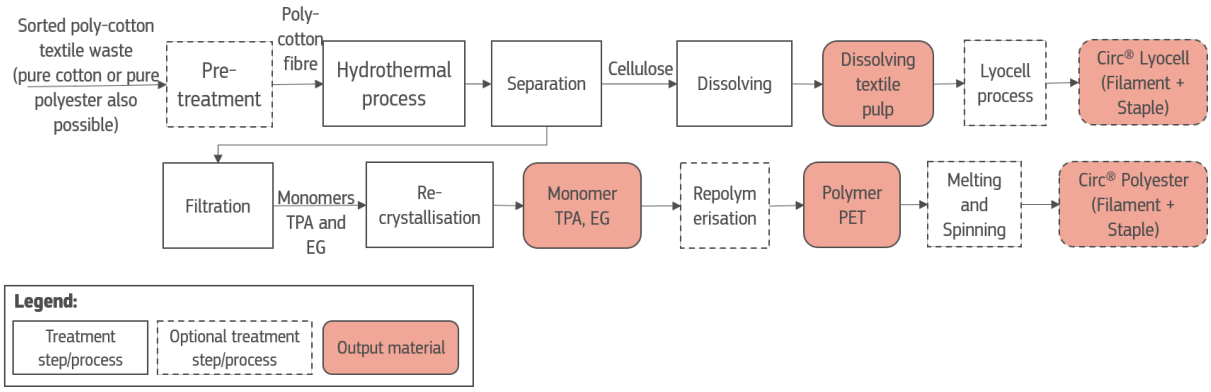
Before entering the main recycling process, poly-cotton textiles undergo visual inspection and segregation for contamination. The poly-cotton textile waste is shredded and then fed into the hydrothermal process which leverages heat, pressure and specific chemicals to depolymerise the polyester and separate it from the cotton (cellulose) fraction. These processes rely on water, pressure, temperature and organic or sulphuric acid but do not use organic solvents (see **Figure 12**).

Due to the high temperature and pH increase, the polyester liquefies quickly and breaks into monomers of terephthalic acid (TPA) and ethylene glycol (EG). At the output of the system, a liquid stream contains only TPA and EG while a separated solid stream contains only cotton. TPA and EG are filtered, re-crystallised and finally re-polymerised in PET chips (AZO, 2022).

The solid cellulose stream is dissolved in a solvent and, after filtering, solvent recovery and decolourisation, the dissolving textile pulp can be used as input to produce man-made cellulosic fibres (MMCF) in a wet spinning process (Barla et al., 2019).

For poly-cotton, a bio-chemical approach focuses on the (partial) degradation with an enzymatic route using for example a fungus secreting the required enzymes. Cotton is hydrolysed into cellulose and soluble glucose. The polymer PET remains intact and is separated as fibre via filtration.

Figure 12. Exemplary process scheme for hydrothermal recycling of poly-cotton-rich textile waste

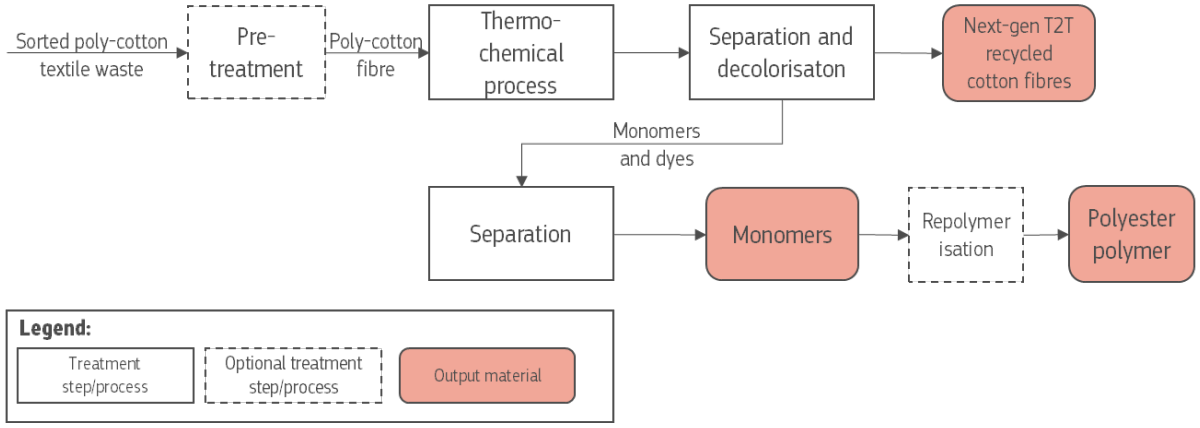


Source: own elaboration

Other technology operators use sorted poly-cotton textile waste as input and depolymerise the polyester at moderate heat and pressure in the presence of alkaline chemicals. During the depolymerisation of polyester to monomers, the cotton part remains intact with minimised damage to cotton fibres. In a next step, the cotton fibres are separated from the monomers and decolourised. Compared to other chemical fibre recycling technologies, the cotton fibres are not converted into regenerated fibres. According to RE&UP (2025), the recycled cotton fibres can be

used directly in conventional cotton spinning lines. The recycled monomers can be repolymerised to polymers again.

Figure 13. Exemplary process scheme for thermo-chemical recycling of poly-cotton-rich textile waste



Source: own elaboration

4.2.4.4.3. (Bio-)chemical recycling

Carbamation and pulping of cotton-rich textile waste

Depending on the pulping recycling technology, the requirements for the input material can vary with regards to the cotton fibre content, colour, and the presence of non-cotton fibres (e.g. polyester, elastane) or unwanted parts of textiles such as hard parts (e.g. zippers, buttons), labels or print.

While some technologies depend on already intensively prepared cotton-rich textile waste (cotton content of 95%, no hard parts, no elastane), some recycling technologies have an integrated pre-treatment process to even accept cotton and polyester blends with a polyester content of up to 30% (in some exceptional cases 50%) and hard parts and are capable of removing colours during the recycling process.

However, with regard to the cotton content, a higher proportion of polyester is in many cases not economically feasible due to the cost of its removal during the recycling process. In **Figure 14** the various approaches to chemically recycle cotton-rich textile waste are presented.

One approach performs a carbamation of the cotton-rich fibre with urea (**Figure 14**; process flow scheme 1). The input material for this process should have a cotton content of around 90% but can contain polyester, elastane, and cellulose fibres such as viscose or lyocell, and can be of any colour. A first step includes the removal of non-fibrous materials such as buttons and zippers, and the textiles are mechanically disintegrated to fine shreds. Then the cotton-rich shreds are captured and separated from the non-cellulosic fibres. The next step involves the activation of the cotton fibres with urea (carbamation), to produce a stable, dissolvable cellulose carbamate powder. The cellulose powder is turned into a dense liquid from which impurities are filtered out. The production of fibre filaments, made of MMC fibre, is an integrated process of this recycling technology. The fibre filament is produced by crystallisation of the dissolved cellulose in a wet spinning process and is then cut to staple length, washed and dried ready to produce new textiles (Infinna™ (InfinitedFibre, 2024)).

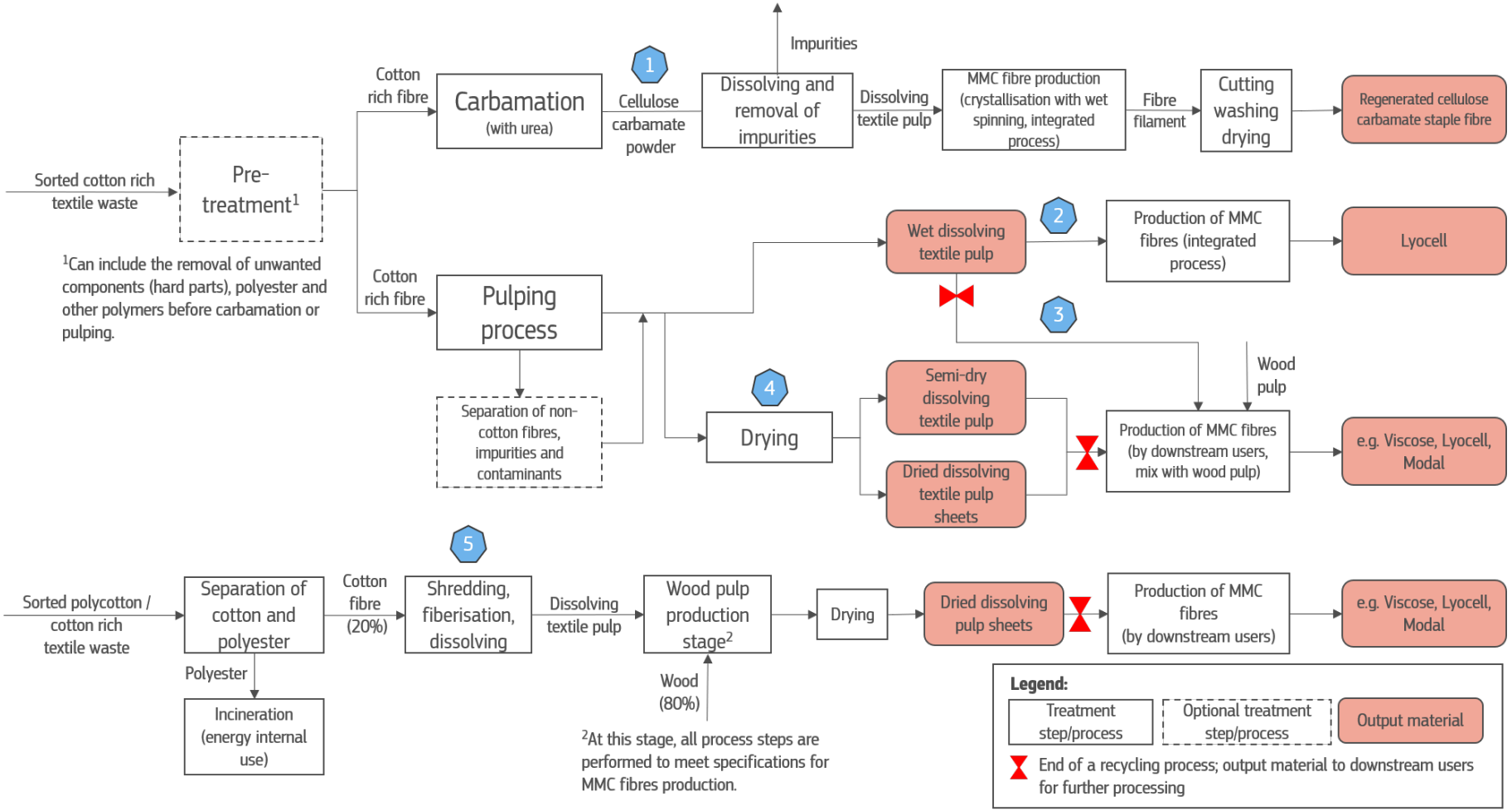
Other recycling technologies apply a pulping process to the cotton-rich fibres directly after a pre-treatment step, similar to pulping processes used in the paper industry. In the pulping process, cellulose fibres are separated from non-cotton fibres, impurities and contaminants and a wet dissolving textile pulp is produced. Colours can be removed with a bleaching step. The wet dissolving textile pulp (**Figure 14**; process flow scheme 2) is then either converted directly into MMC fibre in an integrated process of the recycling technology (SaxCell®/Nucycl® (SaXCell, 2024)) or (**Figure 14**; process flow scheme 3) is mixed with virgin dissolving pulp from wood (Refibra® (Lenzing, 2024)) in a common process to produce MMC fibres such as viscose, lyocell or modal (Textile_Exchange, 2022; Zhang et al., 2018).

Some recyclers follow another approach and dry the dissolving textile pulp and send the (semi-)dried dissolving textile pulp to third parties for further processing (**Figure 14**; process flow scheme 4) ((Circulose® (ReNewCell, 2024)). At this point the recycling process is completed for the recycler. The dissolving textile pulp produced shows similar physical and chemical properties to virgin wood dissolving pulp and is usually mixed with virgin wood pulp to produce MMC fibres such as viscose, lyocell or modal.

Another approach is to use cotton-rich textile waste or poly-cotton textile waste (with a cotton to polyester ratio of 70/30 (in some cases even 50/50; (Soedra, 2024)) as input (**Figure 14**; process flow scheme 5). In a pre-treatment step, the cotton and polyester are separated and the cotton fibres are dissolved. However, with the applied treatment, the dissolving textile pulp does not have the necessary properties for direct use as raw material for the production of MMC fibres. Thus, the recovered dissolving textile pulp is added to a wood pulp production stage. The ratio between virgin wood pulp and dissolving textile pulp is 80/20. Within the pulp production stage, the typical treatment steps to produce a market-ready dissolving pulp are applied (e.g. acid hydrolysis, bleaching; see glossary). According to the recycler, the intention is to extend the share of cotton fibres to 50% and to substitute even more virgin wood. The dissolving pulp is then dried (OnceMore®) and transported to third parties for the production of MMC fibres. The removed polyester and other polymer fibres are not recycled but incinerated and the produced energy is used in the process.

According to cotton textile waste recyclers, the recovered dissolving textile pulps have the same specifications and properties as virgin dissolving pulp produced from wood pulp or other cellulosic sources. The same is valid for recycled MMC fibres showing similar properties to MMC fibres produced from wood pulp (see **Table 24** in **Annex 3**).

Figure 14. Exemplary process schemes of carbamation and pulping for cotton-rich textile waste



Note: The numbers in the blue heptagons in the figure correspond to the process flow schemes described in the preceding text. MMC= man-made cellulosic.

Source: own elaboration

Depolymerisation of synthetic fibres

Depolymerisation technologies allow the breakdown of synthetic fibres like polyester and nylon into their raw chemical building blocks, the monomers or oligomers, which can then be used for re-polymerisation into high-quality polymers. Depending on the technological approach, different requirements apply to the input materials, regarding for example purity, water content, hard parts, colours and print (more details in **Table 33** in **Annex 11**). Some of the pre-treatment steps can be performed by the recyclers themselves, or by a third party.

The core process is then depolymerisation; however, various approaches are applied to break down the polymers into monomers or oligomers. A selection of processes with a high TRL for polyester and nylon recycling are described in the following paragraphs. The aim is to give an overview, among other things, of the different (intermediate) output materials that can be produced by these recycling processes.

The partial depolymerisation recycling technology presented (Cure, 2024) (**Figure 15**; process flow scheme 1) is capable of treating textiles with a limited amount of hard parts (the vast majority of the hard parts must be removed before feeding the textile waste to the extruder). As the colour removal capacity is limited, colours should be removed upfront. After a compacting step, the decoloured textile pellets are fed into an extruder where they are mixed with glycol. Compared to other depolymerisation processes, the polymer is not completely depolymerised to a monomer, but to oligomers. The oligomer fraction from the extruder is a honey-like substance and undergoes various purification steps (e.g. density separation, (ultra-)filtration). The oligomer is then directly fed into the depolymerisation process to produce rPET polymer. The resulting rPET is fit for use for yarn spinning and other applications like production of (non-food) packaging. The technology provider states that if other textile fractions, such as cotton, elastane and PU, are present in the input textile waste, those are individually separated for further recycling by third-party recyclers.

The **selective depolymerisation of polyester** (**Figure 15**; process flow scheme 2) is based on alkaline hydrolysis (NaOH, 130-160 °C) of the ester bond (RevolTEX® technology (RITTEC, 2024; Textile_Technology, 2023)). The depolymerisation is carried out continuously in a twin-screw extruder on a pre-shredded and granulated polyester-rich textile waste. The output of the extruder is an intermediate fraction containing a TPA salt and ethylene glycol (EG) is obtained. In subsequent process steps, namely 'dissolving' and 'filtration', the intermediate product is completely dissolved in water and insoluble components, such as cotton, are separated by filtration. Cotton, which remains chemically unchanged during the hydrolysis, can be recovered in the form of short fibres. The separated cotton materials can be sold on the market to be fed to other suitable recycling processes (e.g. pulping). To remove water-soluble contaminants, the filtrate is then further purified by means of an adsorption treatment. In the subsequent process step called 'TPA precipitation', the dissolved TPA salt reacts by adding sulphuric acid (H_2SO_4) to form the recyclate r-TPA. The TPA, which is hardly soluble in water, precipitates almost completely and is then filtered, washed and dried. The recycled r-EG is separated by distillation from the mother liquor produced in the TA precipitation. The other saleable product obtained from the mother liquor is the sodium sulphate (Na_2SO_4).

The **accelerated depolymerisation** recycling process (GR3N, 2024) (**Figure 15**; process flow scheme 3) is based on two key steps: **M**icrowave-**A**ccelerated **DE**polymerisation (MADE) and highly effective downstream purification of monomers. The technical concept is to break down polyester

into its main components (monomers terephthalic acid (TPA) and monoethylene glycol (MEG)) so they can potentially be re-polymerised endlessly to provide brand new virgin PET or any other polymer using one of the monomers. The reaction taking place is an alkaline hydrolysis (adding NaOH, at 180-200 °C, 10 minutes) transforming the polyester into TPA and MEG that are then separated. Due to the small amount of water used in the depolymerisation process, it is possible to distil MEG with generating azeotropes and without consuming a huge amount of energy. The output is a purified transparent rMEG. Due to the addition of NaOH, sodium terephthalate (Na_2TA) is formed which is first dried and then purified. After the first purification step(s), the TPA would already be pure enough for re-polymerisation; however, the TPA is further treated by adding HCl to achieve a quality like crude TPA. In addition, the purified TPA is fed into a crystallisation reactor to produce round particles instead of needle-shaped particles. The crystallisation process purifies the TPA even further, as unwanted substances do not blend into the crystalline TPA structure and chlorine is removed. TPA is recovered from the liquid phase by filtration and then dried. A special feature of this process is that individual chemicals required in the process are produced in the plant from the side streams of the process.

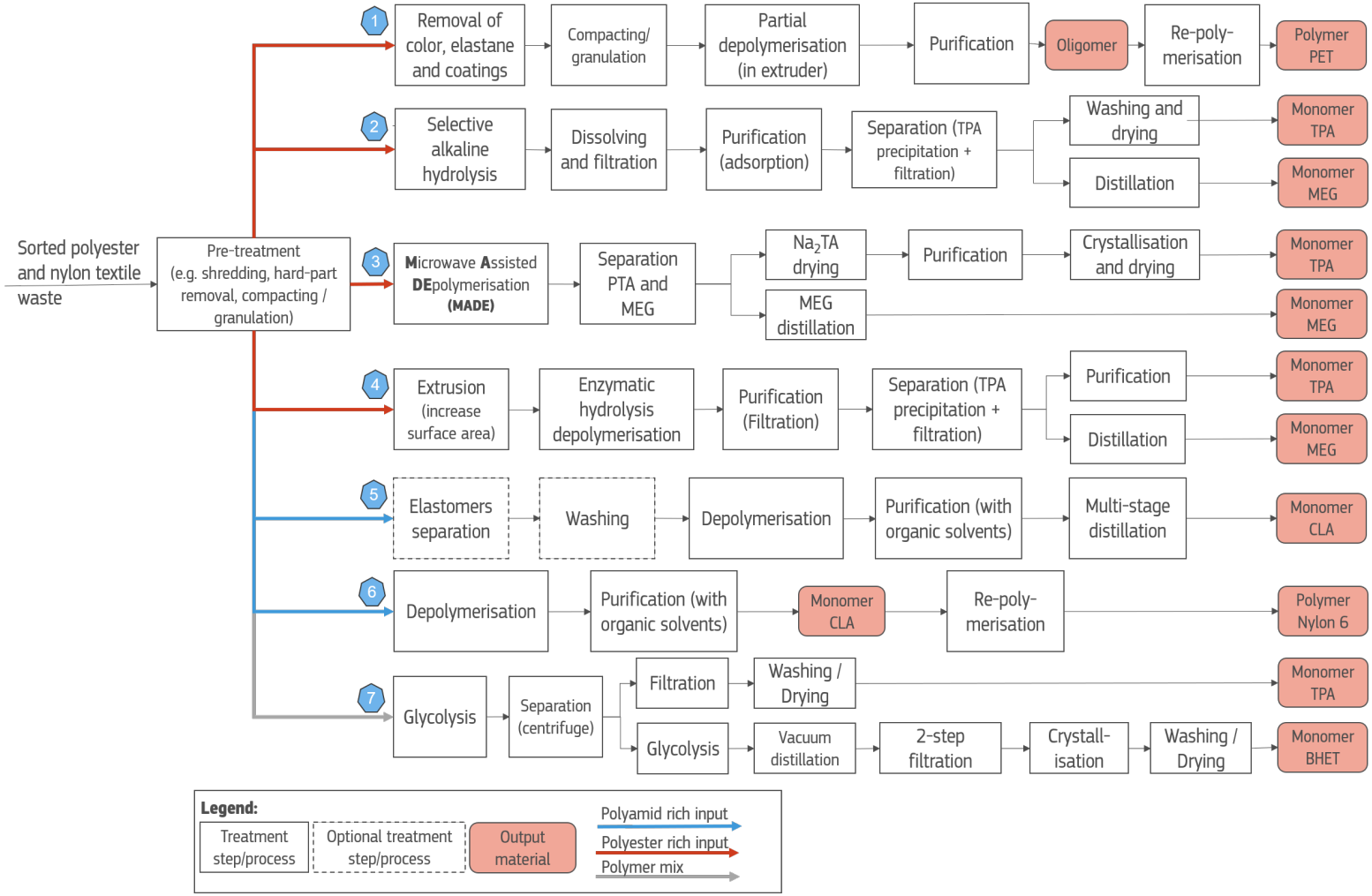
In a pre-treatment for the enzymatic depolymerisation (Carbios, 2024) (**Figure 15**; process flow scheme 4), hard parts are removed from polyester-rich textile waste by shredding, separation using magnets (for ferrous parts) and eddy current (for non-ferrous parts) and density separation via airflow (other hard parts). The pre-treated textile waste has a low density and needs to be pelletised for the extrusion step. The goal of the extrusion process is then to produce pellets with an increased surface area to improve the enzymatic reaction during depolymerisation. In the depolymerisation reactor (NaOH, < 70 °C, enzymes, 10-15 h), polyester is depolymerised into the monomers TPA and MEG to a great extent (90-95%). After a filtration step, colours are removed from the liquid phase by passing an activated carbon colon. TPA is then precipitated, subsequently crystallised, removed from the liquid phase via a filter and dried after further purification. The liquid MEG is fed to a distillation and subsequent evaporation process to produce MEG of high purity (99.9%).

For the recycling of nylon via depolymerisation (Econyl® (Aquafil, 2022, 2023) (**Figure 15**; process flow scheme 5), the input material can be optionally pre-treated to remove elastomers that negatively affect the recycling process and also washed to prevent impurities entering the recycling process. The recycling of polyamide 6 (PA 6) involves several steps in which the nylon-rich textile waste is broken down into its molecular building blocks (monomers) by depolymerisation. The monomer produced is caprolactam (CLA) which is the most indispensable intermediate in the production of nylon or PA 6. BASF for example (Loopamid® (BASF, 2024)) also performs depolymerisation with purification but repolymerises the monomers to new nylon polymers on site (**Figure 15**; process flow scheme 6). This polymer is ready for the production of new fibres (re-melting and extrusion through fine openings).

One technology focuses on the recycling of textile waste consisting of the complex blend of nylon, polyester and elastane (Cecilia & Anna, 2022; Ericsson et al., 2022; Johansen et al., 2023) (**Figure 15**; process flow scheme 7). The recycling process is based on a two-step approach, in which the nylon is first dissolved in ethylene glycol at 165 °C and separated as polyamide powder (10–100 microns) with a centrifuge. The powder TPA is then filtrated, washed and dried. During the filtration, the EG is recycled for the first glycolysis process. The polyester and elastane mix, which is separated in the centrifuge, is then completely depolymerised in ethylene glycol at higher temperatures (230 °C) and with the help of catalysts. The elastane breaks down into an oil-phase Bis(2-

hydroxyethyl) terephthalate (BHET) and the EG is separated with vacuum distillation. EG is returned to the second glycolysis process. Water is added to the BHET and any insoluble materials are removed, and BHET oligomers that are not completely depolymerised are returned for glycolysis. The BHET monomers are then crystallised, washed and dried for transport shipment.

Figure 15. Examples of process schemes for polyester and nylon recycling with depolymerisation (non-exhaustive)



Note: The numbers in the blue heptagons in the figure correspond to the process flow schemes described in the preceding text.

Source: own elaboration

Bio-chemical recycling of various fibre types

In comparison to chemical recycling, which relies on the use of mineral chemicals to degrade textile waste, bio-chemical recycling uses biological agents like enzymes or microorganisms to degrade textile waste into raw materials for new fibres or materials. Similar to chemical recycling, biochemical recycling approaches can be applicable to natural, synthetic and blended fabrics. Enzymatic hydrolysis, microbial fermentation and anaerobic digestion are examples of bio-chemical recycling (Ho & Tang, 2023). Enzymatic hydrolysis is procedurally similar to chemical hydrolysis, except that textile waste is heated with water and enzymes, such as cellulase, β-glucosidase or cutinase, instead of acid or alkali, in a reactor. Microbial fermentation, utilising microorganisms such as bacteria, fungi and algae, converts the biodegradable fraction of textile waste into biofuels, biopolymers and organic acids. Furthermore, microbial fermentation can be used to produce enzymes such as cellulases and xylanase as well as organic acids from textile waste.

In summary, the bio-chemical recycling of textile waste often involves enzymatic hydrolysis, microbial fermentation and anaerobic digestion sequentially or separately to yield a wide range of products, comprising biofuels, biopolymers, biomolecules, organic acids and enzymes. Bio-chemical recycling processes are currently still the subject of research and have not been implemented on a pilot-plant scale or on a large scale yet.

Other technologies to recycle cotton-rich textile waste

Besides the pulping of cotton-rich textile waste, which is already done at industrial scale, new approaches are under development, producing different output materials to dissolving pulp or MMC fibres.

One approach using denim as input material involves first a decolourisation with N-dimethylformamide. After tearing, the decoloured cotton fibres are mixed with hydrogen peroxide (H_2O_2) to bleach and then dissolve the bleached cotton fibres in H_2SO_4 to produce microcrystalline cellulose (MCC). MCC has various applications in the food, pharmaceutical, cosmetic and composite material preparation industries (Abdul Rahman et al., 2022).

Another approach applies acid hydrolysis to produce MCC through filtration, washing, drying and grinding (Shailey et al., 2024). Additional processes are under investigation (Hou et al., 2024; Wang et al., 2022).

Table 4 provides an overview of the different textile recycling approaches, considering technical maturity, input and output materials, and the ability to return textile waste into new products, in the case of thermo-mechanical, physical and chemical recycling into output materials with properties similar to virgin raw materials. Some of these recycling technologies are able to remove non-targeted components, which is not always possible with mechanical approaches.

Table 4. Overview of textile recycling technologies (non-exhaustive)

Approach	Mechanical recycling			Thermo-mechanical recycling	Physical recycling	(Bio-)chemical recycling					
	Cutting	Cutting and sheering/ fraying	Advanced mechanical recycling			Gasification and pyrolysis	Hydro-thermal	Pulping/ carbamation	Depolymerisation	Bio-chemical	Others
TRL	Commercial scale (TRL 9)	Commercial scale (TRL 9). New innovative technologies prevent fibre-length reduction	Commercial scale (TRL 9)	Commercial scale (TRL 9)	Demonstration scale (TRL 7) ready for upscaling to commercial plants	Under development (TRL 5-7)	Demonstration scale (TRL 7) ready for upscaling to commercial plants	Commercial scale for cotton recycling (TRL 9)	Nylon (PA 6): TRL 9. Polyester: Demonstration scale (TRL 7) ready for upscaling to commercial plants. PES, PA 6 and elastane mix: TRL 7	Research	Research
Input	Textile fibres with high absorption capacity	Any textile fibre	Any textile fibre	Thermoplastic fibres, e.g. polyester, polyamide, polypropylene (only one or compatible polymer types)	Primarily polymers (polyester) but also poly-cotton	Any textile fibre	Poly-cotton and polymers	Cotton-rich textile waste	Polyester or nylon rich textile waste	Natural, synthetic and blended fabrics	Cotton-rich textile waste
Output	Cleaning rags or cleaning mops	Spinnable fibres	Spinnable fibres	Polymer	Polymer	Syngas and pyrolysis oil. Possible to convert	Dissolving textile pulp and monomers,	Wet, semi-dry or dried dissolving textile pulp	Esters, monomers,	Monomers	Microcyrstalline cellulose,

		Unspinnable fibres / fluff Powders	Unspinnable fibres / fluff Powders			output materials (e.g. syngas) to base chemicals to produce polymer again	oligomers or polymers	to substitute wood-based pulp: man-made cellulose fibre	oligomers, polymers		cellulose film
Potential for closed-loop recycling	Low In the event that cleaning rags or mops will be disposed of (linear recycling)	Low Closed-loop recycling limited. A large proportion of the fibres is downcycled	Medium Closed-loop recycling limited, but improved compared to basic mechanical recycling	High Recovered polymer can be used for fibre production or other plastic applications)	High Potential to recover virgin-quality polymers.	Low/Medium Potential to recover virgin-quality fibres or polymers, although in practice a substantial fraction is converted (in)directly to energy or fuels	High Potential to return virgin-quality fibres or polymers	High Potential to recover virgin-quality MMC fibres	High Potential to recover virgin-quality monomers, oligomers, or polymers	High Potential to recover virgin-quality monomers	High Potential to recover materials for various sectors (e.g. food, pharmaceutical, cosmetic, composite material industry)
Ability to remove impurities	None	None	Partly given by cleaning and bleaching steps	Partly given, depending on the process steps	Given. The extent of the removal depends on the recycling targets and process control.						

Source: own elaboration based on Duhoux et al., 2021; Janmark et al., 2022; Köhler et al., 2021

4.2.4.5. Recycling of footwear waste

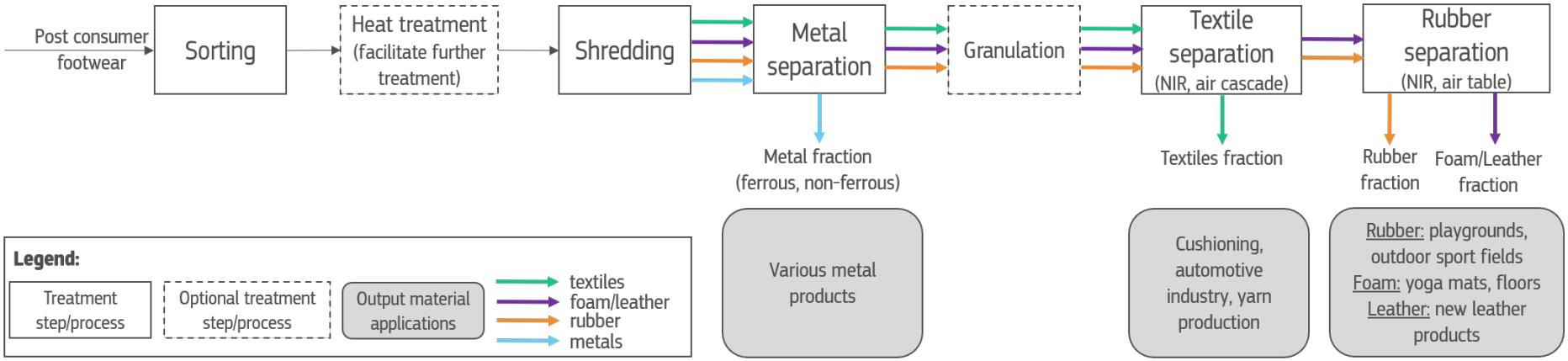
In 2022, approximately 24 billion pairs of footwear were produced worldwide and Europe accounted for 15% of footwear consumption (Statista, 2023). The footwear industry is diverse and uses a range of different processes to produce different types and styles of footwear made of different materials (Rensburg et al., 2020). Unlike apparel or home textiles articles, footwear can consist of many different materials, and its share of textiles is lower and can vary significantly depending on the type of footwear. A trainer for example consists of 20 to 40 different materials with a high share of textiles (~30%) but also different synthetic plastics, silicones, foams, metals and rubber (Lee & Rahimifard, 2012). A typical running shoe consists of 40 to 60 different parts and dozens of different materials (FFG, 2024).

According to Rahimifard et al. (2007) the material composition of an average shoe (wt%) is: 25% leather; 17% polyurethane; 16% thermoplastic rubber; 14% ethylene vinyl acetate; 8% polyvinyl chloride; 7% rubber; 7% other; 6% textiles and fabrics. Reaching its end of life, footwear can undergo recycling. At present, recycling is primarily mechanical, although it should be noted that only a limited number of facilities recycle footwear in Europe.

4.2.4.5.1. Mechanical recycling of footwear

Usually, the different materials of footwear are strongly bonded with powerful glues or are sewn together. This makes separation and separate recycling resource-intensive and costly. The current recycling approaches are based on a first sorting step of separately collected footwear, optional heat treatment to facilitate the separation due to the degradation of the glue, shredding and cascaded separation of metals, textiles, rubber, and foam/leader with standard market technologies such as magnets, eddy current, NIR or density separation (see **Figure 16**; FFG, 2024; Lee & Rahimifard, 2012). **Figure 16** also provides an overview of the possible applications of the output material. As the adhesives can barely be removed, this leads to adhesion of different materials but can also to them being found in the ‘clean’ output materials, which in turn prevents high-quality recycling (FFG, 2024).

Figure 16. Exemplary process scheme for a mechanical footwear recycling approach



Source: own elaboration based on FFG, 2024 and Lee & Rahimifard, 2012

In most cases, the recycled materials are used for other purposes besides the production of new footwear. The recovered textile fibres could be used in other recycling technologies to produce new raw material that can be used in textiles or footwear again (see section below).

In addition to footwear, various accessories such as bags and hats are also partially or entirely made from textiles. These items could potentially serve as a source for textile recycling. Nevertheless, the JRC is currently unaware of any specific technologies that focus on the recycling of textiles from accessories, regardless of whether they are partially or completely composed of textiles.

4.2.4.5.2. Other recycling technologies for footwear

Thermo-mechanical, physical or chemical recycling technologies as described in the sections above can be important, particularly for the **various separated fractions from mechanical footwear recycling**, when the goal is to enable high-quality recycling. However, unlike mechanical footwear recycling, no other large-scale operating recycling facilities specifically for footwear are known at the time of writing this report.

5. Background information for the development of end-of-waste criteria

As mentioned in Section 1.2, the conditions for a waste to cease to be waste are:

> *"(a) the substance or object is to be used for **specific purposes**;*
> *(b) a **market or demand** exists for such a substance or object;*
> *(c) the substance or object fulfils the **technical requirements** for the specific purposes and meets the **existing legislation** and **standards** applicable to products; and*
> *(d) the use of the substance or object will not lead to overall **adverse environmental or human health impacts**."*

Besides, the Commission shall take as a **starting point** the most stringent and environmentally protective **criteria established in Member States**.

The following sections provide an overview of the market and demand as well as common applications for recovered textiles. Technical requirements, standards and legislative aspects are introduced. Environmental and human health impacts related to the use of recovered textiles are discussed. Finally, a benchmarking of EoW criteria in Member States is presented.

5.1. Market, demand and common applications

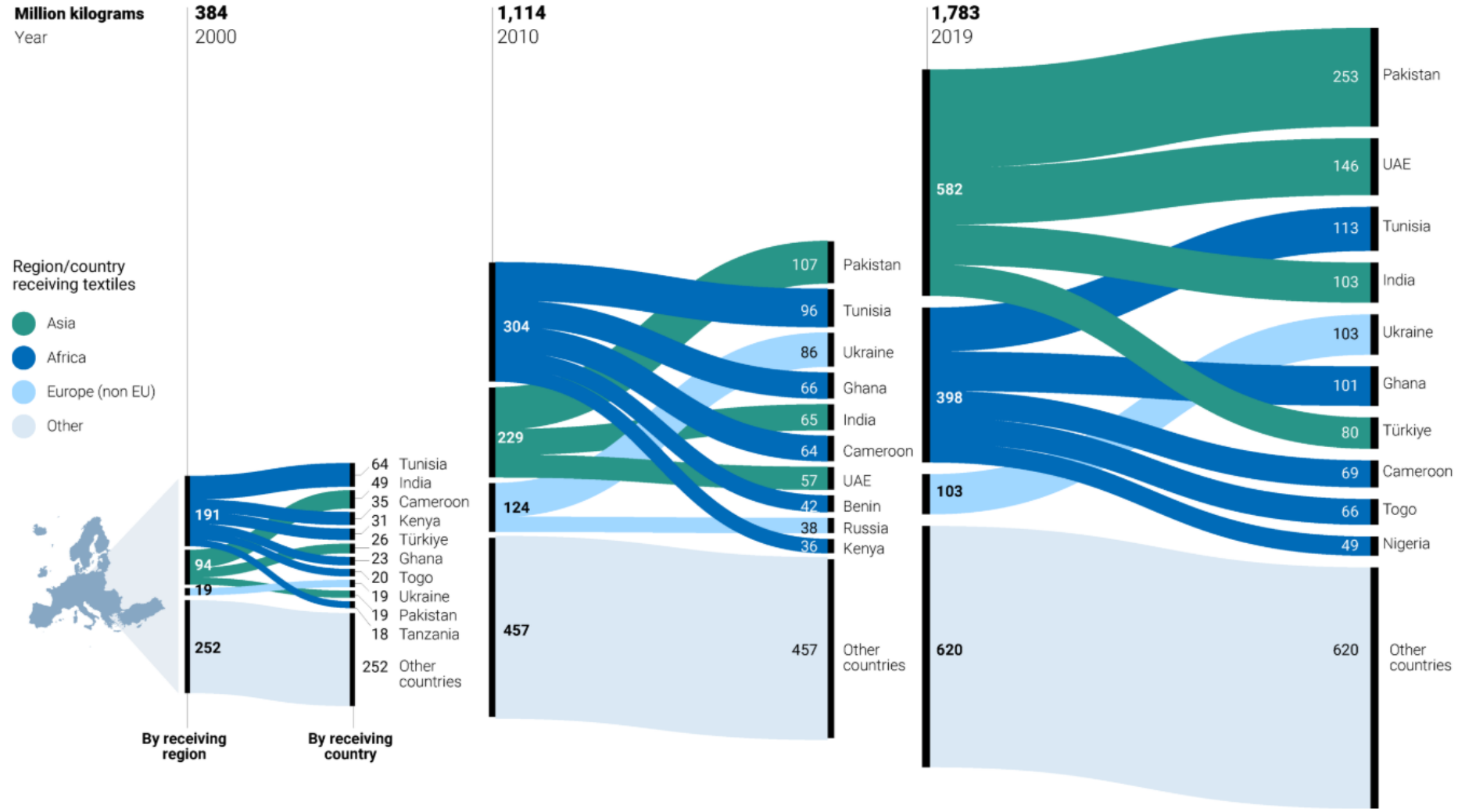
In the global market for used textiles there is an increased trend in the supply of used textiles and a stabilisation of the demand. Due to a stabilisation of demand for used textiles, prices are falling (EUR 0.70/kg in 2020). The price fall is also due to an overall reduction in the quality of textile items produced. There is also an increased use of consumer-to-consumer (C2C) second-hand platforms, where high-quality textiles are sold independently by consumers (Trzepacz et al., 2023).

Due to limited re-use and recycling capacities in Europe, a big share of used textiles is exported outside the EU (see **Figure 17**); 6.5% of all exports are to OECD countries and 93.5% to non-OECD countries. **Exports outside the EU** have tripled over the last two decades, reaching **1.7-1.8 Mt** in 2019 (EEA, 2023a; Eurostat, 2021; Halleux, 2023; Huygens et al., 2023).

The main importers are Africa and Asia. Russia, Ukraine and Cameroon acquire the most expensive textiles (EUR 2.26/kg, EUR 1.28/kg and EUR 0.99/kg, respectively) (Trzepacz et al., 2023).

There is a high level of uncertainty in relation to the final fate of used textiles, once they are exported. Used textiles exported to **Africa (46% of EU exports)** seem to be mostly directed to local re-use and are of a **medium quality**. The fraction that is not deemed suitable for local re-use is likely diverted to landfills. Used textiles exported to **Asia (41% of EU exports)** are of **medium or low quality** and are processed in dedicated economic zones. Low-quality textiles are downcycled into industrial rags or filling, exported to other Asian countries for recycling or to African countries for re-use. The remaining fraction is likely landfilled (EEA, 2023a).

Figure 17. EU exports of used textiles



Source: (EEA, 2023a)

5.1.1. Market, demand and common applications for recycled textiles

The fate of textiles that have been sorted and pre-treated is determined by the fibre composition and characteristics (mono-material, multi-layered, etc.) (Trzepacz et al., 2023). It also depends on market prices and competitiveness with virgin fibres.

As mentioned in Section 4.2.2, automated sorting technologies capable of determining the fibre composition with adequate precision are key to exploiting the potential for recycling. Less than 1% of material used to produce clothing is currently recycled into new clothing, mainly because the recycling technologies are not market-ready yet. Around 20% of the separately collected textiles in Europe are recovered into products of lower value (e.g. cleaning rags or insulation material), while the rest is diverted to incineration or landfill (Köhler et al., 2021).

Unspinnable fibres, also known as fluff, that result from mechanical recycling are used for the production of filling products like insulation or technical nonwovens for the automotive industry. Fibres that have been drastically altered during the recycling process are mainly compressed and used as fuel, but can also be used as filling or reinforcement material in plastics or composites (Duhoux et al., 2021).

5.2. Technical requirements and standards

5.2.1. Standards

For textile fibres and textile-related articles produced out of virgin materials, different standards exist. The technical body CEN/TC 248[39] (textile and textile products standard) covers the standardisation of the following aspects of textiles, textile products and textile components of products: 1) test methods; 2) terms and definitions; 3) specifications, and, if necessary, classifications, in terms of their expected behaviour, in particular where required by other CEN Technical Committees or the CEC or EFTA. Recommendations for the design and manufacture of children's clothing are part of this set of standards. The technical body CEN/TC 309[40] covers test methods and environmental aspects for footwear. A non-exhaustive list of standards, guidelines and specifications is presented in **Table 5**.

Table 5. Overview of standards, guidelines or specifications with regard to characterisation of textiles in general, and more specifically regarding sorting, preparing for re-use and recycling (non-exhaustive list)

Standard / guideline / specification	**Content**
CEN/TC 248/WG 39 (EN, 2023)	Circular textiles chain - requirements and categories (under development).

[39] CEN/TC 248 – Textiles and textile products: https://standards.cencenelec.eu/dyn/www/f?p=205:7:0::::FSP_ORG_ID:6229&cs=10D5E9507DBA0195D1D470609DD93A3DC

[40] CEN/TC 309 – Footwear: https://standards.cencenelec.eu/dyn/www/f?p=205:7:0::::FSP_ORG_ID:6290&cs=17352FCE0EDE7F4AB7FBD23531A86A66C

CEN/TC 309	Footwear.
UNE 40700:2023	Spanish Norm - Handling and sorting specifications **for re-use and recycling** of used textiles.
DIN 61650: 2005-04 (DIN, 2005)	Standard applicable to **cleaning rags**, made from larger pieces of rags manufactured in textile sorting shops and cleaning rag factories. Cleaning rags are intended for cleaning purposes of different kind.
Global Recycled Standard (GRS) (Textile Exchange, 2019)	Voluntary product standard to track and verify the content of recycled materials in a final product (applicable to products with a minimum of 20% recycled content).
Recycled Claim Standard (RCS) (Textile Exchange, 2019)	Voluntary chain of custody standard to track recycled materials through the supply chain (applicable to products with a minimum of 5% recycled content).
EuRIC Textiles Handling & Sorting Specifications (EuRIC, 2021)	Guidelines for **re-use and recycling** of used textiles.
LAGA Communication 40 (LAGA, 2023)	Implementation aid for the prevention as well as the collection, **sorting and recycling** of used textiles (2020).
Sorters Handbook - Sorting for circularity Europe (Good, 2022)	Handbook for the conduction of **sorting analyses** using hand-held near infrared scanning technology.
Materials Matter Standard (Textile_Exchange, 2024)	Materials Matter Standard aligns the fashion, textile, and apparel industry on a shared trajectory by establishing what best practice looks like for different materials in various settings, from farms to recycling facilities.
Standards for fibres and certain textile products	
BS 1781:1981	Specification for linen and linen union textiles
CEN/TC 134/SC1 and WG 8	Textile floor coverings
EN 14465:2004/A1:2007	Textiles - Upholstery fabrics - Specification and methods of test
EN 14697:2005	Textiles - Terry towels and terry towel fabrics - Specification and methods of test
EN 266:2020	Wall coverings in roll form - Specification for textile wall coverings
EN ISO 1833-1-29	Textiles – Quantitative chemical analysis of various mixes of fibres
EN ISO 5059:2000	Textile fibres - Determination of breaking force and elongation at break of individual fibres
ISO 1130:1975	Some methods of sampling for testing
ISO 5084:1996	Determination of thickness of textiles and textile products
ISO 9073-1-	Test methods for non-wovens
ISO 10290:2018	Textiles – Cotton yarns – Basis for specification

Source: own elaboration

5.2.2. Specifications and quality requirements for output materials of textile recycling

Preliminary data on the specifications, quality requirements and limit values for output materials of textile recycling was shared by stakeholders during the first stakeholder consultation (see stakeholder feedback in Section 6.4.1.1). However, the data and information provided were insufficient to establish robust requirements for output materials of textile recycling (Section 0). To address this knowledge gap, the JRC undertook a comprehensive research effort, which included in-depth analyses, bilateral meetings with industry stakeholders, and site visits to recycling facilities. The findings are outlined in the following sections.

5.2.2.1. Output materials of mechanical recycling

5.2.2.1.1. Cleaning rags

In the current standard DIN 61650:2005-04 it is defined that textiles shall be cut into irregular pieces of at least 20 x 30 cm and packed (DIN, 2005).

In general, cleaning rags shall be free from foreign bodies (e.g. hard parts) to avoid scratching the surfaces to be cleaned and excessive thicknesses shall be avoided. Depending on the intended use, the cleaning rags have to fulfil certain specifications. Parameters that describe the quality and performance of a cleaning rag include:

- lint-free or low in lint;
- absorbency;
- durability in case of multiple uses after washing;
- softness for cleaning of specific surfaces;
- static-reducing properties for use in critical areas; and
- chemical resistance or resistance to other substances (e.g. oil).

5.2.2.1.2. Fibres for yarn spinning

It is well documented that fibre properties of virgin cotton show variability in terms of length and other yarn spinning properties within fibres from the same cotton crop depending on the year of production and given location conditions (e.g. weather, climate) (Yu, 2015).

In addition, different yarn spinning processes, such as ring spinning and rotor or open-end spinning, place different demands on a virgin cotton such as length, uniformity, maturity, strength and foreign material. Synthetic fibres have a more uniform and consistent quality than natural fibres, as the raw materials used for spinning have a clear and defined quality. **Annex 4** provides a non-exhaustive list of parameters including certain limit values that are demanded by the yarn spinning industry (Chattopadhyay et al., 2023; CYM, 2024; Motin et al., 2024; Textilecoach, 2021). Furthermore, **Table 23** in **Annex 3** gives an overview of relevant virgin fibre properties for spinning.

Mechanically recycled fibres are usually mixed with virgin fibres to obtain the properties demanded by the yarn producer. The textile product to be manufactured defines the requirements for the quality of the recycled fibres and the yarn spinning process.

5.2.2.1.3. Cut, shredded, frayed and ground textiles[41] for various specific purposes

As already emphasised in Section 4.2.4.1, the shapes of mechanical recycled output material are manifold. In some cases, the output materials can be directly used for a specific material purpose or further treatment is applied for a certain purpose (e.g. compressing and pelletising, compounding,

[41] Other than cleaning rags for cleaning purposes or fibres for yarn production

laying and carding, chemical treatment to achieve certain properties such as waterproofness, flame retardance).

The different output materials are used for example for (Re-fashion, 2018):

- sewing of various products (cuts);
- carpets (woven or knitted cuts);
- composite materials (moulding/injection of cut or coarse ground/shredded textiles);
- sporting goods, garden furniture, spare parts (compressing and pelletising of coarse ground/shredded textiles);
- padding material for furniture and decorative items (fibres);
- automotive industry (nonwoven fibres);
- substrates/geotextiles/green walls (thermo-bonding and chemical treatment of fibres);
- building equipment (thermo-bonding and chemical treatment of fibres);
- insulation and decoration of buildings (thermos-bonding and chemical treatment of fibres);
- structural insulation of buildings (thermos-bonding and chemical treatment of fibres);
- flocking material (textile powder).

5.2.2.2. Output materials of thermo-mechanical, physical and chemical recycling

5.2.2.2.1. Dissolving pulp

Dissolving wood pulp specifications vary from manufacturer to manufacturer and depend largely on the wood species and the pulping process (Cafuta Korn, 2024). Dissolving pulp recovered from cotton-containing textile waste (dissolving textile pulp) must meet certain criteria in order to be processed further in the MMC fibre production process. The requirements differ for the various MMC fibre production processes such as production of lyocell, viscose or rayon (Balkissoon et al., 2023; Gao et al., 2019; Sixta, 2006; Södra, 2024a). Fibre spinning is a very delicate process in terms of the purity of the raw materials. Even small amounts of an incompatible polymer and other contaminants can lead to problems during processing. Therefore, **dissolving textile pulp made from cellulose-based textile waste** must be as similar as possible to dissolving pulp made from wood. The main difference is the small amount of impurities/contaminants (e.g. incompatible textile fibres, dyes, finishing chemicals) that are atypical for the dissolving wood pulp.

Technical data sheets from dissolving pulp producers indicate the quality requirements and limit values for wood-based dissolving pulp that is used for viscose or fine yarn production (Södra, 2024b). Quality requirements are given for example for alpha cellulose and brightness: ≥94% and ≥92%, respectively. The intrinsic viscosity of such dissolving pulp is in the range of ±25 cm^3/g to ±40 cm^3/g (see detailed list of parameters and analytical results in **Table 22** in **Annex 4**).

Exemplary, the specification for dissolving textile pulp recycled from cotton fibres (CIRCULOSE®) is graded similarly to dissolving wood pulp in terms of **brightness, viscosity and cellulosic content** (Renewcell, 2024). Such a recycled dissolving textile pulp complies with industry standards

for cellulosic fibre from dissolving wood pulp. As a consequence, MMC fibres made from this dissolving textile pulp are equivalent to MCC fibres made from virgin raw materials in applicability and quality. Therefore, fabrics and fibres made from recycled dissolving textile pulp (CIRCULOSE®) are indistinguishable from virgin man-made cellulosic fibres and fabrics. Such dissolving textile pulp can be used on its own or is blended with virgin dissolving pulp from wood.

Annex 5 provides deeper insights into the typical quality of dissolving pulp from wood for the production of various MMC fibres.

According to C. Chen et al. (2016), the key quality parameters for dissolving pulp for rayon fibres include α-cellulose content, alkali solubility, degree of polymerisation, molecular weight distribution, and reactivity.

Dissolving pulp can be recovered wet (40–55 w%), semi-dry (>10–<40 w%) or dry (5–10 w%). In the event that the dissolving pulp is directly transformed at the recycling site or the recycling site is located close to a MMC fibre production plant, the wet dissolving pulp is used without drying. To transport dissolving pulp to third parties located far away, the dissolving pulp is usually (semi-)dried. The degree of drying depends on the energy costs, transport distances and requirements of the processor.

Based on available data, the JRC concludes that the output materials from chemically recycling cotton fibres exhibit significant variability, depending on factors such as:

- the specific recycling processes employed;
- whether additional processing is conducted on site or outsourced to third parties; and
- the intended type of man-made cellulosic (MMC) fibres to be produced (lyocell, viscose or rayon).

5.2.2.2.2. Man-made cellulosic fibres

In certain chemical recycling processes, the recovered dissolving textile pulp is further converted into man-made cellulosic fibres on site. In these cases, the respective industrial specifications for MMC fibres serve as a quality reference for further processing into yarn. Important parameters in this context are, for example, toughness, strength and elongation (H. Chen, 2015; EFT, 2024; Sateri, 2024). These parameters are defined for both dry and wet. Detailed technical specifications for various man-made cellulose fibres are provided in **Table 25** of **Annex 6.**

5.2.2.2.3. Microcrystalline cellulose (MCC)

The recycling of MCC from cotton textile waste is still at laboratory-scale level and thus under development. Therefore, the data available on specifications for MCC from cotton textile waste is limited and the intended use of this recycled MCC is only described theoretically (e.g. food, pharmaceutical, cosmetic and composite material preparation industries' products). For these intended uses, the technical specifications are different.

Given the current early stage of development (research level) and the uncertain future applications of these technologies (see Section 4.2.4.4), technical specifications for each potential theoretical use case of MCC are not reported at this time.

5.2.2.2.4. Monomers

The most technologically advanced processes are those recovering monomers such as TPA and MEG (both from polyester-rich textile waste) and CLA (from nylon-rich textile waste). Therefore, detailed specifications are provided for these three monomers.

To compete with virgin monomers, the recycled monomers need a high purity, similar to virgin ones. Based on the data provided by recyclers, the concentration of the targeted monomer is 99.3-99.9% for TPA and 99.9% for MEG for example (Carbios, 2024; GR3N, 2024). Detailed technical specifications for virgin TPA (**Table 26**), virgin MEG (**Table 27**) and CLA (**Table 28**) are given in **Annex 7** In order for the recyclers to bring their products to market, the specifications must be fulfilled.

5.2.2.2.5. Polymers

For certain chemical recycling processes, the recovered monomers or oligomers are re-polymerised back into their original polymers, such as PET or nylon polymers, as an integral step in the recycling process. In these cases, the respective customer or industrial specifications for polymers serve as a quality reference for further processing into synthetic yarns or plastic products. Detailed technical specifications for virgin PET and virgin nylon polymers are provided in **Table 29** of **Annex 8**.

5.3. Legislative aspects

5.3.1. Relevant waste legislation

Waste legislation applies when the textile material is still in the waste regime, namely at the point of collection, when accepting the waste at the waste management facility (e.g. sorting, recycling) and during processing.

Particularly relevant for the development of EoW criteria are the classification of waste as hazardous or non-hazardous, and provisions on waste shipment and on the sound management of textile waste.

5.3.1.1. Legislation on hazardousness classification of waste

The primary legislation governing waste management in the EU is the WFD.

The classification of waste as hazardous or non-hazardous is outlined in Annex III to the WFD, and the classification laid down in the Annex to Commission Decision (EC) No 2000/532 on the **List of Waste**[42].

Commission Notice 2018/C 124/01[43] on the classification of waste offers further guidance on the correct interpretation of the waste classification rules. While certain criteria in Annex III to the

[42] Commission Decision (EC) No 2000/532: https://eur-lex.europa.eu/eli/dec/2000/532/oj/eng

[43] Commission Notice 2018/C 124/01: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:JOC_2018_124_R_0001

WFD reference the CLP hazard classes and statements, the CLP Regulation and hazardousness classification rules apply only to substances and mixtures, not to waste.

5.3.1.2. Basel Convention

The Basel Convention is an international treaty designed with the objective of reducing the transboundary movements of hazardous waste, and preventing shipment of hazardous waste from developed to less developed countries. Additionally, the convention aims to reduce both the quantity and toxicity of hazardous waste produced and to ensure its environmentally responsible management (UNEP, 2019a).

5.3.1.3. Waste Shipment Regulation

The Waste Shipment Regulation (henceforth: **WSR**) (EC No 1013/2006, as amended by Regulation (EU) 2024/1157, which came into force on 20 May 2024) governs waste shipments between EU Member States, from third countries to the EU, from the EU to third countries and in transit through the EU. It lays down shipment rules, depending on the origin, destination and path of the waste as well as the type of waste and treatment.

The primary goal of the new Regulation is to prevent the EU from transferring its waste management challenges to other countries and to promote environmentally sound management of waste. Additionally, the focus is on enhancing enforcement to reduce illegal shipment of waste, as well as improving the traceability of waste and promoting preparing for re-use and recycling.

Waste shipment rules **between EU Member States** vary based on waste type andintended treatment. As per Article 4, waste destined for disposal as well as hazardous waste or mixed waste destined for recovery requires a **prior notification and consent procedure**. Green-listed (non-hazardous) waste for recovery within the EU or OECD countries requires the transport to be accompanied by general information[44], if the quantity of waste shipped exceeds 20 kg.

Two types of textile waste (as described in entries B3030 and B3035 in Annex III to the Regulation) are **green listed**. Entry B3035 covers only "Waste textile floor coverings, carpets". Entry B3030 applies to the wider category of textile waste, but it does not cover all possible mixtures of textile waste. For example, a mixture of waste clothes and waste shoes does not fall under that entry, in contrast to a consignment consisting only of waste mattresses. The notification procedure applies to shipments between Member States or with OECD countries if textile waste is mixed with other types of waste, is contaminated to an extent which prevents the recovery in an environmentally sound manner[45] or if it is contaminated with persistent organic pollutants (POPs) in quantities exceeding the limit values established in Annex IV to Regulation (EU) 2019/1021. In all other cases, the information requirements laid down in Article 18 apply.

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44 Following the requirements laid down in Article 18 of the Regulation.

45 The Commission services are currently working on a corresponding guideline for textile waste, to specify contamination values.

Exports **from the EU to OECD countries** will be closely **monitored**, to assess possible environmental damage in the country of destination, especially if certain exports are increasing (cf. Article 45).

Article 39 of the Regulation prohibits the export **from the EU to non-OECD countries** of hazardous waste and certain other types of waste (e.g. e-waste, plastic waste).

Article 40 of the Regulation prohibits the export **from the EU to non-OECD countries** of other types of non-hazardous waste, unless a third country demonstrates its ability to manage this waste in an environmentally sound manner. This regime also applies to textile waste.

Article 29 of the Regulation lays down what rules apply in the event that competent authorities disagree on the classification of a material as waste (basically providing for the stricter approach to be respected for the purposes of the shipment of that material). In that context, and complementary to Articles 5 and 6 of Directive 2008/98/EC, Article 29(1) stipulates that an object or substance is to be considered a **used good** and not waste, if the following conditions are fulfilled:

> "*(a) further use or reuse of the object or substance is certain;*
> *(b) the object or substance can fulfil its intended function without significant pre-processing;*
> *(c) where relevant, the object or substance is tested to ensure its full functionality;*
> *(d) further use is lawful, that is to say that the object or substance fulfils all relevant product, environmental and health protection requirements for the specific use and will not lead to overall adverse environmental or human health impacts;*
>
> *(e) the object or substance is properly preserved and protected against damage during transport, loading and unloading.*"

In order to avoid certain types of waste being falsely declared as used goods, Article 29(3) includes an empowerment for the Commission to adopt implementing acts establishing criteria to distinguish between used goods and waste, for products of particular concern. The impact assessment envisages a preparatory study to identify waste streams for which the Commission has to set out criteria and a preparatory study to set out criteria to differentiate between used goods and waste for each waste stream.

5.3.1.4. Other rules on waste shipment in third countries

In Africa, several nations, including Nigeria, Zimbabwe and South Africa, have debated or implemented bans on used textile imports to protect domestic textile industries. While these imports provide affordable clothing and employment, they also pose social and environmental challenges. In 2016, the East African Community (EAC) aimed to ban used clothing by 2019, arguing that low prices hinder regional development, though not all EAC members followed through. Rwanda enforced a 2018 ban, prompting the U.S. to suspend its duty-free clothing export privileges under the African Growth and Opportunity Act (AGOA) that same year. However, the effectiveness of these bans remains contested, with external pressures (e.g. from the U.S.) influencing their implementation.

5.3.2. Relevant product legislation

One of the main questions related to the implementation of EoW criteria is how product legislation regulates environmental and health risks, once waste has achieved EoW status. Once the material

ceases to be waste it leaves the waste regime and enters the product regime, hence having to comply with legislation applicable to products. EoW textiles have to comply with existing restrictions related to hazardous substances, substances of concern and persistent organic pollutants (POPs) as well as any other restrictions related to safety.

5.3.2.1. CLP Regulation

Regulation (EC) No 1272/2008 on Classification, Labelling and Packaging of substances and mixtures (henceforth: **CLP Regulation**) aims at ensuring a high level of protection of human health and the environment, while promoting the free movement of substances, mixtures and articles.

The Regulation requires those placing substances and mixtures on the market to classify and label them according to the rules established therein. This also applies to those placing recycled substances and mixtures on the market.

As per Article 1(3) of the CLP Regulation, waste is not a substance, mixture or article. Hence, the provisions laid down in the CLP Regulation are not applicable to input materials (i.e. textile waste) of the recycling operation.

Article 3 and Annex I (Parts 2 to 5) set out the criteria for classification in hazard classes and their differentiations and set out additional provisions on how the criteria may be met. These are important in the context of EoW criteria for recycling.

5.3.2.2. REACH Regulation

One of the key objectives of Regulation (EC) No 1907/2006 (henceforth: **REACH Regulation**) is ensuring a high level of protection of human health and the environment from chemicals. It stipulates provisions for the manufacturing, placing on the market and use of substances on their own, in mixtures and in articles.

As in the CLP Regulation, in Article 2(2) of REACH, waste is not a substance, mixture or article. Therefore, this Regulation does not apply to waste. However, as soon as textile waste ceases to be waste, the product legislation applies, including various obligations defined in REACH for substances on their own, in mixtures and in articles.

Manufacturers or importers of substances and substances in mixtures above 1 tonne/year have to register those substances to gain access to the EU market (subject to exemptions). Article 33 requires that any supplier of an article meeting the criteria in Article 57 in a concentration above 0.1% weight by weight shall provide the recipient of the article with information on the substance.

Other relevant obligations include substances listed in Annex XIV, for which an authorisation is needed to place them on the market for a particular use or to use them in the EU, pursuant to Article 56. In addition, restrictions pursuant to Article 67 and listed in Annex XVII to REACH may apply to the manufacturing, placing on the market and use of certain hazardous substances.

5.3.2.3. Forthcoming restriction on skin-sensitising chemicals

The Classification and Labelling Inventory[46] of the European Chemicals Agency (**ECHA**) contains notifications covering over 120 000 hazardous substances present on the EU market. A fraction of these substances (e.g. chromium VI, nickel and cobalt compounds) have been identified as skin sensitisers (i.e. substances that can cause an allergic response following skin contact) (ECHA, 2020). The Commission is working on a proposal for a restriction of skin sensitisers (categories 1, 1A and 1B) in textile and leather products, based on a dossier prepared by France and Sweden, and considering an opinion[47] issued by the relevant ECHA committees (Committee for Risk Assessment and Committee for Socio-economic Analysis).

5.3.2.4. POPs Regulation

Persistent organic pollutants (POPs) are chemicals that persist in the environment, bio-accumulate and can potentially cause significant adverse effects to human health or the environment.

Regulation EU 2019/1021 (henceforth: **POPs Regulation**) aims at protecting human health and the environment from these chemicals with specific control measures.

Article 7 lays down provisions for the management of POPs waste. Notably, "*waste consisting of, containing or contaminated by any substance listed in Annex IV to this Regulation shall be disposed of or recovered, without undue delay and in accordance with Part 1 of Annex V to this Regulation, in such a way as to ensure that the POPs content is destroyed or irreversibly transformed so that the remaining waste and releases do not exhibit the characteristics of POPs"*.

By way of derogation, Article 7(4)(a) states: "*waste containing or contaminated by any substance listed in Annex IV may be otherwise disposed of or recovered in accordance with the relevant Union legislation, provided that the content of the listed substances in the waste is below the concentration limits specified in Annex IV*".

These provisions are relevant for the treatment of textile waste containing substances listed in Annex IV and are hence applicable to input materials of the recycling operation.

Article 2(1) of the POPs Regulation defines 'placing on the market' in accordance with point 12 of Article 3 of the REACH Regulation. Article 3 of the POPs Regulation prohibits the manufacturing, placing on the market and use of substances listed in Annexes I and II, whether on their own, in mixtures or in articles, unless covered by any of the exemptions in Article 4. These exemptions include the use of the substance at lab scale for research, as a reference standard or if the substance is present below its 'unintentional trace contaminant' limit value (which is defined for some POPs in Annex I). Recycled textiles that achieve EoW status will have to comply with the POPs Regulation, including the limit values imposed therein.

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46 ECHA Classification and Labelling Inventory: https://echa.europa.eu/information-on-chemicals/cl-inventory-database

47 https://echa.europa.eu/registry-of-restriction-intentions/-/dislist/details/0b0236e182446136

5.3.2.5. Ecodesign for Sustainable Products Regulation (ESPR)

Regulation (EC) No 2024/1781 (Ecodesign for Sustainable Products Regulation; henceforth: **ESPR**) aims at promoting the sustainability of products over the whole life cycle by establishing eco-design requirements.

Article 2(27) lays down a definition for substances of concern (SoCs), including substances meeting the criteria of Article 57 of the REACH Regulation, substances classified as hazardous pursuant to Annex VI to the CLP Regulation, substances regulated under the POPs Regulation and other substances negatively affecting the re-use and recycling of materials in the product in which they are present.

The ESPR does not impose limitations on those substances. Article 7 of the Regulation establishes information requirements for SoCs, which must be included either on the product or must be accessible via a digital passport accompanying the product. Information requirements for specific product groups will be specified in secondary legislation.

Chapter VI of the ESPR (Destruction of unsold consumer products) prohibits economic operators from destroying unsold goods – including apparel, clothing accessories and footwear – that are listed in Annex VII (reported in **Annex 1** of this document). Under Article 25(1) this ban came into force in July 2026 for large enterprises and will come into force in 2030 for medium-sized companies. The prohibition does not apply to activities that prepare the products for re-use or for remanufacturing, which are expressly promoted as circular-economy measures. Specific derogations on the prohibition of destruction of unsold consumer products are laid out in Commission Delegated Regulation (EU) 2026/296.

5.3.2.6. Biocidal Products Regulation

Regulation (EU) No 528/2012 (Biocidal Products Regulation, henceforth: **BPR**) aims at enhancing the internal market with harmonised rules for the distribution and use of biocidal products, while ensuring high protection for human and animal health, and the environment.

The Regulation mandates the European Chemicals Agency (ECHA) to establish and maintain a list of approved active substances that can be used in biocidal products[48], which shall be reviewed periodically.

Biocidal products require authorisation (which can be granted at Union level, at national level or through mutual recognition) to be placed on the market. The manufacturers of articles treated with biocidal products have to ensure that the biocidal treatment does not pose a risk to human health, animal health or the environment.

Annex V to the Regulation lists the biocidal product types within the scope. Disinfectants and preservatives used in textiles are listed, namely:

[48] List of approved active substances: https://echa.europa.eu/regulations/biocidal-products-regulation/approval-of-active-substances/list-of-approved-active-substances

— products commonly incorporated in textiles and other articles or materials with the purpose of producing treated articles with disinfecting properties;

— products used for the preservation of fibrous or polymerised materials, such as leather, rubber or textile products by the control of microbiological deterioration.

Products containing unauthorised biocides cannot be placed on the market. For textiles, the allowed usage is regulated at fibre level. The provisions are hence relevant for EoW criteria for recycling.

5.4. Environmental and human health impacts

One of the conditions to be fulfilled to attain EoW status is that the use of the material that has achieved EoW status shall not lead to adverse environmental or human health impacts. Once waste ceases to be waste, it shall comply with product legislation and the relevant requirements to prevent adverse impacts to human health and the environment, as described in the previous section.

Environmental and human health impacts can occur at any step of the textile value chain, including production of new textiles, as well as collection and management of textile waste. Those impacts include (Villanueva & Eder, 2014):

— energy and resource use;

— climate-relevant emissions to air (CO_2 and other greenhouse gases);

— emission of toxic and/or environmentally harmful substances as well as dust into the air;

— leaching or leakage of liquid components into the ground;

— accumulation and/or release of toxic substances;

— fire hazards; and

— accidents at work when handling the waste.

Recycling prevents textile products and textile waste streams from being incinerated or landfilled, thereby fulfilling the waste hierarchy principles.

Huygens et al. (2023) estimated the environmental benefits of moving textile waste up in the waste hierarchy and carried out a life cycle assessment. The findings of the study demonstrate that the environmental impacts of recycling depend on the input material and the recycling technology used. In the study, either landfilling or incineration is taken as the benchmark, when comparing the environmental impacts associated with recycling operations. Recycling always offers environmental benefits compared to landfilling. When using incineration as a benchmark for the comparison, recycling does not necessarily provide environmental benefits, due to additional impacts not only from recycling but also from preceding phases (collection, transport, sorting). Technological progress could lead to higher recycling yields in the future, increasing the environmental benefits of recycling versus incineration.

As a significant share of textile products (apparel, home textiles) come into direct contact with the skin, it is imperative to evaluate the impacts on human health that could be caused by chemicals contained in those products. This aspect is described in detail in the following subsection.

5.4.1. Chemicals of concern

Systems for providing information on chemicals in textile products are considered as one of the examples in the 'Chemicals in Products Programme'[49]. The programme is part of the Strategic Approach to International Chemicals Management (SAICM)[50] of the United Nations Environment Programme (UNEP). The approach aims at increasing the availability of and access to the information that actors need to properly manage chemicals in those products.

Different substances can be incorporated into textile products during production, use and recovery. The chemical substances used in textiles can be classified into (KEMI, 2014, 2022):

- **functional chemicals** – to confer specific functional properties (e.g. oil/soil and water repellents, flame retardants, biocides) or aesthetic properties (e.g. dyestuffs and pigments) – these typically remain in the final product;
- **auxiliary chemicals** – necessary for the textile production process (e.g. organic solvents, softeners, salts) – these are typically washed out during the production process;
- **unintended chemicals** – contaminants and degradation products with no specific function in the production process or in the finished article (e.g. formaldehyde, polyaromatic hydrocarbons impurities, heavy metals) – these may remain in the final product in relatively low concentrations but may nonetheless be of concern for human health and the environment.

Chemicals present in textile items may be released during the use phase and end of life, leading to potential exposure of humans and the environment. The way they are released depends on the inherent chemical/physical properties of the substance, on the incorporation into the textile material and the type of fibre as well as on the use patterns of the textile item (KEMI, 2014).

Human exposure to chemicals in textiles can occur through dermal contact, inhalation and ingestion. Clothing and bed linens, being in close contact with the skin, pose a risk of dermal exposure (potentially leading to allergic reactions). Oral exposure can be of concern for small children, especially in the case of water-soluble compounds that can migrate to the saliva. Textile fibres can be released into indoor dust, potentially affecting children who may ingest or inhale them. Inhalation exposure primarily affects retail workers and those in environments with high textile concentrations (e.g. warehouses, clothing and furniture stores). Chemical exposure through inhalation may also occur due to volatile compounds emitted from textiles or intentional additives like fragrances (KEMI, 2014).

As mentioned in Section 5.3.2.3, under the CLP Regulation a substance is classified as a **skin sensitiser** if it shows allergenic properties in toxicity tests or if there is evidence that the substance can cause a skin allergy in humans. The most common substances reported to cause dermatitis are

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49 UN Chemicals in Products Programme: https://www.unep.org/explore-topics/chemicals-waste/what-we-do/emerging-issues/chemicals-products#:~:text=The%20Chemicals%20in%20Products%20%28CiP%29%20Programme%20is%20an,information%20on%20the%20chemicals%20contained%20in%20everyday%20products.

50 Strategic Approach to International Chemicals Management: http://saicm.org/

dyes (particularly disperse dyes) and finishing resins (which can release formaldehyde) (KEMI, 2014).

Environmental exposure to chemicals in textiles primarily occurs through leaching during laundering, textile fibre release due to wear and tear, and waste disposal. Substances can enter waste-water during textile washing, which may then affect aquatic ecosystems and potentially lead to human exposure through food. Chemical substances can also bind to textile fibres, which may end up in waste-water or household dust, further impacting the environment. Consumer use of textiles, such as laundering and recycling, can contribute to these environmental exposures, although the specific impact of various chemicals is not well understood. One known example is nonylphenol ethoxylates and their degradation product, nonylphenol, which have been identified as significant sources of exposure to aquatic environments from textile washing (KEMI, 2014). **Biocides** can be used to prevent bacterial growth and odours during use. The most common antibacterial or antimicrobial substances are **zinc pyrithione** and **silver**. These agents can be released to the environment during washing (KEMI, 2022).

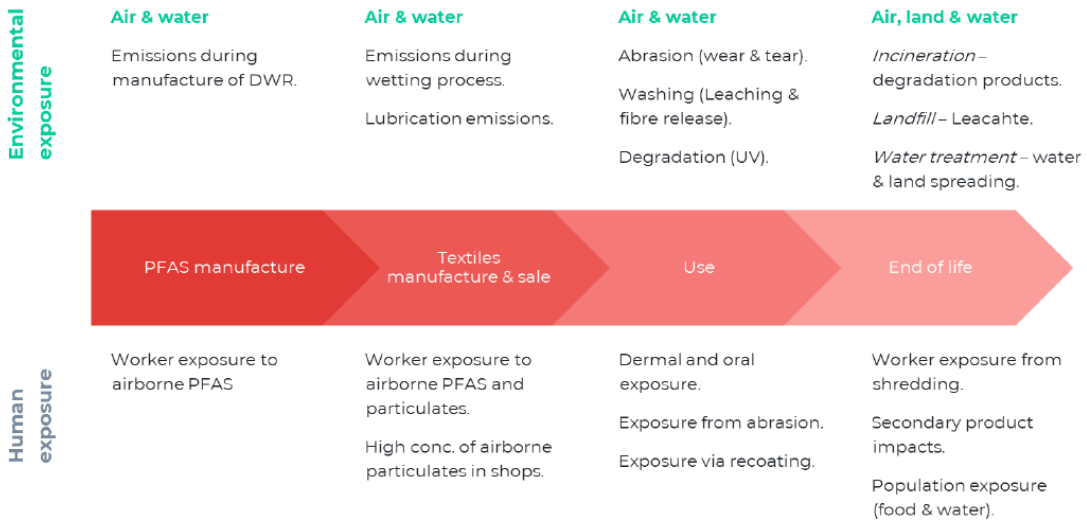
Per- and polyfluoroalkyl substances (PFAS) have been identified as a class of toxic chemicals and have gained attention under both the Strategic Approach to International Chemicals Management (SAICM (NRDC, 2021)) and the Stockholm Convention on Persistent Organic Pollutants (ECHA, 2023) but also within the EU in the context of the Chemicals Strategy for Sustainability[51], under the REACH Regulation and beyond. Under REACH there are restrictions in place for some of the substances belonging to the PFAS group in textile products. A dossier to extend the restrictions to the whole group of PFAS is currently under evaluation by ECHA.

PFAS can cause serious health effects, even at low levels of exposure, including cancer, hormone disruption, liver and kidney damage, developmental and reproductive harm, changes in serum lipid levels, and immune system toxicity (UNEP, 2021). PFAS are persistent and very hard to degrade, due to their strong chemical bonds. Once they are released they can spread quickly, also representing a threat for the environment (contamination of groundwater, surface water and soil) (NRDC, 2021).

Textiles represent a significant contributor to PFAS pollution in the EU and globally (35% of the total global fluoropolymer demand). Environmental and human exposure to PFAS can occur through the whole textile life cycle, from production to sale, use and disposal (see **Figure 18**) (Doyle et al., 2024; EEA, 2024b).

51 EU Chemicals Strategy for Sustainability: https://environment.ec.europa.eu/strategy/chemicals-strategy_en

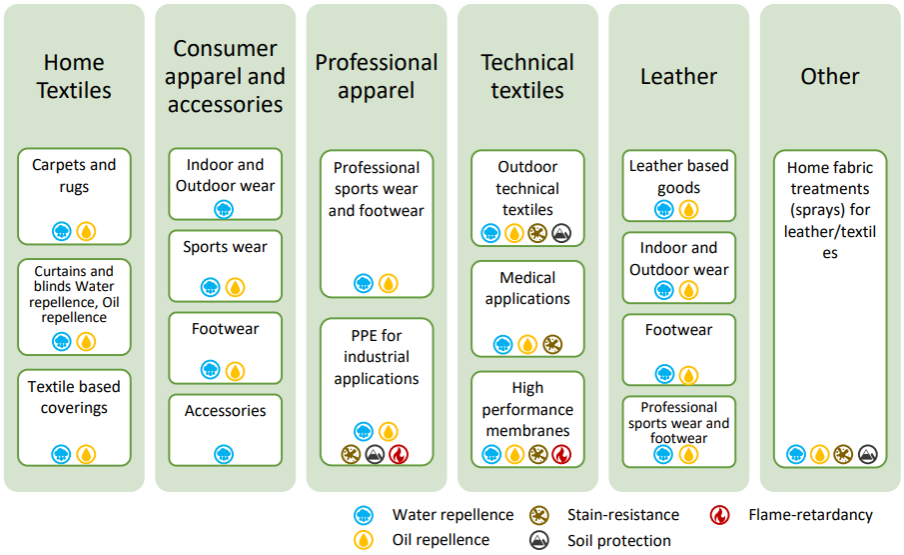
Figure 18. PFAS in the textiles life cycle



Source: Doyle et al., 2024

Some types of PFAS are used in different textile products (see **Figure 19**), specifically as water and oil repellents (e.g. in carpets, curtains, sportswear and footwear), stain resistants and flame retardants (e.g. in technical textiles) (Doyle et al., 2024; UNEP, 2021).

Figure 19. PFAS in the textile sector



Source: UNEP, 2021

PFAS exist in polymeric and non-polymeric form. Polymeric PFAS are intentionally added to the article to provide the desired properties during manufacturing or during their lifetime. For instance, in the case of carpets, certain PFAS are added during manufacturing as stain repellents but also during use for cleaning purposes. Non-polymeric PFAS are used during manufacturing as processing

aids and can be released during washing (Bečanová et al., 2016; Doyle et al., 2024; Herzke et al., 2012).

A set of strategies to reduce the negative impact of PFAS in the textiles sector have been proposed by EEA (2024b), including:

— finding safe alternatives;

— tracing PFAS in textiles before and during use;

— identifying, separating and sorting PFAS after use or at the end of life;

— improving incineration techniques and avoiding landfill;

— minimising impacts beyond the EU.

The use of PFAS is not always a technical necessity (except in the case of speciality articles such as firefighters' clothing) and it is possible to replace them with other substances. Some manufacturers of textile products have started to replace certain PFAS with fluorine-free substances.

Denmark notified the European Commission[52] of an Order banning PFAS in consumer clothing and footwear by July 2026. The use of PFAS professional and safety clothing will still be allowed until valid alternatives can be found. The ban will apply to imports from Member States, but not to recycled textiles.

Technically, current recycling technologies struggle to remove or neutralise persistent pollutants like PFAS, as existing methods are often inadequate for eliminating these substances. This limitation risks transferring harmful chemicals to new products, undermining the safety of recycled materials and perpetuating contamination cycles. To address these challenges, innovative recycling technologies must be developed to effectively remove or neutralise persistent chemicals. Improved sorting and separation infrastructure is also essential to divert high-risk materials from the recycling stream.

A critical barrier is the lack of transparency in textile supply chains, which hinders the identification of contaminated materials before they enter the recycling stream. Chemicals are often not disclosed on product labels, and their presence in polymeric or non-polymeric forms complicates detection. This opacity makes it difficult to assess risks and develop safe handling practices, particularly for used textiles that may carry legacy contaminants from previous production or use phases.

5.5. Mapping existing end-of-waste criteria for textile recycling in Member States

The mapping of existing EoW criteria at national level is based on in-house research and on input received from stakeholders and Member States within the scoping study (see Section 1.3) and the stakeholder consultations.

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[52] Notification by Denmark on the Order prohibiting the import and sale to consumers of clothing, footwear and waterproofing agents containing PFAS: https://technical-regulation-information-system.ec.europa.eu/en/notification/26455

France implemented national EoW criteria for wiping cloths (see **Table 6**) (Legifrance, 2019). The EoW criteria include requirements on input materials (e.g. defined European waste codes[53], input has to be non-hazardous and also clean and dry), processing techniques and processes (e.g. wet, dirty or other textiles need to be removed, foreign matter such as buttons or zippers need to be removed, cloths need to be cut and sized according to customer or industry specifications, stored separately), and the quality of the cut cleaning rags (e.g. clean and dry, assembly in batches according to the customer's specifications or according to a particular category of textiles, each batch is packaged and stored according to practices that ensure its integrity).

Italy is currently working on the development of national EoW criteria for textile recycling (see **Table 6**). The stakeholder consultation on the draft decree was closed in January 2024.

An in-depth analysis of these national EoW criteria is reported in **Annex 9**.

Table 6. EoW criteria for recycling of textile waste in Member States (non-exhaustive list)

Member State	Targeted waste	Status
France (FR)	Cut wiping cloths from recycled textile waste	Implemented: Order of 25 February 2019 setting out the EoW criteria for cut wiping cloths made from textile waste. JORF n°0064 du 16 mars 2019: https://www.legifrance.gouv.fr/eli/arrete/2019/2/25/TREP1833757A/jo/texte
Italy (IT)	Textile waste	Under development: EoW criteria for textile waste: https://www.mase.gov.it/bandi/consultazione-con-le-parti-interessate-la-definizione-dello-schema-di-regolamento-recante

Source: own elaboration

[53] 15 01 09 textile packaging, 15 02 03 absorbents, filter materials, wiping cloths and protective clothing other than those mentioned in 15 02 02, 18 01 04 wastes whose collection and disposal is not subject to special requirements in order to prevent infection (for example dressings, plaster casts, linen, disposable clothing, diapers), 19 12 08 textiles, 20 01 10 clothes, 20 01 11 textile.

6. End-of-waste criteria development for recycling of textile and textile-related waste

In the following sections the scope, system boundaries and the **EoW criteria for recycling** are presented and discussed in detail.

The feedback and additional evidence received from two stakeholder consultation rounds, as well as during bilateral meetings and site visits, was thoroughly analysed and critically assessed and served to build the basis for the technical proposals.

As illustrated in Section 4.2.4, textile recycling encompasses a diverse range of technologies, which can be broadly categorised into the following main approaches: mechanical recycling, thermo-mechanical, physical and chemical recycling.

The primary distinction between mechanical textile recycling compared to any other textile recycling lies in the alteration of the textile fibres. Mechanical recycling processes in principle preserve the fibre's general properties but are limited in their ability to produce output materials for closed-loop recycling and remove impurities, such as unwanted substances, but also colours, dyes and print.

In contrast, thermo-mechanical, physical and chemical recycling technologies alter the fibre structure. In the case of chemical recycling, fibres are transformed into new chemical compounds, enabling the removal of contaminants and the purification of the output materials to a greater extent. Purification is also possible with physical recycling technologies.

As a result, the output materials from mechanical recycling and thermo-mechanical, physical and chemical recycling differ significantly, leading to distinct downstream applications. Hence, in some instances, a distinction between those technologies is made.

6.1. Scope and system boundaries

6.1.1. Textile sources within the scope

The JRC's initial proposal covered a wide scope of sources including:

- pre-consumer and separately collected post-consumer household and commercial textile waste that have been deemed not suitable for re-use during pre-sorting, sorting for re-use or preparing for re-use operations;
- post-industrial textile waste[54];
- textiles filtered out of mixed MSW or other waste fractions;
- textile fractions separated from post-consumer household and post-consumer commercial waste streams that are not primarily made up of textiles.

[54] Production scrap re-used within the production process or by-products are not under scope.

6.1.1.1. Stakeholders' feedback

In general, a vast majority of stakeholders were in agreement with the JRC proposal on the sources within the scope. The stakeholder feedback, in particular the concerns to include these sources within the scope, are summarised below.

— **Pre-consumer and post-consumer household/commercial textile waste deemed not suitable for re-use**

No arguments against the inclusion of this source were received.

— **Post-industrial waste**

One stakeholder argued that the inclusion of post-industrial waste would compromise the opportunity to use post-consumer waste, as the collection, sorting and preparation of post-consumer waste is more expensive compared to post-industrial feedstock. Another stakeholder advocated to not include this source as it is largely composed of reusable technical textiles.

— **Textiles filtered out of mixed municipal solid waste and other waste fractions**

Among the stakeholders not agreeing with the proposal, many argued that allowing textiles filtered out of mixed municipal solid waste and other waste fractions could be an incentive to decrease separate collection, whereas separate collection needs to be a priority. Separate collection is especially preferred to limit the risk of (cross-)contamination. Textiles have a high capacity to absorb liquids which, in turn, favours the growth of bacteria and mould.

Individual stakeholders argued that it is not common practice to sort and process this source of textile waste to a state that makes it viable for recycling. Criteria for sorting of textiles from mixed municipal solid waste have not been established. Other stakeholders highlighted that some advanced recycling technologies can process these textiles after extensive sorting, cleaning and pre-treatment. However, wet or soiled textiles generally remain unsuitable for high-quality recycling. Chemical recyclers highlighted that certain technologies can process contaminated textiles from this source. However, the removal of the contamination makes recycling more complex and costly.

If textile waste filtered out of mixed municipal solid waste were to be included within the scope, cross-contamination should be avoided by separating them from separately collected textiles.

— **Textile fractions separated from post-consumer household and post-consumer commercial waste streams that are not primarily made up of textiles**

Only a few stakeholders asked to exclude this source but did not provide any further argumentation. Other stakeholders confirmed that this source of textiles should remain within the scope due to its good potential for recycling.

6.1.1.2. JRC assessment of feedback

— **Post-industrial waste**

Post-industrial textile waste is a source of textile waste that arises in the production stage (see Section 4.1.1) and is usually of a very high purity (e.g. similar fibre type(s), same colour), making it an attractive input material for recycling. Some parts of the post-industrial textile waste may

be reusable for technical textiles as argued by stakeholders, but recycling is and will remain an important route for this source of textile waste.

Furthermore, the JRC does not share the opinion that the inclusion of post-industrial textile waste would compromise the use of post-consumer waste for recycling. Site visits and bilateral exchanges with stakeholders showed that mechanical recycling of post-industrial waste is common practice in Europe and its use for recycling is often prioritised because of its consistent quality. Excluding this source of textile waste from recycling does not necessarily lead to an increase in the recycling of post-consumer waste. This is mainly due to the heterogeneous composition of post-consumer textile waste which requires additional recycling efforts to transform it into usable output material for new products.

— **Textiles filtered out of mixed municipal solid waste and other waste fractions**

Despite the obligation to separately collect textiles as of January 2025, some textiles will likely continue to be discarded together with other wastes such as municipal solid waste. Studies suggest that currently textiles make up around 4% of mixed municipal waste (Kählig et al., 2025). As described above, textiles coming into contact with other wastes can absorb moisture. However, from a technical point of view it is feasible to separate textiles from other wastes, recover a textile fraction and prepare it for recycling.

The JRC is aware that this recycling path is of secondary importance, and it is currently still at the experimental stage. The JRC also agrees with the stakeholders that this approach will be more costly compared to the processing of separately collected textile waste and may not become a generalised business model for textile recycling. However, with a view to increasing the recycling of textile waste and adopting a technology-neutral approach, the JRC proposes to include this source of textile waste. This textile waste may require specific treatment - such as sanitation and/or decontamination - before or during recycling (see Section 0 for further details).

— **Textile fractions separated from post-consumer household and post-consumer commercial waste streams that are not primarily made up of textiles**

The JRC evaluated the recycling of textile fractions from post-consumer household and post-consumer commercial waste streams that are not primarily made up of textiles. Examples are footwear, household textiles (e.g. mattresses), upholstery from vehicles and other transportation systems, as well as construction and demolition waste, among others (see also Section 4.1.3). To render these waste streams suitable for textile recycling, a pre-treatment should be employed to separate textiles from the other waste materials. Explicit examples are as follows:

- Footwear: separated textile fractions from footwear can then be used for recycling (currently under development, see Section 4.2.4). Currently, the recovered textile fraction is used for example to produce new shoe laces (FFG, 2024).
- Mattresses, pillows and duvets: are all textile-rich products whose textile fractions can be separated from foam, wood and metals and can be used as feedstock for textile recycling (Auping, 2024; RetourMatras, 2024).

- In vehicles, textiles are used for upholstery (e.g. seats, dashboards, door panels, and headrest covers), carpets and floor mats as well as insulation panels. The textile-rich fractions of end-of-life vehicles (ELVs) can be removed by dismantling or separated from shredder fluff after shredding[55].

To date, the recycling of textile fractions separated from these items remains limited or is still in the research phase. However, the JRC believes that, following the necessary pre-treatment steps, these separated textile fractions can be a viable input material for all recycling processes.

At this point the JRC would like to clarify that the scope of the EoW criteria for recycling differs in several aspects from the criteria applicable to preparing for re-use and remanufacturing (Pérez Arribas et al., 2026). The scope distinction is most evident for footwear. Waste material within the scope of EoW criteria for preparing for re-use and remanufacturing is very much in line with the items subject to extended producer responsibility (EPR) obligations under the WFD. The EPR scope also encompasses footwear made of non-textile materials (e.g. rubber, plastic, leather). These materials are not considered in the EoW criteria for textile recycling. Footwear may contain textile components, but these need to undergo mechanical pre-treatment to separate the textile fibre from other parts of the footwear. Only after this separation can the textile fraction be used as input material for textile recycling.

Beyond footwear, other waste streams (both from post-consumer household and commercial sources) contain textile fractions that are not the primary material of the item. Those are also included in the scope of textile recycling.

6.1.1.3. JRC proposal

For the development of EoW criteria for recycling, the JRC proposes to include:

— **post-industrial textile waste**[56];

— **pre-consumer and separately collected post-consumer household and commercial textile waste** that have been deemed **not suitable for re-use** during pre-sorting, sorting for re-use or preparing for re-use operations, **nor suitable for remanufacturing** (if applicable);

— **textiles filtered out from wastes in which textiles are considered a misthrow** (e.g. mixed municipal solid waste);

— **textile fractions** separated from post-consumer household and post-consumer commercial waste streams **that are not primarily made up of textiles** (such as footwear, duvets, vehicle upholstery).

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55 Shredder fluff is the light vehicle scraps derived from shredding and accounts for about 15-25% of the total vehicle. It can include seals, rubbers, textiles, plastics or tyre fragments from vehicles.

56 Production scrap re-used within the production process or by-products are not within the scope.

6.1.2. Textile fibres within the scope

In its initial proposal, the JRC proposed to include all natural and man-made fibres and mixtures thereof within the scope for EoW criteria for recycling, but to exclude mineral and inorganic fibres.

6.1.2.1. Stakeholders' feedback

An overall majority of stakeholders were in favour of the proposed scope as it would allow a broad range of textile fibres to be recycled. No stakeholder was in favour of restricting fibres within the scope.

Certain stakeholders were of the opinion not to exclude certain fibre types *a priori* and include mineral and inorganic fibres within the scope. Stakeholders acknowledged that some mineral fibres, especially older forms like asbestos, are known to be hazardous and must not be recycled. However, modern mineral fibres are typically engineered to reduce these risks. In general, all non-hazardous fibres should be within the scope, and the recycler should have the freedom to decide if their facility can process a given material.

Stakeholders highlighted successful research on carbon fibre and (para-)aramid recycling and thus would not exclude them. These fibres are sorted, precision-cut, sized and milled into powders for delivery to the compounding industry.

Another stakeholder highlighted that inorganic components such as metal threads may be present in textiles in varying quantities and also have the potential to be recycled.

6.1.2.2. JRC assessment of feedback

Further JRC research revealed that carbon fibres are increasingly being used, especially for high-strength applications such as in protective clothing but also sports equipment, due to their durability and lightness (Manis et al., 2021). At the same time, as mentioned by stakeholders, new recycling technologies are evolving and entering the market with the potential to recover inorganic fibres, such as metal and carbon fibres (Barnett & Ghossein, 2021), apart from the mainstream fibres. Thus, the JRC recommends including inorganic fibres in the scope.

The stakeholder feedback revealed that certain textiles can contain a varying share of metal threads. The JRC has no scientific evidence on how different levels of metal threads affect the recycling of textiles. However, it can be assumed that different technological approaches have different capabilities to recycle textiles containing metal threads. In addition, it is possible that new technological approaches will emerge in the future that will enable textile recycling that is currently not technically feasible. Therefore, the JRC refrains from setting thresholds for metallic threads.

With regard to mineral fibres, the JRC refrains from considering them within the scope. The two main reasons are that hazardous fibres such as asbestos are excluded *a priori* due to their hazardousness nature and that mineral fibres play a minor role in the manufacture of textiles. Mineral fibres are mainly used in construction materials (e.g. isolation material, fireproofing).

6.1.2.3. JRC proposal

The JRC proposes to include all **natural and man-made textile fibres** and **mixtures thereof** within the scope.

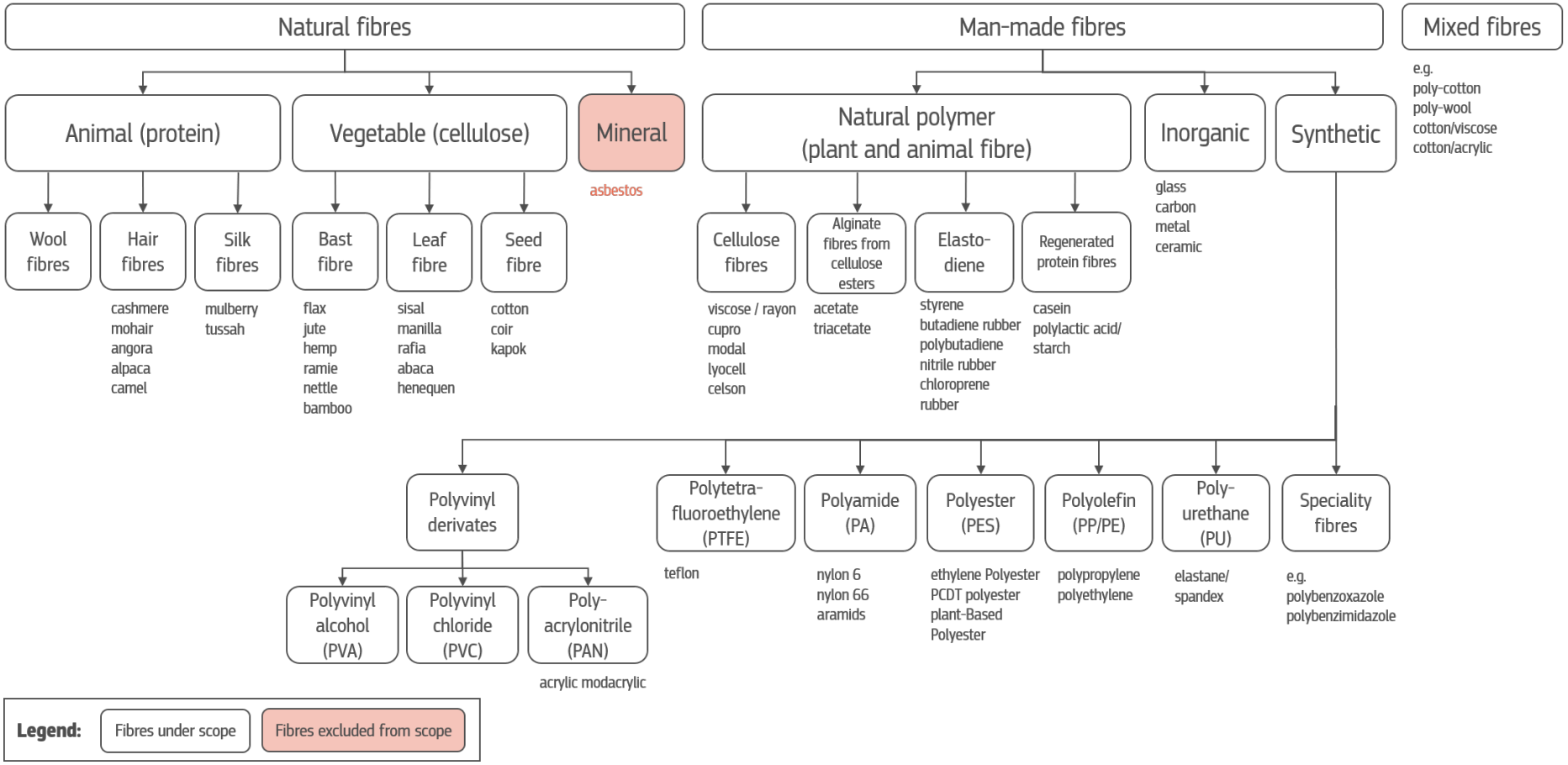
The JRC proposes to **exclude mineral fibres**.

For the sake of completeness, it is noted that leather and other animal-originating materials such as fur and down, as well as cork, cannot be considered equivalent to textile fibres and are therefore outside the scope for textile recycling.

Error! Reference source not found. gives an overview of the textile fibres within the scope (white boxes) and those excluded from the scope (red boxes) and provides a non-exhaustive list of examples for fibres within each fibre category.

An extensive list of natural-origin fibres and man-made fibres is given in **Annex 2**.

Figure 20. Overview of textile fibres within the scope (white) and excluded from the scope (red) for textile recycling (non-exhaustive list)



Source: own elaboration

6.1.3. Recycling technologies within the scope

The JRC initially proposed a largely technology-neutral approach which includes all mechanical, thermo-mechanical, physical and chemical recycling technologies and combinations thereof within the scope, with the exception of recycling technologies that recover so-called dual-use output materials which are not exclusively used for material recycling, but also for the production of energy or fuels, such as gasification and pyrolysis processes.

6.1.3.1. Stakeholders' feedback

— **Extension of scope**

All stakeholders welcomed the proposed technology-open scope and particularly emphasised the importance of including chemical recycling technologies such as depolymerisation. Stakeholders did not propose to restrict any technology from the scope.

Beyond the current scope, stakeholders highlighted that all recycling technologies will be required in the transition to a more circular economy and new technologies are able to produce secondary raw materials that are replacing virgin fossil feedstock. Technologies such as pyrolysis and gasification are capable of treating textile waste that other methods cannot treat and can reprocess waste streams from other textile recycling processes to materials.

EoW criteria should be defined based on the quality, safety and compliance of the output materials, rather than being restricted by the recycling process used, according to stakeholders. A technology-based approach risks creating unjustified barriers for companies deploying innovative solutions that may not currently fall within the proposed scope.

Dual-use materials should not be relevant for EoW criteria as materials to be used as fuels are already excluded from the definition of recycling in the WFD. All technologies that reprocess waste materials into products, materials or substances according to the definition of recycling in the WFD should be within the scope of the EoW criteria. One stakeholder questions the JRC argument to exclude chemical recycling technologies with dual-use technology as the compliance with EoW criteria does not always coincide with the point to calculate the recycling rate.

Stakeholders agreed that the recycling output (beyond the compliance with EoW criteria) should exclude fuel or energy uses but also refer to pyrolysis and gasification processes that already convert textile waste in general or specific textile fibres into new materials. Examples are as follows:

- Pyrolysis: carbon fibre composites are pyrolysed and the value of the recovered carbon is still high (Naqvi et al., 2018);
- Gasification: certain gasification technologies can use multiple fibre types and blends and recover virgin-quality fibres which are indistinguishable from conventional products.

6.1.3.2. JRC assessment of feedback

— **Pyrolysis and gasification**

Given that the scope of the proposed EoW criteria envisages material recycling of textiles, the JRC considers that for pyrolysis and gasification two main conditions are not fulfilled to possibly include the processes and their outputs in the scope.

Firstly, pyrolysis and gasification result in considerable material losses, up to half or more of the actual input (Arjona et al., 2024; Athanasopoulos & Zabaniotou, 2022), during the conversion process of the input material, either as gaseous emissions or as residues that need to be discarded as waste. This means that the actual material conversion potential of these processes is limited.

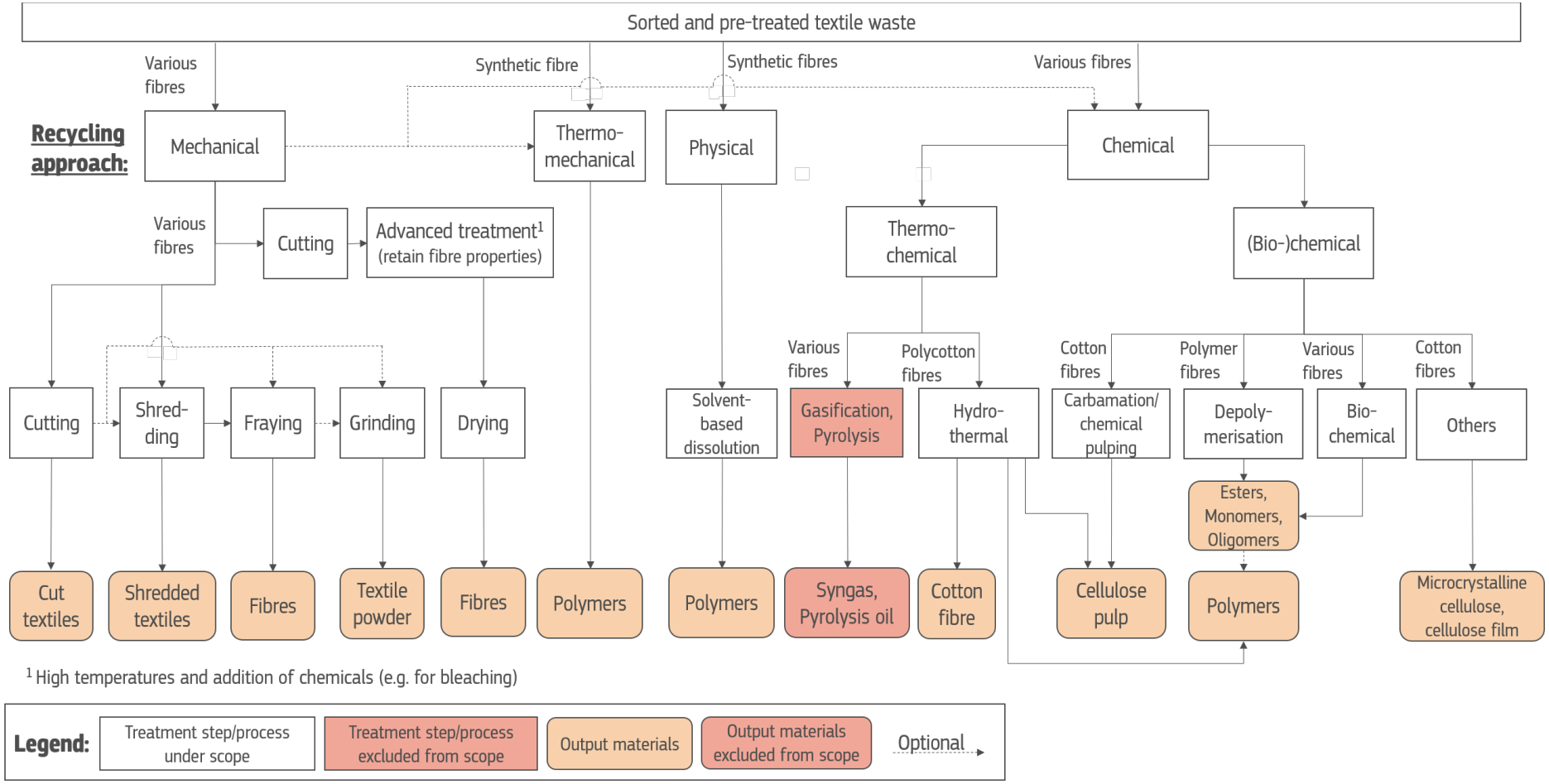
Secondly, the valuable intermediate outputs from these processes, such as pyrolysis oil or syngas, which can be further converted to new chemicals, have dual-use properties. This means that a further partial, or even complete, conversion to energy or fuel products will occur in practice during the downstream processing of these intermediates. The JRC is of the opinion that possibly awarding the status 'end-of-waste for recycled textiles' to intermediates stemming from the pyrolysis and gasification of textile waste would thus create legal confusion on the actual level of recycling for this waste. In addition, the JRC is aware that in some Member States national EoW criteria exist for such intermediates, like pyrolysis oil, and that inclusion of pyrolysis and gasification processes in the scope of the present EoW criteria could thus possibly lead to changes in the legal status of these intermediates. As already discussed in the JRC Technical Proposals for EU-wide end-of-waste criteria for plastic waste (Pierri et al., 2024), a change in national EoW recognition for intermediates is not desired by most industry actors (see also Box 1 below).

6.1.3.3. JRC proposal

The JRC proposes a technology-neutral approach and to include all **mechanical, thermo-mechanical, physical and chemical recycling technologies and combinations thereof within the scope**[57]. Excluded are conversion technologies that partly convert the input materials to energy or recover output materials which may be partly or entirely used for the production of energy or fuels, such as syngas from **gasification and pyrolysis oil from pyrolysis processes** (see **Figure 21**).

[57] The overarching term 'mechanical, thermo-mechanical, physical and chemical recycling' will be used hereafter to collectively refer to all recycling technologies within the scope.

Figure 21. Textile recycling technologies within the scope (white) and excluded from the scope (red)



Source: own elaboration

Box 1. Comparison with the approach proposed by the JRC for EU-wide EoW criteria for plastic waste

The reader may notice that the current proposals for EU-wide EoW criteria for textile waste include certain chemical recycling technologies as eligible technologies within the scope, whereas the 2024 JRC proposals for EU-wide EoW criteria for plastic waste (Pierri et al., 2024) did not. There are a number of specific reasons for this, as outlined below.

Technology maturity: For plastics, mechanical recycling is an established technology, while chemical recycling is still growing (Plastics Europe, 2022). In the case of textiles, and in particular for chemical recycling, certain technologies such as thermo-mechanical recycling and certain chemical recycling technologies such as pulping are already in full-scale operation, or are highly likely to be operational on a large scale in the coming years for textiles.

Market share: For plastics, mechanical recycling dominates the current recycling landscape with a market share of about 99% (EEA, 2024a). Moreover, mechanical recycling provides a considerable amount of material back to the plastic economy, with about 13% of all plastics put on the market coming from mechanical recycling (Plastics Europe, 2024). For textiles, the current ratio between mechanical and other recycling technologies is much less pronounced, with about 71% for mechanical recycling versus 29% for the other recycling technologies at global level (GVR, 2022). Moreover, at present, less than 1% of textiles are recycled mechanically to produce new fibres for fabrics (Janmark et al., 2022). The quality of fibres (e.g. fibre length and strength) degrades with each subsequent cycle of mechanical recycling.

Achievable output quality: Plastic recyclates resulting from mechanical recycling are generally of very high quality. In the case of textiles, this is not always the case due to the complexity of textile fibres and their blends. About 60-70% of the worldwide fibres used in textiles are blended fibres (e.g. poly-cotton, poly-viscose, acrylic and/or nylon wool) (Textile Exchange, 2023). Blended fibres, which combine two or more different types of fibres, pose a significant challenge when it comes to recycling and most blended fibres cannot be recycled using traditional mechanical recycling approaches. A large proportion of the mechanically recycled textile fibres are used for other purposes besides the production of yarns, resulting in downgrading and open-loop recycling (see Section 4.2.4.1). The recycling of textiles in closed loops is only possible through chemical recycling (see Section 4.2.4.4). Recovered materials from chemical recycling have similar properties to virgin raw materials and can therefore be used for the same purpose as the initial one and be recycled multiple times via thermo-mechanical, physical and chemical recycling processes with a high material yield.

Actual material recycling rate of predominant chemical recycling technologies: Pyrolysis dominates chemical recycling technologies for plastics and is expected to continue to do so in the future (Siepen et al., 2024), whereas it is pulping for organic fibres, and solvent-based and depolymerisation recycling for synthetic fibres. Hence, a much larger share of the emerging recycling technologies available for textile recycling constitutes high-yield material recycling, compared to the plastics case, considering that substantial fractions of pyrolysis oil are generally converted directly or indirectly to energy.

Finally, the approach taken in the JRC proposals for EU-wide end-of-waste criteria for plastic waste by (Pierri et al., 2024), namely to exclude chemical recycling from the working scope, ensured that existing or future national end-of-waste criteria for outputs from chemical recycling of plastics would not be affected by the EU-wide EoW criteria for mechanically recycled plastic waste, while maintaining the possibility of developing a separate set of EU-wide EoW criteria for plastic waste recycled via chemical recycling processes.

6.1.4. Compliance with EoW criteria and system boundaries

The JRC initially proposed to define different steps in the recycling processes for the output material to comply with EoW criteria and different intended uses for mechanical recycling, preserving the key characteristics of the input textile fibres[58], and thermo-mechanical, physical and chemical recycling.

For mechanical recycling, it was proposed that EoW status shall be granted to output material that is either ready to be used directly as a textile product or is ready to be used for the production of new textile products or articles containing textile parts and which complies with the full set of EoW criteria for recycling. The output material has to be handled as waste if it is discarded or used for any other purpose besides the production of new textile products or articles containing textile parts (e.g. energy recovery, fuel production, feedstock for other recovery operations, or backfilling operations).

For thermo-mechanical, physical or chemical recycling, the JRC proposed that EoW status shall be granted to output material that is authorised under Regulation (EC) No 1907/2006 (REACH), is used for a specific material purpose, and which complies with the full set of EoW criteria for recycling.

Any further treatment of output materials from thermo-mechanical, physical and chemical recycling processes for transformation[59] into a new substance or material to be used for a specific material purpose is allowed (e.g. re-polymerisation of monomers or oligomers into polymers, production of man-made cellulose fibres from recycled dissolving textile pulp). The output material will have to be handled as waste if it is discarded, it is not used as material for a specific purpose, it is used for energy recovery and fuel production or for backfilling operations.

6.1.4.1. Stakeholders' feedback

— **EoW status**

Stakeholders recommended that the JRC acknowledges the diversity of output materials generated from the various textile recycling technologies. Mechanical recycling processes, for example, produce more than just fibres – they yield a variety of raw materials that can enable different types of circular business models. This diversity should be reflected in the EoW criteria to avoid unnecessarily limiting innovation and the implementation of practical solutions.

A high number of stakeholders agreed to set the compliance with of EoW criteria after a recycling operation is completed. Some stakeholders raised concerns about this approach, arguing that recycling units are centralised due to the economy of scale and hence textile waste often needs to be transported over long distances to reach the recycling facilities. The shipment of textiles under the waste regime was identified as a significant bottleneck. Another counter-argument is the consequence that new recycling units would be classified as waste operators, resulting in a competitive disadvantage compared to industries that utilise primary raw materials such as crude oil or wood to produce the same product. Considering a recycling unit a waste processing unit

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58 The fibres (organic and/or man-made) within the input textile waste are not subjected to any process that changes the basic properties of a textile fibre. The typical textile fibre shape is still detectable in the output materials.

59 Transformation is a process that changes the chemical structure of a substance, resulting in a new substance with different properties.

requires permitting with frequent renewal, constant recording of input, additional costs for storage, higher cost for transporting the waste compared to primary raw materials and tracking processes (e.g. water).

Stakeholders also pointed out that some existing factories, which currently use virgin raw materials, have already implemented– or plan to implement – sorting and pre-treatment operations to introduce textile-waste-derived feedstocks. One stakeholder described the process in which poly-cotton textile waste is sorted and pre-treated to recover a dissolving pulp that can be fed into the conventional production line, partially replacing virgin feedstock such as wood. The same sorting and pre-treatment chain generates additional side streams that can be valorised within the production plant.

The main difficulty is that existing production processes are authorised only for virgin raw materials but not for waste-derived inputs. If compliance with EoW criteria can be demonstrated only after the recycling process is completed, every upstream step in the factory would require a waste permit – a permit that may be challenging to obtain for certain operations within the current production setup.

Due to the additional complexity of their management, and the risk of losing their local permit, waste processing units are less attractive to investors than conventional manufacturing plants.

One stakeholder also noted that established industrial processes such as shredding or garnetting must remain outside the scope of waste management to keep existing value chains intact.

Stakeholders provided the following alternative proposals:

- Before or after sorting for recycling: one stakeholder commented that EoW status should be granted at an early point, either before or at the moment the textiles are delivered to a facility specialised for sorting and/or preparation of textiles. One stakeholder suggested to set the point at which EoW status is granted after a qualified person performs visual inspection, sorting and even sanitisation where necessary, and declares a textile ready for recycling. The qualified person should decide based on objective criteria when a textile must be sent for re-use, recycling or landfill/incineration. Infrared machinery can complement the manual selection done by individuals. Stakeholders highlighted that advanced sorting technologies are able to separate by fibre composition. If necessary, a sanitisation process can be applied. When sorted textiles meet recycler specifications and have a confirmed buyer, they should be reclassified as secondary materials.

- After pre-treatment for recycling: by granting EoW status after preparing for recycling, the (cross-border) movement is facilitated to subsequent centralised recycling facilities. Certain stakeholders described the steps of pre-treatment in detail, including among others the removal of non-textile parts (e.g. zippers, buttons, labels, plastic, paper), removal of textiles with excess print or sequins, disassembly and cutting to various sizes. The output of a pre-treatment shall be fully sorted, characterised by its composition (e.g. minimum content of targeted textile fibres) and/or shall meet the specifications of the downstream recycling process. This means that specifications will depend upon the recycling route and have to be clearly established, process by process.

Other stakeholders, on the contrary, expressed concerns that granting EoW status early may facilitate the export of textiles outside the EU under the label of products. This would undermine investments in European recycling infrastructure and the broader circular economy objectives. They therefore suggested granting EoW status to output material that is purchased or is actually used to manufacture new products (EoW status is granted at the point of conversion into new products).

— **Intended use**

A stakeholder mentioned that the terminology '*used for a specific material purpose'* should be a pre-condition for all recycling technologies within the scope to highlight that the output is used particularly for a material purpose and no other purpose such as energy recovery.

A stakeholder highlighted that it is essential to increase textile recycling, without limiting the number of applications where recycled materials are used. Fibre-to-engineering plastics or plastic compounds or any other applications are as beneficial and important as textile-to-textile recycling.

Stakeholders disagreed with the proposal that an output material of a mechanical recycling facility can receive EoW status after grinding or shredding for a specific use, but the same output materials cannot be redirected to further recycling as product. Two different designations for the same output material resulting from the same process would create legal uncertainty with competent authorities, especially on border checks.

Stakeholders clarified that monomers recovered from polyester could be used as intermediates for other applications. The JRC proposal would limit the capability of recyclers to valorise these products.

— **REACH**

Stakeholders highlighted that complying with REACH is already part of the EoW criteria (see Section 6.4.1) and should not be stated separately in the scope and system boundaries.

6.1.4.2. JRC assessment of feedback

— **End-of-waste status after sorting and/or pre-treatment**

The main argument from stakeholders to have an early granting of EoW status is to be able to ship a product instead of a waste within and between Member States, but in some cases also to further process a non-waste material in existing production plants. The JRC is aware that textile waste is typically generated in a decentralised manner across the EU, whereas recycling facilities are often concentrated in central locations, and may not be present in every Member State. As a result, the transboundary shipment of textile waste is inevitable, and must be carried out in accordance with the Waste Shipment Regulation ((EU) 2024/1157).

In the following paragraphs, the assessment of the stakeholder feedback is conducted from three different perspectives, considering the existing legal framework, technical feasibility and challenges related to the global market.

Legal perspective

The WFD and in particular Article 6 stipulates that *'waste which has undergone a recycling or other recovery operation is considered to have ceased to be waste".* Granting EoW status at the sorting or pre-treatment stage, before recycling or other recovery operations have been performed, would be inconsistent with the above requirements.

As described in Section 1.2, four conditions have to be fulfilled for EoW status. The JRC is of the opinion that after sorting or preparation for recycling at least two of the four conditions for EoW status are not fulfilled, in particular the following:

- *"the substance or object is to be used for specific purposes"*: If EoW criteria are set at the sorting or pre-treatment stage, it may be challenging to monitor and control the subsequent path to a recycling process. This could lead to a lack of transparency and accountability, making it difficult to ensure that the material is properly recycled.
- "*the use of the substance or object will not lead to overall adverse environmental or human health impacts*": Sorting or pre-treatment may likely not remove contaminants or hazards that can be found in textile waste, which could still pose risks to the environment or human health. EoW criteria should ensure that the material has been treated in a way that prevents harm to human health and the environment, which requires a more comprehensive assessment of the entire recycling process. Compliance with chemical and product legislation prevents harm to human health and the environment. Previous JRC EoW work (e.g. EoW for plastic waste (Pierri et al., 2024)) and also the latest proposal stipulate that existing chemical and product legislation must be complied with. With regard to thermo-chemical, physical and chemical recycling in particular, the JRC has found that the most frequently recycled output materials, such as dissolving pulp, monomers, oligomers or polymers, are already registered under REACH (see **Table 34**, **Annex 12**). In contrast, there is no REACH registration for sorted or pre-treated textiles.

In addition, as detailed in Sections 4.2.2 and 4.2.3, the WFD lacks a legal definition for *'sorting'* in general, as well as *'sorting for recycling'* or *'pre-treatment for recycling'* in particular. As already explained in Section 4.2.3, individual treatments such as removal of hard parts or cutting can be carried out during pre-treatment or recycling. The absence of a clear legal definition and distinction between these waste management processes hampers the development of harmonised EU-wide criteria that shall be legally binding at later stages.

It is important to clarify that transboundary shipment of waste is regulated under the Waste Shipment Regulation. Transboundary shipment is subject to prior notification and consent procedures which can lead to administrative burden and cost. A way to facilitate transboundary waste shipment within the EU is to categorise waste as green-listed. Certain textile waste categories such as B3030 and B3035 are already green-listed and transboundary shipment facilitated (see Section 5.3.1.3). Textile waste sorted and pre-treated for recycling could be classified as green-listed waste to simplify transboundary shipment. In this context, the JRC emphasises that an early-stage EoW status must not be exploited as a mechanism to bypass existing legal frameworks, particularly for textiles that still demonstrate waste-like properties.

Technical perspective

From a technical point of view, the JRC sees a number of challenges in granting EoW status for textile waste at an early stage, already after sorting or pre-treatment. The main reason is due to the complexity of textile waste and the diversity of recycling approaches.

As described in Section 4.1, textile waste originates from various sources, can be very complex in its composition, and is already being recycled using a wide variety of technologies, a trend that is set to increase in the future. This results in a wide range of possibilities for sorting and/or preparing textile waste and thus varying quality of sorted and/or pre-treated textile waste.

Certain recycling technologies use input materials with minor sorting and basic pre-treatment efforts, whereas other recycling technologies require complex preparation steps to produce homogeneous input materials. The inherent complexity and diversity of sorted or pre-treated textile waste would necessitate the development of tailored EoW criteria.

Market perspective

- Fate of textiles that achieved EoW status: Granting EoW status too early in the process can create uncertainty about the ultimate fate of the material, as it may not necessarily be transformed into a new product or remain in the material cycle.

  As highlighted by individual stakeholders, granting EoW status too early poses a risk that sorted or pre-treated textiles may be exported from the EU as the vast majority of textile recyclers and textile producers are currently located outside the EU. This could deprive the existing and emerging European textile recycling industry of valuable textile materials. This would ultimately have the opposite effect of what is intended by providing harmonised EU-wide EoW criteria and creating a single market.

- Distortion of competition: As outlined above, there is a clear distinction between recyclers who utilise pre-treated input materials (drop-in solutions) and those who incorporate pre-treatment steps as part of their recycling process. Granting EoW status after pre-treatment could result in a competitive imbalance. Recyclers using pre-treated textiles would receive a product that offers advantages such as exemption from the Waste Shipment Regulation and no requirement for a waste management permit for their facility. Conversely, recyclers with integrated pre-treatment processes must transport textiles as waste, necessitating compliance with the Waste Shipment Regulation and additional administrative burdens related to transport and waste management authorisations for their facilities. Consequently, the JRC believes that granting EoW status after pre-treatment creates unequal conditions among market competitors, leading to competitive distortion, which should be avoided.

— **EoW status at the point of conversion into new products**

Granting EoW status at the moment of conversion of output material into a new product does not, by itself, solve the practical challenges associated with the current waste-centric supply chain. The output material would be subject to waste-specific legal, administrative and financial constraints during the crucial transport and hand-over phases. Downstream manufacturers may be reluctant to accept material that is still legally waste, fearing regulatory non-compliance or reputational damage. This could hamper market development for recycled inputs.

A more effective approach would be to shift the EoW status determination upstream at the recycling plant, so that the material can be treated as a marketable product, thereby unlocking logistical efficiencies, reducing costs, and encouraging greater uptake of recycled inputs. In this way it can be assured that a textile waste is converted into an output material that fulfils legal requirements, specifications or standards and can be used again in various product applications. This approach is consistent with the requirements of the WFD.

— **Intended use**

Based on the stakeholder feedback, the JRC agrees to propose a broad scope for intended uses of recycled textile output materials and emphasises the importance of material recycling. The review of recycling technologies (see Section 4.2.4) showed that the applications of output materials from the recycling technologies within the scope are extremely diverse. Chemical recycling technologies for example can produce base chemicals (e.g. monomers), intermediates (dissolved pulp) or output materials for direct use to produce new products (polymers, fibres). This diversity was in turn already reflected in the previous proposal and was also confirmed by stakeholders. The JRC is convinced that this diversity should also be reflected in the EoW criteria and applications should not be limited as long as a market and potential applications exist.

Several stakeholders mentioned that output materials should not only be used for textile-to-textile applications but also for fibre-to-engineering plastics or plastic compound application. As the JRC decided to extend the scope of fibres (now including also inorganic fibres, see Section 6.1.2.3), all applications with fibres within the scope should be possible.

Because the output materials of the various recycling technologies are highly heterogeneous, a generic wording is required to cover the full range of possible applications while still demanding a defined end use. The JRC proposes to include the generic terminology *'specific material purpose'* which allows a broad field of intended uses but also ensures that the output material is used in a clearly identified way (material recycling), rather than being diverted to alternative uses such as fuel or energy recovery.

For mechanical recycling, a *'specific material purpose'* may be the use of the output material for cleaning (cleaning rags), as insulation material or as stuffing.

For output materials from thermo-mechanical, physical and chemical recycling, a *'specific material purpose'* means that the output material may be used for the production of new plastics or textile products. However, for certain output materials, the *'specific material purpose'* can even go beyond this meaning, in instances when for example monomers are used as precursors for surfactants, plasticisers and solvents or dissolving textile pulp used for paper and board.

The JRC does not agree with the proposal by stakeholders that EoW status can be granted for mechanically recycled textile waste if the output material will be used as input material for another recycling step. This could imply that only minor treatment such as cutting or shredding is applied and then the output material is shipped as product, with contaminants that may harm the environment or human health. It should be noted once again that EoW status can only be achieved once a recycling or recovery process has been completed (see Article 6 of the WFD). Hence, if an output material from mechanical recycling is used as input for another recycling unit, EoW status cannot be granted at that stage.

The JRC welcomes the clarification on the use of monomers recovered from polyester as intermediates for other applications. It is highlighted that output materials such as monomers can achieve EoW status in the event that the monomers are 'used as material with a specific material purpose'. This allows the use of monomers for various other applications besides for repolymerisation for example. Furthermore, this allows certain intermediates such as esters, polymers or oligomers to also achieve EoW status.

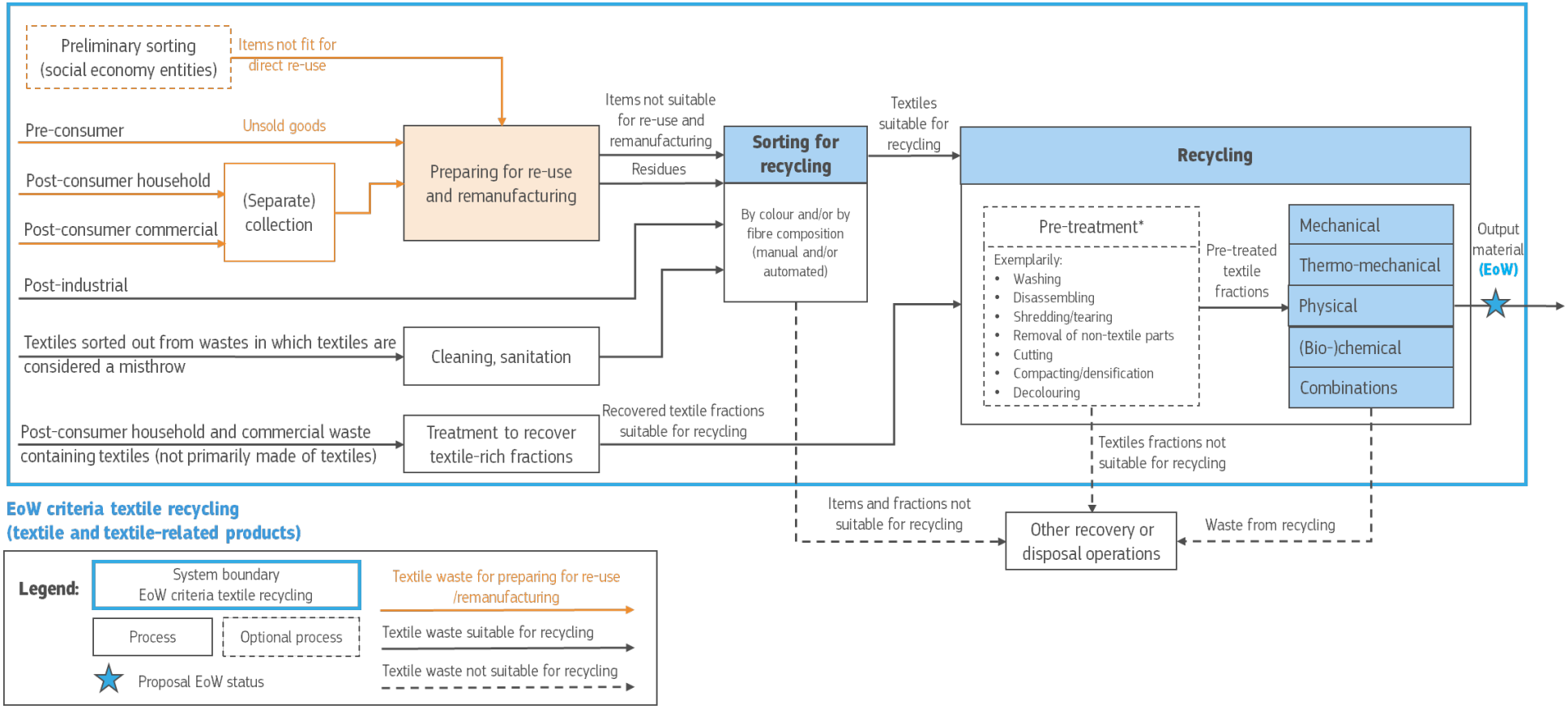
— **REACH**

Based on stakeholders' feedback, the JRC refrains from determining compliance with REACH or any other product legislation and refers to requirements on product quality and specific to the criterion on compliance with product legislation in Section 6.4.1.

6.1.4.3. JRC proposal

The JRC proposes that EoW status can only be achieved after sorting for recycling, pre-treatment for recycling and recycling of textile waste have been completed (see **Figure 22**).

Figure 22. Proposal for granting EoW status for textile recycling



Source: own elaboration

Mechanical recycling

The JRC proposal for granting **EoW status for mechanical recycling** preserving the key characteristics of the input textile fibres is presented in Figure 23.

EoW status shall be granted to output material that:

- is either ready to be used for a specific material purpose or for the production of new products or items containing textile fibres within the scope; and
- complies with the full set of EoW criteria for recycling**.**

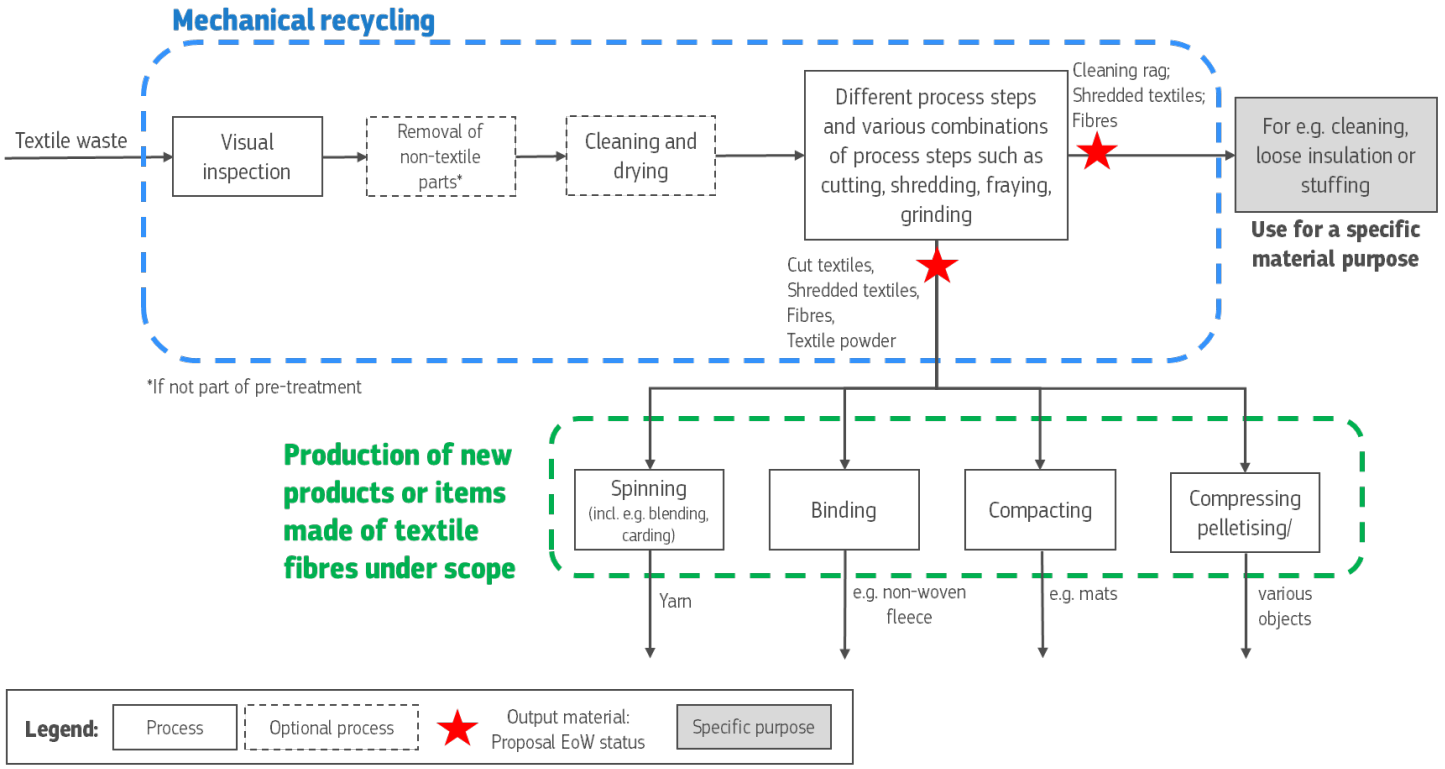
Considering that the shape of the incoming textile waste is modified based on the requirements for a specific material use or for the subsequent production processes, granting of EoW status is not linked to a specific physical shape (e.g. piece, fibre, powder).

It is pointed out that the user of the output material will have to handle it as waste if:

i. it is discarded; or

ii. it is used for any other purpose besides a specific material purpose or for the production of new products or items containing textile fibres within the scope, such as for energy recovery, for fuel production (e.g. solid recovered fuel), as feedstock for other recovery operations (e.g. thermo-mechanical, physical or chemical recycling), or for backfilling operations.

Figure 23. Exemplary scheme for mechanical recycling of textile waste (non-exhaustive)



Note: Potential EoW status (represented by red stars) for the use for a specific material purpose and subsequent processes for the production of new products or items containing textile fibres within the scope; (blue: system boundary mechanical recycling; green: system boundary for production of new products or items containing textile fibres within the scope; shaded grey: examples for use of output materials from mechanical recycling

Source: own elaboration.

Thermo-mechanical, physical and chemical recycling

The JRC proposal for granting **EoW status for thermo-mechanical, physical and chemical recycling processes** is presented in **Figure 24.**

EoW status shall be granted to output material that:

— is used for a specific material purpose; and

— complies with the full set of EoW criteria for recycling.

Any further treatment of output materials from thermo-mechanical, physical and chemical recycling processes for transformation[60] into a new substance or material to be used for a specific material purpose is allowed, with the exception of production of energy or fuels. Common applications include re-polymerisation of monomers or oligomers into polymers or the production of man-made cellulosic fibres from recycled dissolving textile pulp.

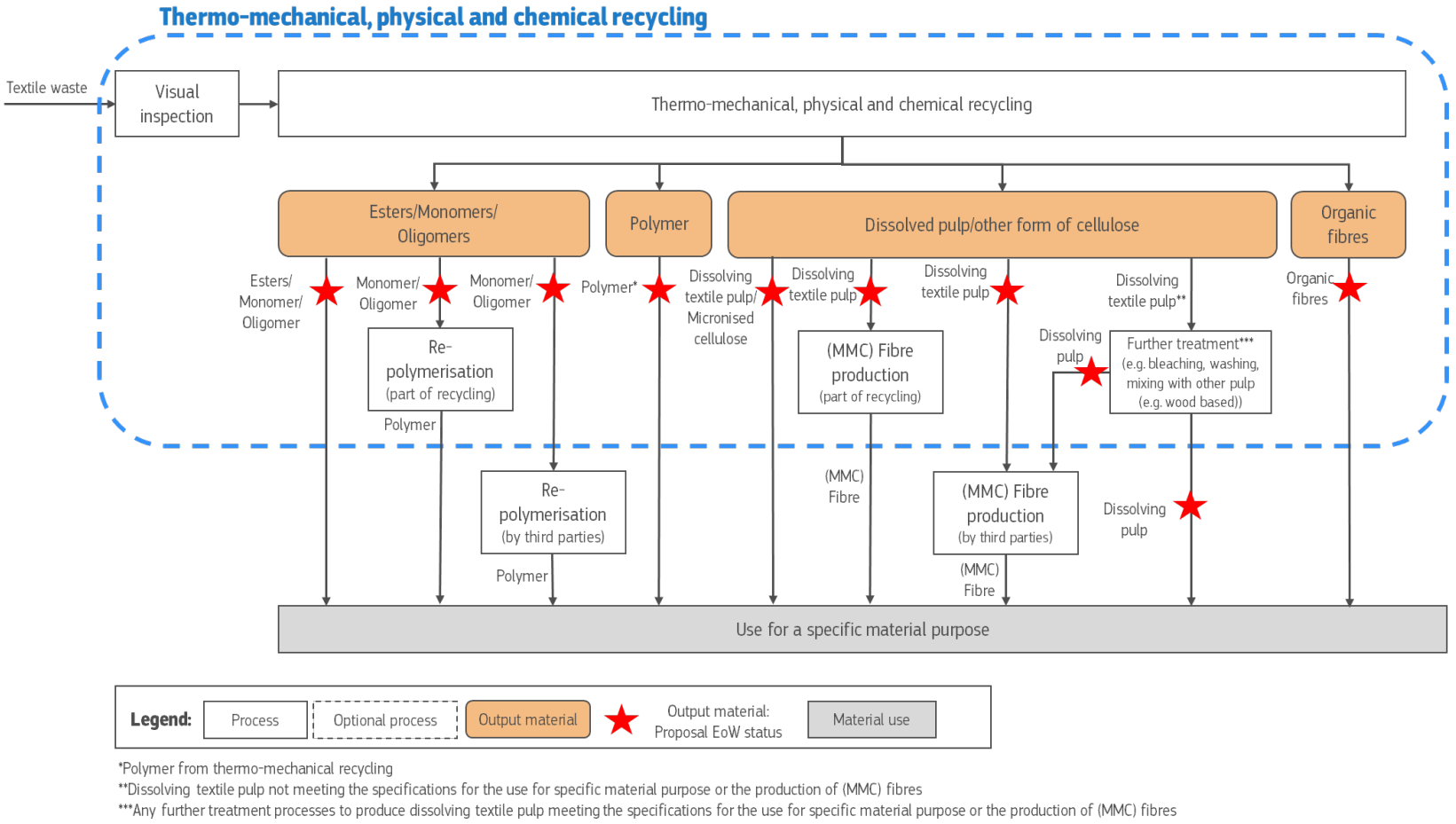
Hence, the user of the output material will have to handle it as waste if:

i. it is discarded; or

ii. it is not used for a specific material purpose, e.g. if it is used for energy recovery, fuel production or for backfilling operations.

[60] Transformation is a process that changes the chemical structure of a substance, resulting in a new substance with different properties.

Figure 24. Exemplary scheme for thermo-mechanical, physical and chemical recycling of textile waste (non-exhaustive)



Note: Potential EoW status (represented by red stars) for the use for a specific material purpose and subsequent processes; (blue: system boundary thermo-mechanical, physical and chemical recycling

Source: own elaboration.

6.2. Requirements on input materials (feedstock to recycling)

The aim of this group of criteria is to define clear limits on input materials that could compromise the recycling process and, consequently, degrade the quality of the final product. The rationale behind these criteria is that it is often simpler and more cost-effective to restrict certain feedstocks upfront than to implement extensive testing of the output.

Villanueva & Eder (2014) identified two principal strategies:

— Negative (exclusion) list – specifies materials or sources that must be banned because, if mishandled, they could pose environmental or human-health risks.

— Positive (inclusion) list – enumerates the materials that are expressly permitted as feedstock.

6.2.1. Criterion 1.1: Recognition of the waste hierarchy and compliance with the ESPR

The JRC proposed that only post-consumer textile waste deemed unsuitable for preparing for re-use during the sorting process shall be allowed as input to the recycling operation. As mentioned in Section 1.1, Article 25(1) of Regulation (EU) 2024/1781 on Eco-design for Sustainable Products (ESPR), prohibits the destruction of unsold consumer goods, including apparel, clothing accessories and footwear (see **Annex 1**). Destruction covers recycling, other recovery or disposal operations. Derogations on the destruction ban have been laid down in a Delegated Act[61] of the ESPR. Therefore, the JRC proposed that pre-consumer textile waste should not be used as input for the recycling operation, unless it can be demonstrated that a specific derogation, as established in the Delegated Regulation of the ESPR, applies.

6.2.1.1. Stakeholders' feedback

The main comments received from stakeholders on the preliminary proposals are reported below.

— **Omission of criterion 1.1**

Some stakeholders proposed to omit this requirement as it is duplication of existing legislation (the WFD and ESPR).

— **Clarification and consistency**

A majority of stakeholders not agreeing with this criterion reported a lack of clarity in the terminology, as post-industrial textile is within the scope (see Section 6.1.1), but not among the list of input materials in this criterion 1.1. This should however be the case and corrected where possible to ensure consistency. Stakeholders proposed that three sources shall be deemed suitable as inputs for recycling: (1) post-industrial, (2) post-consumer unsuitable for re-use, and (3) pre-consumer that meets derogations of the ESPR.

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61 Commission Delegated Regulation setting out derogations from the prohibition of destruction of unsold consumer products: https://environment.ec.europa.eu/publications/commission-delegated-regulation-setting-out-derogations-prohibition-destruction-unsold-consumer_en

Stakeholders asked to clarify if the obligation to redirect textiles preferentially to re-use also applies in the event that a derogation from Article 25 is applicable.

— **Remanufacturing**

Stakeholders highlighted that remanufacturing must be a priority before fibre recycling within the scope of recycling.

— **Self-monitoring**

Stakeholders pointed out that it is not the responsibility of a recycling plant to verify what efforts the supplier has made to take out the textiles for re-use. Stakeholders also highlighted that this aspect does not typically fall under EoW criteria provisions.

6.2.1.2. JRC assessment of feedback

— **Omission of criterion 1.1**

Although the proposed criterion repeats existing legislation, the JRC has chosen to retain the reference to the ESPR and the related Delegated Act laying down derogations on the application of the ban. This is because the JRC is introducing self-monitoring requirements, which will serve as a complementary control mechanism to ensure compliance with these relevant legal requirements.

— **Clarification and consistency**

The JRC would like to note that **all textile sources proposed within the scope** (see Section 6.1.1) are allowed to be used as input material for recycling, except for those limited under criterion 1.2.

The aim of this criterion is to make it clear that the principles of the waste hierarchy are being followed and the input material is in line with the proposed EoW criteria for preparing for re-use and remanufacturing outlined in outlined in Pérez Arribas et al. (2026).

In the self-monitoring requirements, it is clarified that if the recycler is able to document the application of a derogation from the ban on destruction of unsold goods, the item can be redirected to recycling.

— **Remanufacturing**

According to Article 22d (5c) of the revised WFD ((EU) 2025/1892), *'items that are assessed as not suitable for re-use are sorted for remanufacturing and recycling including, where technological progress allows, fibre-to-fibre recycling, with a view to prioritising remanufacturing over recycling'*. The JRC recommends omitting reference to this provision in this criterion as this is already covered in Section 6.1.1.3, and its inclusion would be redundant.

— **Self-monitoring**

The JRC agrees with stakeholders' comments that a recycling plant is not responsible for verifying a supplier's efforts to meet criterion 1.1. Nevertheless, when accepting post-consumer textiles and textile-related products that a sorter has deemed unsuitable for re-use or

remanufacturing, the recycling plant should request documentation from the sorter to confirm this assessment.

6.2.1.3. JRC proposal

The proposal on compliance with the ESPR is presented in **Table 7**.

Table 7. EoW criteria for textile recycling - requirements on input materials – Criterion 1.1

No	Proposed EoW criteria on input material	Self-monitoring requirements
1.1	In compliance with Article 25[62] of Regulation (EU) No 2024/1781, pre-consumer textile waste shall not be used as input to any recycling process, unless it can be demonstrated that one of the derogations set out in the Delegated Regulation[63] supplementing Regulation (EU) 2024/1781 applies.	When using pre-consumer textile waste as input, the operator of the recycling facility shall demonstrate the applicability of derogations. This documentation shall be recorded in the quality management system.

Source: own elaboration

6.2.2. Criterion 1.2: Minimum requirements and restriction of textile sources, categories and items

The following section summarises the feedback from stakeholders and the JRC assessment on minimum requirements as well as on restriction of textile sources, categories and items.

Minimum requirements

In the draft subject to consultation, the JRC proposed that the input material for a recycling operation shall have undergone sorting and appropriate pre-treatment steps to meet the recycler's specifications[64]. For mechanical recycling, it was further specified that the input material shall be dry and shall not present any residues of oil, solvents, glues or paint that can be detected by visual inspection and an olfactory test.

Restriction of textile sources, categories and items

The JRC initially proposed that textile waste to be used as input may originate from any source of waste containing textiles, with the exception of mixed municipal solid waste in the case of mechanical recycling. In addition, it was proposed to ban workwear originating from healthcare facilities and laboratories, underwear and reusable absorbent hygiene products as input materials for mechanical recycling. For thermo-mechanical, physical and chemical recycling, it was proposed to allow those items as input as well as textiles filtered out of mixed municipal solid waste or other

62 Destruction of unsold consumer products

63 Commission Delegated Regulation setting out derogations from the prohibition of destruction of unsold consumer products: https://environment.ec.europa.eu/publications/commission-delegated-regulation-setting-out-derogations-prohibition-destruction-unsold-consumer_en

64 The requirements on the sorting and pre-treatment depend on the technical ability to carry out any pre-treatment steps as part of the recycling process (e.g. removal of hard parts).

waste fractions if proof of sanitation and/or decontamination can be provided by the user of the applied recycling technology.

6.2.2.1. Stakeholders' feedback

Minimum requirements

— **Requirement for sorting and appropriate pre-treatment steps**

One stakeholder did not agree with the requirement that textile waste must undergo appropriate pre-treatment steps. Some recyclers conduct the pre-treatment themselves. Furthermore, sorting and pre-treatment may be optional when the input is homogeneous (e.g. white cotton production scraps).

Stakeholders asked for clarification on what is meant by *'appropriate pre-treatment steps'*.

— **Provision of documentation on sorting and pre-treatment steps**

According to stakeholders, it is the responsibility of the previous holder to ensure that sorting and pre-treatment steps have been taken to meet the recycler's specifications. The previous holder should therefore provide a certificate of conformity to prove that the specifications of the recycler have been met. Otherwise, the recycling facility must hold documentation in its QMS specific to an operation over which it has no control.

— **Restriction of residues for mechanical recycling**

Some stakeholders did not agree with the additional requirement initially proposed by the JRC for mechanical recycling, namely that the input material shall be dry and free from any residues of oil, solvents, glue or paint. Certain dry and wet mechanical recycling already allows the recycling of wet textiles or textiles with oil residues, even without the need for pre-treatment.

Textile waste can be stained, even with paint, without this causing any problems for recycling or for the use of the recycled fibre. Small stains such as a minor paint stain or oil stain will be removed in the mechanical recycling process and will not be present on the finished fibre.

In the view of one stakeholder, the wording *'shall not present any residues'* is too conservative, unnecessarily strict and cannot be assessed by visual and olfactory inspection as defined in the self-monitoring requirements. Thus, stakeholders suggested instead *'shall not contain significant amounts of residue'* or *'no considerable residues shall be present'*.

Furthermore, the stakeholder outlined that the proposed JRC approach would limit the future development of upcoming recycling technologies. Already today, research is conducted on new techniques to recycle textiles with oil and solvent residues. Limiting this kind of input material would disincentivise research and development. What matters is the final quality of the output materials.

Restriction of textile sources, categories and items

A high number of stakeholders agreed with the proposed restrictions of textile sources, categories and items for the different recycling technologies. When setting restrictions on input materials, it should be considered that recycling technologies are likely to improve in the coming years. Thus, the criteria should be designed in such a way as to not hinder technological progress and should not

exclude any input. Stakeholders also emphasised that any restrictions would lead to the unnecessary exclusion of recyclable waste streams. Preventing the recycling of these materials risks diverting significant volumes of usable fibres to landfill or incineration.

One recycler reported that their plant processes the waste either mechanically or at high temperatures and using treatment certain chemicals, depending on the characteristics of the waste. With the high temperatures and chemical processes, the hygiene risks are fully mitigated. Therefore, it was advised to either broaden the acceptable inputs to allow more flexibility based on the recycling process applied or include exceptions for processes where hygiene and other concerns are addressed through appropriate treatment steps.

Chemical recyclers highlighted that their technologies do not necessarily need sanitation and/or decontamination of the input materials. In general, chemical recycling processes are capable of decontaminating and sanitising the textiles as a natural part of their process. For example, in depolymerisation processes the high process temperatures decontaminate the input.

According to stakeholders, if the chemical recycling processes are able to remove contaminants and can handle wet products, there is no reason to exclude specific waste streams, as long as they are not contaminated with blood, bacteria, viruses or other contaminants which pose a risk to human health. In this context, the JRC could consider an exemption whereby a recycling facility that processes contaminated items must receive appropriate registrations on their waste permit prior to accepting this material.

Stakeholders reported that thermo-mechanical recycling processes, however, are not capable of decontaminating or sanitising input materials.

Comments on the restriction of specific sources are reported below.

— **Textile waste filtered out of mixed MSW or other waste fractions**

  A few stakeholders reported that textiles filtered out of mixed MSW are contaminated (moisture, dirt, mould) and likely not able to meet the same quality requirements as textile streams that have been collected separately. Considering that separate collection of textiles is mandatory as of January 2025, the volume of textiles within MSW is expected to decline. Processing MSW textiles with separately collected textiles would require additional process steps (e.g. cleaning and sanitation), making the whole process more costly and less efficient from an environmental perspective. Therefore, stakeholders suggested to either restrict this source of textile waste or alternatively to set a requirement for pre-treatment (washing/decontamination step).

— **Underwear and absorbent hygiene products**

  Several stakeholders mentioned that underwear should not be categorically excluded, since the term is overly broad including items like tops, bras and socks. Underwear as a category does not inherently pose environmental or health risks if other input criteria are met (e.g. dry, uncontaminated and odour-free) and excluding underwear would be impractical in real-world collection settings, as such items are typically bundled together with shirts, trousers and other garments in the same bag. No specific comments against the exclusion of absorbent hygiene products were received.

— **Healthcare workwear**

Stakeholders clarified that in the case of hospital clothing, they are already obliged by law to incinerate any clothing that has been in contact with potentially harmful substances and/or bodily fluids. According to stakeholders, workwear from healthcare is a relevant input material for recycling. Workwear originating from healthcare facilities are textiles with a defined colour and fibre composition, which arise constantly and are currently recycled to a great extent.

Stakeholders proposed two approaches to allow healthcare workwear as input material:

1) Perform effective sanitisation methods, such as high-temperature washing or chemical disinfection to adequately eliminate contamination risks to use as input material[65].

2) Workwear from healthcare and laboratories should be allowed for recycling (regardless of the nature of the process) if proof of sanitation and/or decontamination can be provided.

6.2.2.2. JRC assessment of feedback

Minimum requirements

— **Requirement for sorting and appropriate pre-treatment steps**

The JRC proposed that EoW status can only be achieved after sorting for recycling, pre-treatment for recycling and recycling of textile waste have been completed. As mentioned by stakeholders, the necessary and appropriate sorting and pre-treatment steps differ between the various recycling technologies and even between recyclers applying the same recycling approach. In some cases, all necessary pre-treatment steps are performed by the recyclers themselves to produce an input material that meets the requirements of their own recycling technology and, subsequently, the requirements for the output material.

Therefore, the JRC proposes to adapt the proposal for criterion 1.2 (paragraph a) and points out that sorting can be omitted if the input materials can be directly used in a recycling process without sorting and, in the event that pre-treatment is an integral part of the recycling technology itself, pre-treatment before the transfer to a recycler can also be omitted.

— **Provision of documentation on sorting and pre-treatment steps**

The JRC agrees that the responsibility of supplying a feedstock that fulfils the recycler's specifications lies with the previous holder. The JRC leaves it up to the recycler to decide whether to request a certificate of conformity or another type of document that certifies the quality of the input material.

— **Restriction of residues for mechanical recycling**

The JRC agrees with the fact that, in view of the current but also future technical capabilities of certain recycling technologies, the requirements for input material with regard to moisture content or residues are too strict. Therefore, the JRC adopts a more flexible approach, proposing that

[65] Although stakeholders mentioned that proof of decontamination or sanitation is too expensive for sorters.

recycling technologies can accept wet textiles, provided they can demonstrate their ability to effectively treat such waste (see **Table 8**, criterion 1.2, paragraph b).

Restriction of textile sources, categories and items

The stakeholder feedback, but also further bilateral stakeholder consultations, revealed that mechanical recyclers are evolving and that technologies going beyond simple procedural steps such as cutting, shredding and trimming are already in place or will be implemented in the near future. As described in Section 4.2.4.1, these technologies apply water, elevated temperatures, cleaning agents and other substances to even bleach the incoming textile waste to recover white fibres comparable to virgin fibres. Based on these findings, the JRC would tend to allow all sources of textile waste as input material.

— **Textile waste filtered out of mixed MSW or other waste fractions**

  Despite agreeing on the fact that the textiles volume in mixed MSW will likely decline with the implementation of mandatory separate collection and EPR schemes, as already observed for other waste streams with this kind of waste management policies in place (e.g. packaging waste, WEEE), a significant proportion of those waste fractions still end up in mixed MSW.

  The challenges of treating textiles from mixed MSW relate mainly to cross-contamination. Considering that to date there are recycling processes that are able to deal with this type of feedstock, the JRC proposes to allow textile waste filtered out of mixed municipal waste as input material, but on the condition that there is proof of sanitation and/or decontamination.

— **Underwear and absorbent hygiene products**

  Based on the comments received, the JRC refrains from restricting underwear. However, the JRC retains the restriction on reusable hygiene products due to their intended purpose of absorbing blood, urine and other body fluids, posing a potential hygiene and thus health risk (similar to hospital clothing, see below).

— **Healthcare workwear**

  According to stakeholders, healthcare workwear is already a relevant and important input material for recyclers as the accumulation is steady with defined fibre characteristics. This relates not only to clothing, but also to other textile-based equipment such as bed linen from healthcare facilities. To cover all textile waste streams that occur in healthcare facilities, the JRC proposes a more general terminology, namely **healthcare textiles**.

At this point, it should be clarified that in the case of textile waste from healthcare facilities, one can differentiate between a medical textile that is a material of textile-based equipment used to protect the users from any body fluids (e.g. blood, saliva, urine and sweat) (Yuliana et al., 2022) and other textile-based items such as bed linen. According to stakeholders, hospital clothing that has been in contact with potentially harmful substances and/or body fluids is already obliged by law to be incinerated. Nonetheless, other healthcare textiles can pose a certain (hygiene) risk. Therefore, the JRC maintains its preventive position of restricting healthcare textile waste as input material with conditional requirements. Given the potential and relevance of this textile waste stream, as well as the technical possibilities for (pre-)treating these textiles (e.g. sanitation and/or decontamination; (Bockmühl et al., 2019; Das et al., 2021; Yuliana et al., 2022)), it should be

possible to use these textile waste items if effective sanitisation methods such as high-temperature treatment or chemical disinfection can be proven for the input material or by the applied recycling technology.

6.2.2.3. JRC proposal

The proposal on minimum requirements and restriction of textiles sources, categories and items is presented in **Table 8**.

Table 8. EoW criteria for textile recycling – requirements on input materials – Criterion 1.2

No	Proposed EoW criteria on input material	Self-monitoring requirements
1.2	Textile waste to be used as input to any recycling process shall fulfil the following minimum requirements: (a) it shall have undergone all necessary sorting and pre-treatment steps[66]; and (b) it shall be dry, unless recycling is demonstrably capable of treating wet input materials. Textile waste to be used as input to any recycling process may originate from any source of waste containing textiles, with the exception of: (a) mixed municipal solid waste; (b) used healthcare textiles originating from healthcare facilities and laboratories (including laboratories dealing with biological, chemical or clinical research); and (c) used reusable absorbent hygiene products, unless proof of sanitation and/or decontamination by the previous holder or by the recycler can be provided.	The producer or another operator shall establish appropriate risk management measures to identify and remove, where needed, batches of ineligible input material. Quality control measures, in the form of a visual and olfactory inspection of all textile waste received and of an analysis of accompanying documentation, shall be carried out by qualified staff who are trained on how to recognise textile waste allowed but also restricted under this criterion. The staff shall be trained on potential types of contamination that may be associated with textile waste and on material components or features that allow the recognition of the contaminants. Automated inspection systems that provide equivalent verification are also accepted. The procedure of recognising and removing contaminants to the extent needed and the results of the removal of contaminants shall be documented in the quality management system. The producer or another operator shall request the previous holder to provide documentation on sanitation and/or decontamination, where needed. The producer or another operator shall keep track of the eligible textile waste used as input material (date of receipt, supplier, origin, type and quantity of textile waste received) and the textile waste streams

[66] The requirements on the sorting and pre-treatment depend on the technical ability to carry out any pre-treatment steps as part of the recycling process (e.g. removal of hard parts). Sorting can be omitted if the input materials can be directly used without sorting. In the event that pre-treatment is an integral part of the recycling technology, pre-treatment can also be omitted.

		that have been rejected (date of rejection, supplier, origin, type, quantity of textile waste and reason for rejection). The data shall be recorded in the quality management system.

Source: own elaboration

6.2.3. Criterion 1.3: Hazardous waste and waste containing substances classified as hazardous or other restricted substances

In the initial draft, the JRC proposed that textile waste originating from any source that is eligible to be used as input for mechanical, thermo-mechanical, physical and chemical recycling shall be compliant with EU chemical and product legislation. For mechanical recycling technologies, it was additionally proposed that the input material shall not be hazardous or shall not contain hazardous substances, unless it can be treated to the extent that the output material is no longer classified as hazardous according to the CLP Regulation.

6.2.3.1. Stakeholders' feedback

— **Restriction of hazardous textile waste or waste containing substances classified as hazardous under the CLP Regulation**

Stakeholders agreed with the general principle proposed by the JRC that hazardous chemicals should be removed from the value chain. In this regard, it is important to ensure that from the very beginning new products placed on the EU market are compliant with EU regulations. At the same time, stakeholders mentioned that, in practice, hazardous textile waste is usually not used for recycling.

Stakeholders asked for clarification on the terminology *'hazardous textile waste and textile waste containing hazardous substances*', as it has a very broad and unclear scope and thus could create legal uncertainty. This lack of clarity would make it hard to apply the proposed self-monitoring requirements, as it is not clear which hazardous properties are covered, and which limit values apply.

— **Compliance with the REACH and POPs Regulations**

Several stakeholders expressed serious concerns regarding the practicality and feasibility of the proposed input restrictions on textiles based on the REACH and POPs Regulations. They claimed that it is not feasible to examine every single garment or textile item or even batch to see whether it complies with these legal requirements. Considering the heterogeneity and varied origins of textiles, the systematic measurement of restricted substances in the input material is not technically feasible and would be associated with a considerable economic burden. Furthermore, laboratory analysis can take a long time and to date it is not possible to perform instant analyses.

Stakeholders mentioned that it is difficult to ensure compliance with EU products regulation requirements in the input materials, since there is no information about the origin (e.g. country of production), or the date of the production of the incoming products (it could be a product produced in the EU but before the entry into force of a specific regulation). The REACH and POPs Regulations may be updated during the garment life-cycle and a garment may meet

REACH/POPs requirements when first sold but not four years later due to a new restriction (e.g. perfluorooctanoic acid (PFOA)).

Meanwhile, stakeholders highlighted that one advantage of recycling is to transform a heterogeneous upstream into a homogeneous downstream. Therefore, tests shall only be carried out on the homogeneous output material.

Other stakeholders proposed to implement a risk-based approach and highlighted that this is the only feasible way to effectively manage the issue, but without proposing a specific methodological approach.

Stakeholders recalled that for textile waste with substances above the limit values of the POPs Regulation's Annex IV destruction steps are needed to get the values below these limits. These substances are persistent in atmospheric conditions, and it is therefore not possible to comply with the requirements of Regulation (EU) 2019/1021 for output materials, since the substances cannot be removed by mechanical processes.

6.2.3.2. JRC assessment of feedback

— **Restriction of hazardous textile waste or waste containing substances classified as hazardous under the CLP Regulation**

Stakeholders broadly support the conditional restriction on the use of hazardous textile waste (as defined in Article 2 of the WFD), or waste containing substances classified as hazardous under the CLP Regulation, in mechanical recycling. Concerns were raised about self-monitoring obligations and the potential burden of testing. The JRC recognises that clear and harmonised guidance for identifying such substances in textile waste is currently lacking. In order to avoid disproportionate administrative and financial burdens for operators, the proposed criteria therefore do not impose systematic traceability or testing requirements for input materials. Instead, operators are required to establish, apply and document appropriate control measures within their quality management systems to identify hazardous waste and hazardous substances where relevant.

The proposal to require the output material from mechanical recycling not to be classified as hazardous under the CLP Regulation is justified by both technical and policy considerations. From a technical perspective, mechanical recycling processes do not significantly alter the chemical composition of the waste. As a result, hazardous substances present in the input are likely to remain in the recycled output unless they are effectively removed beforehand (e.g. during sorting or pre-treatment). Allowing recycled outputs classified as hazardous to achieve end-of-waste status would create a risk of placing these hazardous recycled materials on the market, thereby undermining the objective of ensuring a high level of protection for human health and the environment.

In addition, this restriction serves broader regulatory and practical purposes. It promotes coherence between waste, chemicals and product legislation, and improves enforceability and legal certainty at the point where waste ceases to be waste and becomes a product. It also helps to prevent the recirculation of legacy hazardous substances, addresses the limited traceability typically associated with heterogeneous textile waste streams, and protects downstream users. By ensuring that hazard management is not simply passed along the value chain, this requirement supports confidence in secondary raw materials and contributes to the development of high-quality and non-toxic material cycles.

The proposed approach centres on the quality of the output rather than on systematic control of the input. Hazardous textile waste, or waste containing hazardous substances, may be used in mechanical recycling only where the process ensures that the resulting output is not classified as hazardous under the CLP Regulation. This approach avoids imposing systematic input testing, while ensuring that only safe, non-hazardous materials can obtain end-of-waste status. The restriction is limited to mechanical recycling, since thermo-mechanical, physical and chemical recycling processes, which typically involve more advanced treatment methods, are generally more effective in removing or reducing contaminants. Nevertheless, outputs from those processes remain subject to the applicable CLP classification and labelling requirements.

To clarify the scope of the criteria, the JRC has reformulated them by referring explicitly to hazardous waste as defined in the Waste Framework Directive (WFD) and to substances classified as hazardous under the CLP Regulation. For mechanical recycling, the following conditions apply:
i) waste classified as hazardous under Article 3 of the WFD may be used only where the process removes the hazardous substances concerned;
ii) waste containing substances classified as hazardous under the CLP Regulation may be used only where the resulting output does not meet the criteria for classification as hazardous.

— **Compliance with the REACH and POPs Regulations**

In order to protect the environment and human health, the JRC suggests that textile waste containing substances restricted under Regulation (EC) No 1907/2006 (REACH) is not a permitted input material, unless the recycling facility is capable of treating the input material to an extent that the output material contains substances in compliance with the limit values defined under REACH.

As regards compliance with the POPs Regulation, certain pre-treatment steps shall be applied to meet the thresholds defined in Annex IV to Regulation (EU) 2019/1021[67] on persistent organic pollutants.

It is worth mentioning that regardless of the nature of the recycling operation (whether mechanical, thermo-mechanical, physical and chemical recycling) the processes must be capable of producing the required output quality, rather than relying on supplementary methods to achieve the desired standards, such as dilution.

[67] Including the last amendment of Annexes IV and V (Regulation (EU) 2022/2400).

The JRC believes that these requirements should guarantee an adequate level of protection for human health and the environment but at the same time stimulate textile recycling. This approach is in line with the EoW criteria developed for plastic waste proposed by the JRC (see Pierri et al. (2024)).

With regard to the self-monitoring requirements including measurement of substances restricted under the REACH or POPs Regulation, the JRC emphasises that the self-monitoring requirements for this criterion do not impose testing on the input materials, but rather the application of appropriate control measures to be established by the recycler. This could include the identification of specific items that are suspected or known to be contaminated with restricted substances.

6.2.3.3. JRC proposal

The proposal on restrictions applicable to hazardous waste and waste containing substances classified as hazardous or other restricted substances is presented in **Table 9**.

Table 9. EoW criteria for textile recycling - requirements on input materials – Criterion 1.3

No	Proposed EoW criteria on input material	Self-monitoring requirements
1.3	Textile waste used as input to any recycling process may contain substances restricted under Regulation (EC) No 1907/2006 only if substances, on their own or in mixtures, that are present in the output material, comply with that Regulation, including Article 56 setting out authorisation provisions for the use of substances listed in Annex XIV and for their placing on the market as well as the conditions laid down in Article 67 setting out the conditions for the manufacture, placing on the market and use of certain dangerous substances restricted in Annex XVII[68]. Textile waste used as input to any recycling process may contain POPs at concentrations above the limit values set out in Annex IV to Regulation (EU) 2019/1021[69] only if there is a (pre-)treatment step in place for textile waste that can result in an input fraction with POPs concentrations below the limit values set out in Annex IV to that Regulation.	An acceptance control, in the form of a visual inspection of all textile waste received and analysis of the accompanying documentation, shall be carried out by qualified staff. The producer or another operator of the recycling facility shall apply appropriate control measures to detect hazardous waste as defined in Article 3(2) of Directive (EC) No 2008/98 and waste containing substances classified as hazardous according to Regulation (EC) No 1272/2008 or other substances restricted under Regulation (EC) No 1907/2006 and Regulation (EU) 2019/1021, paying particular attention to input material originating from waste sources which are more likely to contain such substances. The control measures and their

[68] Including the last amendment of Annex XVII (Regulation (EU) No 2023/923).

[69] Including the last amendment of Annexes IV and V (Regulation (EU) 2022/2400).

	Textile waste used as input to thermo-mechanical, physical and chemical recycling may contain substances classified as hazardous pursuant to Article 3 of Regulation (EC) No 1272/2008, only if the output material resulting from recycling is classified and labelled according to that Regulation. Textile waste used as input to mechanical recycling shall not be classified as hazardous waste as defined in Article 3, point 2 of Directive (EC) No 2008/98 or it shall be possible to remove hazardous substances, on their own or in mixtures, from the textile waste before or during recycling, in compliance with Article 10(5) of Directive (EC) No 2008/98. Textile waste used as input to mechanical recycling may contain substances classified as hazardous pursuant to Article 3 of Regulation (EC) No 1272/2008 and Annex I to that Regulation, only if the output material does not contain substances, on their own or in mixtures, that would trigger its classification as hazardous pursuant to Article 3 of and Annex I to Regulation (EC) No 1272/2008 (CLP).	results shall be documented in the quality management system. The (pre-)treatment steps to separate textile waste containing POPs and the results of the pre-treatment shall be documented in the quality management system.

Source: own elaboration

6.2.4. Criterion 1.4: Eligibility of input materials originating from waste streams partly made up of textiles

The JRC proposed that textile waste fractions recovered from waste streams partly made up of textiles shall have been separated from non-textile parts in an appropriate pre-treatment step, provided that the input specifications of the operator of the recycling facility are met.

6.2.4.1. Stakeholders' feedback

A high number of stakeholders agreed with the JRC proposal. However, those who disagreed argued that separate collection of textiles is a more effective approach than sorting textiles from mixed municipal solid waste. The feedback from stakeholders indicated that the criterion was not fully understood, prompting the JRC to provide a more detailed explanation below.

— **Pre-treatment**

Stakeholders asked for clarification of what constitutes pre-treatment in this context.

6.2.4.2. JRC assessment of feedback

The JRC clarifies that this criterion does not refer to textiles filtered out from waste streams such as mixed municipal solid waste. With this criterion, the JRC is aiming at waste items that are partly made of textiles (e.g. footwear). As the whole waste item cannot be used directly as input material to textile recycling, these waste streams need to undergo a certain treatment to separate textiles **from non-textile parts provided that the separated textiles meet the recycler's**

specifications. Examples of waste items containing textiles for further recycling include, but are not limited to the following:

- **Footwear** undergoes mechanical treatment to separate the textile fraction from other materials such as rubber or foam. As indicated in Section 4.2.4, closed-loop textile recycling in footwear is under development (e.g. new shoelaces (FFG, 2024)).
- **Mattresses, pillows and duvets** are all textile-intensive products. The textile fractions can be removed and used as feedstock for textile recycling (Auping, 2024; RetourMatras, 2024).
- In **vehicles** textiles are used for upholstery (e.g. seats, dashboards, door panels, and headrest covers), carpets and floor mats as well as insulation panels. Textile-rich fractions can be removed after shredding end-of-life vehicles (ELVs) from the shredder fluff[70] and potentially used for recycling.

The JRC is aware that, to date, the recycling of these textile waste fractions remains limited or is still in the research phase, but these can be a viable input material for recycling in the near future.

— **Pre-treatment**

In order to separate textiles from waste items containing textiles, appropriate (pre-)treatment is required. At present, mainly mechanical treatment processes are applied. The separation step can be regarded as pre-treatment. The JRC refrains from using the unspecific wording 'pre-treatment' and specifies that a separation step has to be carried out.

6.2.4.3. JRC proposal

The proposal on eligibility of input materials originating from waste streams partly made up of textiles is presented in **Table 10**.

Table 10. EoW criteria for textile recycling - requirements on input materials – Criterion 1.4

No	Proposed EoW criteria on input material	Self-monitoring requirements
1.4	Waste streams that partly consist of textiles shall undergo a treatment step to separate textiles from non-textile parts provided that the separated textiles meet the specifications of the producer or another operator of a recycling facility.	An acceptance control, in the form of a visual inspection of all textile waste received and analysis of the accompanying documentation shall be carried out by qualified staff. This documentation shall be recorded in the quality management system.

Source: own elaboration

[70] Shredder fluff is the light vehicle scraps derived from shredding and accounts for about 15-25% of the total vehicle. It can e.g. include seals, rubbers, textiles, plastics or tire fragments from vehicle.

6.3. Requirements on processes and techniques (recycling processes)

The purpose of introducing requirements on processes and techniques is to define minimum storage and treatment conditions to achieve output materials of a quality suitable for EoW status. It may be necessary to impose requirements on the storage conditions of the input and output materials to avoid (cross-)contamination. It also needs to be evaluated whether specific treatment steps should be mandatory to obtain an output material of the desired quality. Textile waste originating from specific sources is more likely to contain quality-influencing materials or substances. It is hence fundamental to define requirements to treat textile waste, in particular problematic textile waste streams.

6.3.1. Criterion 2.1: Storage of input and output materials

For the recycling technologies within the scope the JRC initially proposed that all incoming waste should be kept dry, eligible textile waste should be stored separately from non-eligible material, and any output meeting EoW criteria should be kept apart from non-compliant waste.

6.3.1.1. Stakeholders' feedback

— **Separate storage of input materials**

A vast majority of stakeholders agreed with the JRC's proposals on separate storage and mainly proposed different wording, as follows:

- 'All incoming waste shall be stored in a sheltered area to avoid damage or cross-contamination and be kept dry.'
- 'Eligible input materials shall be received, stored or contained in such a way to reduce the risk of contamination and the development of unwanted health and safety hazards, such as mould'.

Stakeholders also asked for clarification on what is meant by *'stored separately'*, as this could imply different locations and that would be unreasonable and associated with additional costs. They proposed using the terminology *'kept separately'*. Storage in the same building and physical separation, e.g. using walls, boxes or similar barriers, should be sufficient and storage in containers should also be allowed.

One stakeholder argued that too many restrictions may slow down the development of recycling. It is necessary to give recycling centres freedom in organisation and storage.

— **Separate storage of output materials**

Stakeholders did not provide feedback on the separate storage of output materials.

6.3.1.2. JRC assessment of feedback

— **Separate storage of input materials**

The JRC clarifies that separate storage can be in the same building, provided that textile waste eligible to be used as input material is kept physically separate from ineligible input materials. This can be achieved simply by distance or any other structural barriers such as walls, boxes or

containers. The JRC refrains from proposing the specific method of separate storage. To clarify the requirements, the JRC proposes the terminology *'kept separately'* instead of '*stored separately'*.

The JRC considers that this basic proposal gives treatment facilities freedom in organising the storage of input materials eligible to achieve EoW status. As part of the self-monitoring requirements, the recycler shall document these handling procedures in the quality management system.

— **Separate storage of output materials**

In line with the requirements with separate storage of input materials, the JRC proposes that EoW output materials shall be stored separately from any output material not complying with EoW criteria. The JRC refrains from proposing any specific method for separate storage. It is proposed to document these procedures in the quality management system.

6.3.1.3. JRC proposal

The proposal on requirements for storage of input and output materials is presented in **Table 11**.

Table 11. EoW criteria for textile recycling - requirements on processes and techniques – Criterion 2.1

No	Proposed EoW criteria on processes and techniques	Self-monitoring requirements
2.1	Textile waste eligible to be used as input material to any recycling process shall: (a) be stored in a sheltered area to avoid damage and cross-contamination; and (b) be kept separately from ineligible input materials to avoid contamination. Output materials that comply with the end-of-waste criteria shall be kept separately from any output material that does not comply with these criteria.	The procedures carried out to fulfil the storage requirements laid down in this criterion shall be documented in the quality management system.

Source: own elaboration

6.3.2. Criterion 2.2: Treatment steps

For mechanical recycling, the JRC proposed that the recycling operation should include all treatment steps needed to prepare the output material to be used directly as a textile product[71] or in the production of textile products or articles containing textile parts.

[71] Depending on the quality, the recovered fraction may be used for different applications, e.g. cleaning, insulation or stuffing material.

For thermo-mechanical, physical and chemical recycling, the JRC proposed that the recycling operation should include all treatment steps needed to prepare the output material to be used for a specific material purpose[72].

6.3.2.1. Stakeholders' feedback

A high number of stakeholders agreed with the JRC proposal for mechanical recycling and an overwhelming majority of stakeholders agreed on the treatment step proposal for thermo-mechanical, physical and chemical recycling as it ensures that no disproportionate burdens are placed on recyclers or hinder the development of viable new thermo-mechanical, physical and chemical recycling processes.

One stakeholder did not agree with the requirement that all treatment steps must be completed within a single recycling operation. This does not reflect how multi-technology recycling systems operate, where one process may produce an intermediate output that is further treated in a subsequent step — often using a different technology — to meet EoW criteria.

For thermo-mechanical, physical and chemical recycling, one stakeholder mentioned that monomers of polyester could be used as intermediates for other applications, but the current criterion limits the capability of recyclers to valorise these products.

6.3.2.2. JRC assessment of feedback

Considering the multitude of recycling approaches within the scope, defining treatment steps would be a daunting task. Moreover, due to a limited understanding of certain recycling technologies available on the market or under development (for example owing to company confidentiality), there is a risk of establishing mandatory process steps that may not be required to meet the quality criteria outlined in this Section. This could inadvertently lead to the exclusion of certain recycling technologies from achieving EoW status.

To avoid hindering current technologies and innovation, the JRC would refrain from imposing mandatory treatment steps for any recycling method. This approach covers any multi-technology setups, where different treatment stages are carried out using different technologies. The applied sequence of treatment steps shall be documented in the quality management system.

The JRC does not see any limitation for monomers, as EoW status can also be achieved for monomers (see Section 6.1.4).

6.3.2.3. JRC proposal

The proposal on requirements for treatment steps is presented in **Table 12**.

[72] Common applications include re-polymerisation of monomers or oligomers into polymers or the production of man-made cellulosic fibres from recycled dissolving textile pulp.

Table 12. EoW criteria for textile recycling - requirements on processes and techniques – Criterion 2.2

No	Proposed EoW criteria on processes and techniques	Self-monitoring requirements
2.2	Mechanical recycling shall include all treatment steps needed to prepare the output material to be used for a specific material purpose[73] or for the production of products or articles containing textile fibres within the scope. Mechanical recycling shall not be limited to merely sorting or visually checking the waste. Thermo-mechanical, physical and chemical recycling shall include all treatment steps needed to prepare the output material to be used for a specific material purpose[74].	The sequence of treatment steps shall be documented in the quality management system.

Source: own elaboration

6.3.3. Criterion 2.3: Treatment of hazardous waste, waste containing substances classified as hazardous or other restricted substances and dilution

The initial proposal for criterion 2.3 was split into two sub-criteria, one for thermo-chemical, physical and chemical recycling, whereby the material shall be treated to the extent that the resulting output complies with the REACH and POPs Regulations and BPR, and one for mechanical recycling, whereby the resulting output additionally complies also with the CLP Regulation, i.e. that output materials are not classified as hazardous. Both sub-criteria also included a clause on dilution.

6.3.3.1. Stakeholders' feedback

— **Treatment of waste**

Stakeholders generally agreed with the JRC proposal on treatment of waste to the extent that the output of thermo-mechanical, physical and chemical recycling complies with the REACH and POPs Regulations and BPR and was additionally not classified as hazardous under the CLP Regulation in the case of mechanical recycling. No specific comments were received on compliance with BPR.

— **Dilution**

As regards the paragraph on dilution, one stakeholder highlighted that removing the mechanism of mixing various input materials calls into question recycling and paradoxically avoiding dilution means not bringing the chemical values to an acceptable level. The JRC were reminded

[73] Depending on the quality, the recovered fraction may be used for different applications, e.g. cleaning, insulation or stuffing material.

[74] Common applications include re-polymerisation of monomers or oligomers into polymers or the production of man-made cellulosic fibres from recycled dissolving textile pulp.

that it is not viable, in the material input phase, to determine which types of textile waste are suitable with regard to the REACH Regulation.

Another stakeholder reminded that for mechanical recycling any decrease in the concentration of regulated substances in the output material will be due to dilution. Therefore, materials containing substances restricted under the REACH and POPs Regulations should be removed from the input as far as technically feasible.

6.3.3.2. JRC assessment of feedback

— **Treatment of waste**

The JRC decided to merge the sub-criteria initially developed for the different recycling technologies into a single criterion, in order to ensure a more coherent and consistent approach across technologies. The wording has been aligned with the changes made to criterion 1.3, namely, for mechanical recycling it is proposed that the input material shall be treated as necessary to ensure that the output material does not contain substances at concentrations that would lead to its classification as hazardous under the CLP Regulation. The JRC would like to emphasise that Regulation (EU) No 528/2012 on Biocidal Products (BPR) (see Section 5.3.2.6) lays down rules for the use of biocidal products and substances contained therein. Certain disinfectants and preservatives used in textiles are within the scope of the Regulation.

— **Dilution**

As clarified in the UNEP general technical guidelines for the environmentally sound management of waste containing POPs, waste may be mixed to optimise treatment efficiency or to obtain a homogeneous feedstock. It is, however, not allowed to mix hazardous waste with non-hazardous waste or waste containing POPs with waste not containing POPs with the sole purpose of dilution (UNEP, 2019b).

Article 18(1) of the WFD lays down a ban on the mixing of hazardous waste, including dilution of hazardous substances. As per Article 18(2), Member States may apply derogations if the establishment has obtained a specific permit, if the operation does not endanger human health or harm the environment or if the mixing operation follows the best available techniques.

The same considerations apply to the intentional mixing of POPs-containing textile waste exceeding the limit values pursuant to Annex IV to Regulation EU 2019/1021. Therefore, the JRC proposes to maintain a clause on dilution.

6.3.3.3. JRC proposals

The proposal on requirements on treatment of hazardous waste, waste containing hazardous substances or other restricted substances and dilution is presented in **Table 13**.

Table 13. EoW criteria for textile recycling - requirements on processes and techniques – Criterion 2.3

No	Proposed EoW criteria on processes and techniques	Self-monitoring requirements

2.3	Eligible input materials to any recycling process shall be treated to the extent that the following conditions are fulfilled: (a) substances, on their own or in mixtures, that are present in the output material, comply with Regulation (EC) No 1907/2006, including Article 56 setting out authorisation provisions for the use of substances listed in Annex XIV and for their placing on the market as well as the conditions laid down in Article 67 for the manufacture, placing on the market and use of substances listed in Annex XVII; (b) substances, on their own or in mixtures, that are present in the output material, comply with the provisions controlling the manufacturing, placing on the market and use of POPs pursuant to Article 3 of Regulation (EU) 2019/1021 and Annex I to that Regulation, regardless of whether a (pre-)treatment step for the textile waste is in place, as indicated in criterion 1.3; and (c) substances, on their own or in mixtures, that are present in the output material, comply with Regulation (EU) No 528/2012. Eligible input materials to mechanical recycling shall be treated to the extent that the output material does not contain substances, on their own or in mixtures, in concentrations that would trigger the classification of the output material as hazardous according to Article 3 of and Annex I to Regulation (EC) No 1272/2008. Eligible hazardous textile waste to be used as input for any recycling process shall not be mixed or diluted with other waste, substances or materials, in accordance with Article 18(1) of Directive (EC) No 2008/98. The derogations set out in Article 18(2) shall apply. According to Article 7(2) of Regulation (EU) 2019/1021, waste consisting of, containing or contaminated by any substance listed in Annex IV to that Regulation, shall be disposed of or recovered to ensure that the POPs content is destroyed or irreversibly transformed.	Particular attention shall be paid to the processing of hazardous waste and textile waste that may contain substances classified as hazardous according to Regulation (EC) No 1272/2008, or other substances restricted under Regulations (EC) No 1907/2006, (EU) 2019/1021, or (EU) No 528/2012, as indicated in this criterion. The procedure and method used and compliance with the substance concentration requirements of Regulations (EC) No 1272/2008, (EC) No 1907/2006, (EU) 2019/1021 or (EU) No 528/2012, as applicable, shall be documented in the quality management system.

Source: own elaboration

6.4. Requirements on product quality (output of recycling)

Product quality is referred to as the quality of the output material that results from a recycling operation. This category of criteria aims at ensuring that the output materials can be used without posing any risk to human health or the environment. Therefore, requirements on the output materials should aim to limit the presence of hazardous substances and other restricted substances such as persistent organic pollutants.

The criteria should also enhance the suitability of the recycled material for the intended use. In this sense, output materials should fulfil existing standards and industry or customer specifications. Certain impurities and contaminants could compromise the suitability of the output materials for further use.

6.4.1. Criterion 3.1: Compliance with product legislation

For the recycling technologies within the scope, the JRC proposed that the output material should comply with relevant provisions of the REACH and POPs Regulations and BPR. It was also proposed that output materials of mechanical recycling should not be classified as hazardous according to the CLP Regulation. Given that thermo-mechanical, physical and chemical recycling can generate materials that in some cases are classified as hazardous (see **Table 34**, **Annex 12**), the JRC refrained from imposing hazardousness classification requirements for output materials of these recycling technologies.

6.4.1.1. Stakeholders' feedback

More than two thirds of the stakeholders agreed with the JRC proposal on compliance with EU chemical and product legislation. As some of the stakeholder responses were general and related to all recycling approaches, the feedback has been analysed collectively for all recycling technologies.

— **Compliance with chemical and product legislation**

Stakeholders argued that textile recyclers should not be held responsible for ensuring compliance with the CLP, REACH and POPs Regulations regarding the chemical composition of incoming textile waste. In practice, recyclers cannot control which chemicals were used in the production of the original textile. Furthermore, the feedstock for mechanical recycling facilities has previously been subject to these Regulations. Thus, it should not be required for recyclers to comply with these Regulations in the output material.

Stakeholders also fundamentally questioned the concept: if textile waste input has been previously used by consumers without any risk and the textile items were used without any order to remove them from the market, the responsibility should not be shifted to the recyclers.

One stakeholder commented on the difficulties to ensure compliance with EU regulation requirements on the output material, since there is no information available about the origin and date of production (e.g. it could be a product produced in the EU but before the entry in force of a regulation or a specific provision).

One stakeholder proposed that the textile waste provider or sorter be required to check and indicate compliance with the REACH and POPs Regulations. This would ensure that recyclers are not burdened with the responsibility of verifying compliance of the materials they receive, which

could be operationally challenging and costly. Clear protocols for upstream verification are essential to ensure that only compliant waste is processed, streamlining the recycling process and supporting adherence to safety and regulatory standards.

Stakeholders argued that requesting compliance with the CLP Regulation for output materials of mechanical recycling is not proportionate, as it would impose stricter requirements for recycled materials compared to virgin materials.

— **Testing**

Stakeholders argued that, given the heterogeneous nature of textile waste, achieving full legal compliance via systematic testing at the recycling output stage is neither technically feasible nor economically viable. This could hamper the development of textile recycling. Stakeholders proposed to develop and adopt a more realistic, risk-based approach rather than exhaustive testing.

One stakeholder raised concerns that, while it is crucial to remove hazardous chemicals from textile recycling, there are currently no effective technologies for detecting such substances in post-consumer textiles during sorting. No standardised sampling, screening or testing methods exist, making it difficult for recyclers to ensure compliance. To address this gap, greater investment is needed in developing fast and cost-effective detection technologies.

6.4.1.2. JRC assessment of feedback

— **Compliance with chemical and product legislation**

While some stakeholders argued that textile recyclers should not bear responsibility for compliance with existing chemicals and product legislation, recyclers are in fact the operators who transform waste into materials intended to re-enter the market. Although sorting operations or pre-treatment processes may in some cases be able to identify and remove textile items containing hazardous substances before recycling, this cannot replace the responsibility of recyclers to ensure that the output they place on the market complies with Union legal requirements.

The JRC acknowledges that certain substances may be present in textiles at concentrations that were permitted when those products were originally manufactured or placed on the market, but which may subsequently become problematic in light of evolving scientific knowledge and regulatory developments, including recent restrictions on PFAS or skin sensitisers. Once waste-derived materials cease to be waste and are placed on the market again as products, they must comply with the applicable legislation in force.

In this respect, REACH constitutes a binding legal framework, and compliance with REACH is required for all operators placing substances, mixtures or articles on the EU market. The same applies, where relevant, to the POPs Regulation and the BPR. The JRC therefore maintains its position that compliance with these frameworks cannot be made conditional or derogated from in the context of end-of-waste criteria.

The JRC recognises concerns that restrictions within the end-of-waste framework for mechanically recycled outputs could be perceived as creating an uneven playing field compared with virgin materials, including in cases where products with hazardous properties may still lawfully be placed on the market. However, this comparison does not alter the need to ensure that recycled outputs are safe for their intended or potential uses. In the case of virgin production, manufacturers can control feedstock composition and tailor fibres to specific applications. By contrast, mechanically recycled outputs (such as cut textiles, fibres and powders) may be used in a broad range of downstream applications, including clothing and other products involving skin contact, without certainty as to the final use at the point of recycling. This justifies a more precautionary approach to the safety of those outputs.

For that reason, the JRC recommends maintaining the requirement that output materials from mechanical recycling must not be hazardous. This is necessary to ensure a high level of protection of human health and the environment and to avoid shifting the burden of hazardous substance control to downstream actors.

By contrast, thermo-mechanical, physical and chemical recycling processes are generally more capable of removing contaminants than mechanical recycling. It is therefore not appropriate to apply the same output restrictions to materials resulting from those processes. In addition, such outputs may in some cases themselves fall to be classified as hazardous, as indicated in **Table 34** in **Annex 12**. For these outputs, the JRC therefore proposes to retain a general requirement for classification and in accordance with the CLP Regulation, rather than imposing the same non-hazardous output condition applicable to mechanical recycling.

— **Testing**

The JRC clarifies that only relevant substances for the specific waste stream treated will need to be analysed in the assessment of compliance with the CLP, REACH and POPs Regulations and BPR, as relevant. Good practice for setting an appropriate monitoring frequency is to evaluate when potentially harmful trends may occur (EC, 2003). This is defined in ISO 9001 as the risk-based approach. The JRC proposes to adopt this approach, allowing operators to determine the frequency of sampling based on the risk of non-compliance and on relevant changes in the process.

The ECHA guidance on biocides legislation[75] clarifies how to satisfy information requirements laid down in the BPR and how to perform the assessment. Particularly relevant are Volume III (Human Health) [76] and Volume IV (Environment) [77]. These guidelines can be used as the basis for the risk assessment to be performed by the recycling facility.

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75 ECHA guidance on biocides legislation: https://echa.europa.eu/guidance-documents/guidance-on-biocides-legislation

76 Guidance on the Biocidal Products Regulation, Volume III Human Health – Assessment & Evaluation (Parts B+C): https://echa.europa.eu/documents/10162/2324906/biocides_guidance_human_health_ra_iii_part_bc_en.pdf/30d53d7d-9723-7db4-357a-ca68739f5094?t=1512979002065

77 Guidance on the Biocidal Products Regulation, Volume IV Environment – Assessment & Evaluation (Parts B+C): https://echa.europa.eu/documents/10162/2324906/bpr_guidance_ra_vol_iv_part_b-c_en.pdf/e2622aea-0b93-493f-85a3-f9cb42be16ae?t=1513159347576

The appropriate frequency of monitoring the output quality by sampling is prescribed in the self-monitoring requirements.

6.4.1.3. JRC proposal

The JRC proposal on compliance with relevant product legislation is presented in **Table 14**.

Table 14. EoW criteria for textile recycling - requirements on product quality – Criterion 3.1

No	Proposed EoW criteria on product quality	Self-monitoring requirements
3.1	The following requirements shall apply to any recycling process: (a) substances, on their own or in mixtures, that are present in the output material, shall comply with Regulation (EC) No 1907/2006, including Article 56 setting out authorisation provisions for the use of substances listed in Annex XIV and for their placing on the market, and Article 67 setting out the conditions for the manufacture, placing on the market and use of substances restricted under Annex XVII[78]; (b) substances, on their own or in mixtures, that are present in the output material, shall comply with the provisions controlling the manufacturing, placing on the market and use of POPs pursuant to Article 3 of and Annex I to Regulation (EU) 2019/1021; and (c) substances, on their own or in mixtures, that are present in the output material, shall comply with Regulation (EU) No 528/2012. The output material from thermo-mechanical, physical and chemical recycling shall be classified and labelled according to Regulation (EC) No 1272/2008. The output material from mechanical recycling shall not contain substances, on their own or in mixtures, in concentrations that would trigger its classification as hazardous according to Article 3 of Regulation (EC) No 1272/2008.	The assessment of compliance with Regulations (EC) No 1907/2006, (EU) No 2019/1021, (EU) No 528/2012 and Regulation (EC) No 1272/2008, as applicable, shall be concluded based on a qualitative and quantitative characterisation of the output material in the consignment. The exemptions laid down in these Regulations shall apply, including in Article 2(7) of Regulation No 1907/2006, Article 4 of (EU) 2019/1021 and Article 29 of Regulation (EC) No 1272/2008. To this end, representative samples of the output material shall be analysed to measure the concentration and nature of hazardous substances. These representative samples shall be taken at appropriate intervals determined on a risk-based approach that considers the following factors: (1) the expected pattern of variability of the output material composition (for example as shown by historical results); (2) the inherent risk of variability in the quality of the waste used as input for the recycling operation and any subsequent processing, for instance the higher average content of waste containing substances classified as hazardous according to Regulation (EC) No 1272/2008 and substances restricted under Regulations (EC) No 1907/2006, (EU) 2019/1021 and (EU) No 528/2012;

[78] Including the latest amendment of Annex XVII (Regulation (EU) No 2023/923).

		(3) the inherent precision of the monitoring method; and (4) the proximity of results to the concentration thresholds that render the material hazardous or restrict its commercialisation. The frequency of monitoring by sampling shall occur at least once every six months and shall be adjusted to ensure that trends or other changes in the input materials can be detected. The process for determining the monitoring frequency and the results of the monitoring shall be documented as part of the quality management system.

Source: own elaboration

6.4.2. Criterion 3.2: Compliance with legal requirements, standards or specifications

The JRC proposed that the output material from the recycling technologies within the scope shall demonstrably fulfil all legal requirements and shall comply with customer specifications, industry specifications and standards.

6.4.2.1. Stakeholders' feedback

There is overall consensus among stakeholders on the JRC proposal. Stakeholders highlighted that the specifications should be targeted to the final application. One stakeholder did not agree to request the fulfilment of customer specifications, as these are subjective expectations.

Stakeholders emphasised that, as long as there is a demonstrated demand for the recycled output material, the material must be considered as fulfilling industry specifications and standards as well as use requirements from the industries. Market uptake is itself evidence of functionality and fitness for purpose.

In particular for mechanical recycling, one stakeholder wanted to clarify that output material should not be expected to meet the same technical standards as virgin raw materials. Recycled materials have inherently different characteristics due to having undergone a prior use cycle. Expecting parity with virgin material benchmarks is unrealistic, would place an undue burden on recyclers and could also risk negatively affecting the uptake of recycled output materials.

For thermo-mechanical, physical and chemical recycling, stakeholders raised concerns as some output materials may not have an industry specification or standard in place yet. The reason is that in recent years new materials—both synthetic (such as pulp-based raw materials) and natural (such as pineapple fibres)—have emerged and entered the market. Stakeholders therefore advocated for flexible requirements that encourage innovation and allow new material types and recycling approaches to evolve and scale.

6.4.2.2. JRC assessment of feedback

The JRC agrees with stakeholders that customer specifications may be subjective, but considering the diverse applications of the output materials, sometimes even in niche markets, not all output materials meet standards or general industry specifications. The JRC believes that if there is a market demand for recycled output material, the (textile) market and the customers themselves define certain specifications depending on quality requirements for their production process. Therefore, allowing compliance with customer specifications ensures that a wide range of output materials can also achieve EoW status.

Based on the stakeholder feedback, the JRC believes that customer specifications, industry specifications and standards do not exist for all output materials yet. This applies in particular to output materials from thermo-mechanical, physical, and chemical recycling processes, as this is an emerging sector. A requirement that all specifications and standards must be met could result in certain output materials not being able to achieve the required quality. Therefore, the JRC proposes that the output material shall either comply with customer specifications or industry specifications or standards. Meaning, that output materials have to show conformity for at least one of the three requirements, but the output material may also satisfy two or all requirements.

The JRC agrees with the stakeholder comment that recycled output material may differ in quality from virgin raw material. Therefore, it is proposed not to set requirements for the output material based on the virgin raw material quality.

6.4.2.3. JRC proposal

The JRC proposal on fulfilling Union product legislation and compliance with legal requirements, standards or specifications is presented in **Table 15**.

Table 15. EoW criteria for textile recycling - requirements on product quality – Criterion 3.2

No	Proposed EoW criteria on product quality	Self-monitoring requirements
3.2	The output material from mechanical recycling processes shall comply with Union product legislation requirements, industry specifications or standards for the use of the output material for a specific material purpose[79] or for the production of new products or items containing textile fibres within the scope. The output material from thermo-mechanical, physical or chemical recycling processes shall comply with Union product legislation requirements,	Qualified staff shall verify that each batch in the consignment complies with the legal requirements and appropriate standards and product specifications, including customer requirements. To monitor compliance, representative samples of the output material shall be taken and analysed at appropriate intervals determined on a risk-based approach, considering the intended specific use of the recycled material.

[79] Depending on the quality, the recovered fraction may be used for different applications, e.g. cleaning, insulation or stuffing material.

	industry specifications or standards for the use of the output material for a specific material purpose[80].	Automated inspection systems that provide equivalent verification are also accepted. The frequency of verification shall be defined in accordance with the characteristics of the textile waste stream treated. The process for determining the monitoring frequency and the results of the monitoring shall be documented in the quality management system.

Source: own elaboration

6.4.3. Minimum requirements for output materials of mechanical recycling

In the draft proposal, only for mechanical recycling the JRC proposed minimum criteria, namely that the output material shall be clean, dry and free of odours. This criterion has been discarded in the final proposal for the reasons outlined below.

6.4.3.1. Stakeholders' feedback

One stakeholder suggested to propose minimum requirements for the input material. If the textile waste being mechanically recycled is clean, dry and odourless, so is the output material.

While certain baseline criteria, such as textiles being dry, uncontaminated and hygienically safe, are important for most recycling pathways, stakeholders highlighted that it is important to recognise that not all end uses require the same quality. Depending on the needs of the recycled output material, the material can be more or less clean, dry and with the presence of odours. This means that a recycled material presenting odours or impurities does not need to be sent to landfill as the textile recycling industry has acquired experience in processing these materials for certain applications.

Stakeholders asked about the possibility of more guidance and explanation on what clean, dry and free of odours mean (e.g. acceptable pollution percentage).

Various stakeholders argued that odour is an unsuitable criterion for recycled textiles. More specifically, the JRC proposal on odour is too generic as there is no recognition of malodour compared to generic odour, or the degree to which odour is present. Various stakeholders highlighted that for some applications odour is not relevant and provided practical examples:

- In the construction sector, the odour in recycled textiles is not of relevance. For instance, when the material is used as insulation material, the odour is automatically removed in subsequent manufacturing processes.

[80] Common applications include re-polymerisation of monomers or oligomers into polymers or the production of man-made cellulosic fibres from recycled dissolving textile pulp.

- The odour of wool can be strong, which does not mean that the product is dirty.
- Jute bags containing certain beans such as cacao beans typically present an acidic odour. After mechanical recycling (pulling), the jute fibres still have this odour. When the material is used as insulation material, the fibres undergo a thermal treatment capable of removing the odour.

In this context, one stakeholder proposed that the output material 'shall be clean, dry and free of unusual odours.

6.4.3.2. JRC assessment of feedback

The JRC disagrees with the stakeholder suggestion to propose minimum requirements for input materials, as mechanical recyclers also apply water, chemical agents or even elevated temperatures to treat unclean, wet and odorous textile waste (see Section 4.2.4). As described in Section 0, the JRC proposes that the input textile waste shall be dry and without a significant amount of residues, unless the recycling technology is demonstrably capable of treating these input materials.

A detailed analysis of stakeholder feedback revealed that a simplified approach to establishing minimum requirements is not effective or feasible. This is due to several factors, including:

- the diverse range of textile waste input materials used for mechanical recycling;
- the quality of output materials, which can differ significantly in terms of impurities and odour;
- the diverse requirements for the application of mechanically recycled textiles.

To avoid setting arbitrary criteria that may not be relevant or could even hinder the mechanical recycling industry, the JRC has decided not to establish minimum requirements for the output material of mechanical recycling.

Instead, we refer to the requirements outlined in relevant standards, customer specifications and industry guidelines (see Section 0, **Table 15**). This approach is more effective as the market and industry are best positioned to determine the quality that can be produced and the requirements that the market demands. By relying on existing standards and specifications, it can be ensured that the output material meets the necessary quality standards.

6.4.3.3. JRC proposal

In the new proposal, the JRC refrains from setting minimum criteria for output materials from mechanical recycling and refers to the requirements on '*compliance with standards and customer and industry specifications'* (see **Table 15**).

6.5. Requirements on quality assurance procedures

6.5.1. Criterion 4.1: Quality management system

Quality assurance is a key element to ensure reliability and verify compliance with EoW criteria. The JRC proposed that the quality management system (QMS) shall include a set of documented

procedures to monitor the input materials, the treatment steps and the quality of the output materials. It should also serve to record the results of the self-monitoring requirements of each criterion and feedback from customers on the quality of the output material. The QMS should also be certified by a conformity assessment body or by an environmental verifier.

6.5.1.1. Stakeholders' feedback

— **Implementation of a QMS with documented procedures**

Stakeholders broadly agreed with the introduction of a QMS, especially as a way to improve performance, output quality and traceability and prevent malpractice. However, certain stakeholders feared that the current QMS design proposed by the JRC will increase the administrative and financial burden. The costs of monitoring, recording and demonstrating compliance should not result in uncompetitive textile recycling operations, especially when competing with cheap virgin fibres.

Some stakeholders argued that a self-assessment and self-declaration by a person responsible could be sufficient, eliminating the need for an external audit process. In the event of possible controls, proof in the form of self-declarations should be sufficient.

With regards to verification intervals, some stakeholders suggested a two-year interval instead of the proposed three-year interval, striking a balance between regulatory oversight and administrative burden.

— **Applications of international standards**

Stakeholders highlighted that a QMS is typically included within the ISO 9001 or ISO 14001 certification, which are common certifications for textile recyclers. Both ISO standards are controlled by the same auditing body and stakeholders argued that using the ISO-based certification could avoid administration costs from other external auditors. Other stakeholders argued that ISO 9001, however, focuses on general quality management procedures and is not suitable for demonstrating compliance with the EoW criteria.

— **Self-monitoring requirements**

During the final event with stakeholders where the JRC presented the final proposals, stakeholders suggested that digital verification methods should be explicitly mentioned as an alternative to the work carried out by qualified staff, as this may become technically viable in the near future.

— **QMS for third-country suppliers**

Stakeholders pointed out that it appears that producers in the EU have to comply with points 1, 2, 3 and 4 of criterion 4.1. and importers only with points 1, 2 and 3. For a fair competition, producers and importers should have to comply with the same requirements.

It is important to ensure that imported products meet the same quality standards as EU-produced products. Therefore, stakeholders asked for specific requirements and controls for recyclers operating in non-European countries that often operate under less demanding legislation. The certifiers and verifiers applied by third-country suppliers should be Europe-based and/or EU-approved (these could be local auditors from international companies) to ensure

fairness between audits conducted inside and outside the EU, and the certification body should be accredited by a national accreditation body of an EU Member State, in line with ISO 17065[81].

One stakeholder argued that requiring third-country suppliers to also implement a QMS may not be operationally feasible or enforceable at scale. They propose a more risk-based and document-driven approach that is aligned with existing chain of custody methods such as:

- using contracts, supplier self-declarations and traceable input documentation to verify quality control at source;
- allowing importers to demonstrate due diligence without requiring full QMS certification by each upstream supplier.

— **NACE codes**

Concerning the NACE (Nomenclature of Economic Activities) code, one stakeholder commented that verifiers with accreditation or a licence other than the five listed in the JRC proposal could be acceptable without proposing any new NACE codes.

6.5.1.2. JRC assessment of feedback

— **Implementation of a QMS with documented procedures**

The JRC recognises that quality assurance is key to ensuring a certain level of confidence in the quality of the output materials. It is also important to be able to distinguish consignments meeting EoW criteria from consignments that have not applied for EoW status or do not meet EoW criteria. Hence, the JRC proposes that the operator of a recycling facility should be required to implement a QMS to keep track of the relevant procedures and to demonstrate compliance with the EoW criteria.

In contrast to suggestions from some stakeholders, the JRC strongly advocates for external assessment and verification of the QMS. The external audit is crucial to ensure uniformity across the market, which cannot be guaranteed with self-assessment. Furthermore, the implementation of independent audits establishes credibility and trust in the products manufactured from textile waste. This implies that no major changes are proposed regarding the assessment and verification of the QMS by a conformity assessment body or an environmental verifier.

The JRC agrees in general that an external inspection of the recycling facility could provide additional confidence to the buyer of the output material. It is clarified that conformity assessment bodies will perform relevant inspections, as appropriate, when assessing and verifying the QMS. It is then up to competent authorities designated by the Member States to verify EoW criteria compliance and to perform additional inspections.

[81] ISO 17065 Conformity assessment — Requirements for bodies certifying products, processes and services.

Opposing the stakeholder proposal, the JRC refrains from shortening the interval of verification of the QMS procedures and proposes to keep an interval of three years to avoid imposing an additional administrative and economic burden on operators.

— **Application of international standards**

The implementation of a standardised QMS based on international standards can pose an additional administrational and financial burden, particularly on small and medium-sized companies. Standards are subject to periodic reviews, hence referencing standards would lead to a need for corresponding amendments. Thus, the JRC proposes not to mandate the application of any (international) standards.

— **Self-monitoring requirements**

Self-monitoring requirements have been updated in the individual categories of criteria, to address the concerns raised by stakeholders (see also Sections 6.2, 0 and 0). The JRC welcomes the proposal by stakeholders to mention automated inspection systems and has introduced this point in the self-monitoring requirements, where relevant.

— **QMS for third-country suppliers**

The JRC agrees with stakeholders that fair competition and a level playing field must prevail. To ensure fairness between audits conducted inside and outside the EU, the JRC extends the requirements for importers of textile material resulting as output of treatment facilities outside the EU. Thus, third-country-based operators should not only implement a QMS complying with the requirements of points 1, 2 and 3 defined in the QMS criteria (see **Table 16**), but also need to be verified by a verifier that has obtained specific accreditation or a licence laid down in EU legislation.

However, the JRC refrains from mandating certain ISO certifications, such as ISO 17065.

— **NACE codes**

Additional reviews revealed that, within NACE code 20, manufacturers of organic chemical raw materials, plastic raw material and man-made fibres are listed. This reflects the output materials from thermo-mechanical, physical and chemical recycling processes (see Section 4.2.4). Therefore, verifiers with the scope of accreditation or a licence based on the NACE code 20 are added to the list of verifiers (point 6 of the criterion).

6.5.1.3. JRC proposal

The JRC proposal on the quality management system is presented in **Table 16**.

Table 16. EoW criteria for textile recycling – requirements on quality assurance – Criterion 4.1

No	Proposed EoW criteria on quality assurance procedures
4.1	1. The producer shall implement a quality management system that allows it to demonstrate compliance with the end-of-waste criteria.

	2. The quality management system shall include a set of documented procedures concerning each of the following aspects: (a) monitoring of textile waste used as input material for recycling including quality control measures and risk management measures; (b) monitoring of the treatment processes and techniques; (c) monitoring of the quality of output material resulting from recycling, including instructions for sampling and analysis and their frequency; (d) record-keeping of the results of monitoring conducted under points (a), (b) and (c); (e) record-keeping of feedback from customers concerning the quality of the output material; (f) record-keeping of the actions taken to improve the performance of recycling, in order to assess non-compliance with the end-of-waste criteria; (g) review and improvement of the quality management system; and (h) training of staff. 3. The quality management system shall cover all the specific self-monitoring requirements set out for each end-of-waste criterion and the statement of conformity. 4. The quality management system shall be assessed by one of the following bodies: (a) a conformity assessment body; or (b) an environmental verifier. 5. The bodies referred to in point 4 shall verify that the quality management system fulfils the requirements on procedures referred to in point 2. The verification shall be carried out every three years. 6. Environmental verifiers, referred to in point 4 (b), shall be permitted to perform the verification referred to in point 5 only if such bodies have obtained an accreditation or licensing with a scope covering at least one of the following NACE codes specified in Regulation (EC) No 1893/2006 of the European Parliament and of the Council[82]: – NACE Code 13 (Manufacture of textiles); or – NACE Code 14 (Manufacture of wearing apparel); or – NACE Code 15 (Manufacture of leather and related products); or – NACE Code 20 (Manufacture of chemicals and chemical products); or – NACE Code 22 (Manufacture of rubber and plastic products); or – NACE Code 38 (Waste collection, treatment and disposal activities; material recovery).

[82] Regulation (EC) No 1893/2006 of the European Parliament and of the Council of 20 December 2006 establishing the statistical classification of economic activities NACE Revision 2 and amending Council Regulation (EEC) No 3037/90 as well as certain EC Regulations on specific statistical domains (OJ L 393, 30.12.2006, p. 1, ELI: http://data.europa.eu/eli/reg/2006/1893/oj).

	7. The producer shall give enforcement authorities, as defined in Article 2, point (26), of Regulation (EC) No 1221/2009, access to the quality management system upon request and make the records referred to in point 2 (d), (e) and (f) of this criterion electronically available to the relevant national authorities upon request, for at least five years after the date of recording. 8. To be allowed to place output materials on the Union market, the importer of such output materials from recycling facilities located in a third country shall require third-country suppliers to implement a quality management system which complies with the requirements set out in points 1, 2 and 3 of this criterion. This quality management system shall be verified by one of the bodies referred to in point 4, which is accredited or licensed in a Member State to perform verification and validation activities for an organisation located in a third country, in accordance with the specifications laid down in Regulation (EC) No 765/2008 or in Regulation (EC) No 1221/2009 in conjunction with Commission Decision 2011/832/EU[83]. 9. If the importer of output materials from recycling facilities located in a third country fails to meet the requirements laid down in point 8, the output materials to be imported shall be considered waste and, therefore, shall comply with Regulation (EU) 2024/1157.

Source: own elaboration

6.6. Requirements on provision of information

The requirements on provision of information are complementary to quality criteria. To minimise the risk that recycled EoW textiles are diverted to uses different to those defined in the EoW criteria, additional requirements are needed, specifically on the statement of conformity (SoC).

6.6.1. Criterion 5.1: Statement of conformity

The JRC proposed that the producer or the importer shall issue, for each consignment of output material complying with EoW criteria, a statement of conformity as set out in the template.

6.6.1.1. Stakeholders' feedback

— **Issuing a statement of conformity**

Stakeholders largely agreed with the JRC proposal to issue a statement of conformity but pointed out that this is associated with an increased administrative burden, especially for SMEs, and thus a balance must be found. One stakeholder proposed that the electronic form be only optional.

[83] Commission Decision 2011/832/EU of 7 December 2011 concerning a guide on EU corporate registration, third country and global registration under Regulation (EC) No 1221/2009 of the European Parliament and of the Council on the voluntary participation by organisations in a Community eco-management and audit scheme (EMAS) (OJ L 330, 14.12.2011, p. 25, ELI: http://data.europa.eu/eli/dec/2011/832/oj).

One stakeholder supported issuing a statement of conformity based on the consistency of the produced output material quality. If a recycler is able to demonstrate consistency of the output material quality over an extended period, the frequency for issuing a statement of conformity should be reduced until a non-conformity occurs. Then the frequency shall reset to the most stringent.

— **Template for the statement of conformity**

Stakeholders in principle agreed with the proposal to create a specific template and the proposed content. Suggestions on specific points were made:

- point 1: specify the address to be provided (headquarters or site of the recycling operation); add a unique company identifier to avoid confusion in spelling;
- point 3: the fibre composition of the product resulting from the textile recycling should be included whenever possible;
- point 7: adding the name of the independent external verifier can help in quickly checking that verification was indeed performed by the external verifier;
- point 9: ensure that only the operator/producer/importer or qualified person can complete the statement of conformity to ensure correct information.

6.6.1.2. JRC assessment of feedback

— **Issuing a statement of conformity**

The JRC is of the opinion that certain information should be passed on when the output material from textile recycling achieves EoW status and is handed over to the next holder to ensure traceability. Hence it is proposed to require the producer or importer of the EoW output material to issue a statement of conformity to the next holder.

One purpose of the statement of conformity is to ensure traceability after textile waste ceases to be waste and attains product status. Therefore, a statement of conformity shall be issued by default for each consignment, independent of the output material quality.

— **Template for the statement of conformity**

Based on the stakeholder feedback, the JRC proposes adapting the following aspects:

- Contact information: The producer/importer shall provide the address of the recycling facility. To avoid spelling confusion, the unique identifier for companies registered in the EU, the European Unique Identifier (EUID), shall ideally be provided.
- The JRC refrains from prescribing specific output material properties such as fibre composition. The output materials from recycling processes can be manifold and a list of mandatory output material specifications would never be exhaustive. The JRC believes that by providing the 'main technical provisions of the customer specifications, industry specifications or standard', the relevant technical specifications will be provided to the next holder.

- The JRC refrains from demanding the mandatory disclosure of the name of the independent external verifier in the statement of conformity, since it does not provide any additional benefits.
- It is already mandated for the producer/importer to certify that the provided information is complete and correct to the best of their knowledge. It shall be at the discretion of the producer or the importer to determine who is authorised as a qualified person.

6.6.1.3. JRC proposal

The JRC proposal on the statement of conformity is presented in **Table 17**.

Table 17. EoW criteria for textile recycling – requirements on provision of information – Criterion 5.1

No	Proposed EoW criteria on provision of information
5.1	The producer or the importer shall issue, for each consignment[84] of output material that complies with end-of-waste criteria, a statement of conformity in agreement with the model set out in the template. The producer or the importer shall transmit the statement of conformity to the next holder of the consignment. The producer or importer shall retain a copy of the statement of conformity for at least three years after its date of issue and shall make it available to relevant national authorities upon request. The statement of conformity may be in electronic form.

Source: own elaboration

Table 18 presents the JRC proposal for the statement of conformity template.

Table 18. JRC technical proposal for the statement of conformity template

1.	Unique identification code of the consignment: Producer/importer of the output material (location of the installation in which the recycling of this consignment was carried out): Name: European Unique Identifier (EUID) (optional, alternative to the name): Address: Contact person: Tel.: E-mail:

[84] Consignment: a batch of EoW textiles which is intended for delivery from a producer to another holder and may be contained in either one or several transport units, such as containers.

2.	Quantity of the consignment in tonnes:
3.	Characteristics and intended use of the output material: a) Name or code that identifies the output material, in accordance with Union product legislation, a standard or product specifications, including customer requirements: b) Main technical characteristics of the output material, in accordance with Union product legislation, a standard or product specifications, including customer requirements:
4.	The output material in this consignment complies with customer requirements, industry specifications or a standard referred to in point 3.
5.	The textile recycling consignment meets the criteria on input materials (1.1, 1.2, 1.3 and 1.4), on treatment processes and techniques (2.1, 2.2 and 2.3), and on product quality (3.1 and 3.2).
6.	**For output materials resulting from mechanical recycling** Substances, on their own or in mixtures, that are present in the output material, comply with Regulation (EC) No 1907/2006, including Article 56 setting out authorisation provisions for the use of substances listed in Annex XIV and for their placing on the market, and Article 67 setting out the conditions for the manufacture, placing on the market and use of substances restricted under Annex XVII . Substances, on their own or in mixtures, that are present in the output material, meet the provisions controlling the manufacturing, placing on the market and use of POPs pursuant to Article 3 of and Annex I to Regulation (EU) 2019/1021, regardless of whether a (pre-)treatment step for the textile waste is in place, as indicated in Criterion 1.3. Substances, on their own or in mixtures, that are present in the output material, meet the relevant provisions laid down in Regulation (EU) No 528/2012. The output material does not contain substances, on their own or in mixtures, in concentrations that would trigger its classification as hazardous according to Article 3 of Regulation (EC) No 1272/2008. **For output materials resulting from thermo-mechanical, physical and chemical recycling** Substances on their own or in mixtures, that are present in the output material, comply with Regulation (EC) No 1907/2006, including Article 56 setting out authorisation provisions for the use of substances listed in Annex XIV and for their placing on the market, and Article 67 setting out the conditions for the manufacture, placing on the market and use of substances restricted under Annex XVII . Substances on their own or in mixtures, that are present in the output material, meet the provisions controlling the manufacturing, placing on the market and use of POPs pursuant to Article 3 of and Annex I to Regulation (EU) 2019/1021, regardless of whether a (pre-)treatment step for the textile waste is in place, as indicated in Criterion 1.3. Substances on their own or in mixtures, that are present in the output material, meet the relevant provisions laid down in Regulation (EU) No 528/2012. The output material is classified and labelled according to Regulation (EC) No 1272/2008.
7.	The producer of the output material applies a quality management system assessed by an accredited conformity assessment body, which is accredited by a national accreditation body, or by

	an environmental verifier as defined in Article 2, point (20)(b), of Regulation (EC) No 1221/2009. Where output items which have ceased to be waste are imported into the customs territory of the Union, the quality management system shall be verified by an accredited conformity assessment body, which is accredited by a national accreditation body, or by an environmental verifier, who has obtained a specific accreditation or licence to operate in a third country, in accordance with the specifications laid down in Regulation (EC) No 765/2008 or in Regulation (EC) No 1221/2009 in conjunction with Commission Decision (EU) No 2011/832.
8.	**For output materials resulting from mechanical recycling** The output material in this consignment is intended to be either ready to be used for a specific material purpose or for the production of new products or items containing textile fibres within the scope. It must not be used for energy recovery, for fuel production (e.g. solid recovered fuel), as feedstock for other recovery operations (e.g. thermo-mechanical, physical and chemical recycling), or for backfilling operations. Where these conditions are not met, the user of the output material shall handle it as waste and shall inform the producer, for the purpose of accurately reporting the weight of textiles that has achieved end-of-waste status. **For output materials resulting from thermo-mechanical, physical and chemical recycling** The output material in this consignment is intended to be used for a specific material purpose. It must not be used for energy recovery, fuel production or for backfilling operations. Where these conditions are not met, the user of the output material shall handle it as waste and shall inform the producer, for the purpose of accurately recording the weight of the output material that has achieved end-of-waste status.
9.	Declaration of the producer/importer of the output material: I certify that the above information is complete and correct to the best of my knowledge: Name: Date: Signature:

Source: own elaboration

6.7. Comparison of JRC proposal for EU-wide EoW criteria for recycling with national EoW criteria

As mentioned in Section 5.5, only France has implemented a national EoW decree for cleaning rags. At the time of completion of the JRC technical proposal, Italy was developing EoW criteria for mechanical recycling of textile waste. As the JRC did not receive any information on progress or on its implementation, the JRC did not consider it in the analysis (see also **Annex 9**).

As pointed out above, the JRC has considered the national EoW criteria for cleaning rags from France in the assessment. It needs to be considered that the French EoW criteria are limited to one specific output material of mechanical recycling, namely cleaning rags. Hence, it is not always meaningful to use those criteria as a starting point for the development of EoW criteria for textile waste recycling. This justifies deviations of the JRC approach compared to the French EoW criteria.

As for the EoW criteria under development in Italy, those have been used in certain instances as inspiration for the development of EU-wide criteria. However, it is to be noted that the Commission is not bound to use them as a starting point, as they have not been implemented.

When comparing the French approach with the JRC approach, the main difference is that the French EoW approach defines a list of allowed input materials (positive list), whereas in the current JRC proposal certain input materials not allowed as input materials are listed (negative list).

The requirements on processes and techniques are more specific in the JRC approach, as these requirements are targeted to a great variety of recycling technologies and not only mechanical recycling. As for the requirements on output quality, the JRC approach is more stringent, as it is requested that the output materials comply with relevant Regulations on chemicals (REACH, CLP, POPs, BPR – depending on the recycling technology used) as well as standards and customer and industry specifications.

7. Conclusions and recommendations

The report demonstrates that the current EU waste legislation lacks specific, harmonised criteria for recycled textiles to be declared end-of-waste. This study aimed to fill this gap providing technical proposals to be possibly transposed to a legal act. The technical proposals are the result of an extensive consultation process involving waste treatment operators, including recyclers, fibre producers, garment manufacturers, NGOs, standardisation bodies and national authorities, among others. This participatory approach has produced criteria that strike a balance between technical feasibility and legal compliance.

This work was developed in close coordination and is well aligned with the forthcoming technical proposals for EoW criteria for preparing for re-use and remanufacturing of textile, textile-related and footwear waste developed in parallel and outlined in Pérez Arribas et al. (2026). The EoW criteria for recycling establish the essential legal framework to facilitate the transition of textile waste that cannot be prepared for re-use or remanufactured. By addressing preparation for re-use, remanufacturing and recycling, comprehensive EoW criteria have been developed to encompass the entire textile waste management chain.

The EoW criteria proposed herein constitute a complete technical framework for recycling operations. They define the conditions that must be met by the input material, the treatment processes, the output material and the associated quality-assurance system as well as the obligations on provision of information. The criteria cover all recycling pathways that are currently, or set to become, viable for textile waste, including mechanical, thermo-mechanical, physical and chemical recycling. This breadth mirrors the diversity of the textile sector and anticipates the rapid development of textile recycling, ensuring that the framework will remain relevant as the sector evolves.

Because textiles often consist of synthetic fibres, operators that treat these waste streams may choose between the textile-specific EoW criteria presented here and the EoW criteria for plastic waste that are being adopted in parallel. The two sets of criteria have similar requirements on hazardous substances, compliance with product legislation and quality-assurance procedures, but they differ in the definition of textile-waste input, the treatment steps that must be performed and the product-quality specifications. A key difference between the textile and plastic-specific EoW criteria lies in their approach to recycling technologies. For both EoW criteria, mechanical and physical recycling are within the scope. For textiles, the scope also encompasses specific chemical recycling methods, including depolymerisation and pulping. Among other reasons, this inclusion is based on the high material yield of these chemical recycling technologies, with low conversion to energy or fuels. Moreover, several of the chemical recycling technologies for textiles show a strong potential to be scaled up for large-scale operations in the near future.

It is worth noting that the proposals for EoW criteria presented here are not intended to regulate the preparatory steps that precede recycling (e.g. collection, sorting or other pre-treatment steps before waste reaches the recycling facility). This is particularly relevant in the context of the debate on where to grant EoW status. The JRC concluded that the only technically suitable point at which to grant EoW status is after the recycling operation has been completed and the output material complies with the full set of EoW criteria. This position respects the hierarchy of the WFD, guarantees that environmental and health safeguards are in place, and avoids market distortions while still allowing the broad range of downstream applications envisioned for recycled textile fibres

and chemicals. Moving the point at which EoW status is granted to earlier steps could undermine existing EU law which provides environmental protection for the handling of waste and prevents unregulated exports of waste outside the Union. It could also compromise product safety, and risk undermining the EU's circular-economy ambition.

The desire expressed by some stakeholders to shift the granting of EoW status upstream reflects the current decentralised generation of textile waste and the current, and in the future possibly even stronger, concentration of large-scale recycling facilities in a limited number of Member States. In this context, the JRC refers to the ongoing work on green-listing certain textile wastes under the Waste Shipment Regulation, which is intended to facilitate cross-border shipments.

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List of abbreviations

BAT	Best Available Technique(s)
BHET	Bis(2-hydroxyethyl) terephthalate
BREF	BAT Reference Document
C2C	Consumer-to-consumer
CAS	Chemical Abstract Service Registry Number
CEAP	Circular Economy Action Plan
CEC	European Footwear Confederation
CEN	European Committee for Standardization
CHF	Clothing Household linen and Footwear
C&L	Classification & Labelling
CLA	Caprolactam
CLP	Classification, Labelling and Packaging
CMC	Component Material Criteria
CMR	Carcinogenic, Mutagenic or toxic for Reproduction
DG ENV	Directorate-General for Environment
JRC	Joint Research Centre
DIN	German Institute for Standardisation
DMT	Dimethyl terephthalate
EC	European Commission
EC / List no	European Community Number / List number assigned by ECHA
ECHA	European Chemicals Agency
EEA	European Environment Agency
EFTA	European Free Trade Association
EG	Ethylene glycol
EoW	End-of-Waste
EPR	Extended Producer Responsibility
ESPR	Eco-design for Sustainable Products Regulation
EU	European Union
GRS	Global Recycling Standard

HS	Harmonized Commodity Description and Coding System
MCC	Microcrystalline cellulose
MD	Modal fibre
MDA	4,4′-methylenedianiline
MEG	Monoethylene glycol
MMC	Man-made cellulose
MMF	Man-made fibre
Mt	Million tonnes
N/A	Not available
NACE	Nomenclature of Economic Activities
NIR	Near-Infrared spectroscopy
OECD	Organisation for Economic Co-operation and Development
PA (6 or 66)	Polyamide (6 or 66)
PAHs	Benzene and Polyaromatic Hydrocarbons
PE	Polyethylene
PES	Polyester
PET (rPET)	Polyethylene terephthalate (recycled Polyethylene terephthalate)
PFAS	Per- and polyfluoroalkyl substances
POPs	Persistent Organic Pollutants
PP	Polypropylene
PTMEG	Polytetramethylene ether glycol
PU	Polyurethane
PVC	Polyvinyl chloride
RAC	Committee for Risk Assessment
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
RCS	Recycled Claim Standard
RFID	Radio-Frequency identification
SAICM	Strategic Approach to International Chemicals Management
SEAC	Committee for Socio-Economic Analysis
SVHC	Substances of Very High Concern

TC	Technical Committee
TFEU	Treaty on the Functioning of the European Union
TPA	Terephthalic Acid
TRL	Technology Readiness Level
UNEP	United Nations Environment Programme
VIS	Visual spectroscopy
WG	Working Group
WFD	Waste Framework Directive
WSR	Waste Shipment Regulation

List of boxes

Box 1. Comparison with the approach proposed by the JRC for EU-wide EoW criteria for plastic waste..... 97

List of figures

Figure 1. Conceptual approach of the EoW mechanism, framework conditions and elements of EoW criteria 24

Figure 2. List of priority streams grouped by category, and ranked based on their overall potential, according to the scoring system 26

Figure 3. Final ranking of the candidate streams for which to develop further EU-wide EoW or by-product criteria based on their overall potential 27

Figure 4. Project timeline and methodology 30

Figure 5. Overview of textile fibres 32

Figure 6. Textile categories and exemplary articles 35

Figure 7. Classification and sources of textile waste – including textile, textile-related and footwear products 37

Figure 8. Exemplary process scheme for mechanical textile recycling, downstream processes and examples of final products based on recycled textiles (non-exhaustive) 49

Figure 9. Exemplary process schemes for thermo-mechanical textile recycling 50

Figure 10. Exemplary process scheme for physical recycling of polymer-rich textile waste 51

Figure 11. Exemplary process scheme for physical recycling as an integral part of poly-cotton-rich textile waste recycling 52

Figure 12. Exemplary process scheme for hydrothermal recycling of poly-cotton-rich textile waste 54

Figure 13. Exemplary process scheme for thermo-chemical recycling of poly-cotton-rich textile waste 55

Figure 14. Exemplary process schemes of carbamation and pulping for cotton-rich textile waste . 57

Figure 15. Examples of process schemes for polyester and nylon recycling with depolymerisation (non-exhaustive) 61

Figure 16. Exemplary process scheme for a mechanical footwear recycling approach 66

Figure 17. EU exports of used textiles 69

Figure 18. PFAS in the textiles life cycle 84

Figure 19. PFAS in the textile sector 84

Figure 20. Overview of textile fibres within the scope (white) and excluded from the scope (red) for textile recycling (non-exhaustive list) 93

Figure 21. Textile recycling technologies within the scope (white) and excluded from the scope (red) 96

Figure 22. Proposal for granting EoW status for textile recycling 105

Figure 23. Exemplary scheme for mechanical recycling of textile waste (non-exhaustive) 107

Figure 24. Exemplary scheme for thermo-mechanical, physical and chemical recycling of textile waste (non-exhaustive) 109

Figure 25. Staple diagram for cotton (left) and synthetic (right) fibres 171

List of tables

Table 1. JRC proposal for EU-wide end-of-waste criteria for recycling and self-monitoring requirements 11

Table 2. JRC technical proposal for the statement of conformity 19

Table 3. Overview of post-industrial textile waste from different stages of manufacturing 38

Table 4. Overview of textile recycling technologies (non-exhaustive) 63

Table 5. Overview of standards, guidelines or specifications with regard to characterisation of textiles in general, and more specifically regarding sorting, preparing for re-use and recycling (non-exhaustive list) 70

Table 6. EoW criteria for recycling of textile waste in Member States (non-exhaustive list) 86

Table 7. EoW criteria for textile recycling - requirements on input materials – Criterion 1.1 112

Table 8. EoW criteria for textile recycling – requirements on input materials – Criterion 1.2 117

Table 9. EoW criteria for textile recycling - requirements on input materials – Criterion 1.3 121

Table 10. EoW criteria for textile recycling - requirements on input materials – Criterion 1.4 123

Table 11. EoW criteria for textile recycling - requirements on processes and techniques – Criterion 2.1 125

Table 12. EoW criteria for textile recycling - requirements on processes and techniques – Criterion 2.2 127

Table 13. EoW criteria for textile recycling - requirements on processes and techniques – Criterion 2.3 128

Table 14. EoW criteria for textile recycling - requirements on product quality – Criterion 3.1 133

Table 15. EoW criteria for textile recycling - requirements on product quality – Criterion 3.2 135

Table 16. EoW criteria for textile recycling – requirements on quality assurance – Criterion 4.1 140

Table 17. EoW criteria for textile recycling – requirements on provision of information – Criterion 5.1 144

Table 18. JRC technical proposal for the statement of conformity template 144

Table 19. Consumer products of which the destruction by economic operators is prohibited – listed in Annex VII to the ESPR 166

Table 20. Natural origin fibres listed in Annex I to Regulation (EU) No 1007/2011 (Table 1) 166

Table 21. Man-made fibres listed in Annex I to Regulation (EU) No 1007/2011 (Table 2) 167

Table 22. Limit values, typical analytical results for wood-based dissolving pulp and applied analysis standards and methods 170

Table 23. Relevant virgin fibre properties for spinning (Chattopadhyay et al., 2023) 172

Table 24. Dissolving pulp from virgin sources (standard) specification for the production of lyocell, viscose and rayon 173

Table 25. Technical specifications for man-made cellulose fibres 174

Table 26. Properties of virgin TPA 174

Table 27. Properties of virgin MEG 175

Table 28. Properties of virgin CLA 175

Table 29. Technical specifications for virgin polymers 177

Table 30. Third-party certification schemes for quality management system in sorting facilities (non-exhaustive list) 182

Table 31. Specifications for cotton-rich input materials for the recycling of dissolving pulp or MMCF 183

Table 32. Specifications for input materials for the chemical recycling of poly-cotton 184

Table 33. Specifications for polyester input materials for the recycling of monomers, oligomers and polymers 184

Table 34. Overview of output materials from mechanical, thermo-mechanical, physical and chemical recycling processes including their status defined by stakeholders (waste, product), examples of possible applications, classification (C&L database including EC / List no., CAS no. and hazardous classification) and applied HS code for shipment 186

Annexes

Annex 1: Destruction of unsold goods (ESPR)

Table 19. Consumer products of which the destruction by economic operators is prohibited – listed in Annex VII to the ESPR

Commodity code	Description
1. Apparel and clothing accessories	
4203	Articles of apparel and clothing accessories, of leather or composition leather
61	Articles of apparel and clothing accessories, knitted or crocheted
62	Articles of apparel and clothing accessories, not knitted or crocheted
6504	Hats and other headgear, plaited or made by assembling strips of any material, whether or not lined or trimmed
6505	Hats and other headgear, knitted or crocheted, or made up from lace, felt or other textile fabric, in the piece (but not in strips), whether or not lined or trimmed; hairnets of any material, whether or not lined or trimmed
2. Footwear	
6401	Waterproof footwear with outer soles and uppers of rubber or of plastics, the uppers of which are neither fixed to the sole nor assembled by stitching, riveting, nailing, screwing, plugging or similar processes
6402	Other footwear with outer soles and uppers of rubber or plastics
6403	Footwear with outer soles of rubber, plastics, leather or composition leather and uppers of leather
6404	Footwear with outer soles of rubber, plastics, leather or composition leather and uppers of textile materials
6405	Other footwear

Source: Regulation (EU) 2024/1781

Annex 2: List of textile fibre names in Annex I to Regulation (EU) No 1007/2011 on Textile Labelling

Table 20. Natural origin fibres listed in Annex I to Regulation (EU) No 1007/2011 (Table 1)

Number	Name	Fibre description
1	wool	fibre from sheep's or lambs' fleeces (*Ovis aries*) or a mixture of fibres from sheep's or lambs' fleeces and the hairs of animals listed in number 2
2	alpaca, llama, camel, cashmere, mohair, angora, vicuna, yak, guanaco, cashgora, beaver, otter,	hair of the following animals: alpaca, llama, camel, kashmir goat, angora goat, angora rabbit, vicuna, yak, guanaco, cashgora goat, beaver, otter

	followed or not by the word 'wool' or 'hair'	
3	animal or horsehair, with or without an indication of the kind of animal (e.g. cattle hair, common goat hair, horsehair)	hair of the various animals not mentioned under number 1 or 2
4	silk	fibre obtained exclusively from silk-secreting insects
5	cotton	fibre obtained from the bolls of the cotton plant (*Gossypium*)
6	kapok	fibre obtained from the inside of the kapok fruit (*Ceiba pentandra*)
7	flax (or linen)	fibre obtained from the bast of the flax plant (*Linum usitatissimum*)
8	true hemp	fibre obtained from the bast of hemp (*Cannabis sativa*)
9	jute	fibre obtained from the bast of *Corchorus olitorius* and *Corchorus capsularis*. For the purposes of this Regulation, bast fibres obtained from the following species shall be treated in the same way as jute: *Hibiscus cannabinus*, *Hibiscus sabdariffa*, *Abutilon avicennae*, *Urena lobata*, *Urena sinuata*
10	abaca (Manila hemp)	fibre obtained from the sheathing leaf of *Musa textilis*
11	alfa	fibre obtained from the leaves of *Stipa tenacissima*
12	coir (coconut)	fibre obtained from the fruit of *Cocos nucifera*
13	broom	fibre obtained from the bast of *Cytisus scoparius* and/or *Spartium Junceum*
14	ramie	fibre obtained from the bast of *Boehmeria nivea* and *Boehmeria tenacissima*
15	sisal	fibre obtained from the leaves of *Agave sisalana*
16	sunn	fibre from the bast of *Crotalaria juncea*
17	henequen	fibre from the bast of *Agave fourcroydes*
18	maguey	fibre from the bast of *Agave cantala*

Source: Regulation (EU) No 1007/2011

Table 21. Man-made fibres listed in Annex I to Regulation (EU) No 1007/2011 (Table 2)

Number	**Name**	**Fibre description**
19	acetate	cellulose acetate fibre wherein less than 92 % but at least 74 % of the hydroxyl groups are acetylated
20	alginate	fibre obtained from metallic salts of alginic acid
21	cupro	regenerated cellulose fibre obtained by the cuprammonium process

22	modal	a regenerated cellulose fibre obtained by a modified viscose process having a high breaking force and high wet modulus. The breaking force (B_C) in the conditioned state and the force (B_M) required to produce an elongation of 5 % in the wet state are: B_C (cN) ≥ $\frac{1,3}{\sqrt{T + 2T}}$ B_M (cN) ≥ $\frac{0,5}{\sqrt{T}}$ where T is the mean linear density in decitex
23	protein	fibre obtained from natural protein substances regenerated and stabilised through the action of chemical agents
24	triacetate	cellulose acetate fibre wherein at least 92 % of the hydroxyl groups are acetylated
25	viscose	regenerated cellulose fibre obtained by the viscose process for filament and discontinuous fibre
26	acrylic	fibre formed of linear macromolecules comprising at least 85 % (by mass) in the chain of the acrylonitrilic pattern
27	chlorofibre	fibre formed of linear macromolecules having in their chain more than 50 % by mass of chlorinated vinyl or chlorinated vinylidene monomeric units
28	fluorofibre	fibre formed of linear macromolecules made from fluorocarbon aliphatic monomers
29	modacrylic	fibre formed of linear macromolecules having in the chain more than 50 % and less than 85 % (by mass) of the acrylonitrilic pattern
30	polyamide or nylon	fibre formed from synthetic linear macromolecules having in the chain recurring amide linkages of which at least 85 % are joined to aliphatic or cycloaliphatic units
31	aramid	fibre formed from synthetic linear macromolecules made up of aromatic groups joined by amide or imide linkages, of which at least 85 % are joined directly to two aromatic rings and with the number of imide linkages, if present, not exceeding the number of amide linkages
32	polyimide	fibre formed from synthetic linear macromolecules having in the chain recurring imide units
33	lyocell	a regenerated cellulose fibre obtained by dissolution, and an organic solvent (mixture of organic chemicals and water) spinning process, without formation of derivatives
34	polylactide	fibre formed of linear macromolecules having in the chain at least 85 % (by mass) of lactic acid ester units derived from naturally occurring sugars, and which has a melting temperature of at least 135 °C

35	polyester	fibre formed of linear macromolecules comprising at least 85 % (by mass) in the chain of an ester of a diol and terephthalic acid
36	polyethylene	fibre formed of un-substituted aliphatic saturated hydrocarbon linear macromolecules
37	polypropylene	fibre formed of an aliphatic saturated hydrocarbon linear macromolecule where one carbon atom in two carries a methyl side chain in an isotactic disposition and without further substitution
38	polycarbamide	fibre formed of linear macromolecules having in the chain the recurring ureylene (NH-CO-NH) functional group
39	polyurethane	fibre formed of linear macromolecules composed of chains with the recurring urethane functional group
40	vinylal	fibre formed of linear macromolecules whose chain is constituted by poly(vinyl alcohol) with differing levels of acetalisation
41	trivinyl	fibre formed of acrylonitrile terpolymer, a chlorinated vinyl monomer and a third vinyl monomer, none of which represents as much as 50 % of the total mass
42	elastodiene	elastofibre composed of natural or synthetic polyisoprene, or composed of one or more dienes polymerised with or without one or more vinyl monomers, and which, when stretched to three times its original length and released, recovers rapidly and substantially to its initial length
43	elastane	elastofibre composed of at least 85 % (by mass) of a segmented polyurethane, and which, when stretched to three times its original length and released, recovers rapidly and substantially to its initial length
44	glass fibre	fibre made of glass
45	elastomultiester	fibre formed by interaction of two or more chemically distinct linear macromolecules in two or more distinct phases (of which none exceeds 85 % by mass) which contains ester groups as the dominant functional unit (at least 85 %) and which, after suitable treatment when stretched to one and half times its original length and released, recovers rapidly and substantially to its initial length
46	elastolefin	fibre composed of at least 95 % (by mass) of macromolecules partially cross-linked, made up from ethylene and at least one other olefin and which, when stretched to one and a half times its original length and released, recovers rapidly and substantially to its initial length
47	melamine	fibre formed of at least 85 % by mass of cross-linked macromolecules made up of melamine derivatives
48	name corresponding to the material of which the fibres are	fibres obtained from miscellaneous or new materials not listed above

	composed, e.g. metal (metallic, metallised), asbestos, paper, followed or not by the word 'yarn' or 'fibre'	
49	polypropylene/polyamide bicomponent	a bicomponent fibre composed of between 10 % and 25 % by mass of polyamide fibrils embedded in polypropylene matrix
50	polyacrylate	fibre formed of cross-linked macromolecules having more than 35 % (by mass) of acrylate groups (acid, light metal salts or esters) and less than 10 % (by mass) of acrylonitrile groups in the chain and up to 15 % (by mass) of nitrogen in the cross-linking

Source: Regulation (EU) No 1007/2011

Annex 3: Limit values and typical analytical results for wood-based dissolving pulp

Table 22. Limit values, typical analytical results for wood-based dissolving pulp and applied analysis standards and methods

Parameters	**Limit value**	**Södra Purple for viscose**	**Södra Purple F for fine yarn which resembles silk**	**Standard/Methods**
Alpha (α) Cellulose	≥94%	96.20%	96.50%	ISO 699:2015
Brightness	≥92%	94.90%	95.00%	ISO 2470-1:2018
Intrinsic viscosity	-	±40 cm^3/g	±25 cm^3/g	ISO 5351:2010
R18	≥96.0%	97.60%	97.80%	ISO 699:1982
Ash	≤0.10%	0.05%	0.05%	ISO 1762
Dirt count	≤30.0 mm^2/kg	1.0 mm^2/kg	0.9 mm^2/kg	ISO 5350-2:1998
Extractive content	≤0.15%	0.06%	0.05%	ISO 14453:2014
Xylan (Pentosan)	≤4.5%	3.60%	3.60%	SCAN CM 71:09
Si	≤20 mg/kg	2.1 mg/kg	2.0 mg/kg	-
Ca	≤50 mg/kg	16 mg/kg	15 mg/kg	ISO 17812
Fe	≤6 mg/kg	0.9 mg/kg	0.8 mg/kg	ISO 17812
Mn	≤1 mg/kg	<0.6 mg/kg	<0.2 mg/kg	ISO 17812
Cu	≤1 mg/kg	<0.2 mg/kg	<0.2 mg/kg	ISO 17812
Moisture	4.0-9.0 %	5.50%	5.50%	ISO 638:2008

Source: Södra, 2024b

Annex 4: Parameters demanded by yarn spinning industry

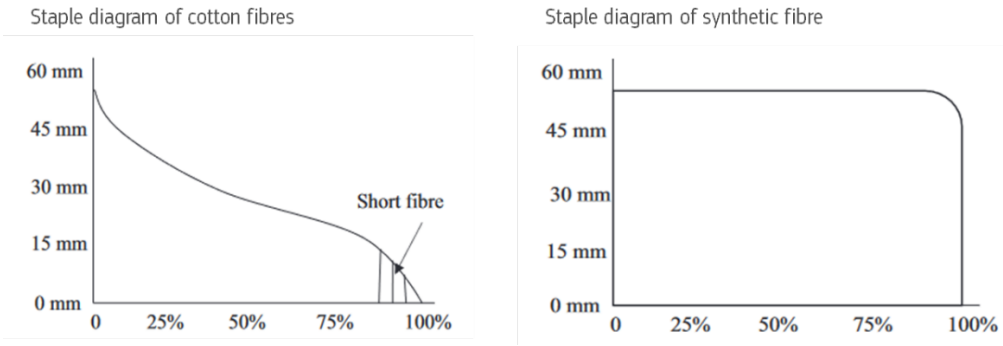
— Cleanliness (-): Contamination or mineral content present in the recycled fibres especially metal parts could cut the fibres and is harmful to spinning machines.

— Colour (-): Mechanical recycling is not capable of removing colours or dyes from fibres, but the colour is crucial for the future use of the recycled fibres.

— Moisture (w%): The recycled fibres shall be dry, as the presence of water increases the risk of growth of microorganisms or mould. With regards to technical properties, moisture can increase fibre strength for natural fibres such as cotton or linen, but has the reverse effect for man-made cellulose fibres such as viscose or nylon.

— Length (mm) and uniformity: Fibre length is one of the most important characteristics for yarn spinning. The length for yarn manufacturing should be for example 15-50 mm. For different types of recycled fibres, length is different: recycled cotton fibres: 4-40 mm; recycled wool fibres: 20-100 mm; recycled polyester fibres: 30-90 mm). Mechanical recycled fibres are shorter than virgin fibres and are therefore mixed with virgin fibres to make sure the final product is of quality and long-lasting. A lot of innovation is pushing the content of recycled fibres, but as recycled fibres are shorter and less uniform, recycled textiles do not contain more than 20-30% recycled cotton. Besides, length is not only about a certain defined length range. For spinning, further characteristics such as staple length values (**Figure 25**), span length values, uniformity, length distribution or short fibre and dust content are of importance. For example the length distribution of cotton and synthetic fibres is very different.

Figure 25. Staple diagram for cotton (left) and synthetic (right) fibres



Source: Chattopadhyay et al., 2023

— Strength (CN/Tex): Fibres show a maximum strength of approximately 60 cN/Tex; however, strength varies significantly between the different fibres types (cotton 20-50 cN/Tex, viscose, acrylic and PP less than <1).

— Elongation (%): A fibre must be able to deform in order to withstand high load but should also have to retain its original shape. At least 1-2% of elongation is required for spinning.

— Micronaire: Lower micronaire fibres break more easily under mechanical stress and entangle more easily to form neps. Both too low (immature) and too high (over matured) micronaire cottons should be avoided. The ideal range is 3.8-4.2.

— Fineness (n): This parameter determines the number of fibres present in the cross-section of yarn. A minimum of 30 fibres are needed but in the present day the minimum value of fibres per cross-section is 100.

Table 23. Relevant virgin fibre properties for spinning (Chattopadhyay et al., 2023)

Parameter	Cotton	Viscose	Nylon	Polyester	Acrylic	PP	Unit
Staple length	20-38	32-60	32-60	32-60	32-60	32-60	mm
Upper half mean length	26-30	-	-	-	-	-	mm
Fineness range	1-4	1-4	1-4	1-4	1-4	1-4	dtex
Tenacity/strength	20-50	0.2	30-60	35-60	0.27	0.65	cN/tex
Breaking	5	15	20	20	30	15	Ext.%
Modulus	300-500	600	250	1000	500	700	cN/tex
Moisture regain	7-9	12.5	4.3	0.4	1.3	0	%
Electrical conductivity	0.14	0.10	0.13	0.08	0.07	0.06	log Rs^{-1}
Heat resistance	105	105	100	140	120	105	°C

Source: Chattopadhyay et al., 2023

Virgin natural and man-made fibres are subject to comprehensive requirements that are defined in the form of various specifications. Recycled fibres are subject to additional requirements due to the deviating quality of the recycled fibres compared to virgin fibres. As the recycled fibres originate from various textile items and sources and are often mixed during sorting and pre-treatment, the following additional specific quality specification are relevant for recycled fibres:

- fibre composition;
- targeted and non-targeted fibre content;
- non-textile content;
- variation in mixture;
- degree of opening, contaminations;
- type of chemical additives used;
- mould;
- fire resistance; and
- general manufacturing quality.

Annex 5: Standard specifications of dissolving pulp from virgin sources for the production of MMC fibres

Table 24. Dissolving pulp from virgin sources (standard) specification for the production of lyocell, viscose and rayon

Parameters	**Quality indexes for wood-based dissolving pulp for lyocell fibre** (Gao et al., 2019)	**Limits for dissolving pulp for viscose filament yarn application** (Södra, 2024b)	**Standard specification for dissolving pulp (viscose fibres)** (Balkissoon et al., 2023) summary from (Sixta, 2006)	**Rayon-grade dissolving pulp**[85] (C. Chen et al., 2016) Treatment: AS: acid sulfid PHK: pre-hydrolysed kraft
Alpha (α) Cellulose	≥92%	≥94%	-	AS: 92 – 94% PHK: 94 – 96
Brightness	-	≥92%	89-93%	
Whiteness	≥90%	-	-	
Intrinsic viscosity	208-350 mL/g	-	450-500 mL/g	400-600 mL/g
Molecular weight distribution and high polydispersity index	-	-	-	AS: 7.6 to 8.5 PHK: 3.8 to 4.5
Reactivity (Fock reactivity)	-	-	-	PHK: 47.67 to 66.02%
Degree of polymerisation < 100	-	-	3-6%	-
Dissolving pulp	650-750	-	-	-
Alkali resistance R18	-	≥96.0%	94-97%	-
Alkali resistance R10	-	-	89-92%	-
Density	-	-	0.9 g/cm^3	-
Ash	<0.1%	≤0.1%	0.1%	-
Dirt count	-	≤30.0 mm2/kg	-	-
Dust	≤0.2 mm^2/m^2	-	-	-
Extractive content	-	≤0.15%	-	-
Acetone extractive	-	-	0.2%	-
Lignin	-	-	0.3 kappa number	-
Xylan (Pentosan)	<2.5%	≤4.5%	3-5%	-
Si	-	≤20 mg/kg	≤20 mg/kg	-
Ca	-	≤50 mg/kg	≤20 mg/kg	-
Fe	<5 mg/L	≤6 mg/kg	<5 ppm	-
Mn	-	≤1 mg/kg	≤0.5 ppm	-
Cu	<1 mg/L	≤1 mg/kg	-	-
Moisture	≤10%	4.0-9.0 %	-	-

Source: own elaboration based on stakeholder input and on literature, as indicated in the headings

[85] A more detailed overview of the physicochemical characteristics and metallic ions present in rayon-grade wood pulps and cotton linter pulps from various sources is provided in Latif et al. (2006).

Annex 6: Technical specifications for man-made cellulosic fibres

Table 25. Technical specifications for man-made cellulose fibres

Parameter	Lyocell	Lyocell	Viscose	Rayon	Tencel	Unit
Length	-	38	-	-	-	mm
Fineness	-	1.33	-	-	-	dtex
Dry Tenacity	4.5-5.0	-	2.6-3.1	2.3-2.7	4.8-5.0	g/denier
Dry Strength	-	4.4-4.6	-	-	-	cN/dtex
Dry Elongation	-	15-18	20-25	-	14-16	%
Elongation at break, dry	24-26	-	-	20-25	-	%
Wet Tenacity	3.9-4.3	-	1.2-1.8	1.4-1.8	4.2-4.6	g/den
Wet Strength	-	4.0-4.2	-	-	-	cN/dtex
Elongation at break, wet	16-18	18-19	25-30	23-35	16-18	%
Water Imbibition	65-70	-	-	90-100	-	%
Cellulose dissolving pulp	550-600	-	-	250-350	-	-
Initial Modulus, wet	250-270	-	-	40-60	-	g/den
Wet Modulus	-	1.1-1.3	-	-	-	-
Resurgence	-	10-12	-	-	-	%
Source	(EFT, 2024)	(Sateri, 2024)	(H. Chen, 2015)	(EFT, 2024)	(H. Chen, 2015)	

Source: own elaboration based on stakeholder input and on literature, as indicated in the table

Annex 7: Technical specifications for monomers

Table 26. Properties of virgin TPA

Parameter	Virgin TPA	Unit
Appearance	Powder	-
Colour	White	-
Purity	>99.9	%
Density (25 °C)	1.58	g/cm³
Melting point (1 atm)	425	°C
Boiling point	Sublimes	°C
Acid Number	674(±3)	mg KOH/g]
Vapour pressure (at 20 °C)	$1.19x10^{-5}$	Pa
Partition Coefficient (Log Pow) (at 25 °C)	1.16 to 2	-
Water solubility (at 10 °C)	15	mg/L
Colour L	>97	-
Colour b	≤2.5	-
Water content	≤0.2	%wt
Para-Toluic acid	≤150	mg/kg
Fe	≤2	mg/kg
Mo, Cr, Ni, Mn, Co, Tl	all single elements ≤1	mg/kg
Ca, Na, K, Al	all single elements ≤2	mg/kg

Source: own elaboration based on stakeholder input

Table 27. Properties of virgin MEG

Parameter	Virgin MEG	Unit
Appearance	Liquid	-
Colour	Transparent	-
Autoignition temperature	427	°C
Critical pressure	8,200	kPa
Critical specific volume	0.191	L/gmol
Critical temperature	446.85	°C
Dielectric Constant at 25 °C	37.7	°C
Electrical Conductivity at 20 °C	1.07 x 10-6	mhos/cm
Evaporation Rate (Butyl Acetate = 1)	0.01	-
Flash Point, Close Cup	126.7	°C
Flash Point, Open Cup	137.8	°C
Heat of combustion at 25 °C	-1,053	kJ/gmol
Heat of formation at 25 °C	-460	kJ/gmol
Heat of fusion	9.96	kJ/gmol
Heat of vaporisation at 1 atm	53.2	kJ/gmol
Molecular Weight	62.07	kJ/gmol
Normal Boiling Point	197.1	°C
Normal freezing point	-13	°C
Onset of initial decomposition	240	°C
Refractive Index at 25 °C	1.4306	
Solubility in Water at 20 °C	100	wt%
Solubility of Water in Ethylene Glycol at 20 °C	100	wt%
Specific gravity (20/20 °C)	1.1153	
Surface tension at 25 °C	48	mN/m
Vapor density (air = 1)	2.1	
Vapor pressure at 20 °C	0.0075	kPa

Source: own elaboration based on stakeholder input

Table 28. Properties of virgin CLA

Parameter	Virgin CLA	Unit
Appearance	Crystalline	-
Colour	White	-
Purity	99.9	%
Crystallisation point	≥ 69	°C
Moisture content	≤ 0.05	%
Volatile bases	≤ 0.5	meq/kg
Melting point (1 atm)	69.2	°C
Boiling point	270.8	°C
Density (80 °C)	1.014	g/cm³
Permanganate number	≥ 10,000	s
Permanganate absorption	max. 5	
Colour of a 50% (by wt.) aqueous solution	≤ 5	APHA

Content of free bases	≤ 0.01	meq/k
Content of free acids	≤ 0.05	meq/k
Alkalinity/Acidity	≤ 0.05	meq/k
Absorbance at 290 nm	≤ 0.05	-
Colour	max. 5	Hazen
Vapour pressure (at 20 °C)	0.13	Pa
Partition Coefficient (Log Pow) (at 25 °C)	0.12	-
Water solubility (at 20 °C)	4.56	g/L
pH (at 333 g/L and 20°C)	7-8.5	
Iron content	≤ 0.5	mg/kg
Ash content	≤ 5	mg/kg

Source: own elaboration based on stakeholder input

Annex 8: Technical specifications on polymers

Table 29. Technical specifications for virgin polymers

Parameter	Virgin PET	Virgin Nylon	Unit
Density	1.38-1.40	1.14-1.15	g/cm³
Softening point	460	149 (PA 6); 229 (PA 6.6)	°C
Melting point	480	215 (PA 6); 252 (PA 6.6)	°C
Melt flow rate	Fibre grade: 10-20	10-40 (PA 6); 5-20 (PA 6.6)	g/10min
Elongation at break	15-45	20-30	%
Tensile Strength	5-150	-	MPa
Young's Modulus	2-4	-	GPa
Stiffness	-	20-40	gm/density
Tensile strength	-	50 – 75	MPa
Elastic modulus	-	2.5 – 3.5	Msi
Water absorption	-	3-10	%
Moisture regain	0.4-0.8	-	%
Modulus	800-1000	-	cN/tex
Breaking strength	40–60	-	cN/tex
Tenacity	3.0-8.0	-	g/den
Minimum Service Temperature	-40-70	-	°C
UL94 Fire Rating	V-0	-	-
Poisson's Ratio	0.37-0.40	-	-

Source: own elaboration based on stakeholder input

Annex 9: Overview of national EoW criteria

A9.1 EoW criteria for recycling

A.9.1.1 France - EoW criteria for cut wiping cloths made from textile waste

Article 6 states that the operator of a recovery facility shall in accordance with Article D541-12-14 of the Environmental Code implement a **quality management system** pursuant to the Ministerial Order of 19 June 2015 on quality management systems.

Furthermore, the operator of the recovery plant shall implement the **self-monitoring obligations** described below:

— The competent staff shall carry out administrative verification, particularly verification that the waste code transmitted by the waste holder matches the batch of waste delivered to the site of the recovery facility.

— Said staff shall also carry out a visual inspection of waste coming into the site of the facility where the recovery operation takes place and of the cut wiping cloths to verify compliance with the criteria in Sections 1 and 3 of Annex I to this order. If there is any doubt as to the nature or composition of the input waste or output cut wiping cloth that additional analyses cannot resolve, the competent staff shall send said waste to a waste management facility that is authorised to receive it.

Annex I to the French Decree defines the EoW criteria for cut wiping cloths made from textile waste. Those are summarised below.

Section 1: Wastes used as inputs in the recovery operation

The allowed input textile waste are (section 1.1):

15 01 09 textile packaging, 15 02 03 absorbents, filter materials, wiping cloths and protective clothing other than those mentioned in 15 02 02, 18 01 04 wastes whose collection and disposal is not subject to special requirements in order to prevent infection (for example dressings, plaster casts, linen, disposable clothing, diapers), 19 12 08 textiles, 20 01 10 clothes, 20 01 11 textile.

Only non-hazardous waste (Section 1.2) is accepted, and textile waste has to be clean and dry (Section 1.3.)

Section 2: Processing techniques and processes

Section 2.1 Used textiles shall be sorted according to the following criteria:

— wet textiles, dirty or not complying with the criteria of Section 1 shall be removed and redirected to a suitable waste treatment pathway;

— textiles are sorted by textile category.

Sorting shall be carried out manually by visual recognition of used textiles complying with the criteria of Section 1. Dirty used textiles or textiles with a bad appearance, very torn, wet or not conforming to the nature of textile compatible with the specification shall be removed. The procedure for detecting and managing undesirable substances or organisms in used textiles shall be recorded as part of the quality management system.

Used textiles shall be removed from foreign bodies (Section 2.2), in particular:

— buttons;

— flash closures;

— metal parts and other hard bodies;

— overthicknesses, including in particular: pockets, necks, sleeves, buttons.

Section 2.3: Used textiles are cut and formatted according to a customer specification or an industrial sector.

Section 2.4: Cut wiping cloths shall be identified and stored separately from any other substances or objects managed on the site of the recovery facility.

Section 3: Quality of the wiping cloths cut from the recovery operation

The wiping cloths are clean and dry (Section 3.1), cut wiping cloths made from used textiles are assembled in batches in accordance with the customer's specifications or according to a particular textile category (Section 3.2.) and batch shall be packaged and stored in accordance with practices ensuring their integrity (Section 3.3).

Annex II defines the information that must appear in the certificate of conformity that is handed over to the next holder (may be issued in electronic form).

A.9.1.2 Italy – EoW criteria for textile waste (draft)

The draft decree addresses pre-consumer and post-consumer textile waste, including garments, clothing accessories and other textile items.

According to Article 3, textile waste shall cease to be waste and shall be classified as recovered textile fibre or recovered fibrous textile material if the output material resulting from the recovery operation complies with the criteria set out in Annex I to the decree.

The waste producer responsible for generating waste for recovered textile fibres must assign waste codes and hazard properties correctly and complete the waste identification. The producer shall demonstrate compliance with Article 3, by issuing a **statement of conformity** for each batch of the recovered material. The declaration must be sent to the competent authority and regional environmental protection agency within six months of production. The producer must keep a copy of the declaration for five years at the facility or registered office, accessible to supervisory authorities upon request.

To demonstrate compliance with Article 3, the producer must take a sample from each batch according to UNI 10802, kept at the plant or registered office for one year after submitting the declaration. The storage method must maintain the chemical and physical characteristics of the fibres to an extent that analyses can be repeated.

Producers must have a **quality management system** in place to demonstrate compliance with the criteria, including quality control and self-monitoring, and where applicable, access to accreditation procedures.

Annex I lists the specific requirements to reach EoW status.

Section 1: Eligible waste and control of incoming textile waste

Only non-hazardous waste identified with specific waste codes can be used as input material, namely:

a) 040209 wastes from composite materials (impregnated fibres, elastomers, plastomers);

b) 040221 wastes from raw textile fibres;

c) 040222 wastes from processed textile fibres;

d) 040299 wastes not otherwise specified, limited to unsold garments and textile articles;

e) 160122 components not otherwise specified, limited to the textile component of end-of-life vehicles;

f) 191208, textile products;

g) 200110, clothing limited to textile products not suitable for preparing for re-use operations;

h) 200111, limited to textile products not suitable for preparing for re-use operations.

Unsorted textile waste shall not be used as input.

The operator shall examine the documentation accompanying the incoming waste, perform visual inspections and additional controls (e.g. sampling and analysis to identify dangerous substances). The producer shall implement a procedure to verify that incoming waste complies with the Regulation.

Section 2: Process and storage

Waste not complying with the input requirements shall be stored in a dedicated area. Waste complying with the input requirements shall be stored separately to prevent accidental mixing with other types of unauthorised waste. During the conformity assessment, recovered fibres and materials shall be kept separate.

Some materials may require sterilisation to comply with the requirements on quality.

Section 3: Quality of recovered textile fibres and recovered fibrous textile material

The following thresholds shall apply to textile post-consumer clothing:

— mesophilic aerobic microorganisms < 10^4 g

— enterococci < 10^2 g

— Escherichia coli < 10^2 g

— Staphylococcus spp. < 10^3 g

— Filamentary mushrooms (mould) < 10^4 g

The following thresholds shall apply to pre-consumer clothing:

— mesophilic aerobic microorganisms < 10^4 g

— enterococci < 10^2 g

— Escherichia coli < 10^2 g

— Filamentary mushrooms (mould) < 10^4 g

The recovered textile fibres and recovered fibrous textile material shall comply with the following regulations:

— Regulation (EU) No 1007/2011 (Textile Labelling);

— Regulation (EC) No 1907/2006 (REACH);

— Regulation (EU) 2019/1021 (POPs);

— Regulation (EU) No 528/2012 (Biocidal Products).

Annex 10: Common third-party certifications for QMS in sorting facilities

Table 30. Third-party certification schemes for quality management system in sorting facilities (non-exhaustive list)

Third-party certification	Country of application
Eco-Management and Audit Scheme (EMAS)	International
GRS (Global Recycled Standard)	International
TÜV Nord[86]	International
MEPEX[87]	Norway
SGS[88]	International
Qualityaustria[89]	Austria
Ecodynamics[90]	Belgium
Rec'Up[91]	Belgium
KIWA[92]	Netherlands

Source: own elaboration based on stakeholder input

86 TÜV Nord: Technical inspection association active in the areas of control, auditing, certification, testing, training and technology in almost all industrial and service sectors. More information is available here: https://www.tuv-nord.com/be/de/homepage/

87 MEPEX: Norwegian independent consultancy firm specialising in waste management, recycling and circular value chains. More information available here: https://mepex.no/en/about-mepex/

88 SGS: world's leading testing, inspection and certification company. More information is available here: https://www.sgs.com/en

89 Qualityaustria: is the leading Austrian contact for the Integrated Management System, based on quality, environmental and OH&S. More information is available here: https://www.qualityaustria.com/produktgruppen/sustainability-und-esg-management/guetesiegel-fuer-soziale-unternehmen-als-partner-von-arbeit-plus-soziale-unternehmen-oesterreich/

90 Ecodynamics: an official and free recognition. It rewards and encourages companies, non-profit organisations and institutions in the public or private sector in Brussels that take action to reduce the impact of their activity on the environment. More information is available here: https://www.ecodyn.brussels/?lang=en

91 RecUp: defines organisational criteria which guarantee the quality of the products and services offered by social economy companies active in the collection, sorting, re-use, recovery and recycling of goods. More information available here: https://www.res-sources.be/fr/recup/

92 KIWA: Testing, inspection and certification organisation. Since January 1, 2022, entrusted with the assessment of the Vereniging Herwinning Textiel (VHT) scheme (Textile Recovery Association in English). More information is available here: https://www.kiwa.com/nl/en/

Annex 11: Specifications of input materials for chemical recycling technologies

Table 31. Specifications for cotton-rich input materials for the recycling of dissolving pulp or MMCF

Fibre type	
Cotton content	Recyclers demand input material with a cotton content between >70% and >95%
Polyester content	Certain recyclers allow a maximum polyester content of <30%. However, information is not available for all recyclers yes
Polyester-based elastic fibres / elastomultiester	Certain recyclers allow a maximum polyester content of <30%. However, information is not available for all recyclers yes
Elastane	For certain recyclers, elastane is very critical and thus prohibited. With further development of the technologies, elastane could be tolerated with max 3%.
Other cellulosics (e.g. viscose, lyocell, hemp)	Certain recyclers allow other cellulosic material with max. 5 %. However, information is not available for all recyclers.
Colours allowed:	
White	White is the preferred colour for all recyclers.
Off-White	Off-white is the preferred colour for all recyclers
Ecru	Certain recyclers allow ecru in the input material. However, information is not available for all recyclers.
All colours	Certain recyclers allow coloured input material, whereas for other colours are not accepted.
Dyes	Certain recyclers allow dyed input material, whereas other cannot remove dyes in their process and forbid dyed input material.
Prints	Certain recyclers allow prints to a maximum content of 5 %. Others do not allow prints.
Trims and threads and other textile parts allowed:	
Trims	Certain recyclers allow a trims in the input material. However, information is not available for all recyclers yes
Threads	Threads are generally accepted if within specification
Labels	Threads are generally accepted if within specification. However, information is not available for all recyclers.
Buttons, Zippers, Beads, Patches	Certain recyclers allow hard parts in the input material, whereas others do not allow them.
Permanent press finishing	Certain recyclers do not allow permanent press finishing. However, information is not available for all recyclers yes.
Other non-textile parts	One recycler defines that the content of non-processable elements shall be less than 1 %.
Moisture content	One recycler indicates that the moisture content should be below 8 %.
Contaminants	Certain recyclers define that textile waste shall not contain restricted chemicals above the reporting limit threshold in the Restricted Substances List[93]. However, information is not available for all recyclers.
Other	Certain recyclers explicitly define that overstock and unsold goods are not accepted as input material.

[93] Published by the Affirm Group (https://www.afirm-group.com/afirm-rsl/)

Source: own elaboration based on stakeholder input

Table 32. Specifications for input materials for the chemical recycling of poly-cotton

Fibre type	
Polyester & cotton blends	Recyclers accept poly-cotton blends with various concentrations. Preferred are input materials with a poly-cotton concentration >90 %.
Pure cotton or pure polyester	Certain recyclers do also accept pure cotton or pure polyester input materials. However, information is not available for all recyclers.
Other fibres or materials	Certain recyclers accept a 10-20 % of others input materials such as wood, nylon or elastane. Concentration of polyamides and wool shall be below 1 % for certain recycling technologies. However, information is not available for all recyclers.
Colours and prints	
All colours	Recyclers accept input materials with all colours.
Dyes	Certain recyclers accept input materials with dyes. However, information is not available for all recyclers.
Prints	No information available
Trims and threads and other textile parts	
Trims	No information available
Threads	No information available
Labels	No information available
Buttons, Zippers, Beads, Patches	Hard parts need to be removed
Permanent press finishing	No information available
Others	
Moisture content	The input materials should be dry. Certain recyclers indicate that the water content should be less than 10 %.
Downsizing	Certain recyclers define the size of the input material to be accepted explicitly[94], while others reduce size as part of their recycling process.
Contaminants	No pre-removal necessary, manual segregation for contamination before pre-processing as part of the recycling process.

Source: own elaboration based on stakeholder input

Table 33. Specifications for polyester input materials for the recycling of monomers, oligomers and polymers

Fibre type	
Polyester content	> 70 to >90%
Polyester-based elastic fibres / elastomultiester	Certain recyclers can process this input material with their technology. However, information is not available for all recyclers.
Elastane	Depending on technological approach, elastane can be part of the input material. For certain recyclers elastane is problematic and should be removed from input material.
Other cellulosics (e.g. viscose, lyocell, hemp)	Certain recyclers can process this input material with their technology. However, information is not available for all recyclers.

[94] For example: cut to square fabrics of 8 mm width: Low levels of materials larger than 20 x 20 mm (<5 %); and materials smaller than 3 x 3 mm.

Other synthetic fibres	Certain recyclers can process this input material with their technology. However, information is not available for all recyclers.
Colours allowed:	
White	All recyclers can process white input material.
Off-White	All recyclers can process off-white input material.
Colours	Recyclers can process coloured input material with their technology. For some technologies, input material needs to be decoloured in advance
Opaque	Certain recyclers can process opaque input material with their technology. However, information is not available for all recyclers.
Dyes	Recyclers can process coloured input material with their technology. For some technologies, dyes need to be removed in advance
Prints	Certain recyclers can process input material with prints. For others, the input materials should be free from prints as the prints consist of PVC, and PVC has negative effects on the process.
Trims and threads and other textile parts allowed:	
Trims	Certain recyclers can process input materials with trims. However, information is not available for all recyclers.
Threads	All recyclers can process input materials with threads
Labels	Certain recyclers can process input materials with trims. However, information is not available for all recyclers.
Buttons, Zippers, Beads, Patches	Certain recyclers allow a limited amount of hard parts, but in general hard parts should be avoided.
Permanent press finishing	Certain recyclers cannot process input material with permanent press finishing. However, information is not available for all recyclers.
Others	<1 % non-processable elements
Moisture content	No data available
Contaminants	Certain recyclers can remove contaminants. Depending on the technology, various level of decontamination can be achieved. But information is not available for all recyclers.

Source: own elaboration based on stakeholder input

Annex 12: Overview of output materials from mechanical, thermo-mechanical, physical and chemical recycling processes

Table 34. Overview of output materials from mechanical, thermo-mechanical, physical and chemical recycling processes including their status defined by stakeholders (waste, product), examples of possible applications, classification (C&L database including EC / List no., CAS no. and hazardous classification) and applied HS code for shipment

Output material	**Cleaning rags**	**Various Fibres**	**Pulp, cellulose**	**Micro-crystalline cellulose (MCC)**	**Man-made cellulosic fibre (MMCF)**	**Terephthalic acid (TPA)**	**Mono Ethylene glycol (MEG)**	**Bis(2-Hydroxyethyl) terephthalate (BHET)**	**Polyethylene terephthalate (PET)**	**Caprolactam (CLA)**	**4,4'-methyl-enedianiline (MDA)**	**Polyamide (PA6)**
	Textile piece	**Fibre**	**Fibre**	**(Fibre)**	**Fibre**	**Monomer**	**Monomer**	**Ester**	**Polymer**	**Monomer**	**Monomer**	**Polymer**
Currently shipped as product	Yes	Yes	Yes	N/A	Yes	Yes	Yes	Yes	Yes	Yes	N/A	Yes
Possible applications (examples)	Cleaning	Yarn; various nonwoven and loose applications;	MMC fibre production, paper making, pharma-ceuticals	Drug fillers: food thickener; emulsifiers; stabilizers.	Yarn	Dominant use: Precursor for PET. Other use: Carrier in paint; Raw material to make terephthalate plasticizers	Coolant and heat-transfer agent; Anti-freeze; Precursor for PET	Ester of ethylene glycol and terephthalic acid	Textiles; Rigid and flexible Packaging, Thermoplastic resins	Dominant use: Precursor for PA6. Other use: Synthesis of several pharma-ceutical drugs	Coating materials; glues; Spandex; fibre; dyes; and rubber.	Textiles, various applications in automotive and EEE due to good insulating properties and high

						and for certain drugs						dielectric strength
EC / List no.:	N/A	N/A	265-995-8	232-674-9	No	202-830-0	203-473-3	213-497-6	607-507-1	203-313-2	202-974-4	607-506-6
CAS no.:	N/A	N/A	65996-61-4	9004-34-6	No	100-21-0	107-21-1	959-26-2	25038-59-9	105-60-2	101-77-9	25038-54-4
HS Code used	6307 1090 (Textile cleaning cloths only)	4411 0000[95] 5104 0000[96] 5202 9100[97] 5503 9000[98] 9603 90[99]	4702 0000[100]	3912 (Cellulose and its chemical derivatives)	5909 0020 (Man-made fibre)	2917 3600 (Terephthalic acid and its salts)	2905 3100 (Ethylene glycol (ethanediol))	291739859 0	3915 9000 10 (of polyethylene terephthalate (PET) plastics	2933 7100 (6-Hexanelactam (epsilon-caprolactam)_	2921 590033	390810

[95] Fibreboard of wood or other ligneous materials, whether or not agglomerated with resins or other organic bonding agents (excl. particle board, whether or not bonded with one or more sheets of fibreboard; laminated wood with a layer of plywood; composite panels with outer layers of fibreboard; paperboard; furniture components identifiable as such).

[96] Garnetted stock of wool or of fine or coarse animal hair, neither carded nor combed.

[97] Garnetted, stock, cotton.

[98] Synthetic staple fibres, not carded, combed or otherwise processed for spinning (excl. those of polypropylene, acrylic, modacrylic, polyesters, nylon or other polyamides).

[99] Mops and leather dusters; prepared knots and tufts for broom or brush making; squeegees of rubber or other flexible materials; brooms and brushes, n.e.s.

[100] Chemical wood pulp, dissolving grades.

REACH compliant	N/A	N/A	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Hazardous statements	N/A	N/A	no	no	N/A	H315, H319, H335	H302, H373	H373	no	H302, H315, H319, H332, H335	H317, H341, H350, H370, H373, H411	no

Note: N/A stands for no information available

Source: own elaboration based on stakeholder input

Annex 13: Glossary

Apparel: a textile category that encompasses different types of articles made from fibres, yarns or fabrics. It includes clothing, footwear and accessories.

Apparent consumption: means domestic retail and textiles placed on the market for business-to-business applications. It is calculated as the sum of EU production plus imports minus exports of finished textiles.

Batch: a quantity of material of the same quality, and produced using uniform production parameters at a certain manufacturing stage, stored and contained to exclude mixing with other materials, or contamination, and designated as such by a single production number, as defined in Article 2(3), point (20) of Commission Regulation (EU) No 2022/1616[101].

Biocidal product (follows (EU) No 528/2012 definition) means:

— any substance or mixture, in the form in which it is supplied to the user, consisting of, containing or generating one or more active substances, with the intention of destroying, deterring, rendering harmless, preventing the action of, or otherwise exerting a controlling effect on, any harmful organism by any means other than mere physical or mechanical action;

— any substance or mixture, generated from substances or mixtures which do not themselves fall under the first indent, to be used with the intention of destroying, deterring, rendering harmless, preventing the action of, or otherwise exerting a controlling effect on, any harmful organism by any means other than mere physical or mechanical action.

A treated article that has a primary biocidal function shall be considered a biocidal product.

Chemical recycling: can be further distinguished between thermo-chemical and (bio-)chemical recycling. In comparison to mechanical recycling, these technologies apply more advanced treatment steps (e.g. high temperature, chemicals) to alter the chemical structure of the textile waste input.

Closed-loop recycling: is the process by which a product or material can be recovered to the extent that it can be converted into the same product or a similar product of similar quality (or converted back to a raw material). The main properties are maintained during the recycling process.

Clothing (also known as **garments**)**:** is an item made of textile or other non-textile material (e.g. leather) designed to be worn on the body for different purposes (e.g. covering, protecting, decorating).

Collection (follows the (EC) No 2008/98 definition): the gathering of waste, including the preliminary sorting and preliminary storage of waste for the purposes of transport to a waste treatment facility.

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101 Commission Regulation (EU) 2022/1616 of 15 September 2022 on recycled plastic materials and articles intended to come into contact with foods, and repealing Regulation (EC) No 282/2008 (Text with EEA relevance) (OJ L 243, 20.9.2022, p. 3)

Collection rate: percentage of textile waste collection compared to the total textile waste generation. Textile waste collected in a country but exported for recycling to another country is included. Textile waste imported from other countries and recycled in the country in question is not included.

Conformity assessment body: shall have the meaning defined in Article 2, point (13) of Regulation (EC) No 765/2008 of the European Parliament and of the Council[102,103], accredited by a national accreditation body that was peer evaluated in accordance with Article 10 of that Regulation (EC).

Contaminants: substances or materials present in textile waste that are not targeted for further recycling and which could pose a risk for human health and the environment (e.g. hazardous substances, persistent organic pollutants, pathogens).

Consignment: one or more batches of output material which is intended for delivery from a an operator to another operator in one or more transport units.

Decontamination: is a broad, intensive process that removes or neutralises all (hazardous) chemical, biological, or radiological contaminants.

Destruction (follows the (EU) 2024/1781 definition): means the intentional damaging or discarding of a product as waste with the exception of discarding for the sole purpose of delivering the discarded product for preparing for re-use, including refurbishment or remanufacturing operations.

Disposal (follows the (EU) No 2008/98 definition): any operation which is not recovery even where the operation has as a secondary consequence the reclamation of substances or energy. Annex I to the Directive sets out a non-exhaustive list of disposal operations.

Dual use: In the case of certain recycling technologies the textile waste is converted into intermediate streams such as pyrolysis oil or syngas. These streams are used for energy, fuel and/or material (e.g. basic chemicals for plastics) production. Therefore, these technological approaches combine elements of recycling and energy recovery to varying degrees (dual use).

Energy recovery: it refers to the use of waste principally as a fuel (e.g. refused-derived fuel (RDF)) or other means to generate energy.

Environmental verifier: a conformity assessment body or any natural or legal person, or any association or group of such persons, which has been accredited or licensed by a national accreditation or licensing body as defined in Article 2, point (30) or point (31) of Regulation (EC)

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102 Regulation (EC) No 765/2008 of the European Parliament and of the Council of 9 July 2008 setting out the requirements for accreditation and repealing Regulation (EEC) No 339/93 (Text with EEA relevance)Text with EEA relevance (OJ L 218, 13.8.2008, p. 30, ELI: http://data.europa.eu/eli/reg/2008/765/2021-07-16).

103 Article 2, point (13) of Regulation (EC) No 765/2008 defines a conformity assessment body as a body that performs environmental verifier' shall have the meaning of a conformity assessment body or any natural or legal person, or any association or group of such persons, which has been accredited or licensed by a national accreditation or licensing body as defined in Article 2, point (30) or point (31) of Regulation (EC) No 1221/2009 of the European Parliament and of the Council[103], and which is subject to peer-evaluation in accordance with Article 31 of that Regulation; conformity assessment activities including calibration, testing, certification and inspection.

No 1221/2009 of the European Parliament and of the Council[104], and which is subject to peer-evaluation in accordance with Article 31 of that Regulation.

Fibre-to-fibre recycling: means recycling whereby textile products that are within the scope of separate collection (Annex IVc to the Regulation) which have become waste are treated so the output material of the recovery operation equals a fibre that can be applied in materials of the same nature.

Fibre-to-engineering: refers to the possibility to use recycled textile fibres apart from new textiles for various engineering applications across industries. Examples are the production of composite materials or using fibres to reinforce construction materials.

Footwear (follows the 94/11/EC definition): means all articles with applied soles designed to protect or cover the foot, including parts marketed separately.

Hazardous substance: a substance fulfilling the criteria relating to physical hazards, health hazards or environmental hazards, as laid down in Parts 2 to 5 of Annex I to Regulation (EC) No 1272/2008 of the European Parliament and of the Council[105].

Hazardous waste (follows the 2008/98/EC definition): waste which displays one or more of the hazardous properties listed in Annex III to the WFD (e.g. explosive, acutely toxic).

Healthcare textiles: textiles used in clinical or patient-care contexts (e.g. gowns, scrubs, protective clothing).

Holder: means the natural or legal person who is in possession of the textile material.

Home/interior textiles: textiles used in households for home furnishing as well as in accommodation services.

Importer: any natural or legal person established within the Union who places output materials into the customs territory of the Union.

Industry specifications: specific requirements and guidelines set by the recycling industry on the quality of the output materials and the processing methods.

Input material: textile and textile waste used as input to a recycling facility.

Input textile: shall mean textile waste that can be used as input for recycling.

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104 Regulation (EC) No 1221/2009 of the European Parliament and of the Council of 25 November 2009 on the voluntary participation by organisations in a Community eco-management and audit scheme (EMAS), repealing Regulation (EC) No 761/2001 and Commission Decisions 2001/681/EC and 2006/193/EC (OJ L 342, 22.12.2009, p. 1, ELI: http://data.europa.eu/eli/reg/2009/1221/oj).

105 Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006 (OJ L 353, 31.12.2008, p 1, ELI: http://data.europa.eu/eli/reg/2008/1272/oj.

Knitting: a mechanical process which consists of knotting yarn together with a series of needles. Knitting, whether by hand or on a machine, is usually done by using warp and weft knitting techniques.

Material recovery (follows the (EC) No 2008/98 definition): means any recovery operation, other than energy recovery and the reprocessing into materials that are to be used as fuels or other means to generate energy. It includes, *inter alia*, preparing for re-use, recycling and backfilling.

Mechanical recycling: for textile waste it refers to the recycling of pre-sorted and pre-treated textile waste through mechanical processes, including washing, drying, cutting, shredding, fraying and grinding. Mechanical recycling does not alter the chemical structure of the textile waste input.

Municipal solid waste (MSW): non-sorted, mixed waste from households and commercial activities. This waste flow excludes the flows of recyclables collected and kept separately, be it one-material flows or multi-material (commingled) flows.

Natural textile fibre: fibre which occurs in nature. It can be categorised according to its origin into animal and plant fibres.

Non-textile components: materials and substances not bound or incorporated to the textile matrix that are part of the products where textile is present.

Non-targeted textiles: textiles present in textile waste, but the presence of which is detrimental to the direct use of the textile waste in the production of new textiles.

Nonwoven textiles: textiles manufactured without an intermediate yarn-processing step. Nonwovens are textiles that are neither woven nor knitted. Nonwoven fabric is typically manufactured by layering medium-sized fibres (4–7 cm) in the form of a sheet or a web and then binding them either mechanically, thermally or with an adhesive.

Operator: the natural or legal person that is in possession of the textile waste or the textile recyclate.

Output materials: output obtained from mechanical (e.g. cleaning rag, fibres, fluff, fillers), thermal (e.g. polymer fibre and pellets, methanol) and (bio-)chemical (e.g. pulp, cellulose powder, resin, polymer pellet) textile recycling processes. The output materials from a (bio-)chemical process can be textile-based or polymer-based.

Physical recycling (e.g. solvent-based recycling or dissolution recycling): process that uses heat and solvents to dissolve polymer-based textile waste into a solution of polymers and additives. In the following step the additives are separated from the polymers before recovering the polymers from the solution. No chemical degradation reaction takes place and the polymer chains remain unaltered.

Preliminary sorting: is part of the collection process, takes place at the collection points and serves as a filter, ensuring that only suitable textile items are accepted as feedstock for the subsequent sorting process.

Primary raw material (virgin material): material which has never been processed into any form of end-use product.

Producer: an operator that treats textile waste so that it ceases to be waste in compliance with the end-of-waste criteria.

Qualified staff: staff who have experience and/or training qualifying them to carry out the control measures set out under the self-monitoring requirements as part of the quality management system.

Recovery (follows the (EC) No 2008/98 definition): any operation generating waste serving a useful purpose by replacing other materials which would have been otherwise used to fulfil a particular function, or waste being prepared to fulfil that function, in the plant or in the wider economy. Annex II to the Directive sets out a non-exhaustive list of recovery operations.

Recycling rate: percentage of textile waste which is re-used and recycled for making new textiles, compared to the total textile consumption.

Restricted substances: any substance in textile waste which represents a risk for health, safety and the environment.

Sanitation: is the hygienic process of removing, inactivating or controlling harmful microorganisms, creating a barrier against disease transmission. In the context of textiles, sanitation refers to the treatment of fabrics to reduce the microbial load (like bacteria, fungi, and viruses) to a safe level.

Sorted textile fraction: a sorted textile fraction contains specific textile items or textile fibres that are destined for recycling.

Targeted textile waste: a textile waste which is collected and treated for recycling, i.e. the direct use of the textile waste in the production of textiles or objects by textile in manufacturing facilities.

Technical textiles: textile products meeting high technical and quality requirements (e.g. mechanical, thermal, electrical, durability) giving them the ability to offer technical functions.

Thermo-mechanical recycling: in addition to the pure mechanical processes, thermal energy is used to soften and break down the textile fibres and to recover polymers in the form of pellets or fibres.

Textile: general term that encompasses various fibre-based materials, including fibres, yarns, filaments, threads, different fabric types.

Textile category: category of textiles that includes a specific type of textile items. For example the textile category clothing includes the textile items t-shirt, trousers, pants, shorts, jackets, socks, underwear, sports- and swimwear.

Textile item: one physical textile object, for example a t-shirt, a blanket or a pair of shoes, but also output material of a mechanical recycling process, e.g. cleaning rag.

Textile fibre (follows the (EU) No 1007/2011 definition): a unit of matter characterised by its flexibility, fineness and high ratio of length to maximum transverse dimension, which render it suitable for textile applications; a flexible strip or tube, of which the apparent width does not exceed 5 mm, including strips cut from wider strips or films, produced from the substances used for the manufacture of the fibres and suitable for textile applications.

Textile product (follows the (EU) No 1007/2011 definition): any raw, semi-worked, worked, semi-manufactured, manufactured, semi-made-up or made-up product which is composed at for least 80% of textile fibres, regardless of the mixing or assembly process employed.

Textile waste: refers to textile waste, which the holder discards, intends to discard or is required to discard. It can be classified into:

— **Post-industrial textile waste**: is generated in the manufacturing of fabrics and textile products. It is generated as a result of technical features of the manufacturing process, inaccurate resource planning or production errors. Production scrap re-used within the production process or by-products are not under scope.

— **Pre-consumer textile waste**: is generated at retail level, including excess stock, returns and unsold goods.

— **Post-consumer commercial textile waste**: arises from any commercial or industrial activities as for example hospitality, healthcare, agriculture, environmental, construction. Technical textiles also belong to this category (e.g. textiles for filtration, professional cleaning items, workwear with highly technical features, personal protective clothing and footwear).

— **Post-consumer household textile waste**: is generated at household level and can contain the following textile categories and items: clothing, clothing accessories, footwear, home/interior textiles, other items partially or fully made of textile materials.

Treatment (follows the (EC) No 2008/98 definition): recovery or disposal operations, including preparation prior to recovery or disposal.

Used textiles (follows recital 23 of the WFD): separately collected textiles that are discarded by the end user, whether or not they are discarded with the intention and possibility for them to be re-used. At that stage, used textiles could be either fit for re-use or waste, as they have not been assessed. For that reason, used textiles that are collected separately should be considered to be waste upon collection unless they are directly handed over by end users and directly and professionally assessed as fit for re-use at the collection point by the re-use operator or social economy entities.

Visual inspection: means inspection of input textile and output material, covering all representative parts of a consignment, using either one or several human senses and any non-specialised equipment, involving manual manipulations and other sensorial checks or the use of appropriate portable sensors.

Weaving: the process by which yarns are assembled together on a loom to obtain a woven fabric.

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