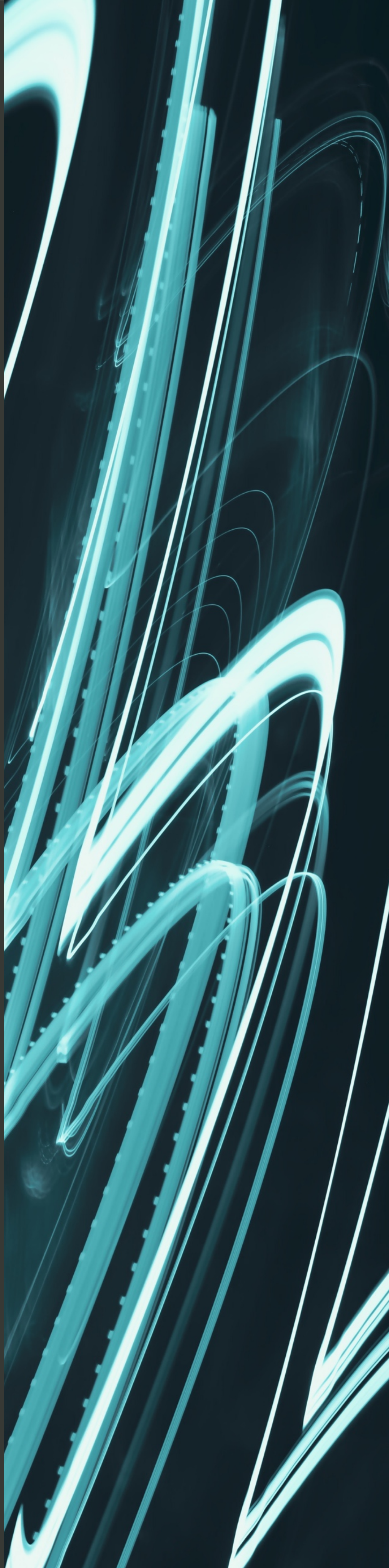
responsiv

simple · effective · distinctive

WHITEPAPER

Recycling Textiles in the United Kingdom



Intended Audience

This paper is intended for anyone involved or considering involvement in sustainability and recycling of textile material in the UK. It considers the social and environmental impact of the collective textiles supply chains, the growing consumer and social pressures for more sustainable practices in all industries, and the opportunity for commercial benefit are problems worth understanding and solving.

Disclaimer

Observations and recommendations documented in this white paper are based on our opinions, experience, and research. They are as objective and representative as we can reasonably be, however Responsiv makes no representation as to accuracy or fitness for purpose. Once you have chosen a course of action, it should be thoroughly evaluated to ensure fitness for purpose.

About the Author

Richard Whyte is an accomplished IT architect with a proven ability to innovate and focus on customer requirements to deliver simple, effective solutions. He has demonstrated thought leadership based on a breadth of technical and project experience spanning Investment Banking, Retail, Manufacturing, and Aerospace, delivering sustainable technology to some of the world's largest companies.

Richard has a degree in statistics and computing and a master's in business administration. He is a Fellow of the British Computer Society (FBCS), Chartered Engineer (CEng), Chartered IT Professional (CITP), and Fellow of the Institute of Engineering and Technology (FIET).

About Responsiv

Responsiv Solutions is a UK based company that specialises in delivering business integration across the enterprise, including API management, Business Process Automation, and Digital-SOA platforms. We work across many industries, including Retail, Financial Services, and Government.

Responsiv can provide fully commissioned solutions that include all the software and professional services needed to deliver an integration platform to support your business plan and grow with your business.

Table of Contents

Introduction

This white paper is intended for those interested in understanding the current state of textile recycling as it applies to potential to recycle.

The paper considers different sources of textile materials and the extended supply chain before discussing the potential for circular textiles in the UK.

In clothes and furniture, medical and protective equipment, buildings, and vehicles, textiles are the fabric of everyday life. European consumption of textiles has the fourth highest impact (from the EU) on the environment and climate change globally after food, housing, and mobility. It is the third highest sector for use of water and land, and fifth for the use of primary raw materials and greenhouse gas emissions.

The average European throws away 11kg of textiles every year; around the world, a truckload of textiles is landfilled or incinerated every second. Global textiles production almost doubled between 2000 and 2015, and the consumption of clothing and footwear is expected to increase by 63% by 2030. In parallel with this relentless expansion, negative impacts on resources, water, energy consumption, and the climate continue to grow. The need to address the production and consumption of textiles is now more urgent than ever before. (European Commission Brussels, 2022)

Motivation

This paper considers (1) the social and environmental impact of the collective textiles supply chains, (2) the growing consumer and social pressures for more sustainable practices in all industries, and (3) the opportunity for commercial benefit are problems worth understanding and solving.

Regulations in the planning stage, and now fragile global supply chains, make the time to face these long-term concerns and propose innovative and exciting solutions that catch the imagination.

The problem is not an easy one to solve. Gaining visibility to the processes and data is a technically complex and commercially sensitive area. The different interest groups will make this a politically challenging situation.

The Textile Industry

The UK fashion and textile (UKFT) industry is one of the largest sectors in the country, and its influence extends around the world. In 2023 the industry contributed £62bn to the UK economy, with 1.3 million jobs, and over £23bn in tax contributions, it makes a significant contribution to the country's growth. (UKFT and Oxford Economics, 2023)

Textiles represent a significant waste stream in the UK because of constantly changing trends and 'fast fashion' manufacturing and production methods, alongside the difficulties recycling complex mixed material apparel. Of 1.13 million tonnes of unwanted clothing thrown out every year, 540,000 tonnes are sent for re-use (around 70 per cent of which is exported overseas) and 160,000 tonnes is recycled. Of that exported overseas the majority ends up illegally dumped[1].

Around 350,000 tonnes of fashion textiles end up in landfill every year, despite much of it still being wearable and holding commercial value. (Welsh Government and WRAP, 2022-23)

Other major sources of textile material include hospitality, health services, home furnishing, and transport sectors.

[1] https://amp.theguardian.com/global-development/2023/jun/05/yvette-yaa-konadu-tetteh-how-ghana-became-fast-fashions-dumping-ground

Textile Supply Chain

The textile supply chain for natural fibres (traditionally) begins at the farm. The example here is for cotton, however wool, leather, and other materials follow a similar pathway.

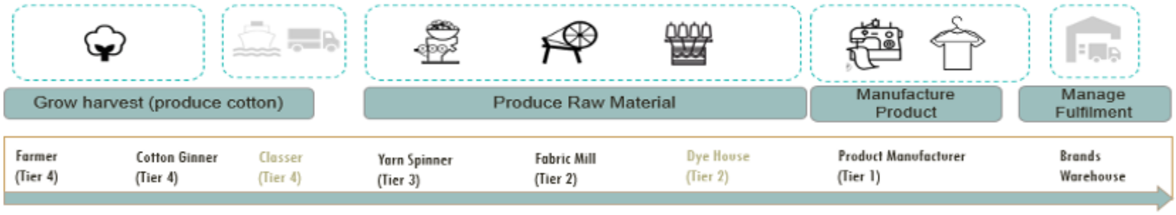


Figure 1; Textile supply chain

Raw materials from individual harvests are combined to produce refined raw materials ready to enter the manufacturing process. At this point, batches of refined materials are combined or split to produce the (in this case) cotton elements of a product. The product is further combined with other materials, for example buttons and zips, to finish the article.

Immediately the traceability of an existing and understood supply chain becomes unclear. The combining and separation of bulk materials complicates tracing the lineage of any “bill of materials,” even for the simplest products. The chain can be traced in either direction, from the consumer order backwards or from the raw fibre forward.

Manmade fibres follow a similar path from oil-based products to a manufactured thread, which is then used in the manufacturing process to produce products or combine with natural fibres to share beneficial properties.

Textile waste that may be suitable for recycling is generated at almost every stage of this supply chain.

Textile Recycling

Textile recycling is not new.

In the 1880s "jumble sales" (Richmond, 2009) and collections, including the far older "rag and bone man" were responsible for re-wearable and recycling collections. The revenue in the fashion E-commerce market in the United Kingdom was forecast to continuously increase between 2024 and 2028 by in total 10.7 billion U.S. dollars (+24.24 percent). (Statista, 2023)

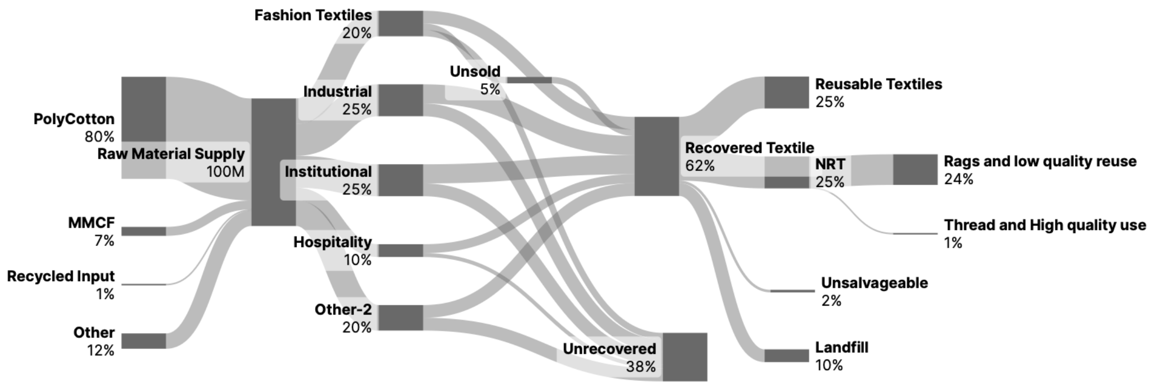


Figure 2; Illustrative textile pathways with approximate proportions.[2]

Currently post-use textiles are processed into lower value industrial products such as rags and vehicle insulation, or are incinerated or sent to landfill if kept in the UK. Otherwise they are exported with unverifiable outcomes that includes significant unmanaged landfill.

25% of all manufactured garments are never sold.

At first glance this problem is commercially inefficient and wasteful.

The problem has at least three major contributing factors: (1) garments must be in the right place to be sold, and that is not known until the customer enters a shop. Some shops run out of stock, while others have too much. (2) Fast fashion is named well; a garment selling today can be dead stock tomorrow, predicting sales volume is difficult, and the cost of manufacturing and shipping smaller batches is worse than disposal. (3) The batch size is somewhat dictated by the materials and scheduling in factories and shipping volumes.

It is easy to criticise the situation but hard to solve the problem without moving cost and inefficiency elsewhere.

A small proportion of textile waste is circular.

UK consumers and industry dispose of approximately 1Bn tonnes of used textiles with around 700 million tonnes collected with the intention to recycle. Approximately half (50%) of textiles intended for recycling are non-re-wearable textiles (NRTs).

The United Kingdom currently lacks the facilities and capacity to make use of recycled textiles. Instead, textile waste is shipped to foreign recyclers in the global south. This creates little-no visibility of the onward chain of custody or impacts of this 'outsourcing'. Recycling textiles is complex, with most items made up of multiple materials and embellishments. Processing and transportation of low value bulk item such as recycled textiles is a significant cost, leading to a preference for virgin materials. This is further impacted by most manufacturers

[2] Man-made cellulosic fibres (MMCFs) are mainly made from wood pulp, the most common form is viscose, our third-most used raw material in Clothing & Home products. Other examples are used in textiles are lyocell and modal. (Marks and Spencer, 2023)

residing outside the UK further increasing transport costs for textiles to become inputs to new clothing and apparel. [4]

Situation in the United States

The United States has a similar problem and similar proportions. Their propensity to discard to landfill appears to be greater than the UK, with only 15% being considered for reuse, recycling, or re-engineering to raw material.

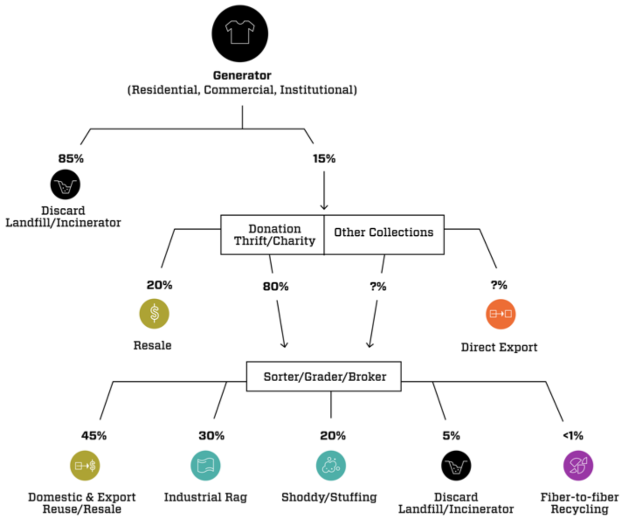


Figure 3; Textile recycling pathways (USA, NIST)

Summary

It is estimated that encouraging re-use and recycling of clothing and textiles has the potential to achieve a 20% reduction of the industry's carbon, water, and waste footprint. WRAP and the Welsh Government point out that 41% of respondents to their recycling survey say they're not aware of recycling or re-use facilities for textiles. (Welsh Government and WRAP, 2022-23)

Re-wearable fashion textiles (RTs) are often unattractive (out of fashion, dirty) to consumers making them difficult to re-sell. This is less applicable to expensive garments and high-quality goods; however, even expensive products go out of style or reach a stage of non-reuse.

Non-fashion textiles account for a significant proportion of textiles being discarded in the UK. These textile products, including worn out seat covers, curtains, hospital gowns, and hotel bed sheets, are unsuitable for reuse. These textiles tend to be more homogenous, so are more easily processed than bundles of mixed consumer textiles, making them more ideal for mass textile recycling.

Inefficiencies in the supply chain can be improved but are unlikely to be completely removed.

Conclusion

Circular Textiles will not answer questions of efficiency in the supply chain and will not be capable of absorbing all discarded textiles. The numbers suggest that the addressable volume for circular textiles recycling in the UK could be 80% of consumer disposed fashion textiles, perhaps the same proportion of the 25% unsold textiles, and a higher proportion of hospitality and institutional textiles. (Souchet, 2019)

These estimates are based on the figures above.

[4] https://textilevaluechain.in/news-insights/top-10-clothing-manufacturing-countries-in-the-world/

Circular Textiles Today

Circular textiles is a term that encapsulates the idea of mechanically or chemically recovering post-use textile raw material in a manner that allows it to be refined into raw materials (thread) suitable for re-entering the supply chain during the manufacturing process.

The goal is to produce thread that is of similar quality to the dismantled garment, that can be used to produce high quality products.

PET Textile Recovery

Textiles and other goods made from PET can be recycled into pellets that can be extruded to produce thread.[5] The 'textile recycling machine' (figure 4) processes shredded fibre waste from production processes to produce pellets that can be used to make ultra-fine fibres.

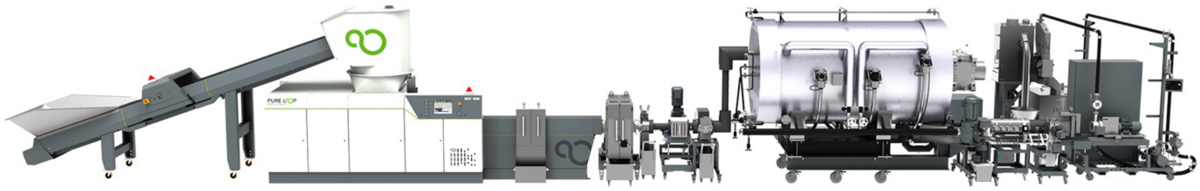


Figure 4; ISEC evo FibrePro: IV – The Textile Recycling Machine (PureLoop, 2023)

The recycling machine shown is an example of what is involved to take PET-based materials and recycle them into raw materials. The machine can use plastic bottles, mouldings, and other goods as well as textile waste (so long as they share compositions).

The resulting fibres are of good quality and can be used to make high quality goods, including textiles and non-textile goods.

While this process demonstrates recycling, it falls short of circular aspirations as it is a linear process from bottles through to textiles for a single iteration.

Natural Material Recovery

One possible process for fibre recycling is fibre reclamation, which is extraction of fibres from textile waste and their reuse. The textile is disintegrated into loose fibres, which can be spun into a yarn. Post-consumer waste is more difficult to recycle by this method than pre-consumer waste because of impurities left on the used products and their varying wear/tear condition.[6] (Irena Wojnowska-Baryła, 2022)

The technologies that do exist to produce wool, cashmere, and cotton lead to shortened fibre lengths in the yarns, which reduces their quality.

[5] Polyethylene terephthalate (PET, PETE, or the obsolete PETP or PET-P), is the most common thermoplastic polymer resin of the polyester family and is used in fibres for clothing, containers for liquids and foods, and thermoforming for manufacturing, and in combination with glass fibre for engineering resins. (https://en.wikipedia.org/wiki/Polyethylene_terephthalate)

[6] Post-consumer waste is waste that comes after use by consumers instead of from the manufacturing process. Pre-consumer waste is produced during the manufacturing process, such as textile offcuts and plastic packaging.

Complexities of Textile Recovery

Textile recycling is a complex business that requires collection, sorting, cleaning, and engineering to produce the new raw material. Impurities in the material, including colours, cleaning fluids, and mixed materials further complicate the process of creating a virgin raw material that can be efficiently used.

The process of material collection to re-entry to the textiles supply chain begins with materials being collected through multiple routes including dead stock, clothes banks, retail drop offs, curb-side pick-up, and charity shops.

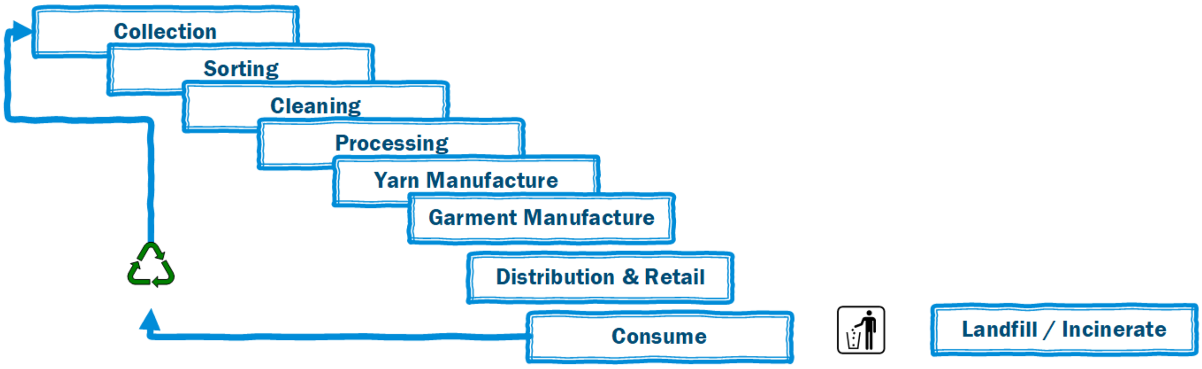


Figure 5; Recovery and reuse process.

Material Recovery Facilities (MRFs) sort and prepare recyclable materials for onward sale to market or manufacturers.

Unrecyclable or non-target materials are sent for further treatment or disposal. Products that contain multiple materials are "cleaned" by separating the materials for onward processing.

Merchants for recyclable waste help buyers and manufacturers to source recycled and recyclable material to use as inputs in their production process and help sellers to find buyers for their materials.

These merchants act as a facilitator for trade in recyclable materials between different markets. Re-processors take sorted recyclable materials and re-manufacture them into new products or raw materials. (My Recycling Wales, 2023)

Collection

Consumers are expected to deliver textiles to local recycling points to concentrate materials, allowing them to be more cost effectively collected and moved to regional or national hubs. The mechanism is funded by charitable contributions (space for collection bins, volunteer logistics), and the sale of reusable textiles (RTs) within the collections.

Logistics are complicated and expensive because the size of collections is too small to be efficient, and they are unpredictable. Adoption of an efficient collection and aggregation mechanism is critical to a successful recycling market.

Sorting

Sorting is largely done by hand with the basic objective of filtering out re-wearables (RTs) from non-re-wearables (NRTs). Detailed sorting of materials to identify PET, natural, and specific types of fibre is more complex and subject to error. Training for professional textiles sorting can take months, increasing the cost of sale and reducing the ROI.

Automated solutions remain immature and subject to capacity and accuracy challenges.

State of the Art

Theoretically, most textiles can be recycled to create raw materials of a similar quality to those being recycled. This is particularly true for artificial/oil-based fibres, which can be recycled almost indefinitely. Natural fibres shorten during the recycling process leading to degradation of quality over time.

Political and Social

The political objective to improve the textile industry by reducing waste and improving reuse is strong and growing. The global nature of the textiles industry means that any regulation in the UK, Europe, or around the world, is highly likely to strongly impact the UK.

https://www.compliancegate.com/clothing-regulations-united-kingdom/

https://www.compliancegate.com/uk-reach/

Social pressures to become more sustainable and sensitive to water and chemical use are strong and growing.

Organisations with non-cash motivations such as Extended Producer Responsibility (EPR), Effort Sharing Regulations (ESR), Environmental, Social and Governance (ESG) goals, and social conscience (marketing) may seek to offset the cost, however, these are not long-term strategies that can be relied upon as the foundations for an industry.

Government regulation (waste taxes) may not be sufficient to drive behaviour towards recycled inputs and can clearly be seen to lead to fly tipping and added pollution.

People are cracking down on fast fashion (the practice of over producing trending textiles that are expected to be used once or not at all before disposal) because of effects on the environment. Fast fashion is a cheap option for textile manufacturers and retailers due to the quick (fast) turnaround in line with current trends with low quality outputs. This means they can be sold at lower or competitive prices to the consumer for a high purchase rate (think Primark, Shien, H&M).

"Six in 10 executives (USA) surveyed said the industry will face increased scrutiny over ESG decisions in 2023. However, many retailers say they will choose to focus on margin enhancement opportunities. More than half are planning minimal to no ESG investments, and the topic did not make the top five list of executive priorities. With only 26% of 250 leading global retailers making commitments to carbon reduction based on Science Based Targets, they (and the world) may not be able to afford these initiatives being on the back burner for long."[7]

Economic Viability

Textile recycling has had limited investment, current industrial processes are immature, and the industry believes it has a lot of scope to improve methods that do exist. For example, a lot of sorting is manual, and where machines are used, such as in shredding, they are not optimised for fibre recycling but for security related requirements. Other technologies such as colour and fibre scanners are expensive, unreliable, and not widespread.

The cost of capturing and moving used materials is often more than the cost of purchasing virgin fibres. This is compounded by distributed sources that are individually disorganised and low volume. Labour charges are often mitigated by charitable work, which is not a sustainable model for an industry.

Motivating the supply chain requires providing a benefit to their contribution and effort to reduce waste such as the ability to offset tax and enhance sustainability credibility to their customers. These benefits will come in part by externally evidencing the contributions they have made within their own operations (e.g. instore collection schemes), as well as their ability to hold their suppliers to account. In a complex multi-tier supply chain with

[7] https://www2.deloitte.com/us/en/pages/consumer-business/articles/retail-distribution-industry-outlook.html

relatively low value, high volume items, the cost of capturing and tracking this information has had major economic impact.

Stakeholders

As with any major shift in an industry, there will be beneficiaries and those that lose out. The extent of these shifts can range from increased costs to impacts on customer satisfaction and loyalty, as well as increased profits from premium uplifts and sales.

Textile Manufacturers

Manufactures will have to change their processes to accommodate the use of yarns from recycled sources. Initially the recycled yarns are expected to be more expensive than traditional sources and it is unclear how the market (consumer) will value their use and whether a premium can be charged to offset costs.

Manufacturers, especially those in fast fashion, are concerned that the use of resources, and the textile waste generated, will lead to regulatory controls on them, and they are keen to be proactive to address, or appear to address, the environmental issues created.

The manufacturing process will adapt to cater inputs that require more processing, such as shorter length natural fibres, or more variance in the colour of the source material. Product designs will also evolve for a reduction in the variety of materials used to reduce the complexity of recycling processes.

Raw Material Producers

Using recycled materials may reduce demands for raw material, impacting chemical companies and farmers. The complex market dynamics and changing demand make prediction about their ability and desire to influence decisions for textile recycling difficult.

Recycled Textile Processors

An increase in market capacity of the kind conceived here is likely to require significant changes to those currently involved in the recycling business, particularly moving from a non-re-wearable (NRT) and waste focused industry to one of recycling.

Retailers

Fast fashion retailers are concerned that the volumes of waste produced is becoming a public issue and their business model is becoming negatively impacted if they are not seen to be addressing this successfully. They want to be seen as contributing to the reduction in textile waste. They are also negatively impacted by sales of second-hand apparel, raising concerns about an expanded RT marketplace (professional and private resellers).

Retailers are concerned about regulation and specifically any requirement to collect and return unwanted products. The cost for existing merchants may be unsustainable and discourage new entrants to the market.

There may be opportunities to market recycled clothing in new ways that consumers value more highly. Likewise standards and evidence expected to support their green credentials is likely to increase.

Technical

The commercial and industrial market exists for buying and selling the intermediate products created by the recycling process. This is currently small-scale operations that appear to be focused on specific sources of discarded material, for example, specialist military uniforms and branded workwear, hospital waste, etc.

Companies that recycle fashion textiles tend to be focused on high quality re-wearables and bulk sources of other materials, or on securely destroying high-end dead stock.

Legal

Taxation and "green tax", including water use and import/export tax will all tend to improve the economic justification for recycling textiles inside the borders of the United Kingdom, especially if garment and product manufacturing is also moved back to the UK.

Extended Producer Responsibility (EPR) legislation coming into effect in 2024/25 seeks to deliver the UK Government and the Devolved Administrations commitment to protecting the environment.[8] It plans to do this by reforming the existing Packaging Waste Regulations to include making producers responsible for the full net cost of managing packaging once it becomes waste; EPR will be coming into force from H2 2023.

Regulation may need to change to support raw materials coming from recycled sources as well as existing virgin materials.

[8] https://www.gov.uk/guidance/extended-producer-responsibility-for-packaging-who-is-affected-and-what-to-do

Information

Large and mature data sets exist for topics common to other industries, for example, sales orders, logistics, energy usage, raw material specifications, and ESG data. Data specific to textile recycling is more sparse, undefined, and not yet standardised.

Because recycling does exist, albeit on a small scale, it is possible to determine the data needed to operate a recycling plant, and the kinds of data available for textile waste specifically. Standardisation of this data is critical to scaling the new high-capacity circular textile industry.

Trusted information is difficult to identify because of its commercial and political sensitivity, and because the value of such data has previously been lower than the cost of collection. There is a danger that special interest groups provide data to support their position, and that important decisions are undermined by incomplete or inaccurate information.

Currently the collection of data is task orientated, i.e., it is collected to achieve sales, transport goods, or calculate LCA for sustainability reporting. The data required is used across these different outcomes, so there is significant overlap of effort and inconsistency between reported outcomes where these activities are addressed separately.

Maintaining information about textiles as they cycle through multiple iterations of the recycling process may be a challenge. Post-consumer textiles are highly variable in the condition they return in, for example with labels cut out to make tracing the item down the chain impossible.

Circular Textiles Tomorrow

An efficient post-use supply chain is critical to the economic and practical success of using recycled textiles versus continuing with virgin inputs. Without industrial-scale recycling capability to produce adequate feed stock and allow textile manufacturers to design and make sufficient volumes of apparel using recycled material, then the market cannot mature.

Critical Factor: Predictable Capacity

The market must predictably develop sufficient volumes of recycled, merchantable, material to establish a stable and attractive market for investment.

The narrative is for circular textiles; however, this seems to be a limiting idea. Instead, consider that PET and other such materials can be interchangeably used to manufacture plastic and textile goods (containers, furniture, bottles, fibres).

By connecting these two industries, the volume of material available for recycling and the opportunities for its efficient and sustainable reuse are dramatically increased.

- Increased volume of discarded raw material (textiles, bottles, other PET plastics)
- Improved quality from larger quantities of similar materials
- Improved opportunity for sale of recycled material (pellets)

The expectation is that future advanced reprocessing facilities, including sorting mixed clothing, or return to yarn or polyester pellets will be continuous processes requiring sufficient volumes of predictable inputs. These will need to meet many factors including the material handling, the size and shape of the textiles at different process phases, and the composition and purity of the resulting materials.

All these aspects will need to comply with industry wide standards to enable a competitive supply chain to grow and evolve.

Critical Factor: Collection and Sorting Economics

The first challenge is to collect discarded material and assemble it in sufficient quantities to make automated sorting economically viable.

Internet shopping has increased the logistics capacity of the country, and specifically the last few yards between the depot and the house. Many goods already need to implement reverse logistics to recover goods being returned.

The cost of logistics is often "hidden" in the price of the product. It may be possible to leverage these logistics to collect textiles for central sorting.

Fundamentally, the collection, sorting, and re-engineering of the materials should amount to less than the extraction/farming, transport, and original engineering.

Critical Factor: Consistent Data Standards

By combining plastic recycling with textile recycling, it must be possible to share data.

Standards already exist for how materials are described. It is likely that these need to be extended to include information about colour and other physical characteristics. Standards for garment labelling already require that any material composing over 15% of the product must be listed, and companies exist to help manufacturers choose fabric mixes that are more simply recycled.

Recycling technology for natural yarns does include consideration for re-dying to achieve low impact consistent neutral colours for materials. (Irena Wojnowska-Baryła, 2022)

Data standards to describe recycled materials are of a low maturity, for example describing the colour of an item of apparel or scrap of material is ill-defined and specific to a particular company or their agreement with a partner. Current data to describe the supply of recycled textile is focused on RT uses rather than as inputs for new yarn or textiles.

The majority of current yarn and textile inputs comprise of virgin materials, and their characteristics are defined accordingly. Recycled materials have different characteristics, of which some such as fibre length may be similarly defined, others such as colour or "purity" are not in the context of a yarn input.

The ability to capture, share, and use data from across supply chain partners is critical to enabling efficient operations. Data from the end-to-end process will be necessary to demonstrate the efficiency of recycling and reuse. This data will be utilised to validate that the anticipated outputs required to meet regulatory requirements and justify cost differentiation to retailers and their consumers are accurate and effective.

Critical Factor: Why now - EU Regulation

The data governance act was adopted by the co-legislators in 2022 as part of the Commission's 2020 European strategy for data. The EU Data act will allow users of intelligent industrial machines to gain access to data generated by their use, and to encourage data sharing between members of the same industry.

https://digital-strategy.ec.europa.eu/en/policies/data-act

https://www.consilium.europa.eu/en/press/press-releases/2023/11/27/data-act-council-adopts-new-law-on-fair-access-to-and-use-of-data/

https://www.whitecase.com/insight-alert/data-act-eus-bid-ensure-fairness-digital-environment-and-competitive-data-market-has#:~:text=While%20the%20scope%20of%20the,of%20application%20is%20clearly%20broader.

Critical Factor: Unintended Consequences

Fast fashion is an industry because it has business benefits of staying in line with current trends with a quick turnaround from design to sale. This industry is not going to disappear, and creating a route where they can 'ethically' recycle overproduced stock may be an unintended consequence of circular textiles. Recycling instead of limiting production.

Waste objectives are typically what recycling targets are set against. Textiles make a marginal contribution to weight despite the volume of fabric being disposed of and recycled. This metric will need to be evaluated and adjusted to be relevant to the material.

Textile shredding is favoured by companies and brands that seek to *securely* dispose of uniforms, documents, or end-of-life designer collections. Uniforms would be ideal for use in textile recycling due to the reliability and volume of feedstock. However, what is considered secure is up to the discretion of the customer, and may not include recycling, rather incineration.

Competitive advantages are found in supply chains. Providing entire chains access to all information about a competitors processes, other suppliers, and textile compositions is not advisable, and will not convince organisations to collaborate. The data that is shared throughout the supply chain will need to be vetted to ensure no sensitive information is published and that competitive advantage is secured.

Findings

The challenges associated with textile manufacturing are multi-faceted; the mixture of materials and the close bonding between them make the physical process of recycling difficult, and the costs of sorting, separating, and cleaning NRTs make recycling economically unviable.

The volume of material is unlikely to be problematic, and the logistics costs for collection are already partially solved in other industries.

Sorting, Separating, Cleaning

This paper has illustrated considering only artificial fabrics made of a single material (PET) then the recycling and, by extension, circular textiles becomes no more difficult than recycling plastic bottles. Recycling of products that use PET technology is understood and has already addressed collection, sorting, cleaning, and engineering into pellets, which can be used to make new bottles and textiles.

Finding: Sorting, Separating, Cleaning are critical points in the process that must be addressed. Collection, processing (of cleaned material), and commercial management is well understood.

Processing Natural Fibres

High value materials, for example cashmere, are commercially valuable but they do not represent the bulk recycling challenge. They also pose issues as the cycle gets longer.

Recycling natural fibres is particularly challenging; fibres are shortened each time they are recycled, and dealing with colours and mixed fibres alters the already distinguished manufacturing process. Spectrographic and other techniques exist to help sorting, however, the most effective method currently is human sorting that does not economically scale.

Finding: Natural textiles are particularly difficult to recycle continuously and economically.

The Need for Data

The industry does exist in a low volume state that has not benefitted from investment or high margins. This means that investment in data collection and cross-industry insights is limited to information about general waste and in pillars.

Finding: Data collection with the ability to combine data from multiple sources will inform decisions about how to sort, separate, and clean textiles, and to identify sources of textiles that are simpler to process.

Conclusion

The problem with textile recycling and, by extension, circular textiles is the cost of collection and logistics, the difficulty of separating materials to form a sufficiently pure source of material for processing, and finding the right market to absorb the knock-on premium costs.

The extent of the problem and its potential solutions can only be properly discovered by first collecting data about how the textiles move, their material content, and the cost of activity. This data will inform on the viability of the industry, and how a solution can be formulated to make circular textiles work in the UK.

Responsiv complete analysis on supply chain partners and systems to develop a service that can be accessed by stakeholders across the industry, and priced to recognise the relative value and profitability of different parts of the supply chain. This service will streamline the critical data required to understand the current state of textile movement and recycling in the UK.

Responsiv Supply Chain Insights Project

The supply chain insights project is intended to provide a politically, economically, and practical way to collect information about supply chain goods that can then be used to optimise many processes including, logistics, sorting, traceability and regulatory reporting. The challenge is not trivial and begins with the "original raw materials" that are farmed, mined, or otherwise extracted from the earth. These materials are refined to become raw materials for manufacture.

Circular-textiles is another form of extraction that must be refined into raw material to enter the supply chain at the same or a similar point in the process.

Supply Chain Insights

Responsiv Supply Chain Insights Project allows stakeholders from any part of the supply chain to submit data about their inputs and outputs, including reference numbers that are passed to their trading partners. The result is a linked set of data that traces the raw material from extraction to disposal.

The data set is augmented with certificates of authenticity and logistics activities that go to complete the picture.

The chain from raw material to retail sale is understood but data tends to focus on the "nodes" or stopping points in the chain rather than including the movements "edges". Certifications can help to address this but the disparity in available technology and funding between the farmers and the retailers, means that the quality is undermined and often does not connect. This means that retailers know about their suppliers and their costs and schedules, but information about specific producers and methods of transport are only recently being added to this, driven by ESG initiatives and without collecting all the information required for recycling.

Supply Chain Insights as a Service

Responsiv is developing a method and mechanism for collecting information from all stakeholders involved in the supply and distribution of products, raw materials, services, and logistics.

Purpose

The supply chain insights project is intended to assemble a body of data that properly describes the multiple working supply chains, with special attention to the textile chains.

Model

The model is based on an adaptable, self-describing ledger, that can collect information about events encountered from participating stakeholders concerning their goods and services. The model describes principles of operation.

Data Acquisition and Storage

Data is pushed to the ledger manually (browser-based portal) or by automated means (e.g. from an existing ERP or logistics system) or configured to be pulled to the ledger using similar techniques. Regardless of collection method, data is tagged with the agent that added the data, and their organisation and placed in a draft state for acceptance into the personal "Evidence Locker".

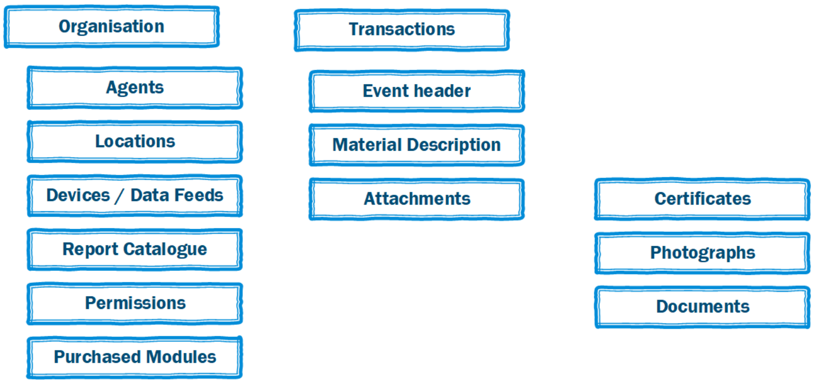
Data Ownership and Control

Data in an evidence locker can be accessed by the owning organisation and its agents and shared using reports.

Reports can be defined by the evidence locker owner or shared with them by another locker owner. Each report must be authorised and can be used to generate human readable, bulk extract, and event (timed or action) reports.

Data Model

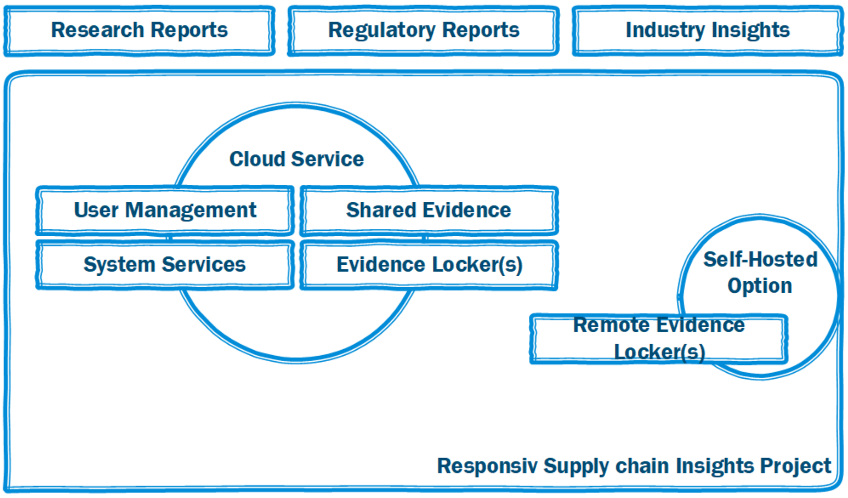
The data required to track goods and services between actors in a supply chain has a consistent portion that identifies the event, and allows it to be connected to the organisation, located in time and space, and attached to the goods. A second part of the data is variable, and may include structured and unstructured data, that is unique to the event, and is different between organisations.



The data model must include information about the organisation, transactions, and how to operate.

Mechanism

The system will be implemented through a cloud service core capability that includes user management, system services (including security), and shared evidence repository. Evidence lockers can be deployed as part of the cloud service and located remotely or locally. For high volume or sensitive users, a self-hosted option supports an evidence locker being deployed and managed remotely.



Responsiv Solutions

Responsiv Solutions is a Technology Consulting company that specialises in delivering enterprise connectivity solutions, including system to system, system to person, and business to market (API).

Responsiv is part of a consortium with industry and technology partners funded in part by the UK government's Digital Catapult organisation. The purpose of this project is to deliver a technical testbed that captures and shares data from participants and presents it to downstream suppliers for use. This data is to demonstrate how a future circular reuse of textiles could be supported by technology.

Responsiv is using our history and expertise in integration and automation to map the previously undefined textile recycling supply chain. We will create a circular textiles process and data model that can be used to support and justify developing a commercially sustainable recycling industry for textiles.

- Reduction in environmental impact of mass-producing oil-based fibres from fossil fuels, and need for intensively produced farmed inputs
- Reduction in environmental and economic impact of transporting discarded textiles abroad from the UK
- Providing solutions to industry related issues such as excess inventory
- An efficient and consistent Circular Textiles supply chain in the UK

These expert skills in data and system integration are not limited to this project, and are transferrable to most circumstances, including integrating with ESG systems.

Works Cited

Irena Wojnowska-Baryła, K. B. *. a. M. Z., 2022. Strategies of Recovery and Organic Recycling Used in Textile Waste Management. *International Journal of Environmental Research and Public Health,* 19(5859).

Marks and Spencer, 2023. *MMCF.* [Online]
Available at: https://corporate.marksandspencer.com/sustainability/our-products/ch-raw-materials/mmcf
[Accessed 2024].

My Recycling Wales, 2023. *My Recycling Wales - About.* [Online]
Available at: https://myrecyclingwales.org.uk/about
[Accessed 2024].

PureLoop, 2023. *ISEC evo FibrePro:IV.* [Online]
Available at: https://www.pureloop.com/en/textile-recycling-machine/?gad_source=1&gclid=CjwKCAiA5L2tBhBTEiwAdSxJX73DiaDB7ATFCBjckcOf-pq1CulNC5Ad-RBEadCL7Kxx2J6eGLdCMRoCaHgQAvD_BwE
[Accessed 2024].

Richmond, V., 2009. Rubbish or Riches? Buying from Church jumble sales in late-Victorian England.. *Journal of Historical Research in Marketing.,* Volume 2 (3) 2010.

Souchet, F., 2019. *how-the-circular-economy-is-redesigning-fashions-future.* [Online]
Available at: https://www.weforum.org/agenda/2019/02/how-the-circular-economy-is-redesigning-fashions-future/
[Accessed 1 2024].

Statistica, 2023. *Revenue of the fashion industry in the UK 2019-2028..* [Online]
Available at: https://www.statista.com/study/35821/fashion-e-commerce-in-the-united-kingdom/
[Accessed 2024].

UKFT and Oxford Economics, 2023. *The UK fashion and textile industry contributes £62bn to the UK economy.* [Online]
Available at: https://www.ukft.org/industry-footprint-report/
[Accessed 22 1 2024].

Welsh Government and WRAP, 2022-23. *My Recycling Wales.* [Online]
Available at: https://myrecyclingwales.org.uk/materials/textiles
[Accessed 2024].

Appendixes

Organisations gathering textile and waste data

Organisation / URL	***Description***	Notes
WasteDataFlow ***https://www.wastedataflow.org***	*WasteDataFlow is a web-based system for municipal waste data reporting by UK local authorities to government. The system has been operating since 30 April 2004.* *The original aim of WasteDataFlow was to replace repetitive waste questionnaires were issued to local authorities by government, departments, agencies, institutions, and organisations, with one data set. WasteDataFlow is now the data collection system for the current Defra Municipal Waste Management Survey in England and similar surveys in Wales, Northern Ireland, and Scotland.*	
Official Statistics: UK statistics on waste ***https://www.gov.uk/government/statistics/uk-waste-data***	Figures compiled on the total waste generated for the whole of the UK. This includes: Waste from Households -2010-21. UK and country breakdown, BMW (Biodegradable Municipal Waste) to landfill - 2010-21. UK and country breakdown, Total waste generated breakdown - 2010-18. UK and England breakdown but not Das, Total waste treated breakdown - 2010-18. UK and England breakdown but not DAs., Infrastructure breakdown -2012-20. UK and England breakdown but not DAs., C&I (Commercial and Industrial) waste generation –UK 2010-20, England 2010-21. UK and England breakdown but not DAs., C&D (Construction and Demolition) recovery - UK 2010-20, England 2010-20. UK and England breakdown but not DAs., Packaging waste recycling and recovery - 2021 (finalised). UK only.	
Collection: Waste and recycling statistics ***https://www.gov.uk/government/collections/waste-and-recycling-statistics***	*This series provides information on waste generation and management. Areas of interest are waste arising from households, business, construction and demolition and fly-tipping. A range of data sources are used to collect data on these themes, including administrative sources and surveys.*	
Circular textiles Foundation ***https://circulartextilesfoundation.co.uk***	The Circular Textiles Foundation supports the work of fibre-to-fibre recycling technologies by guiding brands and manufacturers to ensure that clothing is designed to be suitable for recycling in their systems. The Circular Textiles Foundation aims to increase awareness and understanding by sending out clear messaging to consumers and brands so that everyone can clearly understand the impact of their choices whether they are a consumer, a designer, or a buyer, and crucially, understand where a product will end up at end of use.	
Textile Exchange **https://textileexchange.org/standards/**	*Our standards help companies and consumers to verify sustainability claims.* *To give the fashion and textile industry a way to authenticate their sustainability claims from raw material to final product, we've developed a set of robust standards. They fill the gaps in existing guidelines and verification tools, and we regularly adapt and upgrade them to meet the evolving needs of the industry. Our role is to develop, revise and own these standards. Auditing and certification to our standards is in the hands of third-party certification bodies.*	
Knowledge Hub **Uniform Reuse's Database: The circular potential of each fabric** **https://knowledge-hub.circle-economy.com/wctd/article/8910?n=Uniform-Reuse%27s-Database-The-circular-potential-of-each-fabric**	How can textile producers and manufacturers choose fabrics that are more circular ? The Uniform Reuse database ranks various types of fabrics according to their ability to be reintroduced back into the market through a circular strategy. This database is primarily aimed for uniform producers but can easily be interpreted for all types of textiles. This Fabrics Database gives an overview of fibres and fabric types (including blends) which are found in corporate wear. It looks at properties including durability and after-care, along with how suitable these different end-of-life options are for different fabrics.	
National Institute of Standards and Technology (NIST)	*Circular Economy for Textiles*	*US Data*

https://www.nist.gov/mml/mmsd/security-technologies-group/circular-economy-textiles	*The National Institute of Standards and Technology (NIST) is part of the U.S. Department of Commerce. NIST is one of the nation's oldest physical science laboratories.*	
Recover fibre .com ***https://recoverfiber.com/products/rpure***	*Company recycles natural fibres from pre and post-consumer waste.*	
Avena ***https://avenagroup.co.uk/textile-recycling***	At Avena, we are specialists in secure textile shredding, clothing recycling and uniform destruction. Whether your goal is to protect your branded material or reduce your environmental impact, we have a solution. How confident can you be that expired or damaged branded textiles or garments are being disposed of securely and effectively? Textile shredding from Avena offers a significant advantage to your business, including guaranteed protection for your brand. We collect, destroy and recycle both non-branded textiles and uniform garments for complete peace of mind for business owners and shareholders.	
Shred Station	*Shred Station's business is securely shredding paper, textiles and other materials securely. The majority of the business is paper, but they have a significant set of textiles shredding customers, such as emergency services and high-end fashion brands. Currently their processes focus on secure shredding, but could be optimised to facilitate the recycling of the shredded material. They have IT systems holding relevant information and intend to share and integrate data digitally.*	
UK Fashion & Textile Association Ltd	*UKFT are an industry body involved in a number of research projects to drive developments in textiles and fashion. They are responsible for providing the project management resource for the consortium.*	
Camira Fabrics Limited	*Camira are a large international yarn and fabric producer suppling manufacturers across the UK and beyond. They are looking to test how recycled materials can be used as inputs to their yarns. They have a range of IT systems which hold digital information with the intention that some integrations can be implemented.*	
Circle-8 Textile Ecosystems Limited	*Circle-8 are a new organisation that are planning to build an advanced textile sorting facility in the UK. Currently the plant does not exist but they need to ensure a supply chain exists of sufficient scale and robustness to justify the investment in a new facility. They are leading the consortium.*	
LMB Textiles Limited	*LMB textiles manage textile recycling in the UK on behalf of many councils and charities, running the textile bins often seen in council and supermarket car parks. They are a major component of the current textile recycling activities in the UK. Originally through their Reskinned subsidiary they are part of the consortium.*	
Alex Begg Group Limited	*Alex Begg make high low volume fine woollen items such as scarves, selling in Harrods and similar locations. They are interested in understanding how products made from recycled materials could be included in production and marketed. They have limited IT systems and are unlikely to require significant data.*	
Avery Dennison	*Suppliers of tracking labels and RFID tags for clothing.*	
EON digital	*EON digital passport (https://www.eon.xyz) are a provider of apparel tracing software.*	

Textile Market Analysis

	Sector Size	Challenges	Other Notes
Textiles In 2022 estimated revenue of textiles (manufacturing?) is over 6 billion[9].	The fashion and textiles industry contributes almost 20 billion to UK economy[10]. 34,045 businesses operating in UK fashion and textile sector in 2020 - 6,965 were retailers, 8,825 were wholesalers and 8,245 manufacturers[11].	Sustainability within manufacturing practices- collaboration with stakeholders New fibre development - "smart textiles" Have a circular supply chain[12]. Training and retaining staff. Digitisation in supply chains for reliability and predictability[13] . Supply chain issues because of COVID - 89% of senior fashion executives agreed the rise in cost of raw materials will cause supply chain issues[14]. Omni channel - integrated processes: 60% of fashion executives will be a priority as they look to 2025[15].	Current trends - smart textiles (Hoovers), advanced manufacturing, and 3D technology Market share: Marks and Spencer had 7.6% but recent research found Primark has seen an upturn[16]. Online fashion is expected to grow to over 40bn[17]. Circular textiles - supply chain
Textiles Retailer	Retail industry comprises 5.2% of GDP[18]. 6,965 businesses in UK	Sustainability within manufacturing practices affecting own ESG and EPR reporting - collaboration with stakeholders required	
Textiles Wholesale 200 enterprises with a turnover of more than 5 million GBP[19].	8.825 wholesaler businesses	Up to date inventory for staff and customers - Inventory management Increasing distribution efficiency with digital and analytics tools Logistics distribution - disruptions from IT upgrades or issues causing delays	Legacy system support Integration opportunities
Textiles Manufacturer £6.3bn	8,245 fashion and textiles manufacturers 4,005 garment manufacturers[20]. UK fashion and textile manufacturing sector producing £9.1bn of products[21].	Sustainable practices in collaboration with stakeholders - Hoovers Skills Shortage as a barrier to growth[22]. Increasingly rely on tech skills for operating advanced and digitised machinery[23]. Digitisation of factories that deliver flexibility and cost-effectiveness[24].	Looking for APIs, Cloud Hosting Many companies use Microsoft and AWS for IaaS and cloud. Trend: Increasing automation to reduce workers needed to create clothing (Hoovers)

9 Manufacturing of Textiles in the UK - Industry Insights & Data Analysis | Statista
10 UKFT: UK fashion and textile industry statistics and data
11 UKFT: UK fashion and textile industry statistics and data
12 Textiles 2030 Annual Progress Report 2021/22 | WRAP
13 Statement by Stefan Schmidt: What are the biggest challenges for 2023? (textiletechnology.net)
14 Fashion supply chain leading issues 2022 | Statista
15 State of Fashion Technology Report 2022 | McKinsey
16 The Most Important Fashion Industry Statistics in 2022 (fashiondiscounts.uk)
17 The Most Important Fashion Industry Statistics in 2022 (fashiondiscounts.uk)
18 Economic trends in the retail sector, Great Britain - Office for National Statistics (ons.gov.uk)
19 Textile manufacturing enterprises UK 2023, by turnover | Statista
20 UKFT: UK fashion and textile industry statistics and data
21 Sector profile: Textiles and Fashion (llep.org.uk)
22 Manufacturing a new UK clothing industry (drapersonline.com)
23 Sector profile: Textiles and Fashion (llep.org.uk)
24 Build Back Better: Five priorities for UK fashion and textiles (ukft.org)

Fibre Composition

According to the regulation, only specific names from Annex I to Regulation (EU) No 1007/2011 can be employed for textile fibres. You should seek advice from local trading standards services if the name of a fibre textile cannot be found in the list. Examples of listed textile fibre commonly found in the clothing and textile industry include:

Wool, Polyester, Nylon, Silk, Cotton.

Products made of one textile fibre

Textile products can either be considered made exclusively out of one named textile fibre or be made out of two or more textile fibres. The former situation allows importers and manufacturers to use the following labelling or marking information:

"100%", "Pure", "All"

The product is deemed to be made exclusively out of one named textile fibre even if it contains extraneous fibres provided all the following conditions hold true:

- The extraneous fibres make up for no more than 2% by weight of the product and 5% by weight of textile products that underwent a carding process
- Its existence is unavoidable due to adherence to proper manufacturing practices
- The extraneous fibres are not incorporated into the product as a matter of routine

Multi-fibre textile products

Multi-fibre textile products must generally contain the name and percentage by weight of all named textile fibres and present it in descending order.

Fleece wool and Virgin wool products, decorative fibres, antistatic fibres and other listed products found in Annex IV of the retained EU regulation have unique labelling requirements.

Other information related to the product should always be displayed separately.

Non-textile part of animal origin

Additionally, any non-textile part of animal origin must be clearly communicated through labelling or marking. For instance, if the product contains animal parts, then it should be marked or labelled with the phrase "contains non-textile parts of animal origin". Except for mechanized processing codes, abbreviations should not be used.