a Reconomy Group company

TextileFlow: From Waste to Worth

An analysis of textile recycling opportunities in the UK

Executive summary

Valpak is a UK compliance scheme and environmental consultancy, with a focus on working towards a sustainable, waste-free world.

Valpak has an extensive history of producing reports to generate knowledge and provide industry and government with insight for decision-making. For example, the PackFlow reports calculate UK packaging placed on the market (POM) and recycling by material and industry sector.

The objective of this textiles analysis was to determine the level of reusability and mechanical and chemical recyclability based on textile POM data, as well to provide insight on material breakdown. The purpose of this is to help understand the scale of opportunity for textile reuse and recycling and how they can fit together, with recycling providing a supplement to reuse in the development of a circular economy for textiles.

This study is based on the best available data, and outputs should be considered as indicative, with the potential to expand the scope of the study to increase robustness.

We would like to invite any stakeholders who have any data or insight that could be valuable to a potential second phase of this project to approach Valpak to discuss collaboration.

Material breakdown

The below table shows the breakdown of POM data included in this analysis, by product categories, and material categories used by the Textile Exchange. The methodology involved scaling up available POM data to be reflective of the whole market, which was determined using the total of 1,953,000 tonnes found by WRAP's 2019 Market Situation Report, the most robust and recent available figure that split categories out to the detail required.

Table 1: Split of Material Types Across All Categories According to Textile Exchange Category

Material Category	Tonnage	Proportion (%)
Synthetic Fibre	884,462	45
Plant Fibre	841,318	43
Man-made Cellulosic Fibre	88,249	5
Animal Fibre	84,817	4
Not Fibre	54,155	3
Total	1,953,000	100%

The prevalence of materials varied depending on category. The dominant material in the clothing category was cotton at 57%, followed by polyester at 24%. In the footwear and accessories category, the largest contributing material was polyester at 37%, followed by polyurethane at 18%. In the household and leisure category, the largest contributing material was polyester at 45%, followed by cotton at 33%.

45%

of all material analysed was synthetic fibre, while

43%

was plant fibre

Recyclability and reusability

As indicated in the figure below, 60% of the material analysed is recyclable using a combination of chemical recycling and mechanical recycling, if the feedstock specification for chemical recycling is an item with a composition of 95% cotton or more (referred to throughout the report as Chemical Recycling Scenario A), and the feedstock specification for mechanical recycling (both open and closed-loop) is mono-fibre (meaning it is made from only one material type, such as 100% cotton or 100% polyester). The impact on recyclability of additional components such as zips and embellishments has not been considered in this analysis due to a lack of visibility on these in available data (this issue has been considered for an improvement in a potential re-iteration of this study). Figure 1 (and figure 6) show the breakdown if chemical recycling is prioritised, and figure 7 in the results section of this report shows the breakdown if open-loop mechanical recycling is prioritised.

Figure 1: Split of Types of Recyclability, with Total Recyclability Overall and Total Fibre-to-Fibre Recyclability, To Demonstrate Total Amount of Recyclable Material When Combining Recycling Options

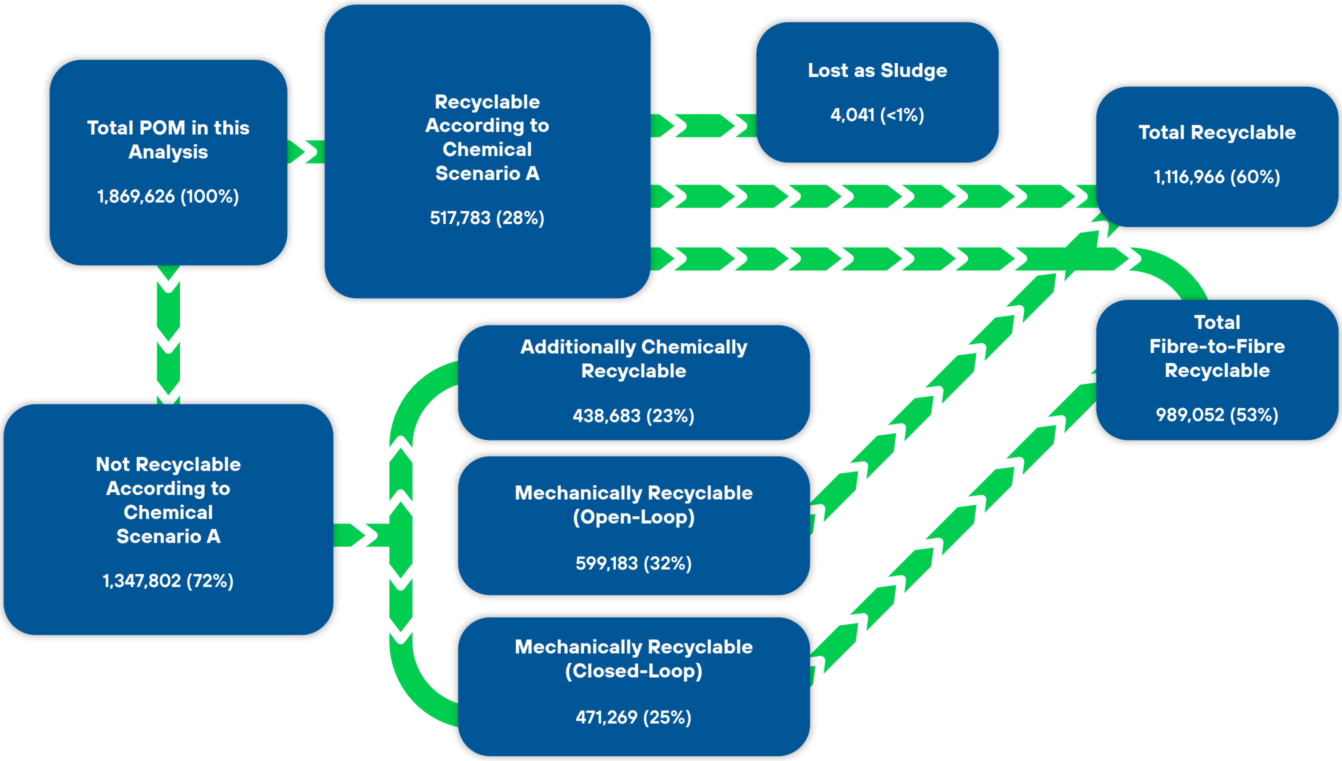
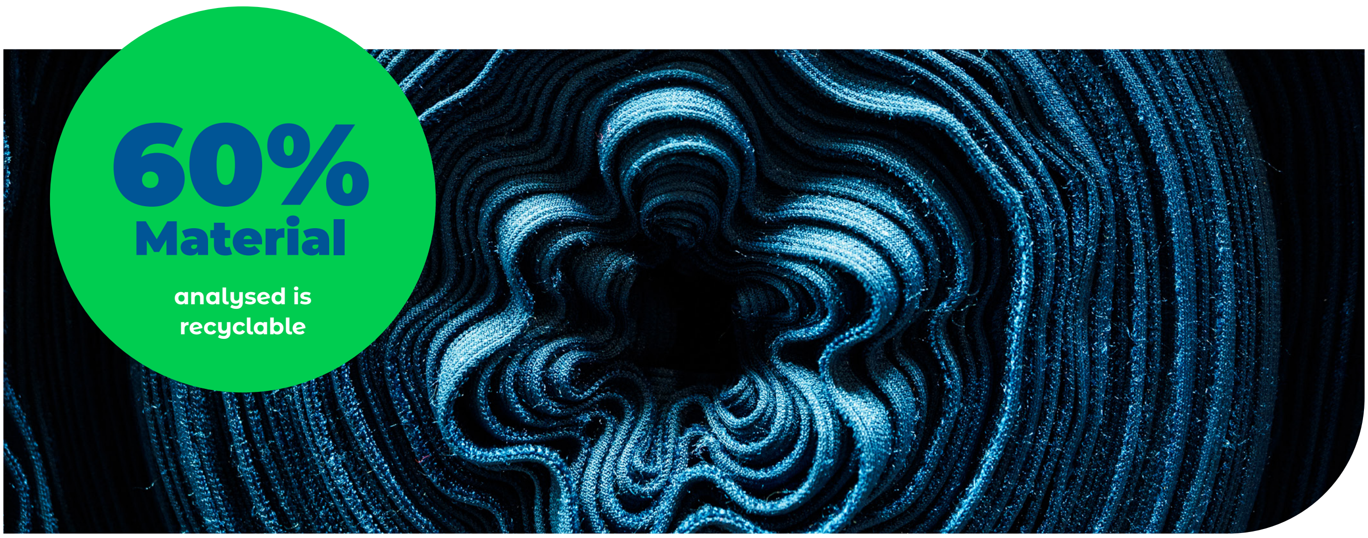


Figure 2 (on page below) shows A scenario of maximum recyclability, where first all open-loop mechanically recyclable material is recycled (as this is the type of recycling that captures most material and is the most achievable with current technology and methods), and then all of the remaining material that is chemically recyclable is recycled. Like figure 1, figure 2 considers chemically recyclable to be items with a 95% or higher cotton content (although other chemical recycling feedstock specifications are considered in the report).



When considering open-loop mechanical recycling independently of other recycling options a total of 53% of material was found to be open-loop mechanically recyclable - when only mono-fibre was considered. However, as some sources claim that fibre blends are open-loop mechanically recyclable, the impact of expanding the specification of open-loop mechanical recycling to include polycotton blends was also investigated, whereby the amount recyclable increased to 68% of material.

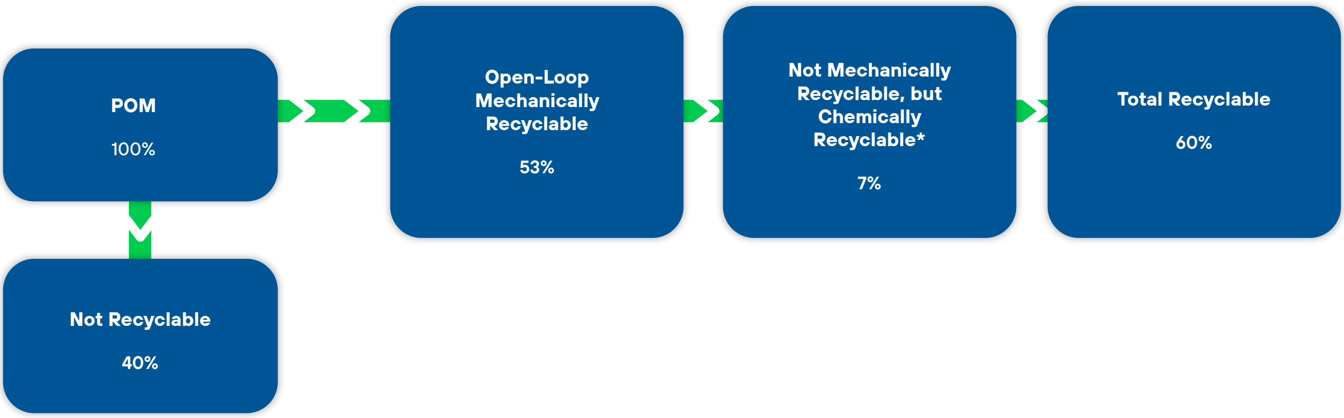
When it comes to fibre-to-fibre recycling (again, when considering each option independently) a total of 46% of material was found to be closed-loop (fibre-to-fibre) mechanically recyclable (again, if only mono-fibre was considered).

When considering chemical recycling, if the feedstock specification consisted of 95% or more cotton (Chemical Recycling Scenario A), 28% of material was found to be chemically recyclable, and, if the feedstock specification consisted of textiles made of 80% polyester, cotton and/or a combination of the two (Chemical Recycling Scenario B), 72% of material was found to be chemically recyclable.

Materials were categorised into low, medium, and high levels of reusability. 33% of the material analysed was considered to have a low likelihood of reusability, 42% a medium level of reusability, and 26% a high level of reusability.

Reusability results were referenced against the recyclability findings. Of the material analysed, 23% was categorised as low reusability material that is theoretically open-loop mechanically recyclable, and 27% was categorised as low reusability material which is theoretically chemically recyclable according to the broadest feedstock specification (referred to throughout the report as Chemical Recycling Scenario B).

Figure 2: A scenario of maximum recyclability, where first all open-loop mechanically recyclable material is recycled, and then all of the remaining material that is chemically recyclable (according to Chemical Recycling Scenario A) is recycled.



Introduction

The expanding provision of recycling solutions offers scope to develop a circular business model for textiles that captures a wider range of post-consumer qualities than a model focused only on reuse. Recycling, rather than replacing reuse options, should contribute to finding end-of-life options for textiles with no reuse option, in order to create as circular a model as possible that aligns to the waste hierarchy. It should be noted that recycling of textiles may be required even in a system that prioritises reuse, as textiles will end up in the recycling stream after being reused as much as possible.

Development of a circular model will include supply chain mapping and evaluation of the value chain[2], which this report aims to support.

This study is based on the best available data, and outputs should be considered as indicative, with the potential to expand the scope of the study to increase robustness. Based on tonnage, the data used in this study before scaling up represents 11% of the UK clothing market, 6% of the UK footwear and accessories market, and 2% of the UK household textiles market from across a range of retailer and product types

Recycling should contribute to finding end-of-life options for textiles with no reuse option, in order to create as circular a model as possible that aligns to the waste hierarchy.

We would invite any stakeholders who have any data or insight that could be valuable to a potential second phase of this project to approach Valpak to discuss collaboration.

Recyclability

Recyclability has been presented in greater detail than reuse in this report, however this does not reflect a preference of recyclability over reuse, but rather is a reflection of the methodology applied and data available. It is acknowledged and agreed that reuse must be prioritised over recycling, in line with the waste hierarchy, in order to minimize the environmental impact of textiles.

Analysis presented in this report is focused on theoretical recyclability of textiles based on data available at the placed on the market (POM) stage of a product's life. A reuse analysis has also been incorporated in which likelihood of reusability is determined based on product category.

This report aims to determine the theoretical recyclability of textile material being placed onto the market. This report focuses on recycling of post-consumer material as this stream of waste textiles has the best data availability for this purpose, and as chemical textile recycling almost always uses post-consumer material as the input, as opposed to post-industrial material, such as manufacturing scraps. Post-consumer textiles also pose more technical challenges to recycling than post-industrial pre-consumer textiles due to the inclusion of fastenings, hard points, and other contaminants, and therefore provide a more complete picture of the issues facing the industry.

It must be noted that although feedstock specifications for chemical or mechanical recycling are being applied to determine technical recyclability of total textiles POM, this is not a statement that such quantities are capable of being processed currently (as this would be prevented by capacity limitations and lack of commercial scalability, as well as by the fragmented nature of available feedstock arisings) or that the technology could be scaled to this extent (issues around the scaling of these technologies are discussed within this report).

The overriding consensus from stakeholder engagement was that reuse should be prioritised over recycling (to reduce energy and resource consumption involved in reprocessing, and to retain product quality), and that reduction should be prioritised over reuse (to overall reduce the environmental impacts associated with production).

Designing for recyclability has also been mentioned during stakeholder engagement as an area that should receive increased attention from manufacturers and Government, as it will enable the highest level of material retention during recycling (by reducing issues associated with contaminants / non-target material).

Definitions

There are various types of textile recycling. In the past, textile recycling has referred to the activity carried out by textile sorters, which typically consists of some level of sorting into grades (grades are very variable between sorters) and then sending graded items for reuse, remanufacturing, export, or disposal depending on their residual value, type and quality. For the purpose of this report, these organisations are referred to as **sorters**.

Recycling of textile fibres into new products can be categorised as open-loop or closed-loop (or fibre-to-fibre).

Open-Loop Recycling

In open-loop mechanical recycling, shredded textiles are used for applications other than their original format. This includes applications such as insulation, filling of car seats, or industrial wipes. This is described as open-loop mechanical recycling, or informally referred to 'downcycling' (although this is seen by some textile recyclers as being a pejorative term that dismisses the real requirement for these products that is fulfilled by post-consumer textiles).

Open-loop recycling is a broad area, and different fibre blends lend themselves to different uses. It is also a long-established process, with proven environmental benefits through providing a recycled resource to make products that may otherwise have used virgin fibres. As noted below, fibre to fibre recycling is in its infancy as a technology, and as this develops, open-loop recycling is well positioned to fulfil the requirement of providing an end-of-life option for recycled fibres.

This report aims to determine the theoretical recyclability of textile material being placed onto the market.

Fibre-to-Fibre Recycling: Chemical and Mechanical

Fibre to fibre or closed-loop recycling refers to recycling of fibre back into new fibre, which could then theoretically be used to create an item of the same format, constituting a circular process.

Fibre-to-fibre recycling is typically split into chemical and mechanical recycling. Chemical recycling in this report refers to depolymerisation, or dissolving using solvent. There are other types of textile recycling such as:

- Physico-chemical (in which fibres are separated using a solvent and precipitation)
- Thermo-chemical (in which organic compounds are separated using pyrolysis)[4] and
- Thermal (in which fibres are melted to be reshaped)[5].

This report, however, focuses on mechanical and chemical (depolymerisation or dissolving using solvent) textile recycling as these are the two most common types both in current technology development and in reviewed literature[6].

Chemical recycling often involves the use of a chemical to break textiles down to its constituent polymers before repolymerisation into new fibre, and some technologies like that of Worn Again use solvents to dissolve the polymer before removing the solvent to regenerate the purified polymer[7]. Mechanical recycling involves the shredding of textiles to obtain the fibre, or (if polyester), the melting of textiles into pellets for re-spinning into yarn. Mechanical recycling results in a much shorter fibre length, which typically reduces the quality of the textiles made from this fibre[8] and therefore reduces the quality of textiles made from the item or reduces the amount of manufacturing streams available to the yarn[9]. Chemical recycling is theoretically better positioned as being able to facilitate a fully circular system as it is able to produce recycled fibres of full length after repolymerisation of depolymerised pulp, and therefore retain the quality (as an input into manufacturing) and value.

Chemical recycling is also able to separate some blends, which mechanical fibre-to-fibre recycling typically does not do. Fabric blends pose a barrier for textile recycling as they can make recycling unecological, uneconomical or technologically unfeasible depending on the composition and approach[3].

Feedstock specifications for chemical recycling vary by the recycler – two are considered in this study, those of Worn Again, a UK-based chemical recycler, and Renewcell, a Swedish chemical recycler (these specifications are outlined below). It should be noted that in a chemical recycling process where a certain quantity of 'contamination' (such as elastane or any other non-target material) is present, this contaminant is not recycled with the target material and instead is lost as 'sludge'.

In comparison to other recycling types, chemical recycling is in its infancy, but is growing fast, with many fibre-to-fibre companies opening new facilities and attracting investment.

Mechanical recycling does not involve any chemicals, and instead recycles the textiles back into their fibres through shredding (in which the textiles are shredded into smaller pieces) and carding (in which machines tear the fabrics with opposite sets of sharp teeth) processes to extract the fibres, which are then spun into yarn.

It is estimated that currently less than 1% of textile waste is fibre-to-fibre recycled[11]. Technologies are developing rapidly in a race towards scale; however, it should be noted that there are some concerns in industry around the potential commercial viability of such technologies. Limitations to fibre-to-fibre are also imposed by collection, sorting, and pre-processing capacity[12].

WRAP's 2019 report on fibre-to-fibre recycling stated that fibre-to-fibre recycling could be financially viable but is presented with barriers such as fibre blends, costs of sorting and logistics, contaminants, lack of demand for recycled textiles, and immaturity of chemical recycling technology and automated sorting technology, among others[13].

Sorting

Sorting is a vital part of the assessment of post-consumer textiles to determine the most appropriate route, and without sorting, waste textiles are likely to be exported or disposed regardless of their type and quality. Sortation workers interpret material quality for the next use, including brand, cleanliness, wear and reusability (a combination of value and likely demand). It should be noted that whilst sorters will produce guidelines for their employees, these criteria are not fixed given the huge range of textiles that are collected and the prevailing market at any moment in time - and are also dependent on the sortation worker, process, demand, and the anticipated next use[14]. It should also be noted that condition is also often impacted upon by the method of collection (for example whether via kerbside collections, recycling banks, charity shops or in-store collections).

Textile sorters sort materials into different grades and find outlets that support reuse and remanufacturing. The export markets play a significant role for items that are not deemed suitable for reuse in the UK, but would have a use elsewhere, with items not suitable for reuse, remanufacture or recycling sent for landfill or incineration. Sorters' categories/grades are based on post-consumer garment quality, some of which is related to data available at the POM stage (such as brand), and other aspects are related to post-consumer condition (such as stains and wear). Colour of textiles is taken into consideration, as this affects the recyclability of the material. For example, sorters have confirmed that white cotton is the most suitable for industrial wiping rags: cotton as it is strong and absorbent, and white because it shows dirt better than coloured material.

Recyclability is dependent on sufficient sorting technology. At present, most sorting carried out is by hand, however research has shown that 25-30% of garment labels have missing, washed out, or inaccurate care labels[15], which limits the effectiveness of hand sorting. Over time, manual sorters can develop the skills needed to identify materials by sight and touch, however the industry faces challenges retaining these skilled workers. Near-infrared (NIR) identification is a possibility but at present the technology is not yet available at a scale to meet what is required, due to the large volumes of material that require sorting.

However, fibre sorting technology, while in relative infancy, is advancing, and the Salvation Army has installed a NIR 'Fibersort system' which uses an infrared camera and air jets to sort and grade textiles based on fibre types and colour, and is able to differentiate blends[16].

A difficulty with both hand and machine sorting is capacity and the associated cost, due to the vast quantities of post-consumer textiles that require sorting.

Most importantly for the context of reporting, most of the above criteria cannot be determined at the POM stage. However, if indicators for durability were implemented, this could give some understanding of a garment's likely condition at the recycling stage (however the actual wear on the item in question could not be known until after the consumption stage, at which point its reusability is assessed by sorters). Understanding potential end-of-life options at the POM stage is likely to have some benefits for potentially upcoming environmental reporting.

Sortation workers interpret material quality for the next use, including brand, cleanliness, wear and reusability (a combination of value and likely demand)

Contaminants

The textile recycling process is also constrained by the presence of contaminants such as zippers, buttons, and other embellishments, which require pre-processing to remove.

Prints are also a contaminant as they are often polyurethane backed.

Textile recycler Sodra, for example, have stated that dyes, prints, buttons, zips, elastane and other fibres prevent them from processing clothing, but that they expect these barriers to be overcome as processing and sorting technology improves, but supply chain partnerships and collaboration will be required[17].

These areas may be candidates for eco-design criteria if designing for recyclability is prioritised in any potential legislation.

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Chemical recyclers

This section contains a description of some chemical textile recyclers. This is not an exhaustive list but gives an overview of some of the companies operating in the area.

Worn Again (UK)

Worn Again is a chemical textile recycler in the UK whose technology is able to separate, decontaminate, and extract polyester and cotton cellulose from non-reusable textiles[18].

Renewcell (Sweden)

Renewcell is a Swedish chemical textile recycler whose technology breaks down used cotton (and other cellulose-rich textiles) into a pulp called Circulose which is used by their customers to create viscose or lyocell textile fibres[19]. The newly opened Renewcell plant in Sundsvall, Sweden is touted as being the world's first commercial scale chemical fibre-to-fibre recycling plant[20].

Lenzing – REFIBRA (Global)

Lenzing has developed a recycling technology for both pre-consumer and post-consumer textiles, in which waste fibre is mixed with wood pulp to create new garments. This process uses cotton as a feedstock[21].

Sodra (Sweden)

Sodra is a chemical recycler of post-consumer waste, creating a recycled viscose product by combining a mix of a dissolving pulp made from post-consumer textile waste and virgin wood pulp[22]. Sodra is a Swedish forest industry group that has expanded into textile recycling with their product OnceMore[23].

Circ (USA)

Circ is developing technology to carry out chemical recycling using a combination of water, heat, pressure and chemicals to separate mixed polymers[24]. The process results in a recovery of 90% of the original materials[25].

Feedstock Specifications

Table 2: Feedstock Specifications of Some Chemical Recyclers

Recycler	Feedstock Specifications
Worn Again	Textiles must be made of pure polyester, pure cotton and/or a combination of the two, with a tolerance of up to 20% contaminant or 'other' which can be other materials such as elastane, nylon, wool etc.
Renewcell	Cotton content must be above 95%, full garments including trims and seams are acceptable, all types of dyes and colours are acceptable, the feedstock should not have plastic prints, and should not have been treated with permanent press finishing or water-resistant finishing.
Lenzing	Pure cotton[11].
Sodra	White/unbleached cotton (although up to 5% coloured material of the textile piece could be tolerated) and/or polycotton blends with a minimum cotton content of 50%. Traces of viscose and lyocell of up to 5% are acceptable, but not others such as nylon or elastane. Zippers, buttons, or other embellishments are not acceptable.
Circ	Pure cotton, pure polyester, and polycotton blends. Circ state that they plan to expand to other fibres such as spandex (elastane)[24].

In addition to the barriers to chemical recycling identified above, there are also some sustainability issues with chemical recycling involving the use of chemicals, however many recyclers take action to minimise this, for example Lenzing's production process recovers and reuses more than 99% of the solvent used[26].

Closed-loop mechanical recycling consists of shredding textiles into fibres that can be turned back into textiles of the same application

Mechanical recyclers

Closed-loop

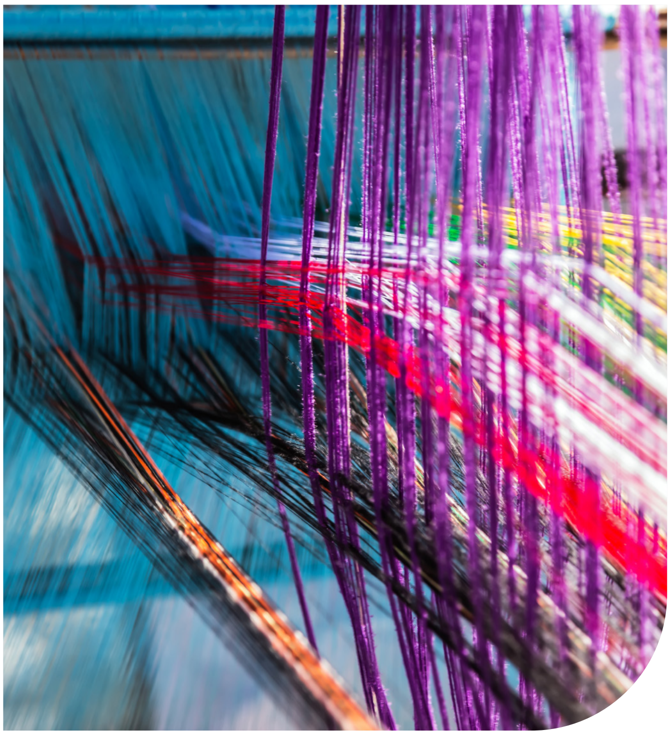
There are far more mechanical recyclers than chemical recyclers, and large variability in the output.

Closed-loop mechanical recycling consists of shredding textiles into fibres that can be turned back into textiles of the same application (e.g., a t-shirt into a t-shirt). This type of recycling uses mono-fibre textiles (textile material made only from one fibre type (i.e., 100% cotton / 100% polyester)) as a feedstock to maintain quality[27]. There are however issues associated with reduced quality of items created from mechanically recycled fibres, as a result of the shortened fibre length. To combat this, mechanically recycled fibres are often mixed with virgin fibres to increase garment quality, but this approach does not provide a fully circular solution[28].

Project B Plan B (UK)

Project B Plan B is an example of a mechanical textile recycler, which recycles 100% polyester materials by converting pre-consumer or post-consumer polyester into pellets which can then be spun into new fibre, making it a closed-loop process. Project B Plan B's focus is on designing garments for recyclability.

Their process is able to remove some degree of contamination but highlights the differences between contamination types and how they can affect the output quality. For example, with a contamination level of 2% nylon, the pellets would be 2% nylon, which would be likely to fail during spinning. Furthermore, a nylon zip would have more impact than a metal zip as a metal zip would be likely to be removed during pre-processing, but a nylon zip would not and would melt and reduce the grade of the yarn.



Recover (Spain)

Recover is another example of a closed-loop mechanical textile recycler, which creates recycled fibres from both industrial waste and used garments that can then be used to create new garments. A focus of theirs is to maintain fibre length as much as possible, to combat the issue of poor output quality from reduced fibre length[29].

iinouiio (UK)

iinouiio (an acronym for It Is Never Over Until It Is Over), which partnered in March 2022 with global fabric manufacturer Camira, is an example of a close-loop mechanical textile recycler focused on wool[30].

Open-loop

Open-loop mechanical recycling consists of shredding textiles into fibres that can be used in applications other than new garments, such as filling of car seats or insulation. Open-loop mechanical recycling also typically uses mono-fibre fabric due to the fibre structure and higher fibre yield[32].

Open-loop recycling can consist of processes that maintain the fibre structure of the existing material, such as the use of materials as cleaning cloths in industrial applications.

Open-loop textile recycling is a long-established practice that is well entrenched in multiple industries.

Capacity

A major barrier to both mechanical and chemical recycling is capacity when considered against the scale of textile waste being produced. Most chemical recyclers are in the trial or pilot stage of development.

- Renewcell's 2022 year-end report stated that their goal for 2023 is to ramp up production to 60,000 tonnes of annual capacity, and then to 120,000 tonnes in their next step in 2024[33].
- Worn Again's plant is expected to have a feedstock capacity of 1,000 tonnes per year. This is expected to "pave the way for industrial-scale operations", highlighting that they expect the technology to be able to scale beyond this[34].
- Sodra announced in 2022 that they were increasing their production capacity to produce up to 6,000 tonnes of textile pulp a year (specifying that this could be enough to make 24 million garments)[35].
- Circ state that they will have the capacity to process two tonnes of textile waste per day once production increases[36].

The capacities of these recyclers, which are based in various places in the world (and therefore not all addressing UK waste), are a fraction of what is required, with over a million tonnes of clothing alone being consumed in the UK in 2017. However, the analysis in this project helps to demonstrate what could be technically achievable with existing technology if the barriers to scaling were removed.

It should be noted that discussions with sorters have highlighted that capacity and feedstock specifications provided by chemical recyclers may be ambitious, and that these claims should be treated with caution. No verification of claims regarding feedstock specifications and capacities has been undertaken as a part of this study.

A major barrier to both mechanical and chemical recycling is capacity when considered against the scale of textile waste being produced. Most chemical recyclers are in the trial or pilot stage.

Potential end-of-life options for different reprocessing types

The below table shows some potential destinations for different end-of-life options. There are some instances in which an item may have no reprocessing options and energy recovery may be necessary, such as if material is unknown or chemically contaminated.

Table 3: Potential destinations of textiles that are recycled, reused, or remanufactured, and for those without these options.

Recycler	Feedstock Specifications
Chemically Recycled	New garments.
Mechanically Recycled (Closed-loop)	New garments (often of a lower quality than those produced by chemically recycled fibres due to shorter fibre lengths).
Mechanically Recycled (Open-loop)	Insulation (various, often wool), flocking (must be at least 40% wool based), rags (typically white cotton), felt, soundproofing, mattress filling, car seat filling, among others.
Reuse / Remanufacture	Direct reuse via charity shops, second-hand marketplaces (online like eBay, Depop, Facebook Marketplace, Refashion etc, or bricks and mortar/ pop-up like vintage sales, Refashion etc.)
No Viable Reuse or Recycling Options	Landfill, incineration / energy recovery.

It should be noted that specific reprocessing activities (such as shredding, for example, as a type of mechanical recycling) within broader levels of reprocessing options (as described above) have varying levels of suitability for particular destinations. In mechanical recycling, chopping and unravelling followed by carding produces material suitable for open-end yarn or carded yarn, while chopping and tearing followed by thermo-bonding produces material suitable for non-woven materials for structural insulation[38].

Methodology

POM data has been obtained by scaling up datasets from a variety of textile retailers based on their tonnage, to be reflective of the total UK market.

The total chemically recyclable tonnage was determined by applying feedstock specifications of chemical textile recyclers to POM data. These totals should be used only when considering what is technically recyclable according to the claimed feedstock specifications, and do not:

- Consider the commercial viability (present or future) of chemical textile recycling.
- Consider the available capacity of chemical textile recyclers.
- Include verification of the claimed feedstock specifications.

A recyclability matrix was developed based on material types that was applied to all mono-fibre components, for both mechanical and chemical textile recycling. With regards to chemical recycling, this captures additional materials that are not considered in the application of chemical recycler feedstock specifications due to their primary focus on cotton and polyester.

Retailer datasets

Six datasets from retailers placing various types of clothing and other textiles onto the market were analysed. Data was provided from across a range of retailer and product types, including a supermarket, multiple UK-wide high-street and online retailers, and a home furnishings retailer.

Most datasets contained sale quantity, material composition (e.g., “90% cotton, 10% elastane”), garment weight, and some level of categorisation. Datasets were provided for either full year 2021, or March 2021 to February 2022.

Data availability

Data availability varied significantly between retailers. For some, data contained category information, weights, and material composition data. For others, data contained category information and composition data but no weights. For some (albeit clothing only), only composition and the total tonnage for that composition was available.

Some datasets split products by size, but coverage of this was not robust enough to include in the analysis. No data had a separate field for product colour or dyes.

Category information was important for categorisation of products into groups that allowed insight into the type of textiles being placed onto the market.

Data was mostly not available for embellishments, zippers, buttons, clips etc (either for their presence/absence or for their material).

A higher level of detail would be required in order to provide a more comprehensive analysis of recyclability from the POM data, or an analysis of total environmental impact. It should be noted that lack of data availability may prove a barrier for reporting under potential future Extended Producer Responsibility (EPR) legislation.

Demographics

42% of clothing considered in this study is children's or baby wear, compared to 19% of the population being under 16[39]. It is, however, possible that more items of clothing per year are purchased for children between the ages of 0-16 than for adults, but this has not been tested.

We compared the composition of children's and adult's clothes and found children's clothing to have a predominant material of cotton at 71%, followed by polyester at 21%, as opposed to adult's clothing which has a predominant material of cotton at 45% followed by polyester at 32%. There is the possibility of some error introduced into this analysis as the data may not be representative of the composition of the market.

To note, there was some variation between the material breakdown of men's and women's clothing, with women's clothing having predominant materials of polyester and cotton at 33% each, then viscose at 16%, while men's clothing had a predominant material of cotton at 58% followed by polyester at 31%.

Men's clothing has a predominant material of cotton at 58%

Women's clothing had predominant materials of polyester and cotton at 33% each

Industry insight

Some textile sorters and recyclers were contacted to determine their perspectives on recycling options and the applicability of the recyclability matrix. This commentary has been added when relevant throughout this report.

This insight was also considered within the analysis. One sorter stated that differentiation is required between open-loop and closed-loop mechanical recycling, which was incorporated into the methodology (previously only closed-loop was being considered).

Application of averages

There was some sales data for which weight or composition data was not available. 10% of the total data (by output tonnage after analysis) contained product-level information (i.e., product code, name, category) but did not contain product weights. To account for these, all products were categorised into defined groups and an average set of weights generated by the products with weights in the group was applied to all products without weights in that group.

5% of output tonnage contained no composition data (e.g. 90% cotton, 10% elastane), and so these weights were excluded from the material analysis below. However, the other 5% of total output tonnage did contain composition data but had no weights prior to analysis, and therefore for these, an average weight was used in conjunction with the original composition data, allowing this data to be included in the material analysis.

Scaling

Data was scaled up to be reflective of the UK market using the total 2017 tonnage estimates from the 2019 WRAP Market Situation Report[40], the most recent available year. The tonnages provided in this report were 1,040,000 tonnes for clothing, 298,000 tonnes for shoes and bags, 295,000 tonnes for household-type textiles, and 320,000 tonnes for leisure textiles (such as sleeping bags), totalling 1,953,000 tonnes.

Market share was considered as a method for scaling up, but UK-specific and category-specific (i.e, clothing, footwear, accessories / bags, and household) market share data was not available for all retailers.

The limitations of this approach include 2017 data being combined with the 2021 data provided by retailers, and furthermore WRAP have highlighted that their estimates are indicative, however the method was applied as this is the most recent year for which data is available and is categorised in such a way that facilitates comparison with the POM data.

Recyclability

Feedstock Specifications

Worn Again and Renewcell were selected to include in the data analysis due to their clearly stated feedstock specifications that can be applied to the dataset using calculations, to generate a broad overview of what proportion of material POM may be recyclable.

Chemical recyclability was determined by applying recycler feedstock specifications to data. Renewcell's feedstock specifications were used for "Chemical Recycling Scenario A" and Worn Again's specifications were used for "Chemical Recycling Scenario B". These terms were used as opposed to using recycler names in order to frame the two feedstock specifications as options with differing levels of feedstock acceptance (to compare with one another as well as to compare to mechanical recycling), without focusing on the companies specifically. These specifications are outlined in Table 1.

The specifications were applied to components, as opposed to items overall, on the basis that considering technical recyclability as opposed to recyclability in practice would also include the pre-processing required to obtain the feedstock. The pre-processing that includes separating a lining from a shell would be similar (in terms of the level of effort) to that which removes buttons, zips, and embellishments. The potential material losses from such pre-processing have not been considered in this analysis.

Recyclability Matrix

The recyclability matrix was developed to be applied only to mono-fibre materials. Blended materials that are able to be recycled are accounted for in applications of the above recycler feedstock specifications. Blended materials are typically not considered to be recyclable through mechanical recycling methods (although it is sometimes claimed that fibre blends are mechanically recyclable3 – this is considered in the mechanical recyclability results section of this report).

The matrix contains all materials present in the data, and recyclability using chemical, closed-loop mechanical, and open-loop mechanical methods has been determined through a literature review. The matrix was reviewed by a sorter to verify accuracy and applicability.

The pre-processing that includes separating a lining from a shell would be similar (in terms of the level of effort) to that which removes buttons, zips, and embellishments.

Reusability

Reusability was assessed using a scale which was developed by categorising the broad product categories into low, medium, and high likelihood of reusability.

This scale was developed based on some of the criteria assessed by sorters at the end-of-life stage, such as likely soiling, likely wear, expected value at end-of-life, and likelihood of being given away or sold after use (such as children's wear, which is frequently outgrown). The scale included categorisations such as:

- All underwear or nightwear garments being categorised as low reusability.
- All household linens with frequent direct skin contact (such as sheets, duvet covers, pillows, and towels) being categorised as low reusability.
- All garments with a relatively high value and less frequent skin contact (such as jumpers, jackets, and coats) being categorised as high reusability.
- Items with high likelihood of wear (such as oven gloves) or low durability (such as leggings) being categorised as low reusability.
- Household items with relatively high value and relatively low wear such as curtains, blinds, cushions, and rugs being categorised as high reusability.
- Items with very variable degrees of wear and reusability, such as shoes, t-shirts, bags, and trousers being categorised as medium reusability.

Results

The total weight of textiles estimated by the 2019 WRAP Market Situation report is 1,953,000 tonnes. Because of the scaling-based methodology, that is also used as the total weight for this analysis. Results are presented in the materials, recyclability, and category (which contains reusability) sections below.

Furniture, while collected in initial data, has not been included in these analyses due to insufficient data to scale up, and insufficient coverage of the market.

Materials

This section details the breakdown of material types, separated by clothing, household, and footwear / accessories.

The breakdown according to the categories that material types are separated into by the Textile Exchange[41] (which provides a broad overview of material types) is shown in table 3.

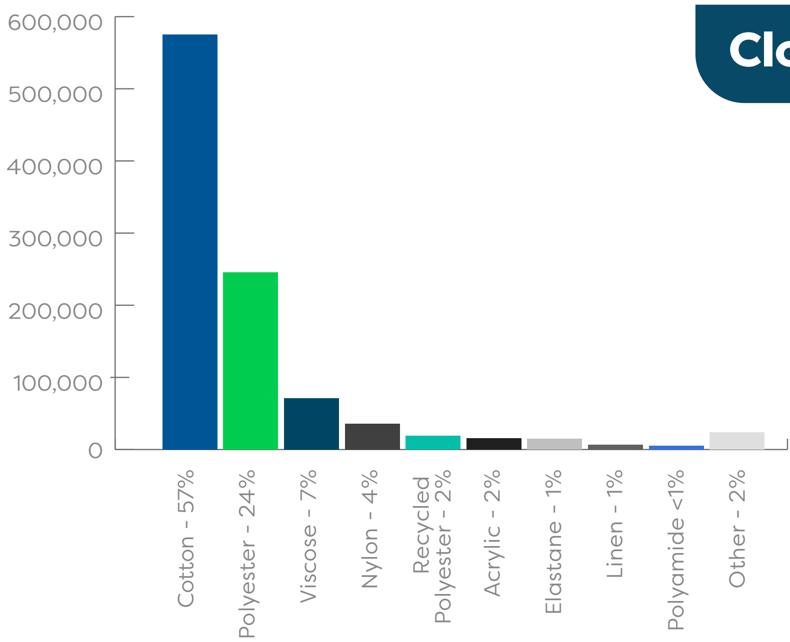
Table 4: Split of Material Types According to Textile Exchange Category

Recycler	Feedstock Specifications	Tonnage	Material Category as Proportion of Product Category
Accessories	Animal Fibre	8,591	16%
	Manmade Cellulosic Fibre	92	0%
	Not Fibre	4,175	8%
	Plant Fibre	2,870	5%
	Synthetic Fibre	39,297	71%
Clothing	Animal Fibre	5,328	1%
	Manmade Cellulosic Fibre	81,192	8%
	Not Fibre	1,197	0%
	Plant Fibre	597,532	57%
	Synthetic Fibre	354,752	34%
Footwear	Animal Fibre	30,491	13%
	Manmade Cellulosic Fibre	53	0%
	Not Fibre	26,767	11%
	Plant Fibre	13,801	6%
	Synthetic Fibre	171,863	71%
Household	Animal Fibre	40,407	7%
	Manmade Cellulosic Fibre	6,913	1%
	Not Fibre	22,016	4%
	Plant Fibre	227,114	37%
	Synthetic Fibre	318,550	52%
Grand Total		1,953,000	100%

Non-fibre materials such as rubber soles are included as they contribute to the weight of the fibre-based item. However, it should be noted that the inclusion of additional constituents was variable by retailer data and did not include non-fibre components like buttons and zippers.

The rest of the material breakdown does not include the weights generated using the averages-based approach and without composition data (which constitute 4% of the total weight), meaning the total tonnage included in this analysis was 1,869,626. This is because products for which average material weights were applied only contained detail down to the Textile Exchange Category and not the individual material.

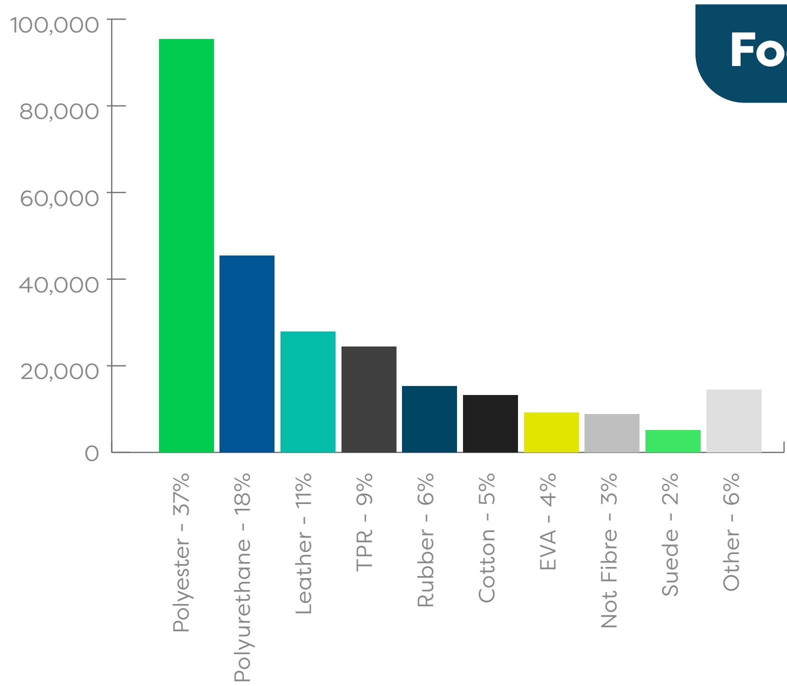
Figure 3: Clothing - Top 10 Materials by Tonnage[42]



Clothing

Clothing constituted 1,012,717 tonnes of the 1,869,626 total. This was dominated by cotton, at 57% of the total, and polyester, at 24%.

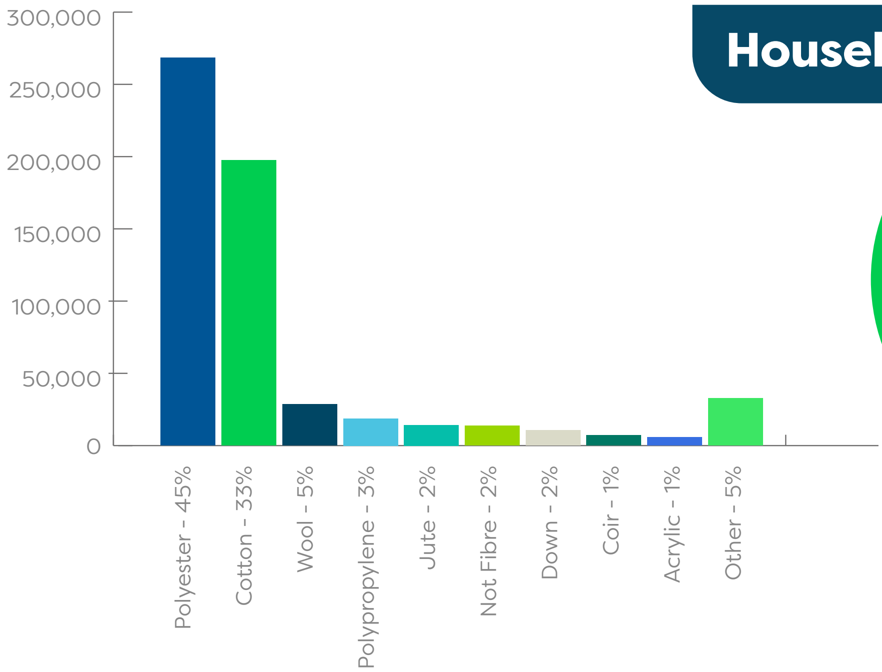
Figure 4: Footwear and Accessories - Top 10 Materials by Tonnage



Footwear & accessories

Footwear and Accessories constituted 259,296 tonnes of the 1,869,626 total. The largest contributing material to this was polyester at 37%, followed by polyurethane at 18%.

Figure 5: Household - Top 10 Materials by Tonnage[44]



Household

Household constituted 597,613 of the 1,869,626 total. The largest contributing material was polyester at 45%, followed by cotton at 33%.

Blends

Table 5: Tonnages and Proportions of Blended Fabrics, and Tonnages of Pure Polyester or Cotton, or a Polycotton Blend (with no contaminants such as elastane).

Recycler	Blended Fabric	Total Tonnage	Percentage of Category	Total Tonnage of Mono-fibre Polyester or Cotton	Total Tonnage of Polycotton Blend
Accessories	No	43,465	95%	27,509	
	Yes	2,092	5%		285
Clothing	No	449,823	44%	405,167	
	Yes	562,894	56%		139,952
Footwear	No	169,396	79%	61,450	
	Yes	44,343	21%		7,898
Household	No	401,523	67%	298,013	
	Yes	196,091	33%		136,531
Grand Total	No	1,064,206	57%	792,139	
	Yes	805,420	43%		284,666

Recyclability

This section details the breakdown of the textiles data according to chemical recyclability and open or closed-loop mechanical recyclability.

The recyclability breakdown, like the material breakdown, does not include the weights generated using the averages-based approach (which constitute 4% of the total weight), meaning the total tonnage included in this analysis was 1,869,626.

Chemical

The below table details the theoretical chemical recyclability of the textiles data according to two separate feedstock specifications (that of Renewcell – referred to as Chemically Recyclable Scenario A, and that of Worn Again – referred to as Chemically Recyclable Scenario B) and anything also chemically recyclable outside of those specifications.

Table 6: Total Tonnage and Tonnage Fibre-to-Fibre Chemically Recyclable

Simple Category	Tonnage	Chemically Recyclable – Scenario A		Chemically Recyclable – Scenario B		Additional Chemically Recyclable	
Accessories	45,557	1,149	3%	28,172	62%	487	1%
Clothing	1,012,717	396,962	39%	778,441	77%	34,281	3%
Footwear	213,739	4,769	2%	76,903	36%	1,668	1%
Household	597,613	114,902	19%	460,654	77%	5,008	1%
Total	1,869,626	517,783	28%	1,344,170	72%	41,444	2%

'Additional Chemically Recyclable Tonnage' in the above table accounts for materials not accounted for by either Chemical Recycling Scenario A or B (i.e., not included in either feedstock specification) but is technically recyclable according to other guidance. This includes materials such as mono-fibre viscose, modal, and nylon, and includes only non-blended materials.

Excluding Scenario B, 'Additional Chemically Recyclable' on top of Chemically Recycling Scenario A would be 438,683 tonnes, i.e. 956,466 tonnes together, 51% of the 1,869,626 total.

It should be noted that the 'contaminant' material in blended fabrics is lost as sludge (non-recoverable material) during the recycling process. This material cannot be recycled.

- With 517,783 tonnes recyclable according to Chemical Recycling Scenario A, 4,041 tonnes (less than 1% of the total material) would be lost as sludge.
- With 1,344,170 tonnes recyclable according to Chemical Recycling Scenario B, 18,409 tonnes (1% of the total material) would be lost as sludge.

'contaminant' material

in blended fabrics, is lost as sludge during recycling.

Mechanical

The below table details the theoretical mechanical recyclability of the textiles data according to the application of the recyclability matrix to mono-fibre materials.

Table 7: Total Tonnage and Tonnage Recyclable by Open or Closed-loop Mechanical Recycling

Simple Category	Tonnage	Mechanically Recyclable (Open-loop)		Mechanically Recyclable (Closed-loop)	
Accessories	45,557	40,490	89%	28,004	61%
Clothing	1,012,717	445,788	44%	443,651	44%
Footwear	213,739	146,595	69%	64,818	30%
Household	597,613	361,210	60%	329,695	55%
Total	1,869,626	994,083	53%	866,169	46%

For the purpose of this analysis, only mono-fibre materials have been considered as open-loop mechanically recyclable, finding a total of 53% to be open-loop mechanically recyclable. However, some sources claim that fibre blends are open-loop mechanically recyclable3, although it is not stated which specific blends are recyclable.

- If working under the assumption that polycotton blends are also open-loop mechanically recyclable, this increased to 68% open-loop mechanically recyclable. The sum of the 284,666 tonnes of polycotton blends and the 994,083 tonnes of open-loop mechanically recyclable material would be 1,278,749 tonnes – 68% of the material included in this analysis section.
- This figure is more in line with the figure of 74% recyclability found in Fashion for Good's 2022 analysis of textile recyclability in Europe[45], although this report focuses specifically on low-value textiles and fibre-to-fibre recycling.

Open-loop recycling is most achievable with current technology and methods, and the current viability of destinations, such as insulation, mattress filling, and underlay (acknowledging of course that capacity for material into these markets is limited by demand). Communication with some textile sorters highlights that increasing the quantity of recycled content in applications such as these could increase viable end-of-life options for textiles and create environmental benefit, since these products will be produced anyway whether they use virgin or recycled content.

The material found to be closed-loop (fibre-to-fibre) mechanically recyclable constituted 46% of the total.

It should be noted that in this study, the specific textile category is not taken into account when determining overall level of mechanical recyclability. In practice, many mechanical textile recyclers may currently not accept very small items such as pants, socks, and tights as these can get stuck in the spikes in a shredder. However, this issue could be solved by using a different shredder (which textile recyclers are currently not incentivised to do due to the large quantity of available feedstock). As this study is considering technical recyclability as opposed to current recycling practices, these items have been considered as mechanically recyclable for this purpose.

For reference, the tonnage of pants, socks, and tights POM in this analysis was 40,237. This does not include other small items that may face the same issues.

Total

Figure 6 (below) shows how the total recyclable figure is reached. Figure 6 shows the breakdown if chemical recycling is prioritised, and figure 7 shows the breakdown if open-loop mechanical recycling is prioritised. The total recyclable figure of 1,116,966 tonnes includes all material that is recyclable according to Chemical Recycling Scenario A and open-loop mechanical recycling (sometimes referred to as 'downcycling') which is the broadest feedstock type and the most achievable given current recycling technologies and methods.

The sum of 'Recyclable According to Chemical Scenario A' and 'Mechanically Recyclable (Open-loop)' is the total amount recyclable, as all material captured by 'Additionally Chemically Recyclable' and 'Mechanically Recyclable (Closed-loop)' is also captured by 'Mechanically Recyclable (Open-loop)'.

The total fibre-to-fibre recyclable figure of 989,052 tonnes includes all material that is recyclable according to Chemical Recycling Scenario A and all material recyclable through closed-loop mechanical recycling.

The tonnage described in Figure 6 as 'Additional Chemically Recyclable' is material which is not chemically recyclable according to the broadest chemical recycler feedstock specifications (for any one organisation) but is theoretically chemically recyclable by other organisations includes materials (in their mono-fibre form) such as viscose, nylon, and polyamide.

Figure 6: Split of Types of Recyclability, with Total Recyclability Overall and Total Fibre-to-Fibre Recyclability

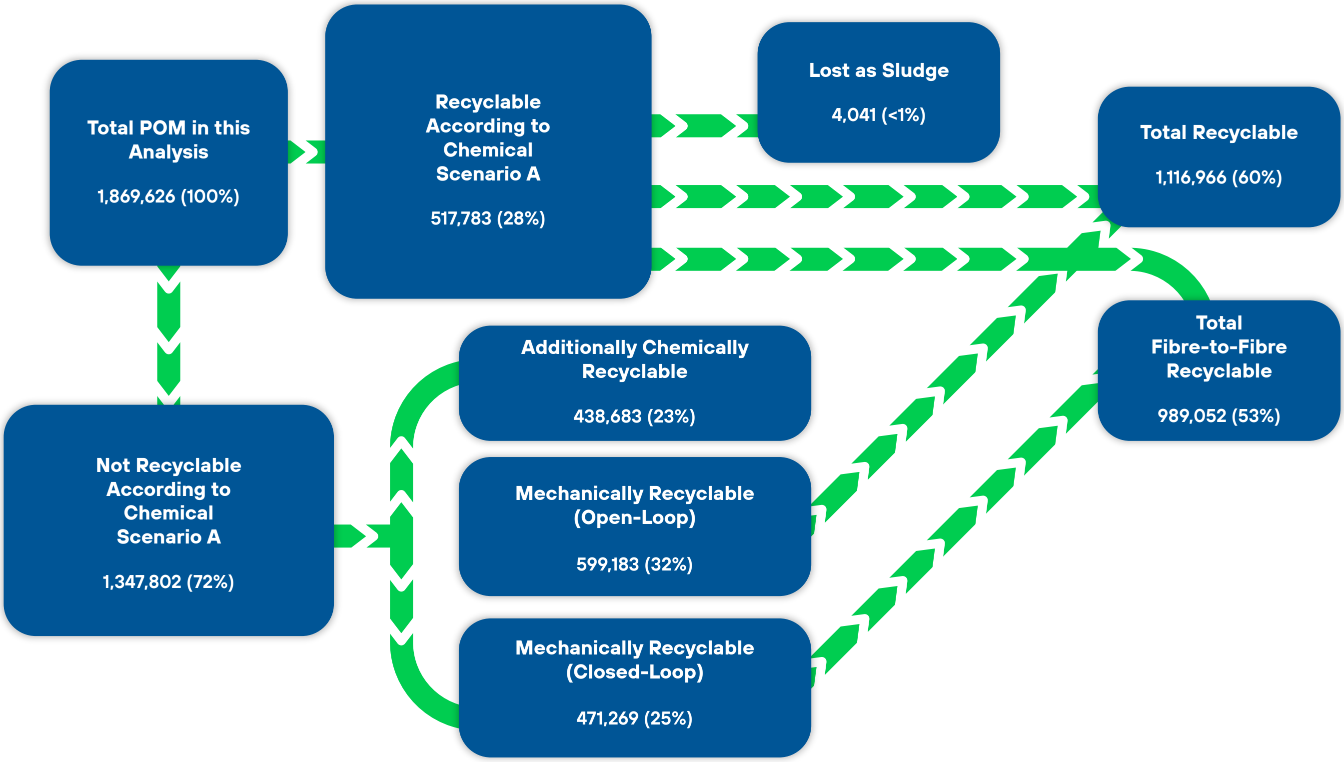


Figure 7 describes total recyclability if open-loop mechanical recycling is prioritised, and Chemical Recycling Scenario A is applied to the material that is not open-loop mechanically recyclable.

All mono-fibre material that is chemically recyclable overall but not chemically recyclable according to Chemical Recycling Scenario A is also open or closed-loop mechanically recyclable, and therefore by adding together Chemical Recycling Scenario A and closed-loop mechanical recycling, total fibre-to-fibre recycling is reached.

Figure 7: Split of Types of Recyclability, with Open-Loop Mechanical Recycling Prioritised

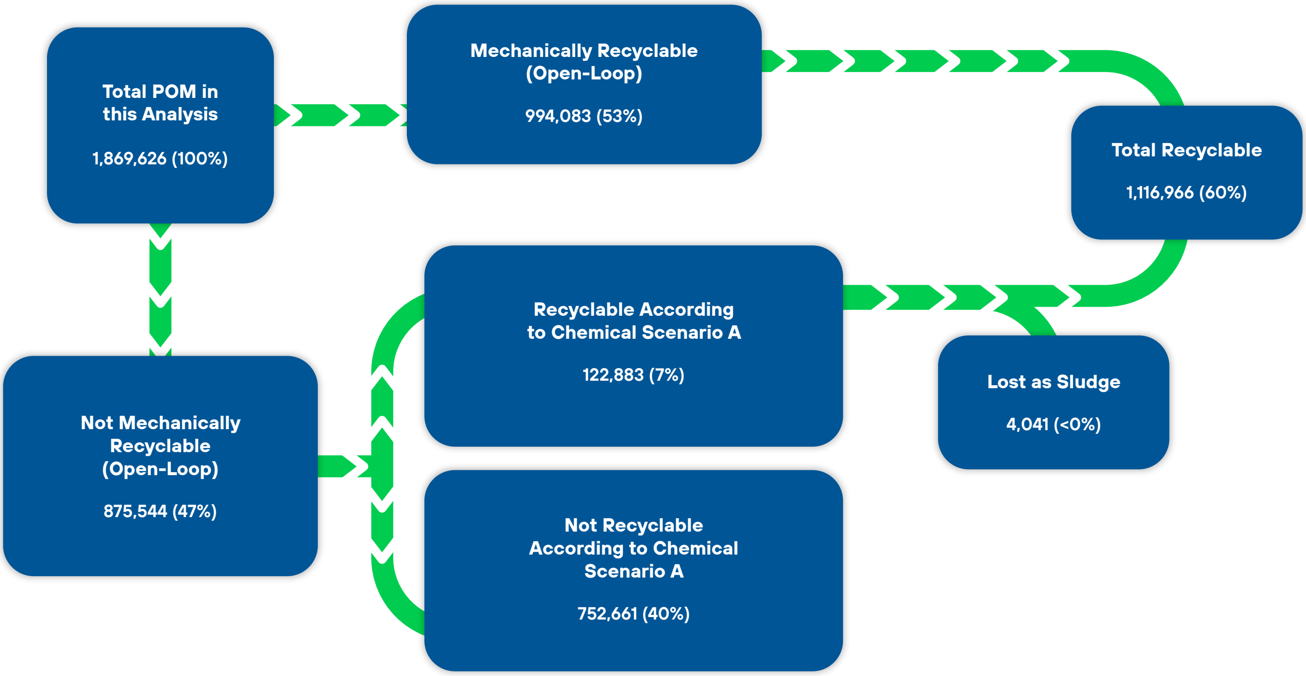
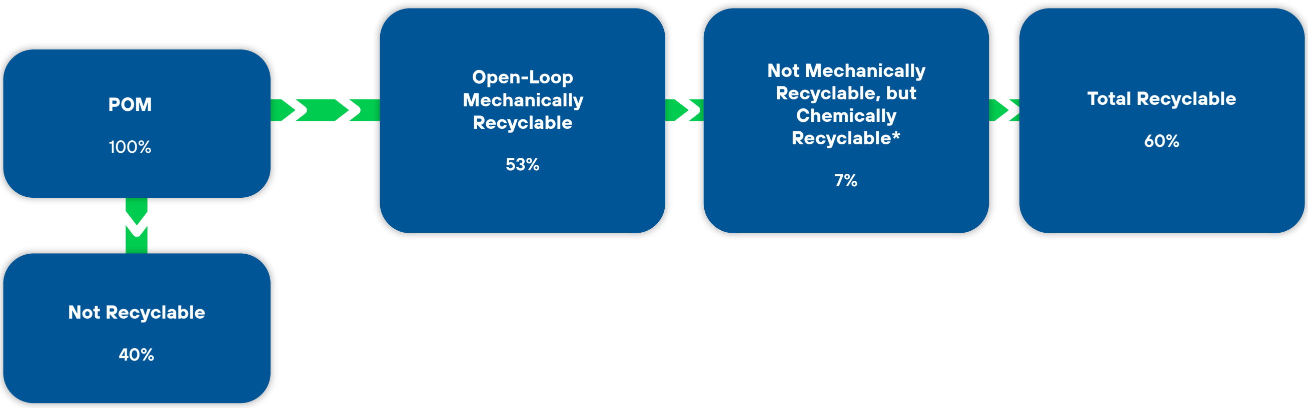


Figure 8 shows a simplified version of figure 7 to present a scenario of maximum recyclability, where all open-loop mechanically recyclable material is recycled, and then all of the remaining material that is chemically recyclable is recycled (according to Chemical Recycling Scenario A).

Figure 8: A scenario of maximum recyclability, where all open-loop mechanically recyclable material is recycled, and then all of the remaining material that is chemically recyclable (according to Chemical Recycling Scenario A) is recycled.



Category Breakdown and Reusability

The category breakdown does not include the weights for which product-level data was not available (which constitute 22% of the total weight), meaning the total tonnage included in this analysis was 1,528,928.

Recyclability

This section considers the category breakdown in terms of recyclability. This analysis may help to identify target areas for which there may be the highest level of benefit for introducing "design for recyclability" principles.

For this section, weights were removed for data without product-level information and for those which were generated using the averages-based approach, meaning the total included tonnage is 1,445,555 (this figure was also used in the reusability analysis, due to the reuse output being considered alongside potential recyclability).

Table 8: The Top 10 Contributing Categories to Total Tonnage, and their Recyclability According to Chemical Recycling Scenario A and B

Simple Category	Material	Tonnage	Proportion Recyclable According to Chemical Recycling Scenario A	Proportion Recyclable According to Chemical Recycling Scenario B
Household	Bed sets	131,501	24%	99%
Household	Rugs	97,172	3%	42%
Household	Curtains	57,702	12%	98%
Household	Cushions	47,774	17%	77%
Household	Bed sheets	38,082	23%	97%
Household	Towels	36,825	98%	100%
Household	Bedspreads & Quilts	36,520	5%	80%
Clothing	Children's T-Shirts	27,825	91%	99%
Household	Table Linen	25,588	9%	16%
Accessories	Rucksacks	24,592	1%	84%

Some of the categories with high tonnages had high levels of recyclability, many of which were household items. Towels were a highly recyclable category according to either chemical scenario, due to their high cotton content.

Household linens had a relatively high rate of recyclability (especially when considered under Chemical Recycling Scenario A), which is particularly relevant as these items may be more suitable for recycling due to limited reuse options.

Reusability

A reusability analysis was undertaken based on product categories. According to the waste hierarchy, reuse must be prioritised over recycling for maximum environmental benefit, as reuse does not involve the resource losses from recycling or remanufacturing, and the energy required is mostly limited to resale, repackaging and transport.

A reusability scale was applied to the product categories. This scale consisted of categorisations of low, medium, and high levels of likelihood of reusability as described earlier in the Reusability section. The split of product types within these categories can be seen in figures 9, 10 and 11 below. A high level of detail on the criteria used can be seen in the methodology section of this report.

Figure 9: Proportion of Categories of Total Material Categorised as Low Reusability

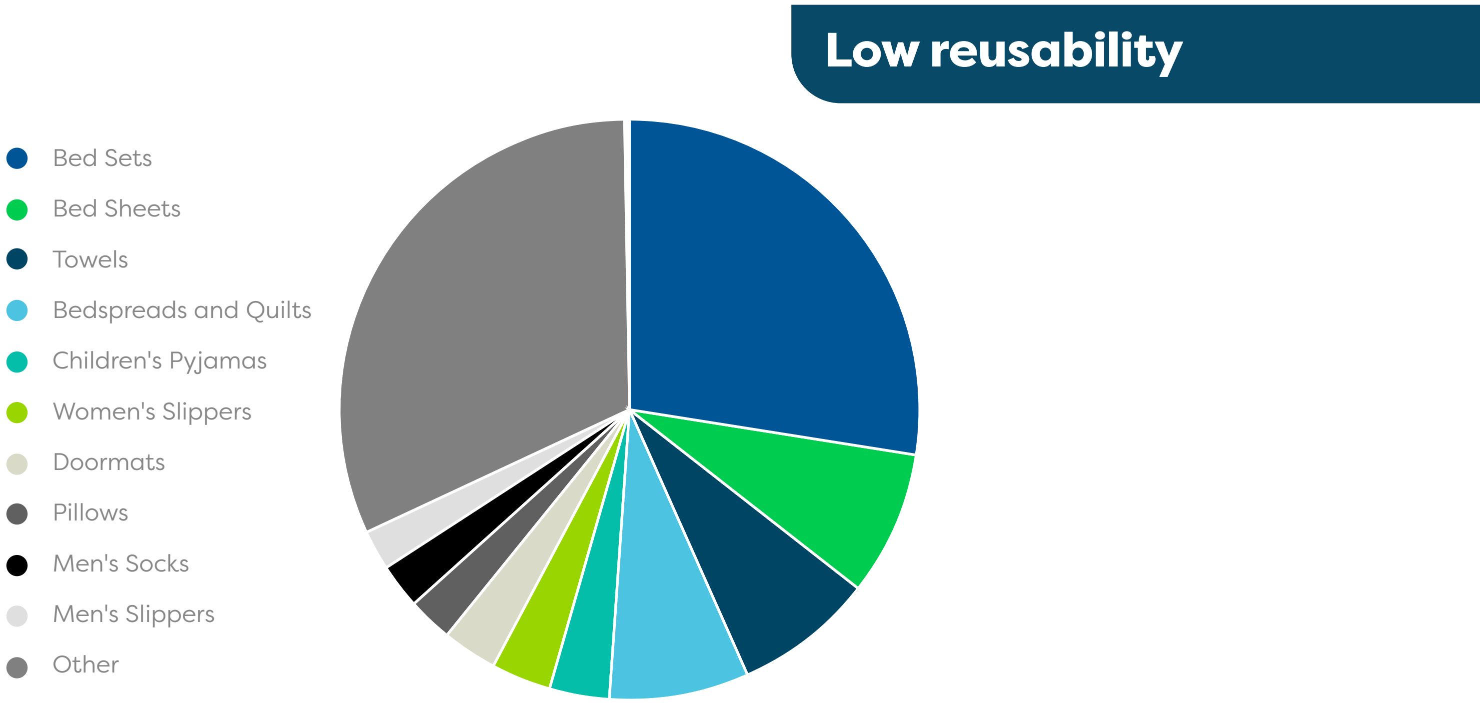


Figure 10: Proportion of Categories of Total Material Categorised as Medium Reusability

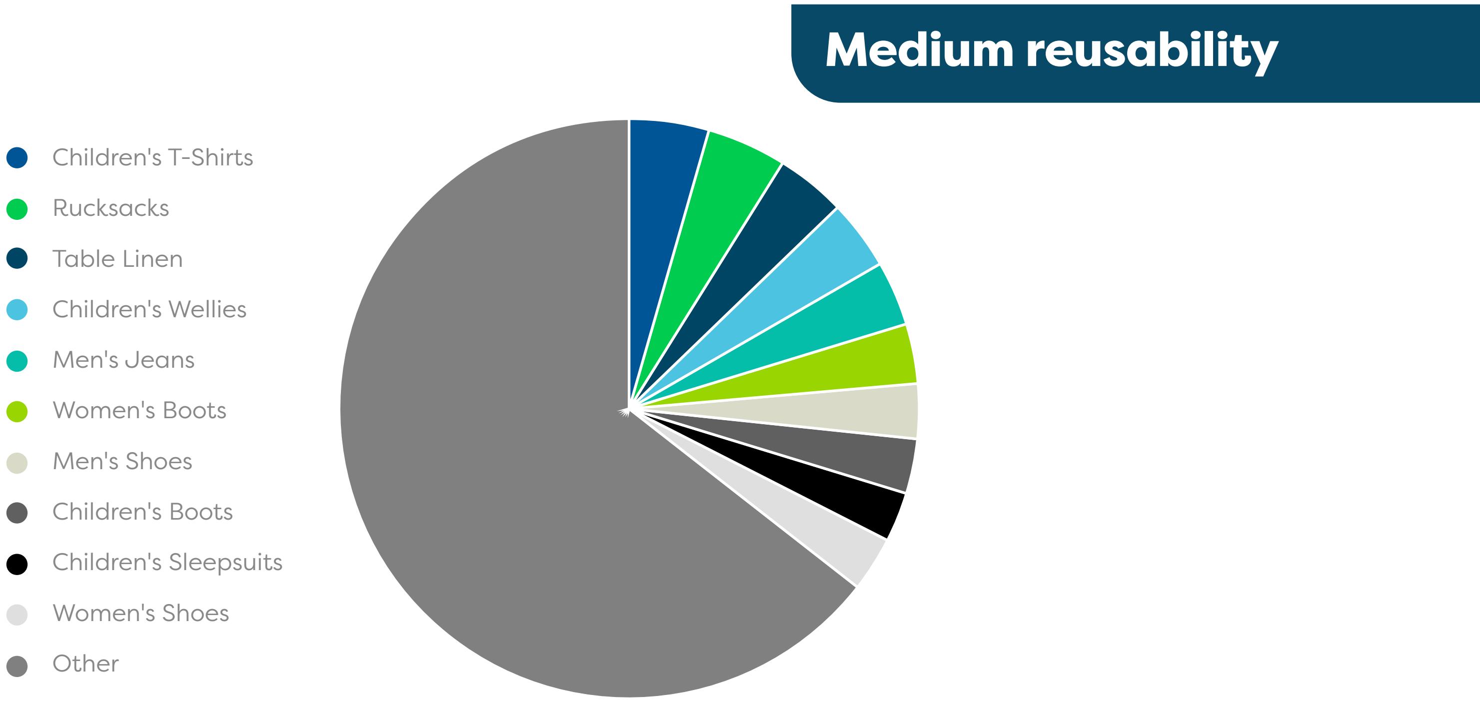
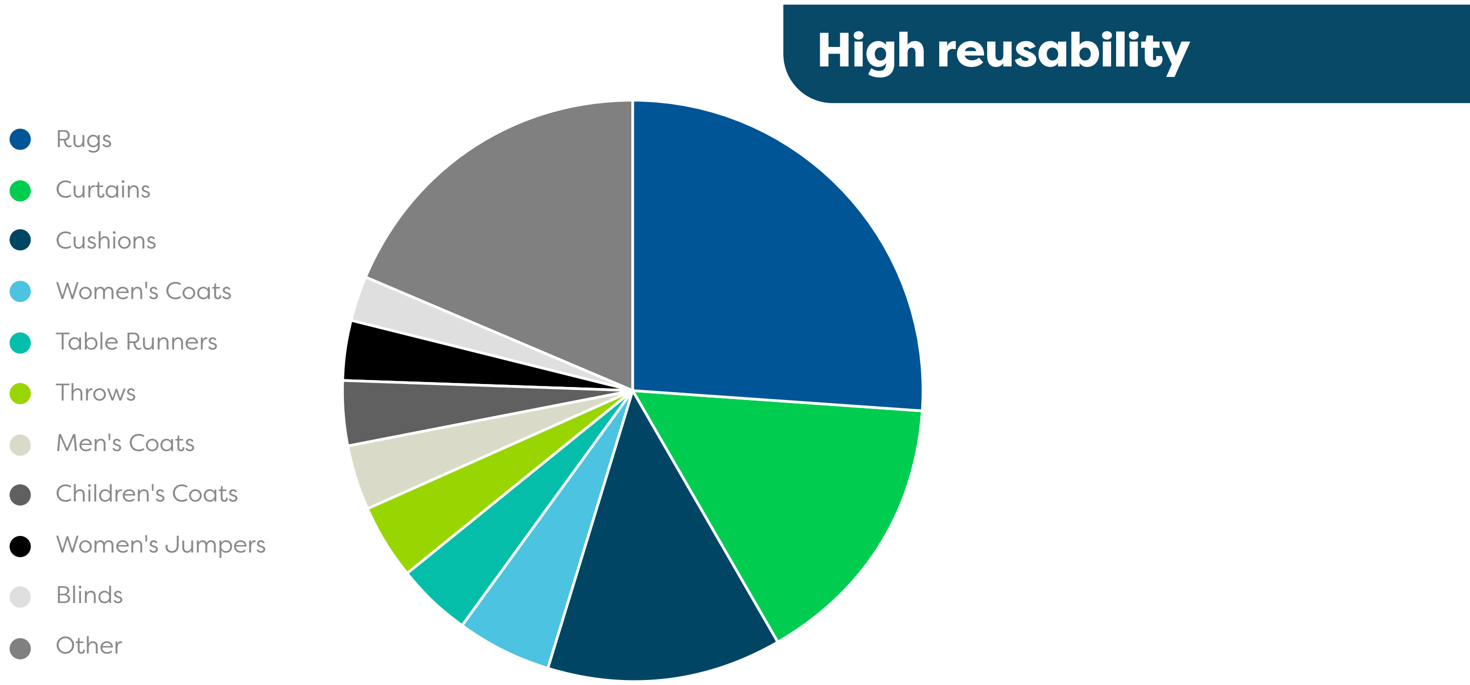


Figure 11: Proportion of Categories of Total Material Categorised as High Reusability



The below table shows recyclability of those items categorised as 'low' reusability according to the above criteria. According to the waste hierarchy, recycling should only be considered when other end-of-life options for waste textiles are not viable, and table 8 aims to describe the scale of this opportunity.

Of those products categorised as low reusability – which are therefore most in need of viable recycling options – 84% would be chemically recyclable according to Chemical Recycling Scenario B, and 51% would be recyclable through open-loop mechanical recycling.

Table 9: Recyclability of Various Levels of Reusability

Reusability	Tonnage Included in This Analysis		Open-loop Mechanically Recyclable	Chemically? Recyclable According to Chemical Recycling Scenario B
Low	475,231	33%	51%	84%
Medium	600,797	42%	56%	64%
High	369,527	26%	71%	64%
Total	1,455,554	-	-	-

Of the total 1,445,554 tonnes included in this analysis section, 334,570 tonnes (23%) were low reusability material which is also theoretically open-loop mechanically recyclable, and 386,431 tonnes (27%) were low reusability material which is also theoretically chemically recyclable according to Chemical Recycling Scenario B – the broadest feedstock specification.

A recent textile waste composition analysis carried out by Wrap Cymru found that from samples taken from five Welsh local authorities collected from recycling banks and kerbside services, the proportion of material suitable for recycling but not for resale was ~8-10% (8.9% at Household Waste Recycling Centres (HWRCs), 9.6% at kerbside, and 8.4% at bring banks)[46]. Compared with the above figures, this shows that there is theoretically recyclable material that is not suitable for resale being placed onto the market which is not deemed recyclable at end-of-life under current recycling practices but may be potentially recyclable with the right technology and infrastructure.

Insight from Sorters

Communication with textile sorters highlighted a variety of potential issues around fibre-to-fibre recycling (particularly chemical) that should be considered when reviewing the output of this report. These included:

- Lack of verified scalability / commercial viability, and no guarantee of whether this will come.
- Some fibre-to-fibre recyclers' feedstock specifications (notably mono-fibre white cotton) being material that currently has a viable open-loop end-of-life route: industrial wiping rags (however it should be noted that this is not a circular solution).
- The energy and chemicals required in chemical recycling.
- The issue of contamination may be underplayed in some feedstock specifications, as it does not account for the decrease in quality of the output when contamination is not effectively removed before processing.

Some sorters are more optimistic about the future of open-loop mechanical recycling, and state that potential destinations of these recycled fibres (such as insulation or underlay) should prioritise recycled content and have restrictions placed on the amount of virgin material that can be used. An issue identified by these sorters is that open-loop recycling (sometimes referred to as 'downcycling') is, despite negativity around the process, actually fulfilling a valid requirement for product that would otherwise use virgin material, and therefore is a valid and valuable route for recycled fibres. Open-loop recycling is given a higher focus in France than we often see in UK discussions, with the French textiles eco-organisation Refashion having developed multi-disciplinary and inter-industry working groups to establish the open-loop industrial recovery solutions available in France[47].

One stakeholder stated that there is often too much focus on recycling when discussing circular business models, however they also state that the reuse markets tend to be more self-sufficient and require less focus.

Conclusions

This study found that a large proportion of textile material being placed onto the market is potentially recyclable using either mechanical or chemical textile recycling, and this figure remains fairly high for items which are less likely to have viable reuse options.

It also shows that limiting the amount of fibre blends being placed onto the market is likely to increase the amount of recycling options available for textiles. Mono-fibre cotton and polyester are prioritised for recycling options, given their dominance in the market, and producers designing for recyclability may be likely to use these fibres to promote streamlining of recycling technology development.

This study provides evidence that significant investment in effective sorting infrastructure is needed to facilitate a circular textiles economy, and that the sorting process will be essential in achieving high recycling rates.

A higher level of detail in the data (such as including information on contaminants) would increase the robustness of the analysis of recyclability.

A large proportion of textile material being placed onto the market is potentially recyclable using either mechanical or chemical textile recycling.

Next Steps

There are a number of ways in which the robustness of this study could be improved. Some of these may be through provision of a higher data quality, an issue which could be communicated to data stakeholders in a repeat study or a reporting service (being considerate of varying levels of data availability).

Higher data quality:

- One of the datasets did contain size and colour data, however this would need to be a larger proportion of the data providers for an analysis to be robust. As colour has an impact on recyclability, this will be important information to collect in order to create a more accurate picture of recyclability.
- Embellishments, zips, buttons, and other possible contaminants have an impact on recyclability, and therefore information on these would also need to be collected - data on the material of these will be required as this affects recyclability as well
- a metal zip, for example, could be easily removed in pre-processing of polyester pelletizing, but a nylon zip would not be removed in pre-processing, and would contaminate and reduce the quality of that batch.

Extended methodology:

- In a repeat study, group weights could also include dominant material (i.e, "Women's Jackets – Polyester-based" vs "Women's Jackets – Cotton-based"), which would increase the accuracy of the group weight.
- A greater number of data providers would help to increase the validity of the study.

A second phase of this report may be developed to provide a more detailed view of potential textile recyclability.

The next stages of this project would also consider the potential role of EPR in resolving some of the issues described above (such as designing for recyclability, providing funds for infrastructure, and developing demand for recycled content), and how EPR can fit alongside other potential developments such as localised infrastructure and the associated self-sufficiency of the supply chain.

We would like to invite any stakeholders who have any data or insight that could be valuable to a second phase of this project to approach Valpak to discuss collaboration.

Acknowledgements

We would like to thank the stakeholders who contributed their data, time, insight, and knowledge to the development of this project, without whom this project would not have been possible.

Footnotes

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[42] Clothing "Other" includes (in order of highest to lowest tonnage) Modal, Lyocell, Wool, TBC, Polyurethane, Down, Recycled Nylon, Rubber, Elastomultiester, Polychloroprene, Modacrylic, Rayon, Viscose, Metallised Fibre, Leather, TPR, Polypropylene, Silk, PVC, Elastodiene, Hemp, Sheepskin, Cupro, Acetate, Suede. Tencel, Flax, Coir, Palm Leaf, Lambskin, Resin, Polyethylene, TPU, and PET.

[43] Footwear and Accessories "Other" (in order of highest to lowest tonnage) includes Recycled Polyester, Nylon, Resin, Acrylic, TBC, Sheepskin, Elastane, Wool, Polypropylene, Jute, Down, Rubber, Viscose, Elastodiene, Linen, Polyethylene, Cork, PET, Polyamide, Metallised Fibre, Lambskin, Elastomultiester, Fur, and TPU.

[44]Household "Other" includes (in order of highest to lowest tonnage) Viscose, Recycled Polyester, Polyurethane, Resin, Nylon, Rubber, Linen, TPR, Cork, Lyocell, Seagrass, Polyamide, Fibreglass (tent poles), Silk, Modal, Sheepskin, Elastane, Polyethylene, TBC, Modacrylic, Metallised Fibre, Rayon, Cowhide, EVA, ABS, Fur, Leather, Down, PET, Mohair, PVC, and Bamboo.

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