Department for
Energy Security
& Net Zero

# Unlocking Resource Efficiency

## Phase 2 Textiles Report

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# Introduction

The Department for Energy Security and Net Zero (DESNZ) and the Department for Environment, Food and Rural Affairs (DEFRA) commissioned Eunomia Research and Consulting to undertake a research project exploring the potential benefits from increasing resource efficiency in the UK. This report outlines the findings of this research for the textiles sector.

For the purposes of this report, resource efficiency is defined as any action that achieves a lower level of resource use for a given level of final consumption. This can occur at any stage of the supply chain including production, consumption, and end-of-life. While material substitution may not always meet the definition of resource efficiency set out above, it is in scope of this research where it reduces whole life carbon.

This research was conducted in the first half of 2023, and reports were written in August 2023. As such, this report does not reflect sector developments beyond that point. Technical experts were consulted as part of research activities for this report. The following report reflects our understanding of the available evidence and is accurate to the best of our knowledge; however, if any factual errors are encountered, please contact us at Resource_efficiency@energysecurity.gov.uk.

## Methodology

This aim of this research was to achieve four key objectives:

- Identify a comprehensive list of resource efficiency measures for each sector;
- Identify current and anticipated drivers and barriers which are affecting improvements in the identified resource efficiency measures in each sector, and their relative importance;
- Build consensus estimates for the current “level of efficiency” and maximum “level of efficiency” in 2035, for each of the identified resource efficiency measures in each sector; and
- Identify the extent to which industry is currently improving resource efficiency and build consensus estimates for the likely “levels of efficiency” in 2035 given current private sector incentives and the existing policy mix (a “business-as-usual” scenario), for each of the identified resource efficiency measures in each sector.

To achieve these research objectives, a mixed-methods methodology was developed. A literature review was conducted for each sector to synthesise evidence from the existing literature relevant to these objectives. In parallel, stakeholder interviews were conducted with industry and academic experts in each sector to test literature findings and fill any outstanding evidence gaps. A summary of findings was then presented and validated at sector-specific facilitated workshops with sector experts.

This project did not aim to identify policy recommendations but rather understand the potential for resource efficiency in the UK. It should be noted that some areas covered as part of the research fall under the responsibility of devolved nations of the UK; however, all reports cover the UK as a whole for completeness.

This project has attempted to identify three level of efficiency estimates for each resource efficiency measure:

- The **current level of efficiency** which is the best estimate for the current level of efficiency of the measure i.e., what is happening in the UK now (in 2023);
- The **maximum level of efficiency** which is the maximum level of efficiency that is technically possible by 2035 in the UK, without factoring in barriers that could be overcome by 2035 i.e., what is the maximum level that could be achieved; and
- The **business-as-usual (BAU) scenario** which is the level of efficiency that would be expected in the UK by 2035 with the current policy mix and private sector incentives i.e., what would happen if there were no substantial changes in the policy or private sector environment.

These levels of efficiencies have been identified to understand the potential for resource efficiency and do not represent government targets.

To estimate these levels of efficiency, indicators have been developed for each of the identified measures. These indicators have been chosen based on how well they capture the impact of the relevant measure, and how much data there is available on this basis (both in the literature review and from expert stakeholders).

For some measures, the current level of efficiency is baselined to 2023. This is not an indication of historic progress, but rather has been done in order to understand the potential for further progress to be made (in the maximum and BAU scenarios) where it was not otherwise possible to quantify a current level of efficiency.

Note, the purpose of the indicators in this research is so estimates on the current, maximum and BAU level of efficiency can be developed on a consistent basis. They are not intended be used as metrics to monitor the progress of these resource efficiency measures over time, or to be used as metrics for resource efficiency policies.

A high-level overview of the research stages is presented below. A more detailed version of this methodology is presented in the Phase 2 Technical Summary which accompanies this publication.

## Literature Review

The literature sources were identified through an online search, and through known sources from DEFRA, DESNZ, the research team, and expert stakeholders.

Once literature sources had been identified they were reviewed by the research team and given an Indicative Applicability Score (IAS) ranging from 1 to 5 which indicated the applicability of the sources to the research objectives of this study. This score was based on five key criteria: geography, date of publication, sector applicability, methodologies used and level of peer review.

After the five criteria of the IAS had been evaluated, the overall IAS score was calculated, ranging from 1 to 5, according to the number of criteria scoring ‘high’ and ‘low.’

A detailed overview of the parameters used to assess high / medium / low scores for each of the five criteria feeding into the IAS calculation and methodology for calculating the score can be found in Appendix A.

The research team drafted a rapid evidence assessment and literature summaries as part of interim reports for each sector which synthesised the best available evidence from the literature for each of the four research objectives. When drafting these summaries, literature sources with a higher IAS score were weighted more than those with a lower IAS score.

## Facilitated workshops

The findings from these literature summaries were then presented at two half-day facilitated workshops per sector. The workshops were attended by a range of sector experts from both academia and industry (covering different aspects of the value chain). The purpose of these workshops was to test the findings of the literature review against stakeholder expertise, and to fill any evidence gaps from the literature.

The stakeholders contributed through sticky notes in a shared virtual Mural board, by participating in the verbal discussions and by voting on pre-defined ranges on the levels of efficiency and the top drivers & barriers.

Finally, the findings of the literature review and the stakeholder engagement were combined to reach final conclusions against each research objective. For the estimates on the level of efficiency for each measure (Objectives 3 and 4), a five-tier evidence RAG rating was assigned to indicate the level of evidence supporting the proposed figures. Only where the datapoints were supported by literature sources with high IAS and a high degree of consensus amongst experts in the workshops, were the datapoints considered to have a “green” evidence RAG rating. The definitions are as follows:

- **Red:** Limited evidence available from literature review or stakeholders
- **Red-amber:** Some evidence available from literature review but it is not relevant/out of date, limited evidence from stakeholders, stakeholders are not experts on this measure
- **Amber:** High quality evidence from either literature or stakeholders
- **Amber-green:** High quality evidence from literature or stakeholders, evidence from stakeholders is supported by some information in the literature (or vice versa)
- **Green:** High quality evidence from literature supported by stakeholder expertise.

It should be noted that the business-as-usual (BAU) level of efficiency was only informed by the stakeholder engagement, so the maximum evidence RAG rating for the BAU is amber.

## Limitations

This report was commissioned by the Government to improve the evidence base on the impact of resource efficiency measures. The methodology is designed to provide robust answers to the research objectives, based on the best available evidence at the time the work was undertaken.

While every effort was made to be comprehensive in the literature review, it is inevitable that some relevant literature may not have been captured. A full list of all the literature reviewed is provided in the annexes of each sector report.

The feedback captured during the interviews and workshops represent the views of a sample of stakeholders from industry, trade associations and academia. Effort was made to ensure that interviews and workshops included a cross-section of stakeholders from each stage of the sectors' supply chain, representing a range of backgrounds and perspectives. It is, however, noted that capacity and scheduling limitations meant that some stakeholders, whose view would have been valuable to the research, were not able to participate. As such, the views expressed by research participants in this report are not representative of the sector as a whole.

A key research objective of this project is to estimate the level of efficiency of resource efficiency measures in 2035. Any future projections are inherently uncertain as they depend on a range of different factors such as technological innovation, consumer behaviour change and the macro-economic environment. The estimates from this research are the best estimates that could be produced, based on the current literature and stakeholder expertise. Evidence RAG ratings have been provided to indicate the level of supporting evidence for each of these estimates.

The report does not seek to make recommendations on the appropriate direction of Government policy or independent industry action. DESNZ and DEFRA will seek to conduct further engagement with stakeholders to inform the next steps for resource efficiency policy within Government, ensuring that any omissions or developments in the evidence reviewed in this report are taken into account.

# Sector Introduction

The textiles sector plays a significant role in the UK economy and is a key element to consider in the move towards more resource efficient production. In 2020, the sector employed 500,000 people and contributed almost £20 billion to the UK economy.[1] International supply chains, which are often long and complex, combined with import and export dependencies, provide significant challenges for identifying and implementing resource efficiency measures.

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[1] UKFT (2021). UKFT's compendium of industry statistics and analysis 2020 – Executive Summary. Available at: link

The textiles lifecycle comprises a long and complex value chain, from the production of polymers and fibre all the way through to disposal. There are a significant number of manufacturing stages in the supply chain, numerous means by which textiles are placed on the market and "consumed" and various options for end-of-life management to divert textiles from disposal.

Each aspect of the value chain provides opportunities for improvement. The stages that are most applicable to the UK include:

- Fibre, fabric and product supply chain (design and manufacture);
- Sale and use; and
- End-of-Life.

The global textiles industry contributes more to greenhouse gas emissions than international flights and maritime shipping combined.[2] There is great potential for resource efficiency and decarbonisation within the sector. Current practices across the textile lifecycle are resource-intensive, which leads to impacts beyond emissions, such as poor resource management, biodiversity loss and water, soil and air pollution. The global nature of textile value chains means that all impacts (positive and negative) occur both within the UK and internationally.

While there are an abundance of resource efficiency measures identified within the literature, the majority are discussed qualitatively. This is largely attributed to a general lack of representative, publicly available data to quantitatively assess resource efficiency. There is also little information generally on the involvement of novel approaches that have yet to be implemented for textiles, which makes it difficult to quantify the measures. The resource efficiency measures that have sufficient data relate to resource use, waste generation, recycled content, circular business models, product lifetimes and waste management. These resource efficiency measures can be implemented simultaneously across the various stages of the textile lifecycle, offering multiple opportunities for decarbonisation.

## Sector scope

To ensure that the resource efficiency measures being identified were able to provide the most significant impact in improving resource efficiency and to facilitate the effective establishment of resource efficiency measures, it was first necessary to limit the scope of fibres, fabrics and products.

The scoping exercise considered both perspectives of production and consumption, targeting the largest quantities produced and/or placed on the market for key fibres, fabrics and products. For example, while clothing is not produced in large volumes within the UK, it is by far the largest category of textile products that are consumed. According to WRAP, 1.7 million tonnes of textiles were consumed in the UK in 2018, of which 1.04 million tonnes were clothing.[3]

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[2] Ellen MacArthur Foundation (2017). A new textiles economy: Redesigning fashion's future. Available at: link
[3] WRAP (2021). Textiles market situation report 2019. Available at: link

Any resource efficiency measures relating to clothing consumption would hence result in significant impacts and so were included. As understanding grows and gaps are addressed, the scope can be expanded. The initial sector scoping was agreed with the Project Team and the key fibres, fabrics and products that were identified as in scope are shown in Table 1.

**Table 1: Textiles sector scoping**

| | Fibres | Fabrics | Products | Other Materials |
|---|---|---|---|---|
| **In scope** | Cotton<br>Polyester<br>Wool | Knitted<br>Woven<br>Non-woven | Clothing (in particular tops, dresses, trousers, skirts & tights)<br>Sheets & bedding<br>Carpet<br>Curtains | Dyes<br>High-volume finishing chemicals<br>Water |
| **Out of scope** | Cellulosics<br>Other plant-derived fibres, e.g. hemp<br>Other synthetic fibres, e.g. nylon<br>Other animal-derived fibres, e.g. leather | | Footwear<br>Accessories<br>Other home textiles, e.g. towels<br>Technical Textiles | Other chemicals |

The literature review and workshops looked to identify data aligned with the in-scope materials and products. It is important to note that in many cases, this level of granularity was not available either in the literature or from stakeholders, necessitating estimates on resource efficiency to be made for groups of in-scope materials (e.g. “fabrics” rather than individual data points for knitted, woven and non-woven materials).

## Literature review approach

The sources included in this research were sourced via several routes. These included: being shared by DEFRA/DESNZ, being shared by sector experts, being shared by workshop participants, or via an online search. An exhaustive list of the search strings used during the literature review is provided in Appendix B and an exhaustive list of the literature that was reviewed is provided in Appendix C.

There were a total of 107 reviewed sources with an average IAS of 3.5, which were made up of:

- 38 academic articles/reports;

- 25 website articles/pages;
- 28 industry reports;
- 11 policy documents; and
- 5 technical studies.

Of the 107 sources, 73 provided relevant information on the finalised measures and the surrounding contextual information. The remaining sources provided useful contextual information, but also information on discarded measures.

More detail on the purpose and approach for these literature reviews can be found in the accompanying methodological annex.

## Workshop approach

There were a total of 18 participants across both workshops. The participants broadly represent the textiles value chain: one manufacturer, three collectors and sorters, one recycler, three retailers, three retail associations, one local authority partnership, five participants from academic institutions and one NGO.

## Drivers and barriers

Drivers and barriers were categorised using two separate systems:

- The PESTLE framework which is focused on the types of changes: political, economic, social, technological, legal and environmental;
- The COM-B framework which is focused on behaviour change:
    - **Capability**: can this behaviour be accomplished in practice?
        - Physical Capability – e.g., measure may not be compatible for certain processes
        - Psychological Capability – e.g., lack of knowledge
    - **Opportunity**: is there sufficient opportunity for the behaviour to occur?
        - Physical Opportunity: e.g., bad timing, lack of capital
        - Social Opportunity: e.g., not the norm amongst the competition
    - **Motivation**: is there sufficient motivation for the behaviour to occur?
        - Reflective motivation: e.g., inability to understand the costs and benefits,
        - Automatic motivation: e.g., lack of interest from customers, greater priorities

# List of resource efficiency measures

Table 2 shows 10 identified resource efficiency measures for the textiles sector, which are as follows:

- One resource efficiency measure under the design phase
- Five resource efficiency measures under the manufacturing phase
- Three resource efficiency measures under the sale and use phases
- One resource efficiency measure under the end-of-life phase

**Table 2: List of resource efficiency measures for the textile sector**

| # | Lifecycle | Measure Name | Measure Indicator |
|---|---|---|---|
| 1 | Manufacture | Implement efficient product manufacturing processes | % of waste generated during manufacturing |
| 2 | Manufacture | Reincorporate production wastes back into manufacturing | % of yarn and fabric/textile material waste reincorporated back into manufacturing |
| 3 | Manufacture | Utilise recycled content from textiles waste | % of fibre sourced from waste recycling, for use in new textiles |
| 4 | Sale | Utilise rental and product-as-a-service consumption models | % reduction in consumption of new products through rental, hiring and subscription services |
| 5 | Sale / Use | Resell/Reuse of unsold stock and second-hand products | % reduction in consumption of new products through clothing reuse |
| 6 | Use | Repair products | % reduction in consumption of new clothing through repair |
| 7 | End-of-Life | Recycle post-consumer (PC) textiles and unsold stock not suitable for reuse | % recycling rate of clothing, household bedding, curtains and carpet |
| A | Design | Substitute chemicals in manufacturing with alternative materials, to reduce/or remove the requirement for chemicals use | % reduction in dyes, finishing chemicals and water use |
| B | Manufacture | Implement efficient textile material manufacturing processes | % reduction in yarn and fabric waste generated |

| | | | |
|---|---|---|---|
| C | Manufacture | Recycle manufacturing by-products | % dye, finishing chemicals and water recycling rates |

Of the 10 measures identified, it was agreed that Measures A, B and C would not be taken forward to the workshops see "8.0 Shortlisted Measures Not Taken to Workshops" for further detail.

Measure A relates to the substitution of chemicals that are used throughout the manufacturing process, of which there are a significant number. Textile chemical products range from highly specialised chemicals (e.g. biocides, flame retardants, water repellents) to relatively simple commodity chemicals (such as bleaches) or mixtures thereof (such as emulsified oils and greases, starch, sulfonated oils, waxes and some surfactants). Measure C relates to the recycling of manufacturing by-products, the majority of these being chemicals as described above.

Measure B relates to the resource efficiency of producing textile materials. There are several stages of textile material manufacturing.[4] First, the fibres must be produced. Cotton and wool must be harvested from plants/animals respectively[5], while synthetic fibres like polyester are melt-spun.[6] These fibres are spun into yarns; and then utilised in textile manufacturing. Fibres can either be woven or knitted, or they can be used to produce non-woven fabrics.[7] At each stage, the efficiency of the manufacturing process can impact output yields and thus the quantity of waste materials generated.

The complexities of these measures are such that the identification of accurate, representative data would not be possible to support modelling. As such, only the literature review information has been included in the following sections (see the linked section "8.0 Shortlisted Measures Not Taken to Workshops" for further detail on the measures themselves).

It is important to note that while numerous measures were identified in the literature, many are discussed only qualitatively, as the quantitative impact is not provided. This is often because the impact of the measure has not been described in the literature, either because it is complex to quantify or likely due to the commercial sensitivity of much of this information. Therefore, engagement with stakeholders in the industry via workshops was used to gather quantitative estimates to supplement the literature findings instead.

[4] Uddin, F (2019) Textile Manufacturing Processes. Available at: link
[5] Mondal, Md. I H. (2021) Fundamentals of Natural Fibres and Textiles. Available at: link
[6] Hufenus et al (2020) Melt-Spun Fibers for Textile Applications. Available at: link
[7] Uddin, F (2019) Textile Manufacturing Processes. Available at: link

# 1.0 Measure 1 – Implement Efficient Product Manufacturing Processes

## 1.1 Textiles resource efficiency measure

### 1.1.1 Description

*The reduction in waste generated during the manufacturing process and therefore increase in material yield.*

The efficiency of product manufacturing techniques and processes can impact output yields and, thus the quantity of waste generated.[8] Various manufacturing stages could be optimised to improve resource efficiency. Examples include cutting and sewing, or attachment of non-textile elements, such as zippers for clothing, filling for bedding, backing for carpets and eyelets for curtains.[9][10] Resource efficiency can also be delivered by tackling overproduction.

### 1.1.2 Measure indicator

The indicator selected was the **percentage of waste generated during manufacturing**. This is a relative measure with the percentage derived from the total amount of waste generated during manufacturing divided by the total amount of resources used for manufacturing. Here, waste is defined as all textile material (off-cuts and scrap, damaged products, or unsold stock that must be disposed of).

Other indicators that were identified but not selected included percentage fabric wastage rate; the percentage of stock that goes unsold; and the return rate for products manufactured (bulk vs. on-demand).

These were not selected as they only account for proportions of textile waste generated at this stage in the supply chain and thus do not encompass all areas of resource efficiency for this measure.

### 1.1.3 Examples in practice

There are several ways described in the literature and corroborated by stakeholders to increase the efficiency of product manufacturing.

- Implementing technological and process efficiencies to improve product yields, including whole garment manufacturing (referenced for clothing and carpet).[11]

[8] Ellen MacArthur Foundation (2017). A new textiles economy: Redesigning fashion's future. Available at: link
[9] Textile Learner (2012) Flow Chart of Apparel Manufacturing Process. Available at: link
[10] Dykon (2021). Automated and Efficient Production. Available at: link
[11] Phruksaphanrat, B. & Tipmanee, N. (2019) Six sigma DMAIC for machine efficiency improvement in a carpet factory. Available at: link

- Regarding manufacturing technologies, the current levels of efficiency are already understood to be high due to better designer education and modernised cutting machines. There is also the development of whole-garment technologies that produce clothing in one step, removing the need for intermediary fabric manufacturing, cutting and sewing and thus eliminating waste reduction from these stages.[12]

- Production on demand and supply management technology (e.g. forecasting technology and production planning) are also discussed as methods to ensure the correct number of products are produced to avoid unsold stock and subsequent waste. Production of on-demand clothing means consumers are more likely to be satisfied with their products, resulting in lower return rates, especially considering that 52% of e-commerce clothing returns are due to size/fit concerns.[13]

- Digitising the design process. By designing digitally rather than producing physical samples, manufacturing of products that are not subsequently sold and therefore disposed of can be reduced[14] (referenced for clothing).

- Digitising the retail process. This enabler provides an opportunity to reduce return rates, using technology such as augmented/virtual reality to allow consumers to 'wear' or 'try on' products virtually before buying. This can be achieved by using innovations such as biometrically specific avatars and 'digital skins'[15] (referenced for clothing).

Specific resource efficiency methods for linen, bedding and curtains were not identified.

## 1.2 Available sources

### 1.2.1 Literature review

Implementing efficient textile product manufacturing processes was a measure identified in a small number of market/industry reports identified in the literature review. Some of the most notable sources were the Ellen MacArthur Foundation's "A New Textiles Economy" [16] and McKinsey & Company's "Fashion on Climate".[17] While the number of relevant sources was limited and the literature was not consistent in the processes to deliver resource efficiency, they consistently highlighted that reducing wastage in manufacturing was necessary. Indeed, the literature focused predominantly on the potential for resource efficiency (i.e. ex-ante assessment), rather than evidence of resource efficiency (e.g. ex-post assessment).

[12] Roth, J et al. (2023). Best Available Techniques (BAT) Reference Document for the Textiles Industry. Available at: link
[13] McKinsey & Company (2020). Fashion on climate: How the fashion industry can urgently act to reduce its greenhouse gas emissions. Available at: link
[14] Eco-Age (2019) How 3D Digital Design and Augmented Reality Can Slash Textile Waste In Fashion. Available at: link
[15] Institute of Positive Fashion (2021) The Circular Fashion Ecosystem: A blueprint for the future. Available at: link
[16] Ellen MacArthur Foundation (2017). A new textiles economy: Redesigning fashion's future. Available at: link
[17] McKinsey & Company (2020). Fashion on climate: How the fashion industry can urgently act to reduce its greenhouse gas emissions. Available at: link

Exploration of this measure identified further qualitative information on specific processes to improve product manufacturing resource efficiency. But these were generally related to "textiles" or clothing alone.

Fourteen sources discussed this resource efficiency measure, these comprised of:

- three industry reports;[18],[19],[20]
- five academic papers;[21],[22],[23],[24],[25]
- three policy documents;[26],[27],[28] and
- three websites.[29],[30],[31]

Most of these sources were of medium to high quality (IAS scores of 3-5). While not specific to the UK market, many were applicable to the UK manufacturing sector. One source highlighted that manufacturing practices in less-developed countries are generally less efficient than in the developed world – which could mean that UK manufacturing has increased efficiency already. However, this was not confirmed in other literature and thus this has not been relied upon in the critical analysis.[32]

Stakeholder responses to the pre-workshop survey identified that this research showed some relevant literature, but that there were gaps in knowledge around best-available technologies for manufacturing. This is not unexpected, as it was also highlighted in the surveys that there is a lot of innovation and best-practice within textile supply chains that is not covered in academic literature. For example, manufacturing yields and thus quantities of waste produced in production processes.

Across the literature and surveys, there was very little applicable quantitative data relating to methods to improve resource efficiency through the identified processes, nor in aggregate

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[18] Ellen MacArthur Foundation (2017). A new textiles economy: Redesigning fashion's future. Available at: link
[19] Institute of Positive Fashion (2021) The Circular Fashion Ecosystem: A blueprint for the future. Available at: link
[20] Textile Exchange (2022) Fiber Conversion Methodology. Available at: link
[21] Phruksaphanrat, B. & Tipmanee, N. (2019) Six sigma DMAIC for machine efficiency improvement in a carpet factory. Available at: link
[22] Larsson, J., Peterson, J., & Mouwitz, P. (2010). One-piece fashion, summary of the Knit-on-Demand project. Available at: link
[23] Rahman et al (2016) Investigation of fabric wastages in knit t-shirt manufacturing industry in Bangladesh. Available at: link
[24] Nchalala et al (2022) Establishing standard allowed minutes and sewing efficiency for the garment industry in Tanzania. Available at: link
[25] Pal et al (2018) Modelling environmental value: an examination of sustainable business models within the fashion industry. Available at: link
[26] Roth, J et al. (2023). Best Available Techniques (BAT) Reference Document for the Textiles Industry. Available at: link
[27] McKinsey & Company (2020). Fashion on climate: How the fashion industry can urgently act to reduce its greenhouse gas emissions. Available at: link
[28] WRAP (2023). Textiles Cost Benefit Analysis. Available at: link
[29] Dykon (2021). Automated and Efficient Production. Available at: link
[30] Eco-Age (2019) How 3D Digital Design and Augmented Reality Can Slash Textile Waste In Fashion. Available at: link
[31] NRDC (2015) Clean by Design, Apparel Manufacturing & Production. Available at: link
[32] Ibid

what this would mean in terms of overall resource efficiency for this measure. The only data found was from a Textile Exchange source (via a workshop participant) with an IAS of 3, which provides global averages of product yield efficiencies.[33] As such, the workshop was used to gather sources and estimates for resource efficiency data.

### 1.2.3 Workshops

The measure was received positively by stakeholders, but it was highlighted in the first workshop that manufacturing efficiencies and levels of waste generated are poorly understood. Relevant attendees in the first workshop included one fabric manufacturer, one clothing brand and one academic – as they are directly involved in or have experience in manufacturing. The second workshop was attended by two additional academics with manufacturing expertise. However, overall, a low proportion of stakeholders that participated in workshops had knowledge of textiles manufacturing.

Based on the literature review and workshops, it can be concluded that Measure 1 is an appropriate resource efficiency measure, but that further engagement with textile product manufacturers in the UK would increase confidence in the qualitative and quantitative data gathered and would also support filling in data gaps.

## 1.3 Drivers & Barriers

The drivers and barriers were identified in the literature and then built upon and added to through the workshops with stakeholders. The drivers and barriers, including their PESTLE and COM-B categorisation, are described in the following sub-sections. Those in bold denote that they had a greater number of votes stemming from the workshops when participants were asked to identify those of being of the highest significance.

### 1.3.1 Drivers

Table 3 shows a list of the identified drivers for efficient manufacturing processes. These drivers are discussed in further detail below.

**Table 3: Drivers for textiles measure 1**

| Description | PESTLE | COM-B |
|---|---|---|
| **Production on demand well-received by distance shoppers and consumers who require non-standard sizing.** [34] | **Social** | **Motivation – automatic** |

[33] Textile Exchange (2022) Fiber Conversion Methodology. Available at: link
[34] Larsson, J., Peterson, J., & Mouwitz, P. (2010). One-piece fashion, summary of the Knit-on-Demand project. Available at: link

| | | |
|---|---|---|
| Whole-garment technology resulting in increased production yield (and reduced waste).[35] | Technological | Capability – physical |
| New technologies to manufacture to a better standard.[36] | Technological | Capability – physical |
| Greater incentives for manufacturers to achieve fewer mixed materials in the design process.[37] | Technological | Capability – physical |
| Potential for cost savings linked to digital design and less physical sampling.[38] | Technological | Capability – physical |

*On demand production*

The greatest consensus in the workshop on a driver for resource efficiency was that consumers receive production on demand well, particularly those requiring non-standard sizing, reducing leftover stock volumes.[39]

*Whole garment technology and other technological interventions*

From a process perspective, literature and stakeholder engagement corroborated that technological interventions already exist that can increase yield and reduce waste. Overall, stakeholders were also aligned that waste generation is already a key driver for manufacturers to implement resource efficiency through Measure 1 to minimise costs.

However, it was identified in the workshops that some solutions, while applicable, would increase cost or may not be scalable for products of large production volume. An example of this was whole garment technologies which result in reduced production time and increased production yield compared to conventional cut and sew manufacture.[40]

*Reduction in mixed materials*

Resource efficiency can also be delivered by reducing materials mixing in the design process.

*Scalable technologies*

A key driver of resource efficiency is supporting the uptake of scalable technologies – particularly by micro and SME businesses – to meet higher resource efficiency standards. These new technologies can help manufacture to a better standard (e.g. agile manufacturing),

[35] Roth, J et al. (2023). Best Available Techniques (BAT) Reference Document for the Textiles Industry. Available at: link
[36] Workshop 2 Stakeholder Engagement
[37] Ibid
[38] Ibid
[39] Larsson, J., Peterson, J., & Mouwitz, P. (2010). One-piece fashion, summary of the Knit-on-Demand project. Available at: link
[40] Roth, J et al. (2023). Best Available Techniques (BAT) Reference Document for the Textiles Industry. Available at: link

or reduce waste (digital design as opposed to physical sampling) and are in development and have potential. To increase the uptake in the UK it may require support, e.g., financially or from an education perspective.

### 1.3.2 Barriers

Table 4 shows the identified barriers for this measure. These barriers are discussed in further detail below.

**Table 4: Barriers for textiles measure 1**

| Description | PESTLE | COM-B |
|---|---|---|
| Lack legislation for compliance, e.g. introducing targets for lay plan[41] efficiencies, international standards. [42] | Legal | Motivation – reflective |
| Digital design is currently used for low value, high volume products – a scenario which will never be financially viable in the UK. Making it viable requires more collaboration.[43] | Social | Capability – physical |
| Lack of training and incentivisation of factory employees.[44] | Social | Capability – psychological |
| Transparency of the supply chain may hinder these indicators.[45] | Political | Opportunity - social |
| Potential impact of greenwashing.[46] | Social | Opportunity - social |
| Mass customisation has not yet become a reality.[47] | Technological | Capability – physical |

*Lack of legislation*

It is recognised that a lack of legislation for compliance (including the necessary due diligence systems), as well as international resource efficiency standards, would be beneficial for this measure to succeed and deliver tangible resource efficiency benefits. This lack of legislation and standards means that greenwashing is more likely to occur – another issue highlighted by stakeholders.

[41] *A lay plan is a guide for fabric cutting process to ensure it is done accurately and efficiently*
[42] Workshop 1 Stakeholder Engagement
[43] Workshop 2 Stakeholder Engagement
[44] McKinsey & Company (2020). Fashion on climate: How the fashion industry can urgently act to reduce its greenhouse gas emissions. Available at: link
[45] Workshop 1 Stakeholder Engagement
[46] Ibid
[47] Workshop 2 Stakeholder Engagement

*Lack of staff training*

Staff training was also identified as essential to ensure they understand how to use these technologies to deliver resource efficiency. Technological advances such as digital design require manufacturers to work with software providers to ensure the technology is fit for needs. More generally, implementing such resource efficiency technologies requires staff training to support appropriate understanding and operation.[48]

*Supply chain opacity and collaboration*

From an implementation perspective, it was highlighted in the workshop that collaboration will be necessary to deliver digital design.[49] Another aspect highlighted as a barrier was the opacity of textile supply chains, which could inhibit widespread implementation of this resource efficiency measure. Where production occurs outside of the UK, the ability to ensure manufacturers can implement the measure was expressed as a concern. For example, where resource efficiency measures are stated as implemented but, due to insufficient due diligence, are not implemented in practice.

## 1.4 Levels of efficiency

**Table 5: Levels of efficiency for textiles measure 1**

| Indicator: % of waste generated during manufacturing | | | |
|---|---|---|---|
| **Level of efficiency** | Current | Maximum in 2035 | Business-as-usual in 2035 |
| **Percentage** | 10 – 15% | 0 – 10% | 0 – 15% |
| **Evidence RAG** | Amber | Red | Red |

### 1.4.1 Current level of efficiency

There was limited quantitative data within the literature on current manufacturing efficiencies for in-scope products that considered all textile waste (off-cuts + damaged products + unsold stock).

[48] McKinsey & Company (2020). Fashion on climate: How the fashion industry can urgently act to reduce its greenhouse gas emissions. Available at: link
[49] Ibid

Data on levels of waste generated related to fabric waste generated during clothing manufacturing. This included a t-shirt (26.5%),[50] a shirt (16%) and trousers (18.8%).[51] Both sources had an IAS of 4.

The Textile Exchange "Fiber Conversion Methodology" provides current yarn, fabric and product yields based on the total fibre input.[52] The table identifies average processing losses data for different types of products in the "cut make trim" phase of manufacturing, based on the fibre type. The figures for cotton and polyester apparel are broadly of the same magnitude as the data for specific products.

**Table 6: Average waste generated from textile "cut make trim" stage**

| Fibre | Apparel (woven) | Apparel (knit) | Home Textiles & Denim | Apparel Mix |
|---|---|---|---|---|
| **Cotton** | 20% | 20% | 5% | 20% |
| **Recycled Cotton** | 20% | 20% | 5% | 20% |
| **Polyester & recycled polyester** | 20% | 20% | 5% | 20% |
| **Wool** | 8.5% | 8.5% | 4% | 8.5% |

No robust data was identified for levels of unsold stock or damaged products left with manufacturers that are disposed of. More generally, it has been referenced that unsold stock levels can range from 2-3% for a product line, up to almost 33%.[53],[54],[55]

Stakeholders provided several datapoints for certain products in Workshop 1. One academic provided data on % waste generated during the manufacturing process for underwear (5 – 8%) and suiting (15%). A fabric manufacturer also identified this for curtains (10%).

As figures from the workshop related to different products than those identified in the literature, no consensus could be reached on the overall level of waste within the entire sector.

Participants were asked to vote on the average % waste generated for in-scope products within the workshop. The vote for this measure yielded a medium to low consensus. Most votes related to a current level of efficiency of 0 – 15%, with the 10-15% category receiving the

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[50] Rahman et al (2016) Investigation of fabric wastages in knit t-shirt manufacturing industry in Bangladesh. Available at: link
[51] Nchalala et al (2022) Establishing standard allowed minutes and sewing efficiency for the garment industry in Tanzania. Available at: link
[52] Textile Exchange (2022) Fiber Conversion Methodology. Available at: link
[53] WRAP (2023). Textiles Cost Benefit Analysis. Available at: link
[54] McKinsey & Company (2020). Fashion on climate: How the fashion industry can urgently act to reduce its greenhouse gas emissions. Available at: link
[55] Pal et al (2018) Modelling environmental value: an examination of sustainable business models within the fashion industry. Available at: link

most votes. But several votes were cast either for higher than 15% (20 – 30% - 1 vote) or for “don’t know”.

Thus, an estimate of 10% to 15% is used for the current level of efficiency with an amber evidence RAG rating.

### 1.4.2 Maximum level of efficiency in 2035

There were differing views as to what the maximum level of efficiency could be. The lowest percentage of wastage was identified by an academic participant in the workshop, who believed that this could be as low as 1-2%.

Overall voting for the average percentage waste generated for in-scope products had medium to low consensus. Most votes were (as with current level of efficiency) between 0 – 15%, but a higher proportion were within the 0 – 10% range, with notes identifying that this maximum efficiency would relate to both clothing and curtains. However, there was again a vote for 20-30% (higher than current efficiency) and a number for “don’t know”.

Thus, an estimate of 0% to 10% is used for the maximum level of efficiency with a red evidence RAG rating due to the lack of literature sources and the lack of agreement by the stakeholders.

### 1.4.3 Business-as-usual in 2035

Stakeholder engagement on business-as-usual data and voting was very minimal. Individual data points of 12% (clothing) and 15% (household bedding) were provided by an NGO during the general discussion.

On voting on the business-as-usual level of efficiency, only one stakeholder cast a vote, which was for <5%. This indicates a range of 0 – 15% for the BAU scenario with a red evidence RAG rating.

This range is consistent with the range for current levels of efficiency, albeit that it overlaps with current and maximum efficiency ranges. Thus, it could be inferred that current and BAU efficiencies are likely to be of similar levels. Given the lack of legislation to drive changes (highlighted as a barrier) and drivers are mainly technological enhancements, or changes that will only impact the efficiency of certain types of product manufacturing – this would support the assumption that little change will occur if manufacturing remains BAU. However, this statement is made with a red evidence RAG rating, due to the low engagement of stakeholders.

## 1.5 Other insights

It was highlighted by some stakeholders that there is, in some cases, a tension between increasing efficiency (resource and cost) through technology (i.e. whole garment production and digital design) and retaining practical design skills and employment within the sector.

# 2.0 Measure 2 – Reincorporate Production Wastes Back into Manufacturing

## 2.1 Textiles resource efficiency measure

### 2.1.1 Description

*The use of waste created during the manufacturing process as direct feedstock for the process, reducing primary resource use.*

Waste is generated at each stage of manufacturing, including the creation of yarns, manufacturing of the fabric and textile and manufacturing of the final product. Where the generation of this waste cannot be avoided (i.e. Measure 1), the next preferred resource efficiency measure is to ensure that the waste can be reused or recycled. This can be done by reincorporating production wastes within manufacturing, either at the same stage of manufacturing (e.g. spinning of yarn waste to create new yarns), at a different stage of manufacturing (e.g. fibre-to-fibre recycling), or within another sector (e.g. offcuts waste into insulation/non-woven).

### 2.1.2 Measure indicator

The indicator selected was the **percentage of yarn and fabric/textile material waste reincorporated back into manufacturing**. This excludes unsold stock, which is instead accounted for within Measure 7. This is a relative measure with the percentage derived from the total amount of yarn and fabric/textile material waste reincorporated back into manufacturing divided by the total amount of yarn and fabric/textile material wasted. Here, waste is defined as any “losses” from the yarn/textile material manufacturing process.

Other indicators that were identified included percentage of waste materials from manufacturing that are collected; and percentage yarn/fabric containing recycled material.

These were not selected as they do not represent how much waste material generated can be repurposed. The collection of these materials is a critical enabler of recycling but is not an indicator of recycling itself. The percentage of recycled content does not link back to the total amount of waste generated and thus, the level of resource efficiency delivered by the measure.

### 2.1.3 Examples in practice

There are a few ways described in the literature or provided by stakeholders to reincorporate waste within manufacturing to avoid disposal to landfill/incineration:

- Reincorporation of yarn spinning waste. Yarn waste is produced at several stages throughout yarn production. It can occur on opening the bales of cotton before spinning, when removing shorter fibres to ensure that quality yarn is produced and during spinning.[56],[57] Yarn wastes created earlier in the process are less likely to be reincorporated into manufacturing. This results in varying quantities and qualities of reusable yarn. As such, varying quantities of yarn can be reincorporated directly within yarn manufacturing.

- Textile Recycling**.** Off-cuts and other fibre wastes are generated during the fabric/material manufacturing process.[58] Two broad methods of repurposing/recycling were identified:
    - Repurposing of leftovers from manufacturing by using the material directly within new products (e.g. off-cuts and leftover fabric from clothing repurposed for footwear).[59]
    - Fibre-to-fibre recycling of textile and fibre wastes. This could be within the textile or "non-textile" sectors (e.g. using for insulation in the construction sector).[60]

While references are not explicitly made to fabric for different products, requirements for recycling may vary. Clothing and household linens will be similar in material composition and therefore, techniques for recycling could be similar. Carpet material recycling will require bespoke recycling due to the mixture of textile and non-textile components. Curtain fabric recycling, due to the use of additives like flame retardants, may require closed-loop recycling to avoid contamination of materials destined for use in new, consumer contact products like clothing.

Enabling measures for these resource efficiency processes included design for recycling[61] and using business-to-business trade platforms to connect textile waste with end-markets.[62]

## 2.2 Available sources

### 2.2.1 Literature review

Recycling of production wastes was identified as a resource efficiency measure by a few industry sustainability market reports looking at textiles circularity: Ellen Macarthur Foundation with IAS of 4, McKinsey & Company with IAS of 4, Institute of Positive Fashion with IAS of 3. However, the detail of this resource efficiency measure was predominantly found within academic papers.

A total of thirteen sources that were reviewed discussed this resource efficiency measure:

[56] Goyal et al (2020) Sustainability in Yarn Manufacturing. Available at: link
[57] Ute et al (2019) Utilization of Cotton Spinning Mill Wastes in Yarn Production. Available at: link
[58] Institute of Positive Fashion (2021) The Circular Fashion Ecosystem: A blueprint for the future. Available at: link
[59] McKinsey & Company (2020). Fashion on climate: How the fashion industry can urgently act to reduce its greenhouse gas emissions. Available at: link
[60] Workshop 1 Stakeholder Engagement
[61] WRAP (2023) Textiles Cost-Benefit Analysis. Available at: link
[62] Institute of Positive Fashion (2021) The Circular Fashion Ecosystem: A blueprint for the future. Available at: link

- four industry reports;[63,64,65,66]
- six academic papers;[67,68,69,70,71,72] and
- three policy documents.[73,74,75]

Most of these sources were of medium to high quality (IAS of 3-5 – average 4.0).

Several sources identified the resource efficiency measure concerning the yarn spinning process, either generally or for specific yarn types (cotton, wool). Sources were not always specific to the UK market, with technical data either not specifying geography or applying to Asian markets (e.g. India and Vietnam). However, figures were tested during the workshops with stakeholders relevant to the UK market. Both markets are hubs for textile manufacturing. There was a significant variation in resource efficiency data identified. Some sources highlighted that the quality of the yarn can be affected by the level of recycled content or type of yarn waste. This could explain variations in study data, particularly where they are undertaken in different geographies or producing different yarns.

Only one source from the Institute of Positive Fashion mentioned offcut repurposing and recycling (IAS of 3).[76] However, it was anticipated that from a technical perspective, leftover fabrics could be recycled through fibre-to-fibre recycling in a similar manner to post-consumer textiles.

As with Measure 3, it was also highlighted in the surveys by a stakeholder that there is a lot of innovation and best-practice techniques within fibre manufacturing and spinning that is not captured in academic literature. This is particularly relevant for waste generation levels, which are *“misreported in many academic publications and LCAs, due to lack of detailed industrial understanding of the supply chain dynamics.”*[77]

As such, supply-chain stakeholder engagement was deemed necessary to identify further data on Measure 2.

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[63] Ibid
[64] Elander, M. and Ljungkvist, H. (2016). Critical aspects in design for fiber-to-fiber recycling of textiles. Available at: link
[65] Ellen MacArthur Foundation (2017). A new textiles economy: Redesigning fashion's future. Available at: link
[66] Rengel, A. (2017). Recycled Textile Fibres and Textile Recycling. Available at: link
[67] Goyal et al (2020) Sustainability in Yarn Manufacturing. Available at: link
[68] Utilization of Cotton Spinning Mill Wastes in Yarn Production. Available at: link
[69] Bhatia, D. et al. (2014). Recycled fibers: An overview. Available at: link
[70] Russell, S. et al. (2016). Review of Wool Recycling and Reuse. Available at: link
[71] Bianco, I. et al (2022). Life Cycle Assessment (LCA) of MWool® Recycled Wool Fibers. Available at: link
[72] Subramanian, K. et al. (2021). An overview of cotton and polyester, and their blended waste textile valorisation to value-added products: A circular economy approach – research trends, opportunities and challenges. Available at: link
[73] McKinsey & Company (2020). Fashion on climate: How the fashion industry can urgently act to reduce its greenhouse gas emissions. Available at: link
[74] WRAP. Textiles Cost-Benefit Analysis. Available at: link
[75] UN Environment Programme (2020). Sustainability and Circularity in the Textile Value Chain - Global Stocktaking. Available at: link
[76] Institute of Positive Fashion (2021) The Circular Fashion Ecosystem: A blueprint for the future. Available at: link
[77] Pre-Workshop Survey Engagement.

### 2.2.2 Workshops

Relevant attendees who attended the first workshop and had knowledge of this measure included one fabric manufacturer, one clothing brand and one academic. Two additional academics with manufacturing expertise attended the second workshop. However, there was a lower proportion of stakeholders that attended workshops who had a strong understanding of manufacturing.

Stakeholders across brands, retailers, collectors, recyclers and academics all provided commentary on the measure. It was noted in the first workshop that the majority of fabric waste is currently sold on to other textile products (i.e. insulation, bedding and non-woven), rather than in recycling into the same products. This was noted due to the costs being lower to recycle into other applications rather than more “closed loop”. However, two industry stakeholders did identify that the development of mechanical and chemical fibre-to-fibre recycling would support recycled fibre generation for use in new products at the same time as the manufactured product i.e. clothing into clothing. An academic also noted that the UK has a smaller clothing manufacturing industry compared to the quantity of textiles it imports. This may mean such a measure has a lower resource efficiency impact in the context of clothing consumed.

## 2.3 Drivers & Barriers

### 2.3.1 Drivers

Table 7 shows the drivers identified for this measure. Those in bold denote that they had a greater number of votes stemming from the workshops when participants were asked to identify those of being of the highest significance. These are further discussed in detail below.

**Table 7: Drivers for textiles measure 2**

| Description | PESTLE | COM-B |
|---|---|---|
| **Improved connections between manufacturers and recyclers to funnel waste management**[78] | **Economic**<br>**Social** | **Opportunity – social** |
| Sorting and collection for recycling reduces landfill / incineration costs.[79] | Economic | Opportunity – psychological |
| Increasing interest in upcycled materials.[80] | Technological | Capability – physical |

78 Workshop 1 engagement.
79 Elander, M. and Ljungkvist, H. (2016). Critical aspects in design for fiber-to-fiber recycling of textiles. Available at: link
80 Workshop 1 engagement.

*Connection between manufacturers and recyclers*

The literature identified drivers focused solely on how waste materials are handled and participants in the workshops could not build upon these. However, there was some consensus that improved connections between manufacturers and recyclers was a key driver - manufacturers agreeing to provide end of line products to the sorting/recycling companies would increase recycling and potentially reduce costs.

### 2.3.2 Barriers

Table 8 shows the barriers identified for this measure. A range of barriers were identified in the literature review. Within the workshop, there was a lack of consensus as to which were most critical to the sector, with voting spread equally across all seven barriers.

**Table 8: Barriers for textiles measure 2**

| Description | PESTLE | COM-B |
|---|---|---|
| Lack of recycling technology, particularly for mixed fabrics.[81] | Technological | Capability – physical |
| Yarn recycling largely unexplored in practice and not yet at industrial scale.[82] | Technological | Opportunity – social |
| Lack of established market for production wastes.[83] | Economic | Capability – psychological |
| Recycling fabric back to fibre may often be unfeasible due to accessories/additives that are difficult to dissemble or compromise usability.[84] [85] | Technological | Capability – physical |
| Lack of coordination and exchange of information across textile value chain.[86] | Social | Capability – psychological |
| Lack of incentivisation of textile producers and training for employees on waste collection and reincorporation.[87] | Social | Capability – psychological |

[81] Elander, M. and Ljungkvist, H. (2016). Critical aspects in design for fiber-to-fiber recycling of textiles. Available at: link
[82] Ellen MacArthur Foundation (2017). A new textiles economy: Redesigning fashion's future. Available at: link
[83] Elander, M. and Ljungkvist, H. (2016). Critical aspects in design for fiber-to-fiber recycling of textiles. Available at: link
[84] Ibid.
[85] UN Environment Programme (2020). Sustainability and Circularity in the Textile Value Chain - Global Stocktaking. Available at: link
[86] Ellen MacArthur Foundation (2017). A new textiles economy: Redesigning fashion's future. Available at: link
[87] McKinsey & Company (2020). Fashion on climate: How the fashion industry can urgently act to reduce its greenhouse gas emissions. Available at: link

| | | |
|---|---|---|
| Woven fabric recycling is more complicated, resulting in yarns of poor recycling efficiency.[88] | Technological | Capability – physical |
| To date, costs to reincorporate are greater than recycling for use in, for example, insulation.[89] | Economic | Capability - psychological |

*Lack of recycling technologies*

It was identified that the lack of recycling technologies, particularly for mixed fabrics, was an issue. Specific issues with manufacturing waste recycling were identified:

- Yarn - while some yarn waste can be respun into fibres, one source stated that wider yarn recycling is largely unexplored;
- Woven fabrics – recycling is more complex and currently has poor yields; and
- Any fabrics that have accessories or additives disrupt recycling, where they are difficult to remove.

This results in a lack of market for production wastes, compounded by a lack of coordination and exchange of waste data necessary to build these markets and develop the necessary technologies for recycling.

## 2.4 Levels of efficiency

**Table 9: Levels of efficiency for textiles measure 2**

| Indicator: % of yarn and fabric/textile material waste reincorporated back into manufacturing | | | |
|---|---|---|---|
| **Level of efficiency** | Current | Maximum in 2035 | Business-as-usual in 2035 |
| **Percentage for Yarn** | >70% | >80% | >75% |
| **Evidence RAG** | Amber-Green | Red-Amber | Red |
| **Percentage for Fabric** | 0 – 10% | Not provided | 0 – 10% |
| **Evidence RAG** | Red | Red | Red |

88 Subramanian, K. et al. (2021). An overview of cotton and polyester, and their blended waste textile valorisation to value-added products: A circular economy approach – research trends, opportunities and challenges. Available at: link
89 Workshop 2 engagement

## 2.4.1 Current level of efficiency

### Yarn

In the literature, most data concerned the reincorporation of yarn waste, specifically natural fibres. For cotton yarn, figures ranged dramatically – from 3%[90] to 100%.[91]

These included evidence for the following aspects of the sector:

- 97%[92] for yarn's generally (IAS 4),
- 3% - 50%[93] (IAS 5, 20%, 25% and 45% all referenced) and 100%[94] (IAS 3) for cotton re-incorporation and 70% (IAS 3),[95] 80% (IAS 3);[96] and
- 100%[97] for wool re-incorporation (IAS' 4).

Many sources were reviewed to identify any differences in the recycling of different types of yarn in scope of the study (cotton, wool, polyester). Participants in the workshops highlighted that modern yarn spinning mills could have an overall yarn waste recycling rate of >98% - a mixture of re-spinning into fibres and sale of yarn waste to other industries such as the non-woven sector. This aligns with the 97% yarn re-utilisation figure from the literature.[98] No data on polyester yarn was identified in the literature or workshops.

There was good consensus between the literature and votes that wool and cotton yarn reincorporation was > 70% (most votes being cast for between 70 – 80% and >80%). Although, there was one vote for cotton yarn achieving between 30 – 40%. Thus, the evidence RAG rating has been defined as amber-green.

### Fabric

No specific data was found in the literature for any specific fabric types (e.g. woven, knitted, non-woven fabrics). It is understood that fabric waste from manufacturing can be recycled through the same means as that utilised for post-consumer textile waste, however, unlike yarn waste, it is hypothesised that there is little opportunity to reincorporate fabric waste in the manufacturing directly and that it must be sent for fibre-to-fibre recycling.

While some stakeholders said that some of this waste is sold to other industries, only one stakeholder commented quantitatively, stating a 5 – 10% recycling rate. As highlighted in the

[90] Ute, T.B. et al (2019). Utilization of Cotton Spinning Mill Wastes in Yarn Production. Available at: link
[91] Bhatia, D. et al. (2014). Recycled fibers: An overview. Available at: link
[92] McKinsey & Company (2020). Fashion on climate: How the fashion industry can urgently act to reduce its greenhouse gas emissions. Available at: link
[93] Ute, T.B. et al (2019). Utilization of Cotton Spinning Mill Wastes in Yarn Production. Available at: link
[94] Bhatia, D. et al. (2014). Recycled fibers: An overview. Available at: link
[95] Rengel, A. (2017). Recycled Textile Fibres and Textile Recycling. Available at: link
[96] Russell, S. et al. (2016). Review of Wool Recycling and Reuse. Available at: link
[97] Bianco, I. et al (2022). Life Cycle Assessment (LCA) of MWool® Recycled Wool Fibers. Available at: link
[98] McKinsey & Company (2020). Fashion on climate: How the fashion industry can urgently act to reduce its greenhouse gas emissions. Available at: link

barriers section, the lack of recycling technologies and markets for fabric waste would infer that there is little fibre-to-fibre recycling.

For fabric wastes, stakeholders identified that the recycling level depends on the end-market for the waste (i.e. fibre recycling into insulation/bedding would occur at higher rates than into clothing) and the types of polymer in the material (natural fibre recognition and recovery being easier than synthetic fabrics).

In the workshop, only a few stakeholders cast votes (one of which cited “clothing” – which was not the focus of the vote). However, all that were cast were in the range of 0 – 10%. Given the lack of literature and the strong reliance on stakeholder voting stemming from the workshop, the evidence RAG rating is red.

### 2.4.2 Maximum level of efficiency in 2035

No data was identified in the literature for the maximum levels of efficiency of yarn or fabric waste reincorporation.

#### Yarn

During the workshop, not all stakeholders voted on this measure, but all those who voted came to a strong consensus of >80% reincorporation rate of yarn waste (cotton, wool and polyester) for the maximum level of efficiency in 2035 with a red-amber evidence RAG rating.

#### Fabric

No votes were cast on fabric waste recycling. Given the lack of engagement on current levels of efficiency, stakeholders did not have the confidence to state how fabric waste recycling may change. Due to the numerous barriers identified, this has made it difficult to estimate and the evidence RAG rating is red.

### 2.4.3 Business-as-usual in 2035

#### Fabric

Very few votes were cast for the business-as-usual levels of efficiency and participants did not split their votes by yarn or fabric waste reincorporation. However, given the votes are in the range of 0 – 10% (which is far lower than the current efficiency for yarn recycling, it could be assumed that the voting is predominantly focused on fabric waste. If so, this would indicate that there will be little change between current and future fabric manufacturing waste recycling. However, given the lack of data across the three resource efficiency data points (current, maximum and BAU), this is uncertain and thus is a red evidence RAG rating.

#### Yarn

Yarn recycling (excluding that which occurs through re-spinning) was highlighted to be in its infancy in the barriers section. However, generally commentary from one stakeholder highlighted that this is improving. As such, we could hypothesis that, in the absence of interventions, yarn recycling rate increase slightly. As such, we propose a business-as-usual efficiency level of >75% - between current and maximum efficiency, but this is a red evidence RAG rating.

# 3.0 Measure 3 – Utilise Recycled Content from Textiles Waste

## 3.1 Textiles resource efficiency measure

### 3.1.1 Description

*The incorporation of reprocessed fibres in the manufacturing stage that have been sourced from textile waste, reducing primary raw material use.*

Utilisation of recycled content from textile waste replaces the need for virgin raw materials. This can currently be sourced through fibre-to-fibre recycling of textile waste or repurposing of existing textile material (linked to Measure 7). Levels of recycled content in products placed on the UK market, and thus resource efficiency, will be dependent on the ability to source these materials and utilise them in manufacturing in place of virgin raw materials.

### 3.1.2 Measure indicator

The indicator selected was the **percentage of fibre sourced from waste recycling, for use in new textiles**. This is a relative measure with the percentage derived from the total amount of fibre coming from the recycling of waste materials, divided by the total amount of fibre used in textile manufacturing.

One indicator that was not selected was the proportion of recycled materials sourced from other wastes (open loop recycling). This is quoted in the literature, as most recycled materials in textiles come from other sources. For example, approximately 15% of the global polyester market is recycled polyester, the majority of which is produced from PET bottles.[99] However, this does not incentivise the development of fibre-to-fibre recycling (closed loop recycling), reducing the circularity of the textiles sector. As such, while a referenced measure for resource efficiency, it was not chosen.

Another indicator discarded was the % of other "circular" materials – i.e. not only recycled materials but also those sourced from biodegraded/composted materials. It is possible to generate new natural materials through biodegradation/composting of textile waste products – which avoids resources from being lost to landfill or incineration.[100] No information was identified in the literature or through stakeholder engagement on the utilisation of biodegraded/composted outputs in new textiles, aside from yields of new crops that do not directly link to textile crops. As such, this element of the resource efficiency indicator was not included as there was no data to base any modelling on. However, as further knowledge is developed on the applicability of biodegradation/composting to produce new fibres, it may be

[99] Textile Exchange (2022) Preferred Fiber & Materials Market Report. Available at: link
[100] Jeanger, P. et al. (2022). A Review on Textile Recycling Practices and Challenges. Available at: link

that this can either be incorporated within this resource efficiency measure or as a measure of its own.

### 3.1.3 Examples in practice

There are a few ways in which recycled content is sourced:

- Utilise recycled material from textiles. Textile fibres or material can be sourced from several recycling methods, as detailed in Measure 7. While there is significant ambition for this form of sourcing, the technology is not widely commercialised. As such, most recycled materials come from other sources i.e. recycled polyester from PET bottles.
- Utilise materials generated through biodegradation/composting of textiles. In some literature sources, the scope of recycling includes the biodegradation/composting of textile waste. [101],[102]

It is important to note that the focus here has been on recycled content, rather than the replacement of virgin materials with other "more sustainable" virgin materials. There is significant debate concerning the "sustainability" of different fibres. For example, natural vs synthetic. Currently – there is no agreement across policy, industry or NGOs on what constitutes a sustainable fibre and through what tools this can accurately be measured without potential unintended consequences. While this is certainly a very important aspect of textile sustainability, it cannot yet be considered from a resource efficiency perspective and thus is not in scope for this review.

## 3.2 Available sources

### 3.2.1 Literature review

This measure was identified as part of Workshop 1, following the literature review. A subsequent review of literature did not identify many sources identifying data relevant to this resource efficiency measure. Most sources discuss recycling (Measure 7), rather than sourcing of the subsequent recycled content. The Ellen MacArthur Foundation report (IAS 4) identifies that only 1% of clothing is recycled into new clothing - linking recycling with actual utilisation of the resulting outputs in textile manufacturing.[103] A Changing Markets Foundation report (IAS 3) discussed fibre recycling of carpet.[104] A few sources (IAS 3 & 4) also identified the biodegradation/composting of textiles – but these sources did not link this particularly to the sourcing/generation of new materials.

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[101] Jeanger, P. et al. (2022). A Review on Textile Recycling Practices and Challenges. Available at: link
[102] The Guardian (2023) Bras fit for burying: Australia to set a world-first standard for composting textiles. Available at: link
[103] Ellen MacArthur Foundation (2017). A new textiles economy: Redesigning fashion's future. Available at: link
[104] Changing Markets Foundation (2019) Smoke and Mirrors. Exposing the reality of carpet "recycling" in the UK. Available at: link

### 3.2.2 Workshops

This resource efficiency measure was proposed by one of the stakeholders in the survey & reiterated in the first workshop, to connect Measure 7 (textile recycling) with incorporation in new textile products. As such, general comments on the measure and the current, maximum and business-as-usual efficiencies were all captured in Workshop 2.

The measure received a high level of engagement, with commentary across a number of types of stakeholder including retail (traditional, charity and circular), local authority, collection and sorting, recycling, NGO, academia and trade association. The updated measure was well received, with stakeholders identifying several drivers and barriers.

## 3.3 Drivers & Barriers

### 3.3.1 Drivers

Table 10 shows the drivers identified for this measure. Those in bold denote that they had a greater number of votes stemming from the workshops when participants were asked to identify those of being of the highest significance. These are discussed in more detail below.

**Table 10: Drivers for textiles measure 3**

| Description | PESTLE | COM-B |
|---|---|---|
| **Brand commitments to recycled content and decarbonisation targets.** [105,106] | **Social** | **Opportunity – social** |
| Consumer awareness, preference & pressure for sustainable products.[107] | Social | Opportunity – psychological |
| Some technologies are already established, they just need to be scaled up. Emerging technologies are also on the brink of commercialisation, and once they are fully mature, will enable fibre-to-fibre recycling. [108] | Technological | Capability – physical |

*Brand commitments*

[105] Textile Exchange (2022). The 2025 Recycled Polyester Challenge was designed to accelerate change. Available at: link
[106] Workshop 2 engagement
[107] Ibid.
[108] Ibid.

It was clear through voting that the key driver to utilisation of recycled content are brand commitments to recycled materials usage and decarbonisation in their supply chains.[109]

*Consumer awareness*

There is also growing consumer awareness/preference and thus pressure for more sustainable products.

*Technological readiness*

Finally, incorporation of recycled content is only possible where it can be produced. Some emerging technologies are already established, they just need to be scaled up and commercialised. Once they are fully mature, they will enable fibre-to-fibre recycling and will be a core driver for the industry to access recycled materials.

### 3.3.2 Barriers

Table 11 shows the barriers identified for this measure. Those in bold denote that they had a greater number of votes stemming from the workshops when participants were asked to identify those of being of the highest significance. These are further discussed below.

**Table 11: Barriers for textiles measure 3**

| Description | PESTLE | COM-B |
|---|---|---|
| **Lack of recycled materials from textile due to a lack of systems and infrastructure.[110]** | **Technological** | **Capability – physical** |
| **Need sufficient recycled material to replace virgin material.[111]** | **Technological** | **Capability – physical** |
| **Lack of cost-competitiveness compared to virgin materials. [112]** | **Economic** | **Motivation – automatic** |
| Lack of due diligence to check recycled content claims are robust.[113] | Legal | Opportunity – social |
| Lack of scaling & investment for infrastructure evolution. [114] | Technological<br>Economic | Capability – physical |

[109] Textile Exchange (2022). The 2025 Recycled Polyester Challenge was designed to accelerate change. Available at: link
[110] Workshop 2 engagement
[111] Ibid
[112] Ibid
[113] Ibid
[114] Ibid

| | | |
|---|---|---|
| Lack of policy to drive demand for recycled content (e.g. textiles EPR, recycled content targets).[115] | Political | Motivation – automatic |
| Different locations of recyclers and manufacturers – mostly the textile products consumed are not manufactured in the UK. [116] | Technological | Capability – physical |
| Recycled materials are in the main are considered as waste and a lot of the countries that manufacture in will not import it.[117] | Legal | Motivation – automatic |
| Growing consumption of "cheap" clothing that cannot be recycled.[118] | Economic<br>Technological | Opportunity – psychological |
| City and country level targets and/or legislation.[119] | Legal | Motivation – automatic |

*Lack of systems and infrastructure*

Despite the capability in some cases of fibre-to-fibre recycling technologies, the lack of systems and infrastructure (e.g. automated sorting, facilities for different fibre types, etc.) is currently acting as a barrier to accessing recycled content. This lack of scaling also impacts cost. Significant demand and more costly processes will increase the cost of recycled materials in comparison to virgin, another barrier to uptake.

Stakeholders highlighted that, linked to this lack of capacity, there is no scaling or investment strategy in place to develop the necessary systems for fibre-to-fibre recycling processes for different fibres to match fibre consumption volumes.

*Lack of incorporation of recycled materials*

Another identified barrier is that to use recycled content, it needs to be incorporated during manufacturing. The UK has a manufacturing sector, but a large proportion of the products the UK consumes are imported. It will either be necessary to increase local manufacturing, or to ship recycled materials to manufacturing geographies – which can be complicated by differences in waste import legislation. Recycled materials are considered as waste and a lot of the countries that manufacture textiles will not import recycled materials. Given end-of-waste criteria do not exist for textiles, it is not yet clear how shipments of recycled fibre will be treated and this could vary between countries.

*Lack of supportive legislation*

[115] Ibid
[116] Ibid
[117] Ibid
[118] Ibid
[119] Ibid.

Finally, the lack of supportive legislation – for example EPR – is seen as a barrier due to not driving enough demand for recycled content and support to the waste management sector to develop recycling capability and capacity. Other policies that are currently not in place, but could help drive demand for recycled content, would be recycled content targets and eco-design. Without these policies in place, uptake will be slow.

# 3.4 Levels of efficiency

**Table 12: Levels of efficiency for textiles measure 3**

| Indicator: % of fibre sourced from waste recycling, for use in new textiles | | | |
|---|---|---|---|
| **Level of efficiency** | Current | Maximum in 2035 | Business-as-usual in 2035 |
| **Percentage for Clothing, bedding** | 1% | Not available | 0 – 10% |
| **Evidence RAG** | Green | Not applicable | Red-Amber |
| **Percentage for Carpet, curtains** | 1% | Not available | Not available |
| **Evidence RAG** | Red-Amber | Not applicable | Not applicable |

## 3.4.1 Current level of efficiency

A number of participants quoted that currently less than 1% of textile waste is recycled and utilised in new textile products. This is corroborated by the literature, which identifies that in the UK only 3% of separately collected material is recycled (only 1% of textiles disposed of) – typically into other applications such as wipers and insulation.[120] For clothing specifically, the Ellen MacArthur Foundation report (IAS 4) identified that <1% of clothing is recycled into new clothing.[121]

On voting, all participants voted for the percentage being <5%, stated especially by stakeholders for clothing and household textiles (assumed to be bedding). Therefore, a figure of 1% can be stated with green evidence RAG rating. It is also reasonable to suggest that <1% of curtain textile is recycled content, due to the lack of fibre-to-fibre recycling of household textiles.

No data was provided by stakeholders concerning carpets and curtains. However, one source identified that most of the carpet recycling (85%) was into “equestrian” uses (IAS 3).[122] Only

[120] WRAP (2019) Textiles Market Situation Report 2019. Available at: link
[121] Ellen MacArthur Foundation (2017). A new textiles economy: Redesigning fashion’s future. Available at: link
[122] Changing Markets Foundation (2019) Smoke and Mirrors. Exposing the reality of carpet “recycling” in the UK. Available at: link

2% was recycled into fibre, with *“an even smaller amount recycled into a high-quality product, as opposed to being downcycled”*. It is reasonable to suggest, therefore, that <1% of carpet material is recycled content from carpet waste. However, this is with red-amber evidence RAG rating as it is only based on one literature source.

### 3.4.2 Maximum level of efficiency in 2035

Stakeholders commented that recycling technologies are developing and will be driven by recycled fibre demand. This could mean higher levels of recycled content will be possible – with one figure of 80% quoted if proper scale-up and investment is put in place.

On voting, however, results were mixed, one voting for 5 – 10%, another for 10 – 15% and three for >20% (one highlighting 80%). Four votes were cast for “Don’t know”. This difference of opinion means that a figure for maximum levels of efficiency cannot be highlighted. It was identified by one stakeholder that providing such data for current, maximum and business-as-usual would be dependent on the availability of waste by application, as well as an accurate understanding of the fibre mix and recycling needs.

No data was found in the literature or through the workshops on carpet or curtains.

### 3.4.3 Business-as-usual in 2035

Figures quoted in the discussion related to recycling rates – quoting 50% and 70% - with caveats that national plans on scaling recycling and/or scale-up and investment would be necessary to deliver these high percentages. However, on voting – most votes were cast between <5% and 5 – 10%. Two votes were cast on 15 – 20%. It can be said, with a red-amber evidence RAG rating, therefore, that the efficiency in a BAU scenario is 0 – 10%.

No data was found in the literature or through the workshops on carpet or curtains that allow a business-as-usual figure to be developed. There is the option that the business-as-usual increase that has been found for clothing and bedding could be applied to carpet and curtains with a red evidence RAG rating. However, we would be reluctant to do so since there is no evidence to suggest how recycled content availability might change for these products in future.

# 4.0 Measure 4 – Utilise Rental & Product-as-a-Service Consumption Models

## 4.1 Textiles resource efficiency measure

### 4.1.1 Description

*The increase in uptake of rental or products-as-as-service business models by consumers, reducing consumption and increasing individual product lifetimes.*

Most consumers purchase brand new products and own these products outright. This model can lead to high consumption levels for certain parts of the sector, such as clothing, linens and bedding, as consumers seek to purchase more items than their daily needs to provide greater choice and flexibility. It also means that items may not be utilised to their fullest extent before they are discarded.

Circular Economy Business Models (CEBMs) are alternative business models whereby economic value is driven by keeping products and materials in use for as long as possible. This increases the utilisation (wears) of each individual product when compared to the linear business model. In the context of Measure 4, this relates to models whereby the ownership of the products remains with the producer or a third-party retailer. This delivers resource efficiency by reducing the resources needed to achieve the same utility (e.g., less clothing needing to be manufactured) and ensures less waste being generated.

### 4.1.2 Measure indicator

The indicator selected was **the percentage reduction in consumption of new products through rental, hiring and subscription services**. This is calculated as the total tonnage of consumption in a given year, multiplied by the % reduction in consumption due to the uptake of CEBMs and divided by the total tonnage.

Other identified indicators included the % increase is product lifetime and % share of the market but these were not selected because they do not relate directly back to how much resource efficiency is improved from a tonnage perspective.

### 4.1.3 Examples in practice

Other CEBM's include reuse and repair (see Measures 5 and 6). Examples of rental and products-as-a-service business models are evident in the market currently but are restricted to certain products. These include:

- Rental, Sharing and Clothing Libraries:[123] These tend to focus on shorter-term hire for expensive, infrequently worn items (e.g., single-use suit hire). Rental is the most

[123] Norman, J. et al. (2021). Resource efficiency scenarios for the UK: A technical report. Available at: link

common business model, which is seen with occasion wear, predominantly men's and baby clothes. For example, a participant at the workshops in the circular retail industry evidenced that their circular business model offers high end garments that are now over 25 years old and have been rented over 80 times.[124] Sharing and clothing libraries allow either business-to-consumer or consumer-to-consumer utilisation of clothing.

- Subscription Models:[125] These services are typically deployed where frequent changes of products are needed by the consumer (e.g., baby clothes which are outgrown).
- Leasing:[126] The final business model is the use of leasing. This tends to happen in the commercial sector, for example, leasing of linen and bedding products.

# 4.2 Available sources

## 4.2.1 Literature review

Limited evidence was observed in the literature relating to the resource efficiency impacts associated with displacing new products and quantifying the extended lifetime of products due to rental and products-as-a-service. A total of 10 of the sources discussed this resource efficiency measure. These included:

- seven industry reports;[127],[128],[129],[130],[131],[132],[133]
- two academic papers;[134],[135] and
- one policy documents.[136]

These sources related almost exclusively to clothing.

While the number of relevant sources was limited, the literature was deemed to be both applicable and credible when assessed against the data assessment framework. The sources exhibited an average IAS score of 3.9, with seven sources exhibiting a score of 4 or above. Three of the sources were focussed on the UK market, while two further sources were based

124 Workshop 1 engagement
125 McKinsey & Company (2020). Fashion on climate: How the fashion industry can urgently act to reduce its greenhouse gas emissions. Available at: link
126 Maldini, I. and Balkenende, A.R. (2017). Reducing clothing production volumes by design: a critical review of sustainable fashion strategies. Available at: link
127 Norman, J. et al. (2021). Resource efficiency scenarios for the UK: A technical report. Available at: link
128 Institute of Positive Fashion (2021) The Circular Fashion Ecosystem: A blueprint for the future. Available at: link
129 Ellen MacArthur Foundation (2017). A new textiles economy: Redesigning fashion's future. Available at: link
130 ECOS (2021) Durable, repairable and mainstream: How ecodesign can make our textiles circular. Available at: link
131 Ellen Macarthur Foundation (2021) Circular business models: redefining growth for a thriving fashion industry. Available at: link
132 WRAP (2017) Valuing our clothes: The Cost of UK Fashion. Available at: link
133 McKinsey & Company (2020). Fashion on climate: How the fashion industry can urgently act to reduce its greenhouse gas emissions. Available at: link
134 Maldini, I. and Balkenende, A.R. (2017). Reducing clothing production volumes by design: a critical review of sustainable fashion strategies. Available at: link
135 Oslo Metropolitan University (2022) Review of Clothing Disposal Reasons. Available at: link
136 WRAP. Textiles Cost-Benefit Analysis. Available at: link

on Europe and one on the US and globally, meaning that most of the figures can be deemed applicable to the UK market. Most quantitative data related to this measure focussed on the global market size and one focused on the increase in lifetime. However, there was no identified quantitative data on how this corresponded to an increase in resource efficiency.

### 4.2.2 Workshops

Although there were no significant comments surrounding this measure in the surveys, two participants highlighted that they agreed with the suggested indicator.

During the workshops, this measure received significant levels of engagement and was the most discussed measure in both workshop sessions. Contributions were from various stakeholders, particularly from retailers, trade associations, academia and NGOs.

One participant from the charity retail sector indicated that although a reduction in consumption was a relevant indicator, rental services are a minor part of circular business models (i.e., compared to the second-hand reuse sector) for delivering resource efficiency. Thus, the impact of this measure was questioned.

Participants provided qualitative feedback on the displacement rate and increased lifetime but did not necessarily have the knowledge to provide accurate quantitative data that they were confident with.

## 4.3 Drivers & Barriers

### 4.3.1 Drivers

Table 13 shows the drivers identified for this measure. Those in bold denote that they had a greater number of votes stemming from the workshops when participants were asked to identify those of being of the highest significance. These are further discussed below.

**Table 13: Drivers for textiles measure 4**

| Description | PESTLE | COM-B |
|---|---|---|
| **Design for durability can facilitate rental models due to longer lasting products.**[137] | **Technological**<br>**Social** | **Motivation – reflective** |
| Growing consumer interest in rental/hire services due to affordability, environmental awareness, convenience and ability to meet latest fashion trends.[138,139] | Environmental<br>Economic<br>Social | Opportunity – social |

[137] Ellen MacArthur Foundation (2017). A new textiles economy: Redesigning fashion's future. Available at: link
[138] Ibid.
[139] Institute of Positive Fashion (2021) The Circular Fashion Ecosystem: A blueprint for the future. Available at: link

| | | |
|---|---|---|
| Gathering of direct valuable customer information[140] | Technological | Capability – psychological |
| Higher margins can be achieved by retailers due to products being cycled several times, with the potential for consumer cost benefit in some instances also. [141] | Economic | Motivation – reflective |
| Cost benefit to the consumer to rent something for a short period of time, rather than buying.[142] | Economic | Motivation – automatic |

*Growing consumer awareness*

Rapid growth in the rental and product-as-a-service sector is already being observed due to greater consumer awareness and engagement.[143] There are several reasons and customer niches for these models:

- These services allow consumers to affordably remain up to date with the latest fashion trends. There is a cost benefit to the consumer to rent something for a short period of time, rather than buying.
- The rental sector has the potential to become a more attractive and accessible option to environmentally conscious consumers who are aware of the impacts of textiles on the environment and are seeking to avoid 'fast fashion'.[144]
- Rapid growth in clothing rental services is found in young consumers and city dwellers, due to improved availability and convenience.[145]

*Higher margins for retailers*

From a retailer perspective, product-as-a-service models can lead to higher margins on a product compared to a linear business model if a product is cycled ten times, for example, rather than two or three.[146] As an additional benefit for retailers, rentals can enable companies to gather valuable customer information directly, such as how consumers buy and use products. This information can be used to improve products and services through feedback loops to product manufacturing departments, generating improvements to boost durability.[147]

*Design for longevity and durability*

From a design perspective, a key element in supporting circular economy business models is design for longevity. Currently, 37% of clothing[148] is discarded due to durability issues and individual improved design elements can help to increase product lifetime. These include the

[140] Ellen MacArthur Foundation (2017). A new textiles economy: Redesigning fashion's future. Available at: link

[143] Institute of Positive Fashion (2021) The Circular Fashion Ecosystem: A blueprint for the future. Available at: link
[144] WRAP. Textiles Cost-Benefit Analysis. Available at: link
[145] Norman, J. et al. (2021). Resource efficiency scenarios for the UK: A technical report. Available at: link
[146] Ellen MacArthur Foundation (2017). A new textiles economy: Redesigning fashion's future. Available at: link
[147] Institute of Positive Fashion (2021) The Circular Fashion Ecosystem: A blueprint for the future. Available at: link
[148] Oslo Metropolitan University (2022) Review of Clothing Disposal Reasons. Available at: link

use of more durable yarn and fabric manufacturing processes as well as product assembly manufacturing techniques. [149],[150],[151] It is complex to quantitatively identify the direct impact of these measures on resource efficiency, but WRAP's "Valuing Our Clothes" report provides estimates of the carbon, water and waste reductions as a result of extended product lifetime.[152] However, the design for durability needs to be balanced with design for recyclability, as previously highlighted. In summary, design for durability is both a driver and a consequence of this measure. Increased focus on longevity facilitates rental models, which in turn give brands more incentives to design for durability.

*Affordability of rental to consumers*

The affordability of rental is also a core driver. If consumer engagement increases, economies of scale can come into play, reducing costs.

### 4.3.2 Barriers

Table 14 shows the barriers identified for this measure. Those in bold denote that they had a greater number of votes stemming from the workshops when participants were asked to identify those of being of the highest significance. These are further discussed below.

**Table 14: Barriers for textiles measure 4**

| Description | PESTLE | COM-B |
|---|---|---|
| **Lack of supporting policies, such as reduced or no VAT or textiles EPR.**[153] | **Political** | **Motivation – automatic** |
| **Renting is not always significantly cheaper than buying new, due to the availability and low cost of fast fashion.** [154] | **Economic** | **Motivation – automatic** |
| **Requirement to restructure business models and invest in circular systems.**[155] | **Social** | **Capability – psychological** |
| **Durable design might impact the ability to recycle/design for recycling (Measure 7 – recycle post-consumer textiles).**[156] | **Technological** | **Capability – physical** |

[149] ECOS (2021) Durable, repairable and mainstream: How ecodesign can make our textiles circular. Available at: link
[150] Oslo Metropolitan University (2022) Review of Clothing Disposal Reasons. Available at: link
[151] WRAP. Textiles Cost-Benefit Analysis. Available at: link
[152] Based on lifetime extension of 9 months for 50% of UK clothing
[153] Workshop 2 engagement
[154] Ibid.
[155] McKinsey & Company (2020). Fashion on climate: How the fashion industry can urgently act to reduce its greenhouse gas emissions. Available at: link
[156] WRAP (2023) Textiles Cost-Benefit Analysis. Available at: link

| | | |
|---|---|---|
| Rental and re-commerce models require new logistical capabilities.[157] | Technological | Capability – physical |
| Requires consumer participation, including overcoming the fear of damaging an item and costly cleaning and repair work.[158] | Social | Opportunity – social |
| Requires investment in garment care technologies.[159] | Technological | Capability – physical |
| Emotional connection of consumers with clothing – consumers desire to own clothing.[160] | Social | Opportunity – psychological |
| Only feasible for some products, e.g., kids clothing, occasion wear.[161] | Social | Capability – psychological |
| Lack of consumer awareness of alternative options to ownership.[162] | Social | Motivation – automatic |

*Lack of supporting policies*

Stakeholders mentioned the lack of supporting policies to promote this measure. VAT is currently being paid multiple times on the resale and reuse of textiles. Stakeholders suggested reduced (or removed) VAT for these models to be more competitive with outright purchasing.

*Availability of fast fashion and e-commerce*

The accelerated consumption of fast fashion and ease of e-commerce means that it is not always cheaper or more convenient for consumers to utilise rental, hiring or subscription services. Because of this, the market saturation of rental and product-as-a-service models is low and currently only utilised for specific product types.

*Requirement to restructure business models*

To move into the market, brands and retailers may need to restructure their business models and invest in necessary circular systems (i.e., garment care, product tracking) to deliver an attractive and viable service that can compete with purchasing products outright.

*Desire to own products*

[157] McKinsey & Company (2020). Fashion on climate: How the fashion industry can urgently act to reduce its greenhouse gas emissions. Available at: link
[158] Workshop 2 engagement
[159] Workshop 2 engagement
[160] Ibid.
[161] Ibid.
[162] Ibid.

Due to the emotional attachment element and the desire to own clothing, the growth of CEBM's will be inhibited as the market currently stands. For day-to-day items that consumers will want to use long-term, it will likely be cheaper and more convenient to own the product outright than to rent a product where there is a risk of damaging the item and having to pay an additional amount for cleaning or repair work.

## 4.4 Levels of efficiency

**Table 15: Levels of efficiency for textiles measure 4**

| Indicator: % reduction in consumption of new products through rental, hiring and subscription services | | | |
|---|---|---|---|
| **Level of efficiency** | Current | Maximum in 2035 | Business-as-usual in 2035 |
| **Percentage** | 2% | 9% | 5% - 9% |
| **Evidence RAG** | Green | Amber | Red-Amber |

### 4.4.1 Current level of efficiency

There was a consensus in the literature that rental services currently comprise only a small proportion of the global clothing market (0.75%[163] - 2%[164],[165]), with subscription services an even smaller proportion (0.2%). The literature also indicated that these business models can currently increase the average utilised lifetime of clothing by up to 80% more than if the items were purchased via a linear business model.[166] It can be assumed that the presence of these business models will be driving the reduction in consumption of new products, however, there was no quantitative data to evidence this.

The workshop engagement indicated that there was no widespread expertise on the topic from the attendees and many participants selected 'did not know' when asked about the current level of efficiency. However, there was strong consensus among those who did vote that the current level of reduction in consumption was <2%, with one circular retailer commenting that it was <10%. Participants from retail and trade associations commented that the services are currently only utilised for niche product types, such as occasion wear and baby clothes.

This corroboration between data from the literature and workshops means that the current displacement of new products through Measure 4 can be estimated at <2% with a green evidence RAG rating.

[163] Ellen Macarthur Foundation (2021) Circular business models: redefining growth for a thriving fashion industry. Available at: link
[164] Norman, J., *et al.* (2021) Resource efficiency scenarios for the UK: A technical report. Available at: link
[165] McKinsey & Company (2020). Fashion on climate: How the fashion industry can urgently act to reduce its greenhouse gas emissions. Available at: link
[166] McKinsey & Company (2020). Fashion on climate: How the fashion industry can urgently act to reduce its greenhouse gas emissions. Available at: link

However, this figure is only applicable to clothing and should not be applied to the other products in scope. All the literature and engagement in the workshop was in reference to clothing items, particularly occasion wear. It is less likely that the other products in scope would be rented. For example, fitted carpets are built into the buildings and are removed once they deteriorate, so would not be suitable for a return, repair and reuse business model. The same applies to bedding where individuals will not be inclined to rent bedding for hygiene reasons i.e., bedding is more likely to be soiled. The main scenario where this is more likely to happen is on a commercial scale, but no evidence was found in the literature to quantify this confidently. This was echoed in the workshops where a participant from academia voiced that a sector wide rate would not be meaningful due to the variation by product type. Therefore, it has been impossible to provide commentary on products in scope other than clothing.

### 4.4.2 Maximum level of efficiency in 2035

The data in the literature ranges and refers to various markets and timeframes. Sources agree that the market share could grow to reach between 3% - 10%, by 2030[167],[168],[169] with reference to both the US, the EU and the UK. The UK focused report has the highest IAS value of 5. However, further sources indicated that ambitious scenarios could reach 21% or 27% market share by 2050 in the UK.[170] These scenarios assumed that 30% of the average wardrobe could be rented out. However, the assumptions that 70% and 90% of people would rent out 30% of their clothes,[171] which in turn grow the market share of the sector to 21% and 27% respectively, seems less realistic, but provides an explanation to the unusually high figures compared with the rest of the literature. The source stating the ambitious values has an IAS score of 3 (despite it being geographically relevant). It can be assumed that the increase in market share of rental will drive a reduction in consumption, although no quantitative value was found in the literature.

It is important to contextualise the maximum level of efficiency in this case. While it is theoretically and technically feasible for consumption of all products to be delivered through rental and product-as-a-service models – it is reliant on consumer preference, acceptance and uptake to deliver resource efficiency. As highlighted in the workshops, while some products are suited to consume through these systems (suiting, occasion wear etc), others are not.

No consensus was reached at the workshops, with votes evenly spread over options covering 0%-2%, 2%-5%, 8%-11%, 11%-15% and >15%. Although some participants from academia, trade associations and the recycling industry indicated that certain drivers had the potential to grow the sector, while others from the retail sector remain sceptical about its potential. Furthermore, a charity retailer indicated in the survey that the rental sector has not demonstrated the potential to scale up significantly.

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[167] McKinsey & Company (2020). Fashion on climate: How the fashion industry can urgently act to reduce its greenhouse gas emissions. Available at: link

[168] Ellen Macarthur Foundation (2021) Circular business models: redefining growth for a thriving fashion industry. Available at: link

[169] WRAP (2017) Valuing our clothes: The Cost of UK Fashion. Available at: link

[170] Norman, J., *et al.* (2021) Resource efficiency scenarios for the UK: A technical report. Available at: link

[171] Ibid

With literature indicating that the market share will increase, it can confidently be assumed that the maximum level of efficiency is greater than the current level. In the absence of a clear consensus, a mid-point of 9% can be taken, with an amber evidence RAG rating.

Participants from the retailer and recycling sector indicated that EPR and the correct media will drive the increase, but there is susceptibility surrounding the actual impact rental models really could have on the reduction in consumption.

### 4.4.3 Business-as-usual in 2035

There was no agreed consensus in the workshop, which saw participants' opinions split across four options ranging from 0% to >15%. As with the maximum level, it can be assumed that the level will increase with the market share, but the lack of consensus means that a mid-point range of 5%-9% can be taken with red-amber evidence RAG rating. This reflects a relatively large increase from the current efficiency level.

Participants from a local authority partnership and a retailer indicated this could be attributed to increased consumer awareness and decreasing costs but is almost the same as the maximum identified efficiency level. Regardless of which participants voted, most of the votes indicate that the BAU will reach a close level to the max. For example, those who voted for a higher BAU scenario, also voted for a higher maximum scenario, in line with the trend shown in the final selected values.

# 5.0 Measure 5 – Resell/Reuse of Unsold Stock and Second-Hand Products

## 5.1 Textiles resource efficiency measure

### 5.1.1 Description

*The direct resale of unsold stock and second-hand products, resulting in a reduction in consumption of new products and increasing individual product lifetime.*

Once products are manufactured, a key method to increasing resource efficiency is to maximise their utilisation. There will be proportion of product stocks that go unsold. Identifying reuse markets for these products will minimise waste generation by avoiding the proportion of material that goes to landfill or incineration.

However, most products placed on the market are sold to a consumer. When a consumer no longer wants them, resale and reuse of these second-hand goods is strongly preferred to recycling to avoid the "waste" of generating a product that has not been used, thereby increasing resource efficiency. In instances where the product is damaged and not suitable for reuse, the best option is likely to be recycling (see Measure 7).

### 5.1.2 Measure indicator

The indicator selected was the **percentage reduction in consumption of new products through clothing reuse**. Other indicators considered included the percentage increase is product lifetime, the percentage share of the product retail market that is reused and the percentage of products unsold that are disposed of.

Product lifetime indicators, while an important aspect, do not necessarily equate to greater resource efficiency – consumers can buy new products through reuse and use them, but continue to buy new products at the same rate. Indicators on levels of unsold stock that are disposed of only consider an aspect of this resource efficiency measure.

### 5.1.3 Examples in practice

The resale sector in the UK is already well established for clothing, with resale platforms present for multiple sales channels. Examples of resale business models are extensive, with multiple examples. These include:

- Domestic Reuse: Domestic reuse can take place in the form of charity or commercial resale. In the UK, around 31% of textiles are reused via charity shops and 2% is sold via second hand commercial outlets.[172]

[172] WRAP (2021). Textiles market situation report 2019. Available at: link

- Export for Reuse: A large proportion of reuse from the UK market is through export (60%[173]), where clothing is graded and sent to various markets depending on its grade, although there is a lack of clarity as to the true end-use of some exported products. Some NGO sources and discussions[174] have intimated that a large proportion of reuse sent to export markets is not actually reused and goes to disposal. However, this is disputed by reuse organisations. Although this is only one example and its veracity as a source was questioned, it identifies the need for quality reuse opportunities, not only to increase product utilisation but also to reduce unintended social and environmental effects.

- Peer-to-peer resale:[175] Recent years have seen a drastic increase in the number of online peer-to-peer sales platforms breaking into the market, further enabling participation outside of traditional retail settings. This increases product utilisation and can be in place of consumers purchasing a new product. Resale can be further supported through the provision of product and care information made readily available via digital product passports on labels.[176]

There is little detail on examples of reuse for other textile products in scope (carpet, bedding, curtains).

Reuse of unsold stock can occur via the domestic market and export for reuse. However, the generation of unsold stock can be reduced in the first instance through the reduction in overproduction through greater efficiencies in manufacturing practices (Measures 1 and B) and demand planning. Minimising returns will also reduce the generation of unsold stock at the retail stage where it is seen that the return rate for e-commerce clothing reduces from 35%[177] to around 1% for companies who produce customised mass garments[178]. There is no data for other products in scope.

## 5.2 Available sources

### 5.2.1 Literature review

The extension of product lifetime and associated potential to reduce the consumption of new products via reuse is well acknowledged to increase resource efficiency through the displacement of new products, but few studies were able to provide actual quantitative data on the topic. A total of 16 sources discussed this resource efficiency measure, this included:

[173] Ibid
[174] Lorenz, J. (2020) Decolonising Fashion: How an Influx of 'Dead White Man's Clothes' is Affecting Ghana. Available at: link
[175] QSA Partners (2022) QSA's pioneering displacement methodology helps DEPOP prove its role in reducing climate impact of fashion. Available at: link
[176] EON (2022) Industry Aligned Action Plan: Digital ID to scale Circular Systems. Available at: link
[177] McKinsey & Company (2020). Fashion on climate: How the fashion industry can urgently act to reduce its greenhouse gas emissions. Available at: link
[178] Larsson, J., Peterson, J., & Mouwitz, P. (2010). One-piece fashion, summary of the Knit-on-Demand project. Available at: link

- six industry reports,[179],[180],[181],[182],[183],[184]
- five website articles; [185],[186],[187],[188],[189]
- three policy documents,[190],[191],[192]
- one academic paper;[193] and
- one technical study.[194]

The relevant sources are considered relatively applicable and credible when assessed against the data assessment framework. The sources exhibited an average IAS score of 4.05, with 16 sources exhibiting a score of 4 or above. Eight of the sources were based on the UK market, while four further sources were based on Europe or the EU, meaning that most of the figures can be deemed applicable to the UK market.

### 5.2.2 Workshops

This resource efficiency measure received a high level of engagement in both workshops, with the most interaction observed in the first workshop. Contributions arose from a range of stakeholders, particularly from retailers, trade associations and academia and in the first workshop, a recycler. The measure was well received, with participants keen to demonstrate their knowledge of the sector and provide quantitative examples of reuse and displacement rates they were aware of. The participants were also well placed to discuss the drivers and barriers behind this sector, where a lot of engagement was observed.

179 WRAP (2021). Textiles market situation report 2019. Available at: link
180 McKinsey & Company (2020). Fashion on climate: How the fashion industry can urgently act to reduce its greenhouse gas emissions. Available at: link
181 ThredUp (2022) 2022 Resale Report. Available at: link
182 Changing Markets Foundation (2019) Smoke and Mirrors. Exposing the reality of carpet “recycling” in the UK. Available at: link
183 Institute of Positive Fashion (2023) Solving Fashion’s Product Returns. Available at: link
184 WRAP (2021) Sustainable Clothing Action Plan 2020 Commitment: Progress 2012-2020. Available at: link
185 Lorenz, J. (2020) Decolonising Fashion: How an Influx of ‘Dead White Man’s Clothes’ is Affecting Ghana. Available at: link
186 QSA Partners (2022) QSA’s pioneering displacement methodology helps DEPOP prove its role in reducing climate impact of fashion. Available at: link
187 Vogue UK (2022) Are Your Online Returns Contributing To Fashion’s Waste Problem? Available at: link
188 iNews (2022) The End of Free Returns Looms. Available at: link
189 Business Waste. Bedding Recycling and Blankets Disposal. Available at: link
190 WRAP. Textiles Cost-Benefit Analysis. Available at: link
191 EU Commission (2022) EU Strategy for Sustainable and Circular Textiles. Available at: link
192 UK Parliament (2019) Textile Waste and Collection. Available at: link
193 Larsson, J., Peterson, J., & Mouwitz, P. (2010). One-piece fashion, summary of the Knit-on-Demand project. Available at: link
194 WRAP (2017). Mapping clothing impacts in Europe: the environmental cost. Available at: link

## 5.3 Drivers & Barriers

### 5.3.1 Drivers

Table 16 shows the drivers identified for this measure. Those in bold denote that they had a greater number of votes stemming from the workshops when participants were asked to identify those of being of the highest significance. These are discussed in more detail below.

**Table 16: Drivers for textiles measure 5**

| Description | PESTLE | COM-B |
|---|---|---|
| **Better national marketing on what to do with used clothes can drive behaviour change.**[195] | **Social** | **Motivation - reflective** |
| **High environmental value of reuse compared to other end-of-life circularity processes.**[196] | **Environmental** | **Opportunity – social** |
| Digital product passports on labels can support resale through provision of product and care information.[197] | Technological | Capability – physical |
| Provision of good quality used clothing at a lower price than new.[198] | Technological | Capability – physical |
| Technology and online marketplaces drive growth of the second-hand market and increasing the value of second-hand items.[199] | Social | Opportunity – social |
| Textiles reuse provides social return to local communities from the provision of good quality used clothing at a lower price than new.[200] | Social | Motivation – reflective |
| Greater consumer awareness of the impacts of textiles on the environment.[201] There is global demand for second hand clothing and the charity retail sector has a strong presence. | Environmental | Opportunity – social |

*Lower price for the consumer*

Unsold stock is not technically second-hand and is therefore not technically being reused, but it is still important to promote its ability to prevent the waste of resources that have been used to

[195] Workshop 2 engagement
[196] Ibid.
[197] EON (2022) Industry Aligned Action Plan: Digital ID to scale Circular Systems. Available at: link
[198] WRAP (2017). Mapping clothing impacts in Europe: the environmental cost. Available at: link
[199] ThredUp (2022) 2022 Resale Report. Available at: link
[200] WRAP (2017). Mapping clothing impacts in Europe: the environmental cost. Available at: link
[201] WRAP (2023) Textiles Cost-Benefit Analysis. Available at: link

create it. The sale of this stock, potentially at a lower price point, may increase its uptake and reduce waste; however, in line with the waste hierarchy, the reduction in the quantity of unsold stock should be prioritised.

*Increased awareness and acceptance from consumers*

With reference to buying post-consumer second hand products, their reuse and resale is a well-established sector already providing resource efficiency. It is also of significant social benefit, providing a means to access good quality clothing at lower cost. Its popularity has increased drastically among consumers in recent years – driven by increased awareness among more eco-conscious consumers. The emergence of new business models for reuse, such as through online marketplaces, has made direct peer-to-peer sales more accessible and has undoubtedly been a driver in its increased its market share.

*National marketing*

In terms of mitigation actions, stakeholders highlighted that better national marketing on what to do with used clothes could drive behaviour change.

*Product longevity and durability*

As with rental and sharing models, the longevity of a product will be a key enabler which can be addressed primarily through product design. Many textile products are not suitable for reuse or resale due to durability issues, which limits the possible utilisation period of a product. Designing for durability will help address this issue, as will designing for repair, which will enable the repair of products before resale, thus improving their utilisation.[202]

### 5.3.2 Barriers

Table 17 shows the barriers identified for this measure. Those in bold denote that they had a greater number of votes stemming from the workshops when participants were asked to identify those of being of the highest significance. These are further discussed below.

**Table 17: Barriers for textiles measure 5**

| Description | PESTLE | COM-B |
|---|---|---|
| **The price of fast fashion makes buying new products attractive.**[203] | **Economic** | **Motivation – automatic** |
| **‘Fast fashion’ and options produce poor quality items that may not be suitable for reuse or resale.**[204] | **Technological** | **Capability – physical** |

[202] WRAP. Textiles Cost-Benefit Analysis. Available at: link
[203] Workshop 2 engagement
[204] Ibid.

| | | |
|---|---|---|
| **Lack of textile EPR to support the reuse sector.**[205] | Legal | **Capability –** physical |
| **Lack of regulation on unsold stock e.g. requirement on companies to report the quantities of unsold products and their disposal methods - could drive better practices through transparency, implementation of EPR etc.**[206] | **Legal** | **Motivation – automatic** |
| Most reuse in the UK is exported and often does not end up being reused at all.[207] | Social | Capability – physical |
| Unsold stock may not be suitable for resale or reuse.[208] | Technological | Capability – physical |
| It is often cheaper or easier for companies to dispose of returned items than to process them for resale or reuse.[209],[210] | Economic | Motivation – automatic |
| Certain textiles products, e.g., bed linens, bedding and carpets, are less suitable for resale or reuse as they are more likely to be soiled.[211] | Technological | Capability – physical |
| Lack of standards and legislation, e.g., ensure all collection and sorting are licensed and controlled.[212] | Legal | Capability – psychological |
| Reuse and recycled content are often mutually exclusive.[213] | Technological | Capability – psychological |
| The amount of unsold stock would need to reduce and is not a sustainable model to have unsold stock in the first place.[214] | Technological | Opportunity – social |
| Barrier around removing the stigma of buying second-hand clothes.[215] | Social | Opportunity – social |

### *Availability of fast fashion*

[205] Ibid.
[206] EU Commission (2022) EU Strategy for Sustainable and Circular Textiles. Available at: link
[207] Lorenz, J. (2020) Decolonising Fashion: How an Influx of ‘Dead White Man’s Clothes’ is Affecting Ghana. Available at: link
[208] UK Parliament (2019) Textile Waste and Collection. Available at: link
[209] Vogue UK (2022) Are Your Online Returns Contributing To Fashion’s Waste Problem? Available at: link
[210] iNews (2022) The End of Free Returns Looms. Available at: link
[211] Business Waste. Bedding Recycling and Blankets Disposal. Available at: link
[212] Workshop 1 engagement
[213] Ibid.
[214] Workshop 2 engagement
[215] Workshop 1 engagement

The resale and reuse market in the UK is already established for clothing, with a high percentage of consumers already engaging with this form of consumption. However, a core barrier to sustaining and growing the reuse sector is the popularity and convenience of fast fashion. Low-cost items that can be freely returned are competitive with reuse pricing – which historically was not the case.

*Export of products*

The second key barrier highlighted was the fact that only one third of materials destined for reuse are reused domestically, the majority going for reuse through export. While for this resource efficiency measure this is not technically problematic, it was suggested by the literature that a proportion of this exported product is not actually reused and instead disposed of. Given this material is exported out of the UK, this also means that this material is not available to be recycled (measure 7). It is not clear how much of "UK-sourced" reuse textiles are disposed of in export markets. Stakeholders did note that "capture for reuse" in the UK is already at high levels but there is a need to drive demand for these captured materials to actually be reused, and displace the purchase of new products.

*Lack of regulation*

A third key barrier is a lack of regulation – specifically EPR. It has been highlighted that the textile EPR could be used as a policy tool to support the reuse sector and reduce unsold stock disposal. It could drive brands and retailers towards responsible management of unsold stock and thus incentivise more proactive forward planning, reducing the amount of unsold stock in the first place. Stakeholders also mentioned the need for requirements on retailers to report quantities of unsold stock and its end market; it is believed that this would place more visibility on the issue and thus drive brands and retailers to act responsibly.[216]

*Other barriers*

Other barriers relate to the ability and motivation to reuse. A proportion of unsold stock and post-consumer collected items will not be suitable for reuse and resale, if they are damaged or soiled. This is a relevant barrier not only to clothing, but other in-scope textiles such as bedding and carpets. A lack of standards and legislation, particularly concerning how these products are collected and handled, compounds this barrier.

## 5.4 Levels of efficiency

**Table 18: Levels of efficiency for textile measure 5**

| Indicator: % reduction in consumption of new products through clothing reuse | | | |
|---|---|---|---|
| **Level of efficiency** | Current | Maximum in 2035* | Business-as-usual in 2035 |

[216] EU Commission (2022) EU Strategy for Sustainable and Circular Textiles. Available at: link

| | | | |
|---|---|---|---|
| **Percentage** | 30% | 50% | 40% |
| **Evidence RAG** | Amber | Red-Amber | Amber |

*The maximum value is a standalone figure and is not a percentage of the current value, but of the consumption of new products in 2035.

*A Note on Efficiencies*

This indicator of efficiency only refers to clothing and is not applicable to the other products in scope. Data on other textile reuse and resale types is limited but can be assumed to be much lower than clothing. This is in part due to the suitability of other textiles. There may be examples of curtain reuse if the item is undamaged, but bedding and carpets are more likely to be soiled and, therefore unsuitable for reuse or resale, so will instead be destined for recycling (Measure 7).[217] Additionally, carpets can also be difficult to remove for reuse and are not often designed for this purpose. However, there are examples of companies that design modular carpets to facilitate repair[218] and increase product lifespan. It is estimated that less than 1% of carpets are reused in the UK.[219]

### 5.4.1 Current level of efficiency

It is currently estimated in the UK that of all textiles deposited in separate collection systems, 93% are sent for reuse (domestic or export).[220] However, only 36% of textiles disposed of in used textile and waste management systems (excluding direct peer-to-peer resale) are separately collected, the vast majority being disposed of in residual waste (IAS 4).

There was no literature data on levels of unsold stock that go to reuse, but it has been highlighted in literature that 2 – 3% of stock produced will be unsold at the end of each season.[221] (IAS 5). Further literature identifies that of all returns, 3% are not resold (50% of which are sent to landfill).[222] Multiple stakeholders from collection and sorting and retail indicated that the reuse of unsold stock could be as high as 100% due to retailers wanting to profit from stock that they have produced.

Reductions in the consumption of new products through reuse is highly uncertain as it relates to individual consumer behaviours. The literature also indicates that the lifespan of a second-hand garment is extended by 1.7 times through reuse,[223] which could result in the displacement of new clothing if this stops a consumer from purchasing a new product. However, this is not guaranteed. This study refers to the EU market, so can be applied with some confidence to the UK market.

[217] Business Waste. Bedding Recycling and Blankets Disposal. Available at: link
[218] Niaga. A circular world is at your feet. Available at: link
[219] Changing Markets Foundation (2019) Smoke and Mirrors. Exposing the reality of carpet "recycling" in the UK. Available at: link
[220] WRAP (2021). Textiles market situation report 2019. Available at: link
[221] WRAP (2023). Textiles Cost Benefit Analysis. Available at: link
[222] Institute of Positive Fashion (2023) Solving Fashion's Product Returns. Available at: link
[223] McKinsey & Company (2020). Fashion on climate: How the fashion industry can urgently act to reduce its greenhouse gas emissions. Available at: link

One source did identify several displacement rates for clothing, varying dependent on the location of resale.[224] Direct resale in the country of disposal was 29%. International resale in other parts of Europe was between 0 – 5%, while in Africa it was 30%. It is noted that there is poor data on export for reuse displacement. (IAS 3). However, a peer-to-peer resale company carried out a study (IAS 3), which identified that purchases through the site prevented the purchase of 9/10 new items in the UK (i.e., a 90% reduction in consumption of new products).[225] Given that this study is for a particular type of business, it is not necessarily representative of the reuse sector. The workshops identified additional literature and data. Stakeholders in the workshop quoted a wide variety of displacement rates, including 10%, 60%, 70%.

Votes within the workshop on the current level of efficiency were spread across different options for the current level of efficiency. Two participants (a recycler and a textile sorter) voted that the current level was minimal (0%-2%) due to a lack of product durability and due to ease of new product consumption through fast fashion, but four participants agreed it was higher, with one vote for 11%-15% and three votes for >15%.

The data present throughout the literature and workshops covers a range of avenues of reuse, with higher values being presented for narrowly scoped studies and lower values being provided for wider scopes. To derive a figure that represents the entire reuse market, a mid-level figure of 30% can be taken with an amber evidence RAG rating due to the wide range of figures identified.

### 5.4.2 Maximum level of efficiency in 2035

No quantitative data on the maximum level of efficiency for this indicator was identified in the literature. However, a participant at the workshop from a trade association indicated that, due to the saturation of the current reuse and second-hand market in the UK, it will be difficult to increase the current level of efficiency.

When voting, workshop participants did not reach a consensus, with votes spread across three different options. Two participants voted that the maximum level would be >15%, which was the highest voting option and supplementary commentary from a retailer suggested that it was believed that the maximum level could reach 50%. It can be presumed from a likely increase in the market size of this sector that the level of efficiency will increase from the current level, but not significantly. However, it is important to note, as raised by a charity retailer in the survey, that large parts of the re-use sector are informal (independent peer-to-peer and swapping) and are not measurable.

Therefore, the maximum level of efficiency is listed at 50% with a red-amber evidence RAG rating, based on the knowledge of stakeholders and examples of business-level displacement rates provided in the literature.

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[224] WRAP (2021) Sustainable Clothing Action Plan 2020 Commitment: Progress 2012-2020. Available at: link
[225] QSA Partners (2022) QSA's pioneering displacement methodology helps DEPOP prove its role in reducing climate impact of fashion. Available at: link

## 5.4.3 Business-as-usual in 2035

Values from the literature indicate that the reuse share of the global market could reach between 9% - 16%[226],[227] by 2030.This is not a significant increase from the figures quoted for the current market share. It could be presumed that there will be a minimal corresponding reduction in consumption of new products on a business-as-usual trajectory without significant consumer behaviour change.

There was consensus from the workshops that business-as-usual level would reach >30%, which is in line with the current level of efficiency, however, two participants believed it would be between 11% to 15% and one participant between 20% to 25%. Participants from trade associations and the charity sector commented that it could reach 50% - 90% based on the current evidence and growth in popularity seen in the sector in recent year, while another participant from a trade association stated that doubling of reuse could reduce the consumption of new clothing by 15%.[228] Extrapolating this figure to match the slight increase in predicted market size growth and based on the number of votes for the different percentages, a figure of 40% has been provided, with an amber evidence RAG rating, for the BAU scenario.

[226]Ibid.
[227] Ellen Macarthur Foundation (2021) Circular business models: redefining growth for a thriving fashion industry. Available at: link
[228] Workshop 2 engagement

# 6.0 Measure 6 – Repair products

## 6.1 Textiles resource efficiency measure

### 6.1.1 Description

*Utilisation of repair services to extend product lifetimes and prevent the purchase of a replacement product, therefore decreasing consumption of new products.*

Repair is a tool that can be used to extend a product lifetime and, at least temporarily, prevent the purchasing of new products. Repair can include visible alterations, such as patching, or can be non-visible and discreet, such as seam repair or button replacements. This increases resource efficiency by reducing the consumption of new products, as well as keeping products from being disposed of. Growth of the repair sector will require consumers to have increased access and engagement with repair services.

However, whether an item is deemed suitable for repair or “worth” repairing is dependent on factors such as the material & product type, original product cost, the function/look of the garment following repair, where on the product the repair will take place, and is subjective to the consumers preferences, skills and motivations. If the consumer deems an item damaged beyond its worth to repair, the best option could be resale where another consumer may see value in the product, or fabric recycling (see Measure 7).

### 6.1.2 Measure indicator

The indicator selected was the **percentage reduction in consumption of new clothing through repair**. The focus is on clothing because no data could be identified for other sectors, either in the literature or from stakeholders.

Other indicators that were considered included the percentage increase in utilised product lifetime, the percentage share of the retail market occupied by repairers, the value (£) of the repair sector and the percentage of consumers that engaged with repair services.

These indicators were not selected because, while they are relevant to resource efficiency, they do not describe how resource efficiency of the sector is tangibly impacted by the measure.

### 6.1.3 Examples in practice

There are numerous methods by which repair services can be delivered for clothing. The extent to which they are used will vary depending on the product type, the value that it holds to the consumer and the comparative cost of replacing the product with a new version. In the UK, examples include:

- At home repairs delivered by consumers themselves.

- In-house services delivered by brands and retailers.[229] For example, Patagonia offering free repair services on their products.
- Third party**.** Consumers can send or take their products to specialist repair/alteration third party services.

For affixed items like carpets, specialist contractors will typically undertake repair services.

## 6.2 Available sources

### 6.2.1 Literature review

A total of six of the literature review sources identified this resource efficiency measure. These included:

- three industry reports,[230],[231],[232]
- two policy documents;[233],[234] and
- one academic paper.[235]

These sources are considered relatively applicable and credible when assessed against the data assessment framework. The sources exhibited an average IAS of 4.16, with four sources exhibiting a score of 4 or above. Three of the sources were based on the UK market, while two further sources were based on the EU or a country in Europe and the final source based on the US market, meaning that most of the figures can be deemed relatively applicable to the UK market. However, few studies were able to provide quantitative data on the topic.

### 6.2.2 Workshops

This measure received some engagement in both workshop sessions, with the most interaction observed in the second workshop. Contributions came from a range of stakeholders, with contributions particularly arising from retailers, trade associations, academia and a local authority partnership. Workshop participants were well placed to comment on this measure, with a lot of participation on the drivers and barriers rather than discussing quantitative evidence. The measure was well received, even though participants voiced their concerns surrounding likely progress of this measure to deliver resource efficiency.

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229 Workshop 1 engagement
230 WRAP (2017). Valuing our clothes: The cost of UK fashion. Available at: link
231 Institute of Positive Fashion (2021) The Circular Fashion Ecosystem: A blueprint for the future. Available at: link
232 Ellen Macarthur Foundation (2021) Circular business models: redefining growth for a thriving fashion industry. Available at: link
233 WRAP (2023) Textiles Cost-Benefit Analysis. Available at: link
234 McKinsey & Company (2020). Fashion on climate: How the fashion industry can urgently act to reduce its greenhouse gas emissions. Available at: link
235 Maldini, I. and Balkenende, A.R. (2017). Reducing clothing production volumes by design: a critical review of sustainable fashion strategies. Available at: link

## 6.3 Drivers & Barriers

### 6.3.1 Drivers

Table 19 shows the drivers identified for this measure. These are further discussed below.

**Table 19: Drivers for textiles for measure 6**

| Description | PESTLE | COM-B |
|---|---|---|
| **The promise of repair from retailers in case of damage, or the offering of lifetime guarantees, and the improved durability that would ultimately emerge from such schemes, could incentivise consumers to shop with them [236],[237]** | **Social** | **Motivation – reflective** |
| **Repair data from in-house repair services can be fed back into design decisions to enable continuous product improvement.[238]** | **Social** | **Opportunity – social** |
| There is a willingness among consumers to utilise repair services: 73% for small repairs at home and 86% for any repair. [239] | Social | Motivation – automatic |
| The carbon footprint of reclaiming products to repair them/extend product lifetime way offsets the footprint of manufacturing it.[240] | Environmental | Capability – physical |
| The growth in popularity of reuse/second hand supports the demand for repair services.[241] | Social | Opportunity – social |
| Technologies advances in the repair field that can enable easier repair.[242] | Technological | Capability – physical |
| Increasing the culture of caring for clothes/emotional connection and valuing them, encourages consumers to repair their items.[243] | Social | Opportunity – psychological |

[236] WRAP (2023) Textiles Cost-Benefit Analysis. Available at: link
[237] Workshop 2 engagement
[238] Institute of Positive Fashion (2021) The Circular Fashion Ecosystem: A blueprint for the future. Available at: link
[239] WRAP (2017). Valuing our clothes: The cost of UK fashion. Available at: link
[240] Workshop 2 engagement
[241] Ibid.
[242] Ibid.
[243] Ibid.

*Offer of guarantees from retailers*

There are already examples of some retailers are already offering free repair services. The promise of repair from retailers in case of damage, or the offering of lifetime guarantees and the improved durability that would ultimately emerge from such schemes, could incentivise consumers to shop with them.[244]

Willingness from consumers

There is a willingness among consumers to utilise repair services: 73% for small repairs at home and 86% for any repair.[245]

*Accessibility*

Easy access to repair services is also a driver, increasing the opportunity for consumers to change their behaviour.

*Access to data*

Repair data can also be utilised to support design decisions.

*Interdependency with reuse*

Furthermore, the increasing demand for reuse, as discussed in Measure 5, could also increase the utilisation of repair services as it is beneficial to increase product lifetime.

### 6.3.2 Barriers

Table 20 shows the barrier identified for this measure. Those in bold denote that they had a greater number of votes stemming from the workshops when participants were asked to identify those of being of the highest significance. These are further discussed below.

**Table 20: Barriers for textiles measure 6**

| Description | PESTLE | COM-B |
|---|---|---|
| **Repair of cheaper items is challenged by the availability and convenience of low-cost new products on the market e.g., fast fashion.246,247** | **Economic** | **Opportunity – psychological** |

[244] Maldini, I. and Balkenende, A.R. (2017). Reducing clothing production volumes by design: a critical review of sustainable fashion strategies. Available at: link
[245] WRAP (2017). Valuing our clothes: The cost of UK fashion. Available at: link
[246] Institute of Positive Fashion (2021) The Circular Fashion Ecosystem: A blueprint for the future. Available at: link
[247] Workshop 2 engagement

| | | |
|---|---|---|
| **Lack of awareness, general education and skills to conduct repairs individually – requires brand communication and local council initiatives.**[248] | **Social** | **Motivation – reflective** |
| **Challenges of commercial viability in the UK, including labour costs.**[249] | **Economic** | **Opportunity – psychological** |
| **Lack of VAT reductions on garment repair to encourage the growth of repair.**[250] | **Economic** | **Opportunity – social** |
| **Minimum standards of manufacture can extend the product lifecycle and improve the value of that product to consumers so they would rather wear a repaired item rather than dispose of it.**[251] | **Technological** | **Motivation – automatic** |
| Role of EPR and guidelines on incorporating repair.[252] | Legal | Capability – physical |
| There is no guarantee that the sustainability savings made on repairing a single product will not be lost on an additional purchase.[253] | Environmental | Motivation – reflective |
| Potential for conflict with recycling repairs such as patches make recycling items more difficult.[254] | Technological | Capability – physical |
| Currently there is low consumer engagement/interest in repair.[255] | Social | Motivation – reflective |
| Product failure is generally around fabric failure, e.g., rips, pilling. These are technically repairable, but not acceptable.[256] | Technological | Capability – physical |
| Lack of widespread repair services.[257] | Social | Capability – psychological |

*Cost of repair compared to new products*

It was agreed by most stakeholders that the biggest barrier to this measure is the cost of repair compared to the purchase of new products. It was highlighted that the commercial viability of

248 Ibid.
249 Ibid.
250 Workshop 1 engagement
251 Ibid.
252 Workshop 2 engagement
253 Maldini, I. and Balkenende, A.R. (2017). Reducing clothing production volumes by design: a critical review of sustainable fashion strategies. Available at: link
254 Workshop 1 engagement
255 WRAP (2023) Textiles Cost-Benefit Analysis. Available at: link
256 Workshop 2 engagement
257 Ibid

repair in the UK market is challenging, high labour costs necessitating a corresponding high repair cost. This results in consumers being more likely to dispose of the product and purchase new. It is currently only deemed beneficial for products of high personal or financial value to the consumer. Repair of cheaper items is challenged by the availability and convenience of low-cost new products on the market e.g., fast fashion.[258] Stakeholders suggested, as a mitigation, that VAT reductions on garment repair would increase the accessibility and appeal to consumers over disposal.

*Lack of consumer engagement*

Despite having identified consumer interest as a driver, several barriers were identified suggesting there is not enough consumer engagement. There is a current lack of consumer awareness and education surrounding available options for repair and its benefits. This is compounded by a lack of consumer skills to deliver repairs individually. Repair could be perceived as an inconvenient option for consumers due to the lack of widespread services.[259] Stakeholders also proposed that there is low consumer interest, but this could be in part explained by another barrier – that repair is possible, but it does not return the product to a state that is currently acceptable to the consumer. For example, visible patching to repair ripped fabric.

*No guarantee of preventing a new purchase*

Equally, there is no guarantee that repairing an item will prevent an additional purchase, particularly with changing fashion trends.

*Conflicts with recyclability*

Finally, although this is unlikely to be deemed a barrier on the consumer side, large repairs (for example, patchwork) could conflict with recyclability, particularly if it interferes with the accuracy of product composition labelling.

As potential mitigations for these barriers, stakeholders suggested the following:

- Policy changes (such as Extended Producer Responsibility and guidelines on incorporating repair, VAT reductions on repair) could play a key role in supporting access to and growth of repair.
- From a design perspective, repair could be enhanced if products were designed for repairability.[260] For example, if products were designed to allow repair without the need for specialist equipment or manufacturing processes or have modular design elements to allow disassembly or replacement, the repair of more products could be observed. However, it must be noted that these elements of design for repairability may conflict with design for durability, where durability will need to be maintained.

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[258] Institute of Positive Fashion (2021) The Circular Fashion Ecosystem: A blueprint for the future. Available at: link
[259] Workshop 2 engagement
[260] WRAP. Textiles Cost-Benefit Analysis. Available at: link

- It was widely agreed that placing obligations or minimum standards on manufacturers or retailers would increase consumers' uptake of repair services, particularly if it is offered for free during a warranty period.

# 6.4 Levels of efficiency

**Table 21: Levels of efficiency for textiles measure 6**

| Indicator: % reduction in consumption of new clothing through repair | | | |
|---|---|---|---|
| **Level of efficiency** | Current | Maximum in 2035 | Business-as-usual in 2035 |
| **Percentage** | 1% | 5% | 4% |
| **Evidence RAG** | Green | Red-Amber | Red-Amber |

*A Note on Efficiencies*

This indicator of efficiency only refers to clothing and is not applicable to the other products in scope. Although it can be assumed that other products in scope, such as carpets and curtains, are likely to undergo repair due to the cost of replacement, there was no explicit data evidenced in the literature or workshops that supported the rate of repair of these products.

## 6.4.1 Current level of efficiency

The literature indicates that repair currently represents 0.5%[261] of the global market and that the professional repair of products can increase the utilised lifetime of clothing by 35%[262], delaying the point of disposal and thereby preventing the consumption of new clothing products. Both sources exhibit IAS of 4. While these are global market figures, the literature are sources developed in western markets – so it could be inferred that these can be applied to the UK market with reasonable confidence. However, there was no data identified in the literature as to how much new consumption is reduced through repair.

There was overwhelming consensus at the workshops that the current rate of displacement was <2%, with a textile collector and sorter stating that it is <1%. This means that the current efficiency is approximately 1% with a green evidence RAG rating.

[261] Ellen Macarthur Foundation (2021) Circular business models: redefining growth for a thriving fashion industry. Available at: link
[262] McKinsey & Company (2020). Fashion on climate: How the fashion industry can urgently act to reduce its greenhouse gas emissions. Available at: link

## 6.4.2 Maximum level of efficiency in 2035

There was no mention in the literature of the maximum decrease in consumption of new products through repair, it can be assumed that a 2.2x increase in market share[263] will result in a corresponding increase in reduction in absolute consumption of products.

Results from the workshop show that participants' opinions were split over two options: 2%-5% and 5%-8%, with participants from retail stating that they doubt there is the possibility for repair to decrease consumption of new products significantly, even with improved consumer awareness and education. Due to a lack of consensus, a mid-value of 5% has be taken with a red-amber evidence RAG rating.

## 6.4.3 Business-as-usual in 2035

Literature reports that the repair industry is likely to make up 1.1% of the global market by 2030.[264] The workshop participants were in consensus that the BAU scenario would reach 2%-5% on the current trajectory. This was based on the votes of 50% of the participants, who were those that felt they could make an informed decision. Although two participants from academia and the charity sector highlighted that the sector has real potential to grow in the current context, voting for 11%-15% and >15%, respectively. Other commentary from academia indicated that this would only be possible with a lot of incentives. Another participant from a trade association also indicated that the growth in repair will not completely prevent new consumption but will only delay it.

Therefore, a median value of 4% can be taken forward with a red-amber evidence RAG rating. This represents a slight increase from the current level but does not quite reach the maximum efficiency.

[263] Ellen Macarthur Foundation (2021) Circular business models: redefining growth for a thriving fashion industry. Available at: link
[264] Ibid.

# 7.0 Measure 7 – Recycle Post-Consumer (PC) Textiles and Unsold Stock Not Suitable for Reuse

## 7.1 Textiles resource efficiency measure

### 7.1.1 Description

*The collection, processing and recycling of true end of life textile products for use as feedstock in manufacturing processes in place of primary raw materials.*

Once textiles reach the end of their useable lifetime, as much of the material as possible can be recycled to avoid resource loss through landfill or incineration. Textiles unsuitable for reuse will typically be worn-out post-consumer textiles. However, a proportion of unsold stock (either with a manufacturer or retailer) will not be sold for reuse (e.g., damaged stock, soiled returns etc). These products are suitable for recycling.

There are different recycling routes that materials can take – material can be recovered for remanufacturing or for use in other sectors (e.g., industrial rags); or fibre can be recovered – for use in new textile products (i.e. clothing fibre into new clothing) or other sectors (stuffing, insulation etc.).

It is important to recognise that there is significant variation in the terms and processes used to encompass "recycling". For example, the terms "downcycling" or "open-loop recycling" are often used to describe the use of recycled textile fibres in other sectors, while "upcycling" is often used for material remanufacturing within the same sector. "Closed-loop" recycling is often related to fibre-to-fibre recycling that delivers fibre outputs of a similar quality to virgin fibre – and thus can be used as a replacement.

In the context of resource efficiency, any situation where recycled material or fibre replaces the use of virgin material will deliver resource efficiency. Stakeholders (both in the literature and in the workshops) were split in whether recycling into other sectors constitutes an appropriate form of recycling that should form part of circular economy and resource efficiency in the UK. Some were of the opinion that recycling focus should be fibre-to-fibre, with the products going back into the same sector i.e. clothing to clothing. However, there was alignment that the high-quality fibre-to-fibre recycling development was an important part of this measure; as well as the enabling systems to allow recycling.

### 7.1.2 Measure indicator

The indicator selected was the **percentage recycling rate of clothing, household bedding, curtains and carpet**. Another indicator that was considered was the percentage avoided water footprint (cotton) – this was discarded as it is related solely to one fibre type and does not consider material resource efficiency.

Other discarded indicators included the percentage end-treatment distribution, the percentage collection rate of textiles for recycling, the percentage yield from recycling technologies and the percentage of textiles containing recycled material.

These were not selected, because they do not identify data that provides material resource efficiency data for the market. They do, however, act as indicators of the effectiveness of the recycling process – which links to overall recycling rate (the indicator chosen).

### 7.1.3 Examples in practice

In the first instance, fabric wastes can be repurposed rather than fibre-to-fibre recycling. This is often termed "remanufacturing" or "upcycling", where components of post-consumer textiles are remanufactured into new products, maximising their utilised lifetime and the value from producing the materials.[265] However, this is estimated to be a very small proportion of the textile retail and CEBM market.

Most of the textile recycling in the UK is currently mechanical. For clothing and household textiles like linens, material can be chopped up into rags or shredded into fibres for stuffing, insulation etc.[266] These processes can lead to a shortening of the fibres[267],[268] or contamination through use.[269] This inhibits continued circularity and thus resource efficiency, as it will limit the availability of recycled materials.

This is less of a factor for wool products, which can be mechanically recycled into high-quality fibres due to the length of wool fibres. [270] This process is already an established resource efficiency measure. 100% pure, synthetic polymer textile materials can also be melted and re-extruded into new products. Carpets are also recycled in "open-loop" systems to produce equestrian products or recover the plastic/fibre.[271]

A significant focus is on developing high-quality fibre-to-fibre recycling technologies that produce outputs (polymer or fibre) of "virgin-like" quality.

1. Mechanical recycling: Shredding and reprocessing/respinning of the resulting fibres into new yarns.[272],[273]

265 Beyond Remade (2023) Our Story. Available at: link
266 WRAP (2012) A review of commercial textile fibre recycling technologies. Available at: link
267 Badía et al (2009) Thermal analysis as a quality tool for assessing the influence of thermo-mechanical degradation on recycled poly(ethylene terephthalate). Available at: link
268 WRAP (2012) A review of commercial textile fibre recycling technologies. Available at: link
269 EU Commission (2021) Study on the technical, regulatory, economic and environmental effectiveness of textile fibres recycling. Available at: link
270 Rengel, A. (2017). Recycled Textile Fibres and Textile Recycling. Available at: link
271 Changing Markets Foundation (2019) Smoke and Mirrors. Exposing the reality of carpet "recycling" in the UK. Available at: link
272 WRAP (2019) An Economic & Financial Sustainability Assessment. Available at: link
273 H&M (2020) From old to new with Looop. Available at: link

2. Solvent dissolution: Selective separation and purification of polymers from textiles products.[274],[275]

3. Chemical Depolymerisation: A form of chemical recycling that uses chemical reagents to break down polymer structure and recover feedstocks (monomers) for use in polymer manufacturing.[276],[277]

4. Cellulose Regeneration: Selective separation and, in some cases, partial or full depolymerisation and subsequent repolymerisation, of cellulose-based fibres.[278],[279]

# 7.2 Available sources

## 7.2.1 Literature review

A total of 24 of the sources that were reviewed identified this measure – the greatest number of all the textiles measures. This was comprised of:

- thirteen industry reports;[280],[281],[282],[283],[284],[285],[286],[287],[288],[289],[290],[291],[292]
- three academic papers;[293],[294],[295]

274 Hann, S. and Connock, T. (2020). Chemical Recycling: State of Play. Available at: link
275 Worn Again (2023) The Challenge. Available at: link
276 Hann, S. and Connock, T. (2020). Chemical Recycling: State of Play. Available at: link
277 CuRe (2023) How it works. Available at: link
278 Seoud et al (2020) Cellulose Regeneration and Chemical Recycling: Closing the "Cellulose Gap" Using Environmentally Benign Solvents. Available at: link
279 Renewcell (2023) Our Technology. Available at: link
280 WRAP (2012) A review of commercial textile fibre recycling technologies. Available at: link
281 Rengel, A. (2017). Recycled Textile Fibres and Textile Recycling. Available at: link
282 Changing Markets Foundation (2019) Smoke and Mirrors. Exposing the reality of carpet "recycling" in the UK. Available at: link
283 WRAP (2019) An Economic & Financial Sustainability Assessment. Available at: link
284 Hann, S. and Connock, T. (2020). Chemical Recycling: State of Play. Available at: link
285 Norion Consult and EuRIC Textiles (2023) LCA based assessment of the management of European used textiles. Available at: link
286 Ellen MacArthur Foundation (2017). A new textiles economy: Redesigning fashion's future. Available at: link
287 WRAP (2020) The Textile 2030 Signatory Commitment. Available at: link
288 WRAP (2019) Textiles Market Situation Report. Available at: link
289 Institute of Positive Fashion (2021) The Circular Fashion Ecosystem: A blueprint for the future. Available at: link
290 Fashion for Good, Circle Economy (2022) Sorting for Circularity Europe: An evaluation and commercial assessment of textile waste across Europe. Available at: link
291 Circle Economy (2020) Clothing Labels: Accurate or Not? Available at: link
292 McKinsey & Company (2020). Fashion on climate: How the fashion industry can urgently act to reduce its greenhouse gas emissions. Available at: link
293 Badía et al (2009) Thermal analysis as a quality tool for assessing the influence of thermo-mechanical degradation on recycled poly(ethylene terephthalate). Available at: link
294 Seoud et al (2020) Cellulose Regeneration and Chemical Recycling: Closing the "Cellulose Gap" Using Environmentally Benign Solvents. Available at: link
295 Sandin, G & Peters, G.M. (2018) Environmental impact of textile reuse and recycling – A review. *Journal of Cleaner Production, 184. Available at:* link

- three policy documents;[296],[297],[298]
- three technical studies;[299],[300],[301] and
- two website articles.[302],[303]

The relevant sources are considered of medium to high applicability and credibility when assessed against the data assessment framework. The sources exhibited an average IAS of 3.86, with 17 sources exhibiting a score of 4 or above. Nine of the sources were based on the UK market, while six further sources were based on the EU or a country in Europe and the remaining sources were based on the US or global market, meaning that most of the figures can be deemed applicable to the UK market.

### 7.2.2 Workshops

This measure received significant stakeholder engagement, with the most interaction observed in the second workshop, where it was one of the most discussed measures. Contributions arose from various stakeholders, particularly from retailers, trade associations, academia and recyclers. Participants were able to provide insight into the complexities of terminology and reporting surrounding the recycling of textiles and the challenges associated with different fibre types. The participants were also well placed to discuss the drivers and barriers behind this measure, where a lot of engagement was observed.

## 7.3 Drivers & Barriers

### 7.3.1 Drivers

Table 22 shows the drivers identified for this measure. Those in bold denote that they had a greater number of votes stemming from the workshops when participants were asked to identify those of being of the highest significance. These are further discussed below.

**Table 22 Drivers for textiles measure 7**

| Description | PESTLE | COM-B |
|---|---|---|
| **Commitments from brands and manufacturers to incorporate recycled fibres into product portfolios.**[304] | **Social** | **Opportunity - social** |

[296] EU Commission (2021) Study on the technical, regulatory, economic and environmental effectiveness of textile fibres recycling. Available at: link
[297] WRAP (2023). Textiles Cost Benefit Analysis. Available at: link
[298] Cunningham, P.R. & Miller, S.A.(2022) A material flow analysis of carpet in the United States: Where should the carpet go? Journal of Cleaner Production
[299] McKinsey & Company (2022) Scaling textile recycling in Europe—turning waste into value. Available at: link
[300] Elander, M. and Ljungkvist, H. (2016). Critical aspects in design for fiber-to-fiber recycling of textiles. Available at: link
[301] WRAP (2017). Mapping clothing impacts in Europe: the environmental cost. Available at: link
[302] Renewcell (2023) Our Technology. Available at: link
[303] Accelerating Circularity (2022) Approximately 70% of Apparel can be Recycled. Available at: link
[304] WRAP (2020) The Textile 2030 Signatory Commitment. Available at: link

| | | |
|---|---|---|
| **Avoidance of incineration/landfill costs.**[305] | **Economic** | **Opportunity – social** |
| **Mono-materials (100% cotton, 100% polyester) and simple blends (polycottons, wool-rich materials) are recyclable through existing recycling technologies.**[306] | **Technological** | **Capability – physical** |
| **Design for recycling is a key enabler of recycling.**[307] | **Technological** | **Capability – physical** |
| High levels of post-consumer textiles in the residual waste stream.[308] | Social | Capability – physical |
| Increasing UK textiles recycling can create more jobs in this sector. This would be supported by better education on materials (e.g. fibres, yarns).[309],[310] | Economic | Opportunity – social |
| Retailers holding detailed information about the product composition.[311] | Technological | Capability - physical |

*Commitments from brands and manufacturers*

There is consensus in the literature and workshops that the technological processes to recycle textiles exist, particularly for mono-materials and simple blends. A key driver to scaling viable technologies (and the enabling systems) are commitments from brands and manufacturers to incorporate recycled fibres into their products – which provides a demand signal to stimulate investment and growth in recycling capacity. This will in turn, give end-of-life textiles a value and be seen as a “resource” rather than a waste for disposal – which can stimulate the necessary upstream processes (collection and aggregation, automated sorting, pre-processing) to grow and be profitable. Across the end-of-life system, there is the potential for job creation, as well as a reduction in costs of disposal.

*Supply chain collaboration*

With reference to the overall textile value chain – a driver recognised is the growing recognition of each actor’s responsibility in delivering and scaling recycling, delivering both greater levels of circularity and supporting the transition to net zero.

*Design for recycling*

[305] Elander, M. and Ljungkvist, H. (2016). Critical aspects in design for fiber-to-fiber recycling of textiles. Available at: link
[306] Accelerating Circularity (2022) Approximately 70% of Apparel can be Recycled. Available at: link
[307] WRAP (2023). Textiles Cost Benefit Analysis. Available at: link
[308] WRAP (2019) Textiles Market Situation Report. Available at: link
[309] WRAP (2017). Mapping clothing impacts in Europe: the environmental cost. Available at: link
[310] Workshop 2 engagement
[311] WRAP (2023). Textiles Cost Benefit Analysis. Available at: link

Another key enabler of recycling is the design for recycling.[312] Sources often identify simple material compositions as a key requirement to support design for recycling, for example, prioritisation of mono-materials. It is noted that products that are required for shorter lifecycles may prioritise design that supports the preparation of products for reuse and recycling, in line with the waste hierarchy. Literature also highlights the need to remove disruptors (e.g., zippers and other attachments, chemicals etc.) to support increased recycling. This can be supported through design for disassembly. Both must, however, be combined with a focus on design for longevity to ensure they are complementary.

### 7.3.2 Barriers

Table 23 shows the identified barriers for this measure. Those in bold denote that they had a greater number of votes stemming from the workshops when participants were asked to identify those of being of the highest significance. These are further discussed below.

**Table 23: Barriers for textiles measure 7**

| Description | PESTLE | COM-B |
|---|---|---|
| **Lack of major recycling infrastructure in the UK.** [313],[314] | **Technological** | **Capability – physical** |
| **Collection, sorting and pre-processing infrastructure (for example automated sorting) is not in place at commercial scale across the UK and most of Europe.** [315,316] | **Technological** | **Motivation - reflective** |
| **A proportion of post-consumer textiles are without a circular destination due to their fibre composition, the presence of multiple layers and/or non-removal disruptors.** [317] | **Technological** | **Capability – physical** |
| **Textiles labelling does not support recycling, with information often inaccurate or missing.**[318] | **Technological** | **Capability – physical** |
| Regulations for import/export of waste, definitions of waste textiles and end-of-waste do not support recycling.[319] | Legal | Opportunity – social |

[312] WRAP (2023). Textiles Cost Benefit Analysis. Available at: link
[313] Institute of Positive Fashion (2021) The Circular Fashion Ecosystem: A blueprint for the future. Available at: link
[314] Elander, M. and Ljungkvist, H. (2016). Critical aspects in design for fiber-to-fiber recycling of textiles. Available at: link
[315] Fashion for Good, Circle Economy (2022) Sorting for Circularity Europe: An evaluation and commercial assessment of textile waste across Europe. Available at: link
[316] Workshop 1 engagement
[317] Fashion for Good, Circle Economy (2022) Sorting for Circularity Europe: An evaluation and commercial assessment of textile waste across Europe. Available at: link
[318] Circle Economy (2020) Clothing Labels: Accurate or Not? Available at: link
[319] Ibid.

| | | |
|---|---|---|
| Complex global value chains and differences in legislation make it difficult to control the presence of chemicals hazardous for or disruptive to recycling (linings, plastic prints, seams).[320] | Legal<br>Political | Capability – psychological |
| Lack of cooperation and coordination across the textiles value chain.[321] | Social | Motivation - automatic |
| Fibre recycling does not currently offer the quality needed to produce a 100% recycled garment from the output. [322] | Technological | Capability – physical |
| For polyester, chemical monomer recycling has a lack of cost-competitiveness compared to virgin polyester.[323] | Economic | Opportunity – social |
| Insufficient verification has allowed brands to claim recycled content without the products containing any recycled material.[324] | Legal | Opportunity – psychological |
| A lack of design for recycling and transparency of recyclability. Designers and buyers need to be connected with recyclers to understand better the available materials and the impact of product design and material choices on recyclability.[325] | Social | Opportunity – social |
| Heavy reliance on incineration for used carpets. This acts as a barrier to recycling, as it does not provide the incentive to increase recycling rates and move to a truly circular economy.[326] | Technological | Motivation – automatic |
| Lack of clear guidelines on how to make products recyclable without compromising durability.[327] | Legal | Opportunity – social |
| Challenges around unsold stock: it needs to be aggregated in sufficient quantities for recycling and reverse logistic systems are required.[328] | Technological | Capability – physical |
| High cost of sorting for recycling and recycling – for which there is also no financial support. EPR is required to sustain the levels of sorting required for high levels of recycling. [329] | Economic<br>Political | Motivation – reflective |

[320] Elander, M. and Ljungkvist, H. (2016). Critical aspects in design for fiber-to-fiber recycling of textiles. Available at: link .
[321] Workshop 1 engagement
[322] Ellen MacArthur Foundation (2017). A new textiles economy: Redesigning fashion's future. Available at: link
[323] Ibid.
[324] WRAP (2023). Textiles Cost Benefit Analysis. Available at: link
[325] Ellen MacArthur Foundation (2017). A new textiles economy: Redesigning fashion's future. Available at: link
[326] Changing Markets Foundation (2019) Smoke and Mirrors. Exposing the reality of carpet “recycling” in the UK. Available at: link
[327] Institute of Positive Fashion (2021) The Circular Fashion Ecosystem: A blueprint for the future. Available at: link
[328] Workshop 1 & 2 engagement
[329] Workshop 1 engagement

| | | |
|---|---|---|
| Economic instability of waste costs. [330] | Economic | Motivation – reflective |
| Brands are committing to incorporating recycled fibres within their clothing products but often these are a small portion of the overall fibre composition and can lead to 'greenwashing'. [331] | Social | Opportunity – social |
| Manufacturers using recycled polyester from plastic bottles which is not closed loop and has other negative impacts. [332] | Environmental | Motivation – automatic |
| Tension between clothing durability and the quantity of material that is unsuitable for reuse (and so available for recycling). [333] | Technological | Capability – physical |
| Lack of legislation that tackles "rogue" recyclers that collect material and likely send to landfill. [334] | Legal | Motivation – reflective |
| Lack of specific recycling targets.[335] | Legal | Motivation – automatic |
| Lack of legislation surrounding net zero targets.[336] | Legal | Motivation - automatic |

*Lack of scaled recycling infrastructure*

A wide variety of barriers were identified to developing recycling. First and foremost, although the technology exists and is capable, there is a current lack of scaled infrastructure for reprocessing and recycling in the UK.[337] Research investments are required to scale up chemical and mechanical recycling and alternative financing models may be needed. Most chemical processes still in the development stage, so economically viable scale-up is required.[338] A lack of investment and economic viability currently is identified as a main barrier for success. Stakeholders mentioned that an increase in the aggregation and provision of textiles to recyclers in sufficient quantities will allow recycling technologies to scale up and become commercially viable.

*Lower quality of recycled fibre*

330 Ibid
331 Ibid
332 Ibid
333 Ibid
334 Ibid
335 Ibid
336 Ibid.
337 Institute of Positive Fashion (2021) The Circular Fashion Ecosystem: A blueprint for the future. Available at: link
338 Elander, M. and Ljungkvist, H. (2016). Critical aspects in design for fiber-to-fiber recycling of textiles. Available at: link

Additionally, fibre recycling does not currently offer the quality of recycled fibres needed to produce a 100% recycled garment from the output, except for wool that is recycled for the first time.[339] This is due to shortening of the fibres in shredding. Therefore, to provide the quality needed for use in a garment, recycled cotton is usually blended with longer fibres, which are mostly virgin cotton or, for cost reasons, polyester.

*Lack of supporting infrastructure*

Asides from the recycling technologies themselves, literature[340] and stakeholders also highlight the need for supporting infrastructure to collect, accurately sort, and disassemble/pre-process textiles for recycling; examples of these include reverse logistics, sorting, pre-processing/disassembly for recycling. For the case of unsold stock specifically, reverse logistics systems are required to collect the unsold stock and deliver to recyclers.

*Varied material composition*

Another existing issue is that textile products are often highly variable in material composition. While some are mono materials, a proportion of the market consists of multi-material blends of different fibre types and quantities (both natural and synthetic) for which recycling technologies do not exist. This makes products difficult to recycle and unsuitable for some processes. This is compounded by insufficient control of hazardous chemicals used in textiles, which disrupts recycling. In addition, labelling is not always accurate or is missing, making it impossible to determine fibre composition without using fibre composition identification technology.

*Requirement for supply chain collaboration*

Each stakeholder group (fashion companies, textile sorters and textile recyclers) sees the responsibility (or ability) to overcome the main obstacles for increased fibre-to-fibre recycling of textiles in other parts of the textiles value chain. There is a clear need for increased coordination and exchange of information across the textile value chain. This could help stakeholders to focus on their contribution for creating more circular textile value chains, rather than focusing only on their current core business.[341] For example, further cooperation between manufacturers and recyclers would ensure that products are designed to be recyclable and the material composition is identifiable, so that they can understand the impact of design and material choices on recyclability.

*Contradictions between design for recycling and design for durability*

There is the potential for tension between design for recycling and design for durability in measures that look to extend the utilisation of products (Measures 4, 5 and 6). Increased material/product durability could be a barrier to Measure 7 – by impacting recyclability – if these design elements are not complementary.

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[339] Ellen MacArthur Foundation (2017). A new textiles economy: Redesigning fashion's future. Available at: link
[340] Fashion for Good, Circle Economy (2022) Sorting for Circularity Europe: An evaluation and commercial assessment of textile waste across Europe. Available at: link
[341] Elander, M. and Ljungkvist, H. (2016). Critical aspects in design for fiber-to-fiber recycling of textiles. Available at: link

*Lack of legislation and targets*

The final barriers relate to market oversight and regulation. It's been highlighted that a lack of recycling targets inhibits the drive to develop the sector. A lack of regulations/guidance on when items become waste and end-of-waste criteria is also problematic. The lack of EPR for textiles is highlighted, which is necessary to support covering the high sorting and recycling costs. Finally, insufficient due diligence in recycling claims has led to greenwashing and thus a loss of trust in the benefits of recycling.

## 7.4 Levels of efficiency

**Table 24: Levels of efficiency for textiles measure 7**

| Indicator: % recycling rate of clothing, household bedding, curtains and carpet | | | |
|---|---|---|---|
| **Level of efficiency** | Current | Maximum in 2035 | Business-as-usual in 2035 |
| **Percentage for Clothing, Home Textiles, Curtain** | 20 – 30% | 60 – 70% | 20 – 30% |
| **Evidence RAG** | Amber | Amber | Red-Amber |
| **Percentage for Carpet** | 11% | No Data | 11% |
| **Evidence RAG** | Red-Amber | N/A | N/A |

*A Note on Efficiencies*

It is important to recognise the difference between the recycling rate of a *process* (i.e. the yield) and the overall recycling rate of *products in the market* (i.e. clothing). A high-yielding recycling process could deliver a recycling rate of 90%. However, if you only recycle 5% of available textile waste, the overall recycling rate will only be 5% of 90% = 4.5%.

Data provided is divided between the amount of recycling in markets (as a proportion of other end-markets, i.e., reuse and disposal) and voting on recycling rates of textiles unsuitable for reuse. The analysis attempts to align these differing types of data to come to efficiency ranges.

Finally, it must also be noted that we are not differentiating between open and closed-loop recycling, however, it is expected that the change between current and BAU/maximum will be made up of fibre-to-fibre recycling – as this is where there is an industry and policy focus to support closed-loop recycling and generation of recycled content.

### 7.4.1 Current level of efficiency

Many research papers, technology patents and market reports reviewed identify yields for recycling processes at laboratory/demonstration level. However, no plant level yields are provided for pilot or commercial scale facilities, therefore, the accuracy of these claims in a "real-world" scenario is unclear.[342] No yields have been identified for "open-loop" recycling processes – but it is anticipated that these would also be reasonably high as the products generated are simple in nature i.e. rags or stuffing.

If looking instead at the overall levels of recycling in the market, one literature source (IAS 4) indicated that in the UK only 36% of used textiles were separately collected, the vast majority of collected material goes to reuse. Only 3% of separately collected material is recycled – this figure is 1% if considered as a proportion of all textile waste disposed of (including that in residual waste).[343] Stakeholder engagement and literature agree that most recycling is mechanical, with the outputs used in other sectors (e.g. post-consumer clothing used for wiping rags, or as insulation in the construction sector). More specifically to particular products (albeit not specific to the UK), other sources have stated that only 1% of clothing material is recycled into materials used in clothing again.[344]

A study from 2023 of seven European countries stated that recycling rates of collected textiles range from 10 – 30%.[345] Although it is not explicitly stated, it only refers to clothing and apparel. Although this is not a UK specific study, this source has a high IAS of 5 due to it being a recent, peer reviewed academic article. Other studies on Europe (IAS 4 - 5) indicated that currently, 7.5 – 17% of post-consumer textile waste is recycled.[346],[347],[348] Together, these sources provide a current recycling rate range of 1 – 30% with a mid-point of 15%.

If we assume the proportion of end-markets that is reuse is between 25% - 35% (based on levels of reuse in the UK and Europe as a whole), then the total proportion of material either recycled or disposed of is between 65 – 75% of discarded textiles. Therefore, the recycling rate (as a proportion of material not reused) would amount to between 20 – 23%.

No information was identified concerning the recycling of linens or bedding. However, as identified in Measure 2 – linens may be suitable for recycling in a similar manner to clothing. However, due to a lack of collection systems for recycling, it could be proposed that current recycling rates are low. For curtains, no data was identified and it is expected that post-consumer recycling is also very minimal.

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342 Hann,S. and Connock, T. (2020). Chemical Recycling: State of Play. Available at: link
343 WRAP (2019) Textiles Market Situation Report 2019. Available at: link
344 Ellen MacArthur Foundation (2017). A new textiles economy: Redesigning fashion's future. Available at: link
345 Norion Consult and EuRIC Textiles (2023) LCA based assessment of the management of European used textiles. Available at: link
346 Sandin, G & Peters, G.M. (2018) Environmental impact of textile reuse and recycling – A review. *Journal of Cleaner Production, 184. Available at:* link
347 McKinsey & Company (2022) Scaling textile recycling in Europe—turning waste into value. Available at: link
348 McKinsey & Company (2020). Fashion on climate: How the fashion industry can urgently act to reduce its greenhouse gas emissions. Available at: link

During the workshops, there was some consensus on the current recycling rate for clothing, "home textiles" and curtains, with most votes on 25 – 35% but a number also on <5%. It is unclear from voting exactly what stakeholders were including in their definition of home textiles – but given the scope was provided, it could be assumed this is household linens and bedding.

25 – 35% is higher than most of the literature identified (20 – 23%). Taking both into account, a range of 20 – 30% is suggested for current recycling rate for textiles not reused. However, the evidence RAG rating is amber since this considers both UK, European nations and European-level data, which will have different recycling capacities.

For carpets specifically, one source indicated that 3% of carpets are diverted from landfill via reuse or recycling in the US, with the remaining going to landfill or incineration. [349] Although this source was based on the US market, it exhibited an IAS of 4. An industry report on the UK market from 2019 found that 11% of carpet waste is recycled in some form. Stakeholders did not provide any additional data or vote on this measure; thus, it is deemed a red-amber evidence RAG rating.

### 7.4.2 Maximum level of efficiency in 2035

Only three sources in the literature mentioned data relevant to maximum efficiency levels, ranging from 30%-40%.[350],[351] The first source, a global industry report, with an IAS of 4, indicates that with a combination of changing attitudes, improved recycling infrastructure and textile waste-related regulations, the current level of efficiency could increase from ~17% to between 30-40%, with a further 10% increase in closed loop recycling that would be driven by improved incentivisation and investment in recycling technology.[352] From a European perspective, the second source identified in an "ambitious scenario", 37% of all textile waste would be recycled by 2030 – albeit this may not be seen as a "maximum". The same source identified that 70% of textile waste could technically be recyclable. Thus, in theory, it could be stated that of all textiles not reused – the maximum efficiency could be 70% if existing technologies are scaled.

In the workshops, voting was spread across different options, with 25%-35% and 35%-50% receiving one vote each and >50% receiving three votes. One of these votes stated "much higher than 50%", >90% for polyester. A previous general comment from a recycler (not on voting) also identified a recycling rate of >95%. Overall, if taking a consensus by majority, the value would be >80%. If considering the literature and lower votes, the mid-point would be 50%. Keeping within a 10% range would equate to 60-70% maximum efficiency. However, this has an amber evidence RAG rating due to the split of opinion across literature and stakeholder views.

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[349] Cunningham, P.R. & Miller, S.A.(2022) A material flow analysis of carpet in the United States: Where should the carpet go? Journal of Cleaner Production

[350] McKinsey & Company (2020). Fashion on climate: How the fashion industry can urgently act to reduce its greenhouse gas emissions. Available at: link

[351] Accelerating Circularity (2022) Approximately 70% of Apparel can be Recycled. Available at: link

[352] McKinsey & Company (2020). Fashion on climate: How the fashion industry can urgently act to reduce its greenhouse gas emissions. Available at: link

### 7.4.3 Business-as-usual in 2035

Sources in the literature indicated that the recycling rate could increase with the current trajectory of technological advancements and innovation. One source for the UK market identified a recycling rate of 9% (of textiles not reused), if continuing with business as usual.[353] Another stated 8%, with a 5% increase in closed loop recycling due to advancements in sorting technology.[354] However, further sources place the recycling rate between 5-13% depending on policy interventions.[355] This source exhibits an IAS of 5, but is significantly lower than the workshop consensus for the current efficiency level.

No consensus was reached in the workshop, with three participants voting that BAU would reach <5%, three voting that it would reach between 5%-15%, two voting for it to reach 15%-25%, and three voting that they did not know. Again, this does not align with the first workshop's results. Given the overall "low" votes – we propose that levels of recycling do not vary from the current efficiency – but this has a red-amber evidence RAG rating due to the voting.

For carpets specifically, there was no data found in the literature or any specific insight from stakeholders during the workshop that allow a level of recycling for the business-as-usual scenario to be developed. However, due to the fact that the figure for clothing does not increase from the current level, the assumption that the figure for carpets recycling will stay the same, in the absence of any external drivers, is valid. Therefore, we propose that the levels of recycling do not vary from the current levels – but this has a red evidence RAG rating due to lack of supporting data.

[353] WRAP. Textiles Cost-Benefit Analysis. Available at: link
[354] McKinsey & Company (2020). Fashion on climate: How the fashion industry can urgently act to reduce its greenhouse gas emissions. Available at: link
[355] WRAP (2023) Textiles Cost-Benefit Analysis. Available at: link

# 8.0 Shortlisted Measures Not Taken to Workshops

In total, 10 resource efficiency measures were identified for the textiles sector. However, it was agreed with DEFRA and DESNZ that three of these measures would not be taken forward to the workshops. These included:

- Measure A: Substitute chemicals in manufacturing with alternative materials, to reduce or remove the requirement for chemicals use.
- Measure B: Implement efficient textile material manufacturing processes
- Measure C: Recycle manufacturing by-products.

This was due to the complexities of these measures.

Measures A and C relate to chemicals substitution or recycling. There are a significant number of chemicals utilised throughout the manufacturing process. Textile chemical products range from highly specialised chemicals (e.g. biocides, flame retardants, water repellents) to relatively simple commodity chemicals (such as bleaches) or mixtures thereof (such as emulsified oils and greases, starch, sulfonated oils, waxes and some surfactants).

Measure B relates to the resource efficiency of producing textile materials. There are several stages of textile material manufacturing.[356] First, the fibres must be produced. Cotton and wool must be harvested from plants/animals respectively[357], while synthetic fibres like polyester are melt-spun.[358] These fibres are spun into yarns; and then utilised in textile manufacturing. Fibres can either be woven, knitted or utilised to produce non-wovens.[359] At each stage, the efficiency of the manufacturing process can impact output yields and thus the quantity of waste materials generated.

The complexities of these measures are such that it was not possible to identify accurate, representative data. As such, only the literature review information has been included in the following sections – without any data on current, maximum and BAU levels of efficiency.

## 8.1 Measure A – Substitute chemicals in manufacturing with alternative materials, to reduce/or remove the requirement for chemicals use

**Table 25: Summary of textiles resource efficiency measure A**

[356] Uddin, F (2019) Textile Manufacturing Processes. Available at: link
[357] Mondal, Md. I H. (2021) Fundamentals of Natural Fibres and Textiles. Available at: link
[358] Hufenus et al (2020) Melt-Spun Fibers for Textile Applications. Available at: link
[359] Uddin, F (2019) Textile Manufacturing Processes. Available at: link

| Textiles | Substitute chemicals in manufacturing with alternative materials, to reduce or remove the requirement for chemicals use |
|---|---|
| **Indicator(s)** | % reduction in dyes, finishing chemicals and water use |
| **Measure theme** | Material Substitution |

Fibres, textile materials and products most-often undergo processing for specific technical or aesthetic properties. To improve overall environmental performance, manufacturing processes can utilise textile materials that have reduced chemical processing needs.[360]

*Substitute chemicals in manufacturing with alternative materials, to reduce or remove the requirement for chemicals use.*

Four key categories of these textile chemicals have been identified as part of the literature review:

- Dyes, printing and bleaching chemicals
- Finishing Chemicals: flame retardants, oil/water/soil repellents
- Sizing/desizing chemicals
- Mineral Oils

There is significant variation in the function of these chemicals, with little detail on the quantities required in the manufacturing process. However, some solutions are noted that reduce the need for chemical processing:[361]

- *Fibres with inherent flame retardance properties* – reduces the requirement for flame retardant additives in products. NB: flame retardants are often used in technical clothing (workwear) and curtains/upholstery.
- *Treatment of textile materials with enzymes* – reduces the requirement for desizing and bleaching chemicals.
- *Polyester fibres dyeable without dye carriers* – reduces the requirement for dye carriers.
- *Optimise the amount of process chemicals used* – for example cold pad-batch treatment, low-liquor-ratio and low-volume application systems to reduce quantities required.[362] Optimisation of chemicals process can result in chemical reductions of 15%.
- *Implement water-free polyester dyeing technologies* – removes the requirement for water in the polyester dye-process. Technically, a maximum efficiency of 100% could be achieved if all dyeing was done in this manner.

[360] EU Commission (2022) COMMISSION IMPLEMENTING DECISION (EU) 2022/2508 of 9 December 2022 establishing the best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions, for the textiles industry. Available at: link
[361] Ibid
[362] Ibid.

- *Optimised cotton dyeing process* – can reduce the dye and water required by 50% through advances in dyeing technologies.
- *Optimisation and automisation of textile printing systems* – reduces the quantity of printing paste waste.
- *Pre-wetting of cotton yarns* – reduces sizing chemicals use.
- *New technologies for sizing* – reduces sizing chemicals use.

**Table 26: Drivers and barriers for textiles measure A**

| Type | Description | PESTLE | COM-B |
|---|---|---|---|
| **Driver** | Water-free dyeing is a growing field with new actors and technological developments[363] | Technological | Opportunity – social |
| **Barrier** | Applicability of the use of inherently flame-retardant materials may be restricted by product specifications e.g. technical properties of yarn/fabric[364] | Technological | Capability - physical |
| **Barrier** | Applicability of technologies may be restricted by availability of enzymes for material treatment[365] | Technological | Capability - physical |
| **Barrier** | Applicability of technologies may be restricted by lack of space for technologies to optimise chemicals usage[366] | Technological | Capability - physical |
| **Barrier** | Water-free dyeing technologies are expensive[367] | Economic | Opportunity – psychological |
| **Barrier** | Water-free dyeing technologies can often only be used with certain kinds of textiles, such as polyester[368] | Technological | Capability - physical |
| **Barrier** | Capex expenses required to implement optimised chemicals systems[369] | Economic | Opportunity – psychological |
| **Barrier** | Technologies for sizing are available that eliminate the need for a sizing application, but the yarns must | Technological | Capability - physical |

[363] UN Environment Programme (2020). Sustainability and Circularity in the Textile Value Chain - Global Stocktaking. Available at: link
[364] Ibid.
[365] Ibid.
[366] Ibid.
[367] Yale Environment 360 (2014) Can Waterless Dyeing Processes Clean Up the Clothing Industry? Available at: link
[368] Ibid.
[369] EU Commission (2014) Environmental improvement potential of textiles (IMPRO Textiles). Available at: link

| | | | |
|---|---|---|---|
| | be of very high quality and of the highest possible uniformity and consistency.[370] | | |
| **Barrier** | Use computer-controlled injection of dye onto textile materials is only applicable to new plants/major plant upgrades.[371] | Technological | Capabi–ity - physical |

## 8.2 Measure B – Implement Efficient Textile Material Manufacturing Processes

**Table 27: Summary of textiles resource efficiency measure B**

| Textiles | Implement Efficient Textile Material Manufacturing Processes |
|---|---|
| **Indicator(s)** | % reduction in yarn and fabric waste generated |
| **Measure theme** | Reduction in Production Wastes |

Yield is defined as the quantity of output based on the quantity of inputs, as a percentage.

There are several stages of textile material manufacturing.[372] At each stage, the efficiency of the manufacturing process can impact output yields and thus the quantity of waste materials generated. Optimisation of the manufacturing process provides opportunities for resource efficiency.

*B. Implement efficient textile material manufacturing processes at the polymer, yarn, textile and product stage.*

### Fibres & Yarns

Melt spinning yields (both current and maximum) for polyester have not been identified in literature.

Yarn yields are referred to as realisation in the literature. Lower yields are realised for higher fibre-count yarns due to spinning limits and customer quality requirements.[373] Ring spinning produces the most durable yarns, but results in higher quantities of waste. While rotor or air-jet spinning reduces waste but also produces courser, weaker yarns.[374] Measures to improve yarn

[370] Ibid.
[371] EU Commission (2022) COMMISSION IMPLEMENTING DECISION (EU) 2022/2508 of 9 December 2022 establishing the best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions, for the textiles industry. Available at: link
[372] Uddin, F (2019) Textile Manufacturing Processes. Available at: link
[373] Yarn recovery: The Indian Textile Journal (2022) The He(art) of spinning. Available at: link
[374] Ashvani Goyal et al (2020) Sustainability in yarn manufacturing.

realisation include controlling contamination, use of technologies to reduce waste generation and yarn conditioning.[375]

A large proportion of remaining resource efficiency measures, however, are related to recycling of production wastes (see Measure 2).

While not related to resource efficiency of manufacturing, a key element of environmental impact in the supply chain is fibre selection. Literature highlights the need to replace “conventional” fibres with “preferred” counterparts to reduce impact.[376] Some of these preferences will have a bearing on resource efficiency, but their impacts are complex to measure and even more so to “compare” between fibres. There is significant divergence of industry opinion on what constitutes “more sustainable” fibre choices, including natural vs synthetic fibres, recycled vs regenerative materials, repurposed waste from other sources vs closed loop recycling.[377],[378] This will be an important consideration in the context of enabling resource efficiency, but currently there is no appropriate measurement.

## Fabrics

Minimal literature was identified on specific yields for types of fabric (woven, knitted, non-woven). It is highlighted that “better design” of fabrics and textile blends will reduce the amount of waste to 5%.[379] This can also be done through other measures relate to recycling of fabric wastes (see Measure 2).

**Table 28: Drivers and barriers for textiles resource efficiency measure B**

| Type | Description | PESTLE | COM-B |
|---|---|---|---|
| **Driver** | Yarn realisation plays a significant role in production economics at spinning mills as resale of cotton waste is far less than the price of virgin cotton.[380] | Economic | Opportunity - social |
| **Barrier** | Limits on spinning for current machinery will limit yarn realisation rate.[381] | Technological | Capability - physical |
| **Barrier** | Presence of micro dusts, cotton trash and short fibres limit the maximum realisation.[382] | Technological | Capability - physical |

[375] Textile Learner (2022) Yarn Realization in Spinning. Available at: link
[376] Textile Exchange (2022) Preferred Fiber & Materials Market Report. Available at: link
[377] The Guardian (2022) Fashion brands pause use of sustainability index tool over greenwashing claims. Available at: link
[378] Kassatly et al (2021) The Great Greenwashing Machine – Part 1: Back to the Roots of Sustainability. Available at: link
[379] McKinsey & Company (2020). Fashion on climate: How the fashion industry can urgently act to reduce its greenhouse gas emissions. Available at: link
[380] Textile Learner (2022) Yarn Realization in Spinning. Available at: link
[381] Ibid.
[382] Ibid.

## 8.3 Measure C – Recycle Manufacturing By-products

**Table 29: Summary of textiles resource efficiency measure C**

| Textiles | Recycle Manufacturing By-products |
|---|---|
| **Indicator(s)** | % dye, finishing chemicals and water recycling rates |
| **Measure theme** | Recycling of Production Wastes |

As previously highlighted, water and numerous chemicals are utilised in textile manufacturing. Where waste generation cannot be reduced, recycling can be implemented to increase resource efficiency.

*C. Recycle manufacturing by-products waste to reduce reliance on virgin resources.*

Aligned with the key chemicals identified in the literature, the following core resource efficiency measures have been identified:

- *Dye recycling from textile waste* – Dyes can be removed from manufactured textiles to recover for reuse in the dyeing process.
- *Recycling of wastewater from dyeing process* – while estimates vary, water consumption in the dyeing process is significant. On average, 100 – 150l of water is needed to process 1kg of textile material. It is estimated that globally, 5 trillion litres of water are utilised in the apparel dyeing process.[383] If this cannot be avoided (through water-less dye – Measure A), waste water recycling can be implemented which removes the dye chemicals.
- *Sizing chemicals recycling* – Sizing chemicals used in the yarn manufacturing process can be recovered for reuse in manufacturing.

Literature has highlighted that, due to the often hazardous and/or polluting nature of finishing chemicals such as flame retardants and oil/water/soil repellents, these wastes typically must be kept separated.

**Table 30: Drivers and barriers of textiles resource efficiency measure C**

| Type | Description | PESTLE | COM-B |
|---|---|---|---|
| **Driver** | Approximately 70% of the dyes used to dye fabrics are not absorbed by the fabric and, consequently, they are discarded in the effluent. Loss of dye to effluent due to this inefficiency wastes resource and so reduces cost efficiency.[384] | Technological | Capability – physical |

383 The Sustainable Business Group (2015) The State of the Apparel Sector: Water. Available at: link
384 Lara, L et al. (2022) Ecological Approaches to Textile Dyeing: A Review. Available at: link

| | | | |
|---|---|---|---|
| **Driver** | Treatment for recycling and the reuse of wastewater is essential in addressing water pollution and water scarcity[385] | Environmental | Motivation - reflective |
| **Barrier** | Wastewater will contain spent dyeing, coating or finishing padding liquors from continuous and/or semi-continuous treatments; de-sizing liquors; spent printing and coating pastes. Some of these materials will be hazardous, inhibiting recycling of the water.[386] | Technological | Capability – physical |
| **Barrier** | Conventional wastewater treatment technologies involve physical, chemical and biological methods that have certain disadvantages, such as high capital investment and maintenance costs; and do not fully remove pollutants.[387] | Economic | Opportunity - psychological |

[385] Ibid.
[386] EU Commission (2022) COMMISSION IMPLEMENTING DECISION (EU) 2022/2508 of 9 December 2022 establishing the best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions, for the textiles industry. Available at: link
[387] Lara, L et al. (2022) Ecological Approaches to Textile Dyeing: A Review. Available at: link

# 9.0 Interdependencies

This report has discussed each of the measures identified for the textiles sector and presented estimates for the maximum and BAU level of efficiency they could achieve independently, that is, not considering any interdependencies or interactions between measures.

However, in practice these measures are likely to occur in tandem, and the levels of efficiency that are reached in each will depend on progress against other measures. The precise nature of these interdependencies should be considered when using any of the level of efficiency estimates from this report in further research or modelling exercises that attempt to produce an estimate of the cumulative impact of these measures over time.

A summary of the key interactions/interdependencies between the measures in this report with other measures in the sector, and with measures in other sectors is presented below. Note, as Phase 2 of this research project is still in the fieldwork stage, the dependencies with other sectors reflect dependencies with other Phase 1 sectors only. The Phase 2 reports will seek to capture any further interdependencies with Phase 2 sectors.

Note, the estimates for the current level of efficiency will by their nature reflect the interactions and interdependencies between measures as they currently occur.

## 9.1 Interdependencies within the sector

**Measures 1, 2, 3 & 7**

- Measure 1 – Implement Efficient Product Manufacturing Processes
- Measure 2 – Reincorporate Production Wastes Back into Manufacturing
- Measure 3 – Utilise Recycled Content from Textiles
- Measure 7 – Recycle Post-Consumer (PC) Textiles and Unsold Stock Not Suitable for Reuse

While efficient product manufacturing is about reducing the generation of waste in the first place, the next way in which to increase efficiency will be recycling of production wastes and PC waste.

However, if higher levels of efficiency are delivered in manufacturing processes, this would reduce quantities of this material available for recycling (which would be appropriate in the context of the waste hierarchy – reduction ahead of recycling).

**Measures 3 & 7**

- Measure 3 – Utilise Recycled Content from Textiles

- Measure 7 – Recycle Post-Consumer (PC) Textiles and Unsold Stock Not Suitable for Reuse

The ability to incorporate recycled content from textiles is linked significantly to the recycling of PC textiles. If fibre-to-fibre recycled rates are not increased, availability of recycled content for use in new products will be limited.

**Measures 4, 5 & 6**

- Measure 4 – Utilise Rental & Product-as-a-Service Consumption Models
- Measure 5 – Resell/Reuse of Unsold Stock and Second-Hand Products
- Measure 6 – Repair Products

Repair has the potential to extend product lifetime, thereby maintaining its suitability for rental and reuse. This is applicable to all the products in the scope of this study.

**Measures 4, 6 & 7**

- Measure 4 – Utilise Rental & Product-as-a-Service Consumption Models
- Measure 6 – Repair Products
- Measure 7 – Recycle Post-Consumer (PC) Textiles and Unsold Stock Not Suitable for Reuse

Rental products may be designed for durability to maximise their product use and lifetime. However, more durable design may impact the recyclability of the products. Similarly, repair may impede recycling e.g., patches on clothing.

**Measures 5 & 7**

- Measure 5 – Resell/Reuse of Unsold Stock and Second-Hand Products
- Measure 7 – Recycle Post-Consumer (PC) Textiles and Unsold Stock Not Suitable for Reuse

Greater levels of reuse will mean lesser amounts of material being disposed of and thus available for recycling. However, if recycling is prioritised by markets or policy, this has the potential to inhibit the growth of resource efficiency through this reuse. Although Measure 7 refers to the recycling of textiles that are not suitable for re-use, there could be a situation where retailers and/or waste management operators recycle products that are technically still suitable for reuse. This may become more prevalent as the availability of fibre-to-fibre recycling end-markets increase, in particular due to growing reputational concerns about exporting reusable textiles to international markets for reuse.[388] However, given reuse has a 70 times

[388] Pre-workshop surveys

lower overall environmental impact than the creation of a new garment, it is imperative that reuse be facilitated as far as possible in preference to recycling.[389]

## 9.2 Interdependencies with other sectors

**Virgin raw material sectors**

Incorporation of recycled content in place of virgin materials will likely have an impact on existing raw material producers in other sectors, namely the plastics industry (polyester) and the agricultural industry (cotton, wool).

**Construction sectors**

Carpets and curtains can be considered both part of the textiles sector and the construction sector. Reuse of building components is one of the resource efficiency measures described in the construction report; however, carpets and curtains represent a small proportion of the building and any potential overlap is expected to be negligible.

[389] Norion Consult and EuRIC Textiles (2023) LCA based assessment of the management of European used textiles. Available at: link

# Glossary and abbreviations

| | |
|---|---|
| BAU | Business-as-usual |
| CE | Circular Economy |
| CEBM | Circular Economy Business Models |
| Closed-Loop Recycling | Textile recycling that results in the fibres being used in new products of the same type. For example, use of recycled clothing fibre in new clothing. |
| IAS | Indicative Applicability Score |
| Open-Loop Recycling | Textile recycling that results in the fibres being used in products different to those the recycled fibres came from. For example, use of recycled clothing fibre as stuffing. |
| PC | Post-Consumer |
| RE | Resource Efficiency |

# Appendix A: IAS Scoring Parameters

**Table 31: Methodology for the calculation of the IAS**

| Number of ‘high’ criteria | Number of ‘low’ criteria | IAS |
|---|---|---|
| Indifferent | 3 or more | 1 |
| <= 1 | 2 | 2 |
| >= 2 | 2 | 3 |
| <= 2 | 1 | 3 |
| >= 3 | 1 | 4 |
| <= 1 | None | 3 |
| 2 | None | 4 |
| >= 3 | None | 5 |

**Table 32: IAS Scoring Parameters**

| **Criteria** | **High** | **Medium** | **Low** |
|---|---|---|---|
| Geography | Specific to UK | Non-UK but applicable to the UK | Non-UK and not applicable to the UK |
| Date of publication | < 10 years | 10 to 20 years | > 20 years |
| Sector applicability | Sector and measure-specific, discusses RE and circularity | Sector and measure-specific, focus on decarbonisation | Cross-sector |
| Methodology | Research methodology well defined and deemed appropriate | Research methodology well defined but not deemed appropriate / Minor description of research methodology | No research methodology |
| Peer Review | Explicitly mentioned peer review | Not explicitly mentioned, but | Unknown |

| | | | |
|---|---|---|---|
| | | assumed to have been peer reviewed | |

# Appendix B: Search strings

The following search strings were used in the literature review:

- (apparel OR textil* OR cloth*) AND (circular economy OR circular*)
- (apparel OR textil* OR cloth*) AND (circular economy OR circular*) AND manufact*
- (apparel OR textil* OR cloth*) AND design for disassembly
- (apparel OR textil* OR cloth*) AND increas* AND durability
- (apparel OR textil* OR cloth* OR fabric) AND (light-weight* OR lightweight*)
- (apparel OR textil* OR cloth*) AND material efficiency
- (apparel OR textil* OR cloth*) AND resource efficiency
- (apparel OR textil* OR cloth*) AND resource efficiency AND certificat*
- (apparel OR textil* OR cloth*) AND resource efficiency AND manufact*
- (apparel OR textil* OR cloth*) AND resource efficiency AND manufact* AND technolog*
- (apparel OR textil* OR cloth*) AND sustainability
- automation AND textil* AND manufact*
- circular* AND textil* AND design
- design* AND textil* AND recycl*
- increas* AND cloth* AND longevity
- minim* AND impact AND textil* AND (fibre OR fabric) AND manufact*
- minim* AND overproduction AND (textil* OR cloth*)
- optim* AND fibre AND yield AND textil* AND manufact*
- optim* AND textil* AND fabric AND durab*
- optim* resource efficiency AND textil* AND assembl*
- optim* AND textil* AND collection AND reuse
- production on demand AND (Textil* OR cloth*)
- reduc* AND return rate AND (cloth* OR apparel)
- resource efficien* AND (textil* OR cloth*) AND (standards OR product standards)
- resource efficien* AND (textil* OR cloth*) AND consumption
- resource efficien* AND model AND textil*

- resource efficien* textil* processing
- textil* AND (eco-design OR ecodesign)
- textil* AND (post-industrial OR post industrial) AND (waste recycling OR recycling)
- textil* AND ("product as a service" OR "product-as-a-service" OR PaaS)
- textil* AND (recycled content OR utilisation recycled content)
- textil* AND (waste minimisation OR waste reduction)
- textil* AND by-product
- textil* AND by-product AND recycl*
- textil* AND Circular Economy Business Model
- textil* AND durab* AND optim*
- textil* AND high-volume collection systems
- textil* AND manufact* AND waste minimisation
- textil* AND optim* AND (sorting OR sorting for recycl*)
- textil* AND product longevity
- textil* AND recycl* AND (optim* yield OR yield)
- textil* AND remanufact*
- textil* AND repair
- textil* AND reuse
- textil* AND sourcing AND strateg* AND optim*
- textil* AND supply and demand AND optim*
- textile to textile AND recycl* AND optm*

# Appendix C: Literature sources

**Table 33: List of literature sources for the textiles sector**

| Title | URL | Author | Year | IAS |
|---|---|---|---|---|
| A material flow analysis of carpet in the United States: Where should the carpet go? | link | Cunningham, P.R. and Miller, S.A. | 2022 | 4 |
| A new textiles economy: Redesigning fashion’s future | link | Ellen MacArthur Foundation | 2017 | 4 |
| A review of commercial textile fibre recycling technologies | link | Wrap | 2012 | 3 |
| A Review on Textile Recycling Practices and Challenges | link | Jeanger P. Juanga-Labayen, Ildefonso V. Labayen and Qiuyan Yuan | 2022 | 3 |
| An overview of cotton and polyester, and their blended waste textile valorisation to value-added products: A circular economy approach – research trends, opportunities and challenges | link | Subramanian, K., Sarkar, M.K., Wang, H., Qin, Z.H., Chopra, S.S., Jin, M., Kumar, V., Chen, C., Tsang, C.W. and Lin, C.S.K. | 2021 | 3 |
| Apparel Consumer Behavior and Circular Economy: Towards a Decision-Tree Framework for Mindful Clothing Consumption | link | Patwary, S., Haque, M.A., Kharraz, A.J., Khanzada N.K., Farid, M.U. & Kumar, N.M. | 2023 | 5 |
| Application of design for disassembly in men’s jacket: A study on sustainable apparel design | link | Gam, H.J., Cao, H., Bennett, J., Helmkamp, C. and Farr, C. | 2011 | 4 |
| Application of nanotechnology in textile engineering: An overview | link | Patra, J.K. and Gouda, S. | 2013 | 4 |
| Approximately 70% of Apparel can be Recycled | link | Accelerating Circularity, Avery Dennison | 2022 | 3 |
| Are Your Online Returns Contributing To Fashion’s Waste Problem? | link | Vogue | 2022 | 1 |

| | | | | |
|---|---|---|---|---|
| Assessing the impact of design strategies on clothing lifetimes, usage and volumes: The case of product personalisation | link | Maldini, I., Stappers, P.J., Gimeno-Martinez, J.C. & Daanen, H.A.M. | 2019 | 4 |
| Automated and Efficient Production | link | Dykon | 2021 | 3 |
| Bedding recycling and blankets disposal | link | Business Waste | No date | 1 |
| Best Available Techniques (BAT) Reference Document for the Textiles Industry | link | Roth, J., Zerger, B., De Geeter, D., Benavides, J.G., Roudier, S. | 2023 | 5 |
| Bras fit for burying: Australia to set a world-first standard for composting textiles | link | Tonti, L. & Gorman, A. | 2023 | 3 |
| Can waterless dyeing processes clean up the clothing industry? | link | Heida, L. | 2014 | 1 |
| Cellulose Regeneration and Chemical Recycling: Closing the “Cellulose Gap” Using Environmentally Benign Solvents | link | El Seoud, O.A., Kostag, K., Jedvert, K. And Malek, N.I | 2020 | 4 |
| Changing our clothes: Why the clothing sector should adopt new business models | link | WRAP | 2020 | 5 |
| Chemical Recycling: State of Play | link | Hann, S & Connock, T | 2020 | 3 |
| Circular business models: redefining growth for a thriving fashion industry | link | Ellen MacArthur Foundation | 2021 | 4 |
| Citizen Insights: Clothing Longevity and Circular Business Models receptivity in the UK | link | WRAP | 2022 | 5 |
| Clean by Design, Apparel Manufacturing and Pollution | link | Clean by Design | 2015 | 3 |
| Clothing labels: Accurate or not? | link | Circle Economy | 2020 | 3 |
| COMMISSION IMPLEMENTING DECISION (EU) 2022/2508 establishing the best available techniques (BAT) conclusions under Directive 2010/75/EU of the European Parliament and of the council on industrial emissions, for the textiles industry | link | European Commission | 2022 | 5 |

| | | | | |
|---|---|---|---|---|
| Critical aspects in design for fiber-to-fiber recycling of textiles | link | Elander, M and Ljungkvist, H. | 2016 | 5 |
| Decolonising Fashion: How an Influx of 'Dead White Man's Clothes' is Affecting Ghana | link | Lorenz, J. | 2020 | 1 |
| Durable, repairable and mainstream: How ecodesign can make our textiles circular | link | ECOS | 2021 | 3 |
| DyeRecycle | link | DyeRecycle | 2023 | 3 |
| Ecofast Pure: Sustainable Fabric Treatment | link | DOW | No date | 1 |
| Ecological Approaches to Textile Dyeing: A Review | link | Lara, L. Cabral, I., and Cunha, J. | 2022 | 4 |
| Emerging partnerships between non-profit organizations and companies in reverse supply chains: enabling valorization of post-use textile | link | Zhuravleva, A., Aminoff, A. | 2021 | 5 |
| Environmental impact of textile fibers – what we know and what we don't know | link | Sandin, G., Roos, S. and Johansson, M. | 2019 | 5 |
| Environmental impact of textile fibres – what we know and what we don't know. Fiber Bible part 2. | link | Sandin, G., Roos, S. & Johansson, M | 2019 | 5 |
| Environmental impact of textile reuse and recycling – A review | link | Sandin, G. and Peters, G.M. | 2018 | 4 |
| Environmental improvement potential of textiles (IMPRO) | link | Beton, A., Dias, D., Farrant, L., Gibon, T., Le Guern, Y., Desaxce, M., Perwueltz, A. and Boufateh, I. | 2014 | 3 |
| Establishing standard allowed minutes and sewing efficiency for the garment industry in Tanzania. | link | Nchalala et al | 2022 | 4 |
| EU Strategy for Sustainable and Circular Textiles | link | EU Commission | 2022 | 3 |

| | | | | |
|---|---|---|---|---|
| Fashion on Climate: how fashion industry can urgently act to reduce it greenhouse gas emissions | link | Global Fashion Agenda & McKinsey | 2020 | 4 |
| Fiber Conversion Methodology | link | Textile Exchange | 2022 | 3 |
| Fibre to Fibre Recycling: An economic & financial sustainability assessment | link | Wrap | 2019 | 5 |
| Flow Chart of Apparel Manufacturing Process | link | Kiron, M.I. | 2012 | 1 |
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| Solving fashion’s product returns | link | Institute of Positive Fashion | 2023 | 5 |
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| Textiles Market Situation Report 2019 | link | WRAP | 2019 | 4 |
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# Appendix D: List of Discarded Resource Efficiency Measures

During the literature review, several measures were de-prioritised due to several reasons, such as overlaps in the definition, being enablers instead of resource efficiency measures, or being outside of the agreed scope. These discarded measures are listed below alongside the reason for their exclusion.

**Table 34: List of resource efficiency measure classified as medium scope for the textiles sector**

| Lifecycle | Sub-theme | Measure name | Measure indicator | Reason for exclusion |
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| Design | Recyclability | Design for recyclability | % increase in recycling rate due to design | Too difficult to quantify and lack of robust data |
| | | Material palette reduction | % reduction in number of materials in a single product | Too difficult to quantify and lack of robust data |
| | | Reduced disassembly time of products | Time disassembly of products (minutes) | Too difficult to quantify and lack of robust data |
| | | Recyclability index of materials | Ability of materials to regain in value through the recycling process | This is regarded as an enabler of recycling rather than a direct measure |
| | | Use of recyclable materials | % of products placed on the market suitable for recycling | This is too difficult to quantify / subjective depending on what is defined as recycling |
| | Durability | Design for durability | % increase to product lifetime | The premise of this measure is already addressed in the shortlisted measures (reuse and repair) |

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| | | | % reduction of textile waste | Not indicative of durability as not the only reason people discard of clothing |
| | | | % of garments manufactured methods that produce more durable types of yarn (rotor spinning or air jet spinning) | Lack of robust and consistent data on manufacturing methods for product types |
| | | Use of better quality fibres to improve durability | % of high durable fibres per product | Lack of robust data on product composition |
| | | Design of modular/versatile garments that can function as multiple garments | % share of modular/versatile garments on the market | This is too narrow a scope and is not indicative of the actions occurring in the textile market. |
| | | Use of nanotechnology for durability, such as anti-microbial properties or UV protection | % concentration of [nanotechnology] used | Use of emerging technologies not disclosed in enough detail to obtain robust and consistent data |
| | Repairability | Design for repairability | % increase in repairability of products due to modular design | The premise of this measure is already addressed in the shortlisted measures (repair) |
| | Material substitution | Use of secondary raw materials | Incentives for companies to change to sustainable alternatives | This is regarded as an enabler of recycling rather than a direct measure |

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| | | | % recycled content (by weight) | Lack of robust data on product composition |
| | | | % market share of secondary raw material usage | This is not indicative of the uptake of recycled content in textile products |
| | | | Value of secondary raw materials compared to virgin | This is regarded as an enabler of recycling rather than a direct measure |
| | | | Availability of secondary raw materials | This is regarded as an enabler of recycling rather than a direct measure |
| | | Industrial symbiosis | % of material used from other industries' waste | The premise of this measure is already addressed in the shortlisted measures (utilise content from other wastes) |
| | | Minimise use of hazardous chemicals | Use of tools to help manufacturers search for safe alternatives | This is regarded as an enabler of improved manufacturing processes rather than a direct measure |
| | | Use of bio-based and renewable materials | % of bio-based and renewable materials | The premise of this measure is already addressed in the shortlisted measures (substitute chemicals) |
| | | Use of bio-based renewable levelling agents | %of levelling agents from bio-based/renewable sources | The premise of this measure is already addressed in the shortlisted measures (substitute chemicals) |
| | | Substitute mineral oils with synthetic/ester oils | Ratio of mineral oil/synthetic oil used | The premise of this measure is already addressed in the shortlisted measures (substitute chemicals) |

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| | | Selection of dyes with dispersing agents that are biodegradable/ compostable | % of biodegradable/compostable dyes used during production | The premise of this measure is already addressed in the shortlisted measures (substitute chemicals) |
| | | Use of auxiliaries that enable more efficient dying | % reduction in intensity of dying process due to use of auxiliaries | The premise of this measure is already addressed in the shortlisted measures (substitute chemicals) |
| | Waste reduction at production stages | Minimise waste generated during garment manufacturing | % wastage in textiles | The premise of this measure is already addressed in the shortlisted measures (efficient manufacturing) |
| | | | % of garments manufactured using higher efficiency methods (rotor spinning or air jet spinning) | Use of technologies is not disclosed in enough detail to obtain robust and consistent data |
| | | Production efficiency | % yield | The premise of this measure is already addressed in the shortlisted measures (efficient manufacturing) |
| | | | % efficiency of machinery | The premise of this measure is already addressed in the shortlisted measures (efficient manufacturing) |
| | | Recycling of production wastes | % manufacturing yarn recycling rate | The premise of this measure is already addressed in the shortlisted measures (efficient manufacturing) |

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| | | | % manufacturing yarn waste reincorporated | The premise of this measure is already addressed in the shortlisted measures (efficient manufacturing) |
| | Design for biodegradation at EoL | Ensuring material can biodegrade/compost at the end of their useable life | % of products made from biodegradable/compostable materials | Could be subjective to what is defined as biodegradable/compostable in the sources |
| Manufacture | Value chain optimisation | Reduction in use of water in dyeing | % decrease in water consumption | The premise of this measure is already addressed in the shortlisted measures (efficient manufacturing) |
| | | Reduction in chemical usage with more efficient technology | % reduction in chemical use compared with current technology | The premise of this measure is already addressed in the shortlisted measures (efficient manufacturing) |
| | Reduction of production wastes | Reduction in off cut waste using software systems and other processes | % reduction in offcut waste | The premise of this measure is already addressed in the shortlisted measures (efficient manufacturing) |
| | | Reduced raw material wasted | % reduction of raw material waste | The premise of this measure is already addressed in the shortlisted measures (efficient manufacturing) |
| | | Hazardous chemical discharge | Reduction in number of hazardous chemicals in supply chain | The premise of this measure is already addressed in the shortlisted measures (efficient manufacturing) |
| | | Minimise chemical waste | Implement maximum storage | This is regarded as an enabler of improved |

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| | | due to expiration | time of process chemicals to avoid perishing | manufacturing processes rather than a direct measure |
| | | Optimise use of printing paste and other materials used in the process | Reduction in use of materials with same quality outputs | The premise of this measure is already addressed in the shortlisted measures (efficient manufacturing) |
| | | Improvement of waste collection during the garment manufacturing stage | % of waste garments collected at the manufacturing stage | Not a useful indicator without inclusion of what is done with the waste |
| | | Increase the reuse and recycling of unsold products | % of unsold products that are disposed of | The premise of this measure is already addressed in the shortlisted measures (reuse) |
| | Recycling of production wastes | Recovery of chemicals in effluent stream and recovery of residual chemicals | % of chemicals recycled | The premise of this measure is already addressed in the shortlisted measures (efficient manufacturing) |
| | | Recovery of dyes from textile waste to reduce consumption of virgin chemicals | % reduction in virgin chemicals used for dying process | The premise of this measure is already addressed in the shortlisted measures (efficient manufacturing) |
| | | Recovery and reuse of wastewater during the manufacturing process | % of wastewater that is recovered and reused during the manufacturing process | The premise of this measure is already addressed in the shortlisted measures (efficient manufacturing) |

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| | | Recycling of printing paste | % of printing paste recovered and reused | The premise of this measure is already addressed in the shortlisted measures (efficient manufacturing) |
| | Performance monitoring | Use of predictive analysis and other management technologies to reduce unsold stock | % reduction in unsold stock | The premise of this measure is already addressed in the shortlisted measures (reuse) |
| | | Increase of on-demand manufacturing | % return rate reduction | The premise of this measure is already addressed in the shortlisted measures (reuse) |
| Sale | Hiring and leasing | Increase the uptake of textile rental services | % of people using rental services for clothing | The premise of this measure is already addressed in the shortlisted measures (rental and products-as-a-service) |
| | | Increase availability of textile rental services | % market share of textile rental services | The premise of this measure is already addressed in the shortlisted measures (rental and products-as-a-service) |
| | | Increase number of wears / uses per product | Average lifetime of a product | The premise of this measure is already addressed in the shortlisted measures (rental and products-as-a-service and repair) |
| | | Use of clothing libraries to extend product lifetime | % of people using clothing libraries | The premise of this measure is already addressed in the shortlisted measures |

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| | | | | (rental and products-as-a-service) |
| | Products-as-a-service | Hire and repair models | % market share | The premise of this measure is already addressed in the shortlisted measures (rental and products-as-a-service) |
| | Performance monitoring | Minimise leftover stock due to returns (from e-commerce) | % return rate | The premise of this measure is already addressed in the shortlisted measures (reuse) |
| | | Reduce production of unsold stock | % of unsold stock | The premise of this measure is already addressed in the shortlisted measures (reuse) |
| | | Reduce the amount of unsold stock that gets sent to recycling | % unsold stock that gets sent to recycling | The premise of this measure is already addressed in the shortlisted measures (reuse) |
| | Digitalisation | Implementing digital services to improve buying accuracy and reduce return rates | Presence and use of technologies in the market | This is regarded as an enabler of reducing unsold stock rather than a direct measure |
| Use | Function and operation | Increase longevity of products placed on the market | Average number of wears / uses | The premise of this measure is already addressed in the shortlisted measures (reuse) |
| | | Increase longevity of products through | % increase in product longevity | Too difficult to quantify and attributed extended lifetime to labelling |

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| | | instructions for proper care via labelling | | |
| | Reuse | Increase in product lifetime due to resale | % increase in product longevity due to resale | The premise of this measure is already addressed in the shortlisted measures (reuse) |
| | | | % share of the second hand market | The premise of this measure is already addressed in the shortlisted measures (reuse) |
| | Repair | Discounted repair services for own brand products | % of retailers offering repair services | This is regarded as an enabler of repair rather than a direct measure |
| | | Displacement of new products purchased through repair | % share of the market | Alternative indicator was chosen for this indicator |
| | | The use of professional repair services or repairing at home | % of people that have used repair services / carried out repairs at home | The premise of this measure is already addressed in the shortlisted measures (repair) |
| EoL | Recycling | Implementation of automated sorting for recycling | Implementation of technology that can automatically sort large volumes of mixed textiles | This is regarded as an enabler of recycling rather than a direct measure |
| | | Decreased environmental impact | % reduction in water/carbon footprint of secondary raw material | This is not indicative of the uptake of secondary material in the industry |

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| | | Divert greater quantities of material to reuse and recycling | % end of treatment distribution of end of life textiles | Progress tracking rather than resource efficiency |
| | | | % reduction of used textiles in residual waste | This is not necessarily indicative of increased recycling |
| | | | % collection rate of used textiles | The premise of this measure is already addressed in the shortlisted measures (recycling) |
| | | | Tonnage of material sold for recycling as a raw material | The premise of this measure is already addressed in the shortlisted measures (recycling) |
| | | | Existence of supplier take-back schemes | This is regarded as an enabler of reuse and recycling rather than a direct measure |
| | | Biodegradation /composting of textile waste | Yields of biogas from processing of textile waste | Too niche and difficult to quantify |
| | | More engagement with recycling through labelling | % of products with product composition on labels | Lack of robust data |
| | | Increase the amount of yarn/fibre-to-fibre/chemical/ mechanical recycling | Tonnage of material recycled by method per year | Lack of robust data on exact recycling methods used, especially as a total % of the total |
| | | | % increase in yield of secondary raw material per year | Lack of robust data |

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| | Reuse | Increase reuse activities | % reuse rate (by weight in tonnes) in the UK or globally | The premise of this measure is already addressed in the shortlisted measures (reuse) |
| | | | % share of the market of reuse/resale in the UK or globally | The premise of this measure is already addressed in the shortlisted measures (reuse) |
| | | Reuse of unsold stock | % share of the market of the unsold stock that has been remanufactured into new products | The premise of this measure is already addressed in the shortlisted measures (reuse and recycling) |
| | Repair | Increase longevity through repair services | % increase in product lifetime due to repairs | The premise of this measure is already addressed in the shortlisted measures (repair) |
| Supply Chain | Value chain optimisation | Deliver partnerships to support embedding circular economy practices | Number of multi-stakeholder initiatives to advance collaborations in resources reuse and recycling from the design stage | This is regarded as an enabler of reuse and recycling rather than a direct measure |
| | | Implement sustainable material sourcing systems | % of producers utilising traceability technology | This is regarded as an enabler of supply chain optimisation rather than a direct measure |
| | | Requirement to offer warranties to repair or replace products | Number of products under warranty | The premise of this measure is already addressed in the shortlisted measures (repair) |

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| | | Corporate fibre and materials benchmarks to help companies measure , manage and integrate a materials strategy | % of companies with a fibre and materials strategy | This is regarded as an enabler of recycling rather than a direct measure |
| | | Development of centralised B2B platforms that allow for industrial symbiosis | % of material purchased from waste of other processes | The premise of this measure is already addressed in the shortlisted measures (utilise recycled content from other wastes) |
| | | Select enzymes to catalyse reactions with textile materials to lower consumption of process chemicals | % reduction in chemical usage | The premise of this measure is already addressed in the shortlisted measures (substitute chemicals) |
| | | Compress fibre strands to reduce the amounts of sizing chemicals used | % reduction in sizing chemicals used | The premise of this measure is already addressed in the shortlisted measures (substitute chemicals) |
| | | Use enzymes to remove unfixed dyestuffs from textile materials | % water saved and reduced rinsing steps | The premise of this measure is already addressed in the shortlisted measures (substitute chemicals) |
| | | Utilise whole-garment production methods to reduce | % reduction of production wastes | The premise of this measure is already addressed in the shortlisted measures (efficient manufacturing) |

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| | | manufacturing waste | | |
| | Incentivised returns | Implementation of supplier take-back collection systems | % of retailers with incentivized return systems | This is regarded as an enabler of reuse and recycling rather than a direct measure |
| | Performance monitoring | Improved procurement systems and product sourcing by suppliers | % of sourced materials from more sustainable suppliers | This indicator is too broad and difficult to certify, and could be subjective to the definition of 'more sustainable' |
| | Raw material extraction | Implemented best-in-class production processes | - | This measure is too broad and non-specific to identify an indicator |
| | | Transition to regenerative agriculture | % of raw materials obtained through regenerative agriculture | This indicator is too specific and there is a lack of robust data to quantify this indicator |
| | | Reduction in the use of process chemicals during | Dosage of process chemical | The premise of this measure is already addressed in the shortlisted measures (substitute chemicals) |
| | | Use of textile materials with reduced processing needs | % reduction in processing costs | The premise of this measure is already addressed in the shortlisted measures (efficient manufacturing) |
| | | Utilise steam fixation of reactive dyes in place of fixation chemicals | % reduction of fixation chemicals | The premise of this measure is already addressed in the shortlisted measures (substitute chemicals) |
| | | Utilise cold-pad batch treatment | % reduction of fixation chemicals | The premise of this measure is already |

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| | | to reduce the use of chemicals and subsequent steps | | addressed in the shortlisted measures (substitute chemicals) |

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