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RRS FASHION FOR GOOD

SORTING FOR CIRCULARITY USA

A COMMERCIAL ASSESSMENT OF FIBRE TO FIBRE RECYCLING IN THE U.S.

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Acknowledgements

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About Us

FASHION FOR GOOD

Fashion for Good is the global platform for innovation.

At its core is the Global Innovation Programme that supports disruptive innovators on their journey to scale, providing hands-on project management, access to funding and expertise, and collaborations with brands and manufacturers to accelerate supply chain implementation.

To activate individuals and industry alike, Fashion for Good houses the world's first interactive museum dedicated to sustainable fashion and innovation to inform and empower people from across the world and creates open-source resources to action change.

Fashion for Good's programs are supported by founding partner Laudes Foundation, co-founder William McDonough and corporate partners adidas, BESTSELLER, C&A, CHANEL, Inditex, Kering, Levi Strauss & Co., Otto Group, Patagonia, PVH Corp., Reformation, Stella McCartney, Target, and Zalando, and affiliate and regional partners Arvind Limited, Birla Cellulose, Norrøna, Pangaia, Paradise Textiles, Teijin Frontier, Vivobarefoot, Welspun and W. L. Gore & Associates.

RRS

Resource Recycling Systems (RRS) is a purpose-driven consultancy working in climate, waste, and resource recovery. RRS provides business, policy, and technical expertise to build the circular economy of the future for client across the global economy.

About Sorting for Circularity

Sorting for Circularity is an ambitious framework driven by the vision of reclaiming textile waste, expediting the adoption of transformative technologies, and fostering circularity across the fashion value chain. The foundation of this framework builds on insights initially published in the 2021 report by Fashion for Good and Apparel Impact Institute (Aii), titled "Unlocking the Trillion Dollar Fashion Decarbonization Opportunity."[1] That collaborative report serves as a roadmap for the industry's pursuit of achieving net-zero emissions by 2050, emphasizing the immense potential and substantial carbon emission reductions attainable through efficient materials management, extended product life cycles, and waste reuse.

Fashion for Good launched the Sorting for Circularity framework, together with Circle Economy, to identify the supply of textile waste and to determine the potential to valorise textile waste. The framework includes a methodology to assess fiber composition of textiles using Near Infrared ("NIR") technology. With scalability as a key consideration, the project was initiated in Europe and expanded to India. Both projects found promising results on textile waste feedstock feasibility for fiber-to-fiber recycling.

The U.S. project launched in January 2023 by Fashion for Good and RRS. Drawing inspiration from the Sorting for Circularity Europe framework, the project adapted the scope and methods for the U.S. context and selected research sites.

The Sorting for Circularity USA project brings together stakeholders from across the value chain including brands, NGOs, retailers, textile sorters, waste collectors and aggregators, academic institutions, trade associations, and service providers to drive the industry forward. Industry funding and engagement for this project came from adidas as the project's lead sponsor, in addition to brand partners Inditex, Target, Levi Strauss & Co., and external partners H&M Group, lululemon, Eastman, Nordstrom, and the New York

State Center for Sustainable Materials Management (NYS CSMM), and key project implementation partners including Matoha, the Secondary Materials and Recycled Textiles (SMART) Association, Goodwill Industries International, Helpsy, Goodwill of Colorado, Goodwill of the Finger Lakes, Goodwill of San Francisco Bay, Goodwill Suncoast, and United Southern Waste.

Scope of This Report

This report interprets findings from the Sorting for Circularity USA project and explores opportunities to maximize recovery of unwanted textiles for reuse and recycling through improved collection programs that distinguish the textiles suitable for recycling. A full presentation of results from each research task can be found in the Appendix I - Composition Analysis Methodology and Results and Appendix IV - Survey Methodology and Results.

Glossary

Capture Rate

The fraction of textiles collected for recovery as a percent of the amount generated as waste.

Circular Economy / Circularity

A circular economy aims to reduce waste and pollution by keeping materials, products and resources in use for as long as possible, through a closed loop system. The current system is linear, based on the take-make-use-dispose model, meaning that resources are extracted to create new products, in use for a limited period of time and then become waste, at which point they are discarded. In contrast, circular systems carefully consider what happens to materials and products at their end-of-use.

Chemical Recycling

Any process that changes a polymer's chemical structure to produce substances that can be used as raw materials to manufacture new products. Sometimes called advanced recycling or molecular recycling. Chemical recycling is a generic term that includes several recycling processes (Solvent Processing, De-polymerization, Gasification). Depending on recycling processes, energy consumption, yield and output vary broadly; reaction outputs are syngas, monomers, polymers, cellulose pulp. The recycling process produces substances that can be used as raw material to manufacture new material.[2]

Cottonpoly

Fiber blend of cotton and polyester with cotton as the dominant material composition.

Contaminants

Any contamination in the recycling stream, including non-recyclables, garbage, dirt, bags, heavily soiled textiles, etc.

Curbside Collection

Recycling service in which recyclables are put outside by residents and collected directly from residences by a hauler and/or recycler.

Disruptor

Elements present on a textile product, such as fastener, button, zipper, fabric patch representing less than 1/3 of the surface area (e.g., pocket liner, badge, yoke, embroidery, lace, etc.) that may be a disruptor to the recycling process and will need to be removed before the product is suitable as feedstock for recycling.

» ***Removable Disruptor.*** For the purpose of this Project, it is defined that metal and plastic hardware are suitable to be removed prior to recycling activities

» ***Non-removable Disruptor.*** For the purpose of this Project, all other hardware found in textiles as well as combinations of different types of hardware are considered as non-removable for the purpose of fiber-to-fiber recycling activities.

Divert/Diversion

A materials management approach that extends the useful life of the products and materials (i.e., not sending the waste to landfill or incineration).

Diversion Rate

The percentage of textiles generated as waste that are diverted from landfill or incineration and which are handled by a materials management approach that extends the useful life of the products and materials.

Fraction

For the purposes of this report, “fraction” refers to residential post-consumer rewearable and non-rewearable textiles.

Generator

An entity which is a source of textile waste.

» ***Consumer Generator:*** A person who purchases, uses, and disposes of a textile product.

» ***Industrial Generator:*** An industrial source of textile waste which may be a textile manufacturer or any other type of industrial company. This waste is typically created during production processes.

» ***Commercial Generator:*** A commercial source of textile waste. Typically a retailer, distributor, or other business that generates any amount of textile waste.

» ***Institutional Generator:*** An institutional source of textile waste, such as a college/university or any other public institution.

Mass Market Textiles

Textiles and apparel sold by a mass market retailer (a retailer that sells large quantities of goods to consumers).

Mechanical Recycling

Physical form of recycling where fiber is cut, shredded, garnetted, melted, or extruded to be used in the process of making new textiles.

Mono-Layer

Products that are made with a single layer or type of fabric.

Multi-Layer

Products that are made from more than one distinct layer representing more than 1/3 of the surface of the article (eg. jacket lining), each of which may be composed of different materials consisting of at least a second layer. The composition of up to two different layers were captured and allocated to the same product using the app.

Non-Wearable Textiles

Post-consumer textiles that cannot be reused in their original form but might be suitable for repurposing or recycling.

Optical Sorting

Optical sorting technologies such as near-infrared recognition (NIR) that are used to sort textile items based on material characteristics.

Participation Rate

The percentage of the population that participates in a collection program compared to the total population with access to the collection program.

Polycotton

Fiber blend of polyester and cotton with polyester as the dominant material composition.

Post-Consumer Textiles

Textiles that have been used and disposed of by a consumer.

» ***Residential Post-Consumer:*** End-of-use textiles generated from personal residences.

» ***Commercial Post-Consumer:*** End-of-use textiles generated by commercial entities (businesses, retailers, warehouses, restaurants, office buildings).

» ***Institutional Post-Consumer:*** End-of-use textiles generated by institutional entities (government, schools, hospitals, prisons).

Post-Industrial Textiles

Textile waste that is generated during the manufacturing process (e.g., fiber waste, yarn waste, fabric waste, etc).

Pre-Consumer Textiles

Unsold or returned finished textile products generated as waste by retailers, brands, and/or distribution channels (e.g., samples, returns, damaged, rejected, overstock, deadstock, etc.). Does not include manufacturing waste.

Pre-Processing

The processes involved with preparing textile waste for recycling (e.g., removal of disruptors, size-reduction).

Recycling Efficiency

A metric that measures the fraction of inputs that result in target outputs a recycling process.

Recycling Rate

The percentage of textiles generated as waste that are recycled (excluding the fraction of what was collected that was too contaminated or unable to be recycled).

Recommerce

Recommerce (originating from “reverse commerce”) is the selling and buying of used products, largely through an online marketplace.

Rewearable Textiles

Post-consumer textiles that can be reused in their original form.

Refuse

Discarded materials destined for landfill or incineration.

Salvage Market

A term used to refer to the downstream sorter-grader pathway for used textiles in which value is extracted from mixed textiles through sorting and grading.

Shoddy Recycling

A type of mechanical recycling in which fabric is shredded and fibers recovered are used to produce recycled products such as yarn, insulation, padding, stuffing, and nonwoven applications.

Size-Reduce

The process of breaking down large materials into smaller pieces for recycling (i.e., cutting, shredding).

Source-Separated Collection

A waste collection approach that requires the generator to separate designated commodities (waste types) for recovery.

Sorter and Grader

A business that purchases post-consumer textiles in bulk from suppliers such as collectors, brokers, wholesalers, thrifts, and charities, and categorizes textiles into commodities according to quality, condition, and category for sale into recycling, repurposing, and/or reuse end markets.

Textile

For the purpose of this Project, the word “textile” means items made from fiber, yarn, or fabric, such as clothing, apparel, and household linens, such as blankets, curtains, bedding, towels, napkins, and tablecloths. Not included in the definition for the purpose of this Project are carpets, shoes, bags, accessories, mattresses, or industrial textiles.

Fiber-to-Fiber Recycling

Recovery of fiber from textile products for use in the production of new fibers for textile production. Can be mechanical or chemical.

Trash

Discarded materials destined for landfill or incineration.

Executive Summary

The U.S. is a world leader in textile consumption and textile waste generation, which also positions it as one of the largest potential sources of secondary raw materials for circular textile supply chains.[2] Of the quantities of textiles generated as waste in the U.S., 85% are disposed of in landfills and incinerators and only 15% of end-of-use textiles are recovered.[4] The textile industry is increasingly focusing on fiber-to-fiber recycling to support the transition to a circular economy. Growing commitments from the public and private sector, coupled with incoming policy across the European Union and several American States, are expected to boost the demand for post-consumer textiles collection, sorting, and recycling infrastructure. To efficiently shift textiles away from disposal and into recovery pathways, there needs to be a coordinated system for end-of-use materials management that accounts for collection, processing (sorting, recycling, and pre-processing), end market uptake, public education, supportive policy, and public-private partnerships.

The Sorting for Circularity USA Project takes a pivotal position as the first initiative in the U.S. in providing crucial information for making informed decisions regarding further investments, infrastructure generation, policy developments, technological advancements, and next steps towards textile circularity. The study's results will contribute to optimizing textile collection programs, increasing recovery, understanding quantities suitable for fiber-to-fiber recycling, evaluating the value proposition of such recycling, and identifying gaps in collection, sorting, and pre-processing infrastructure for effective material recycling preparation.

Two key areas with insufficient data today to inform a functional reverse supply chain and infrastructure are (1) consumer disposal and diversion behavior and (2) material characteristics of post-consumer textiles. The Sorting for Circularity USA project addresses these gaps through the following areas of study:

» ***National consumer survey*** to document consumer disposal and diversion behavior and underlying motivations.

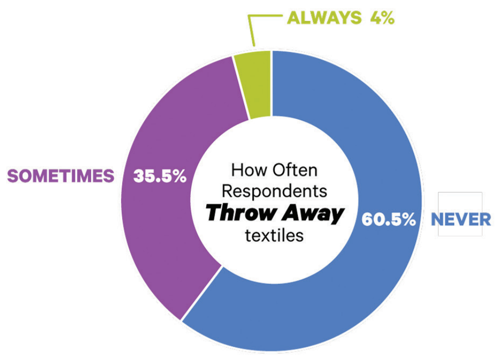
» ***Textile waste composition analysis*** to identify fiber composition and other material characteristics of post-consumer textiles.

The Sorting for Circularity USA Project found that up to 56% of textiles generated as waste are suitable for fiber-to-fiber recycling. These findings demonstrate the promising opportunities for recapturing value from textile waste via mechanical and chemical recycling. This represents a value increase of $1.5 billion per year.

From Closets to Recycling: Understanding Textile Disposal Habits and Charting a Course for Increased Consumer Participation

CONSUMER SURVEY HIGHLIGHTS ROBUST COLLECTION INFRASTRUCTURE BUT A NEED FOR BETTER EDUCATION

A variety of collection channels are available to consumers that wish to divert their used textiles for reuse, repurposing, and recycling. The ecosystem of charities, thrift shops, and the peer-to-peer economy has served consumers for decades, while new textile recovery programs such as collection bins, door-to-door collection services, retail take-back, recommerce, and resale, have emerged to complement existing outlets. A survey of U.S. adults shows that most consumers recognize the inherent value of their unwanted textiles and are already making commendable efforts in utilizing diversion channels for rewearable items, but there remains ample room for improvement in augmenting the recovery of non-rewearable textiles for fiber-to-fiber recycling.



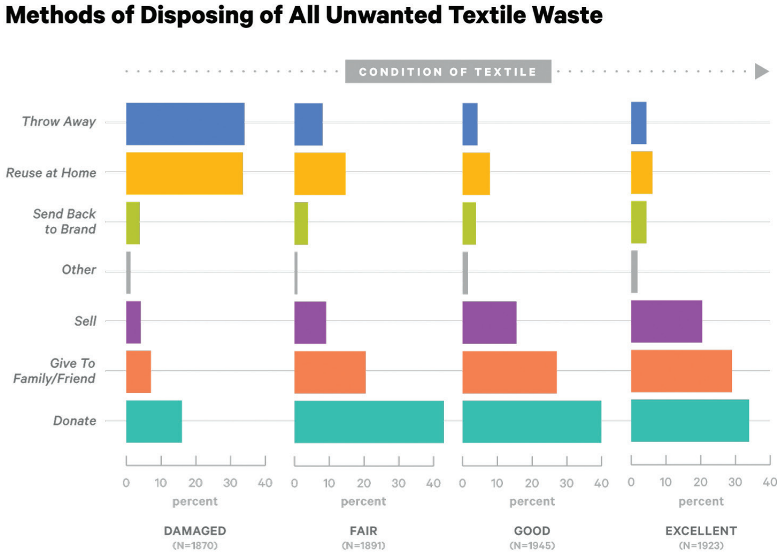


Figure 1: Survey Results for Consumer Disposal Behavior.

Of survey respondents, 60% report diverting textiles, 4% report discarding textiles, and the remainder utilize both options (Figure 1). Overall, **condition and fit are leading drivers of textile waste generation**, and consumers tend to divert "high-value" textiles and discard "low-value" textiles.

The primary reasons consumers discard textiles in the bin are, in order of dominance, poor quality, convenience, lack of confidence in knowing what is accepted for donation / reuse / recycling, and skepticism as to whether textiles are actually reused or recycled. The leading reason survey respondents choose to divert textiles is to help those in need and support a charity.

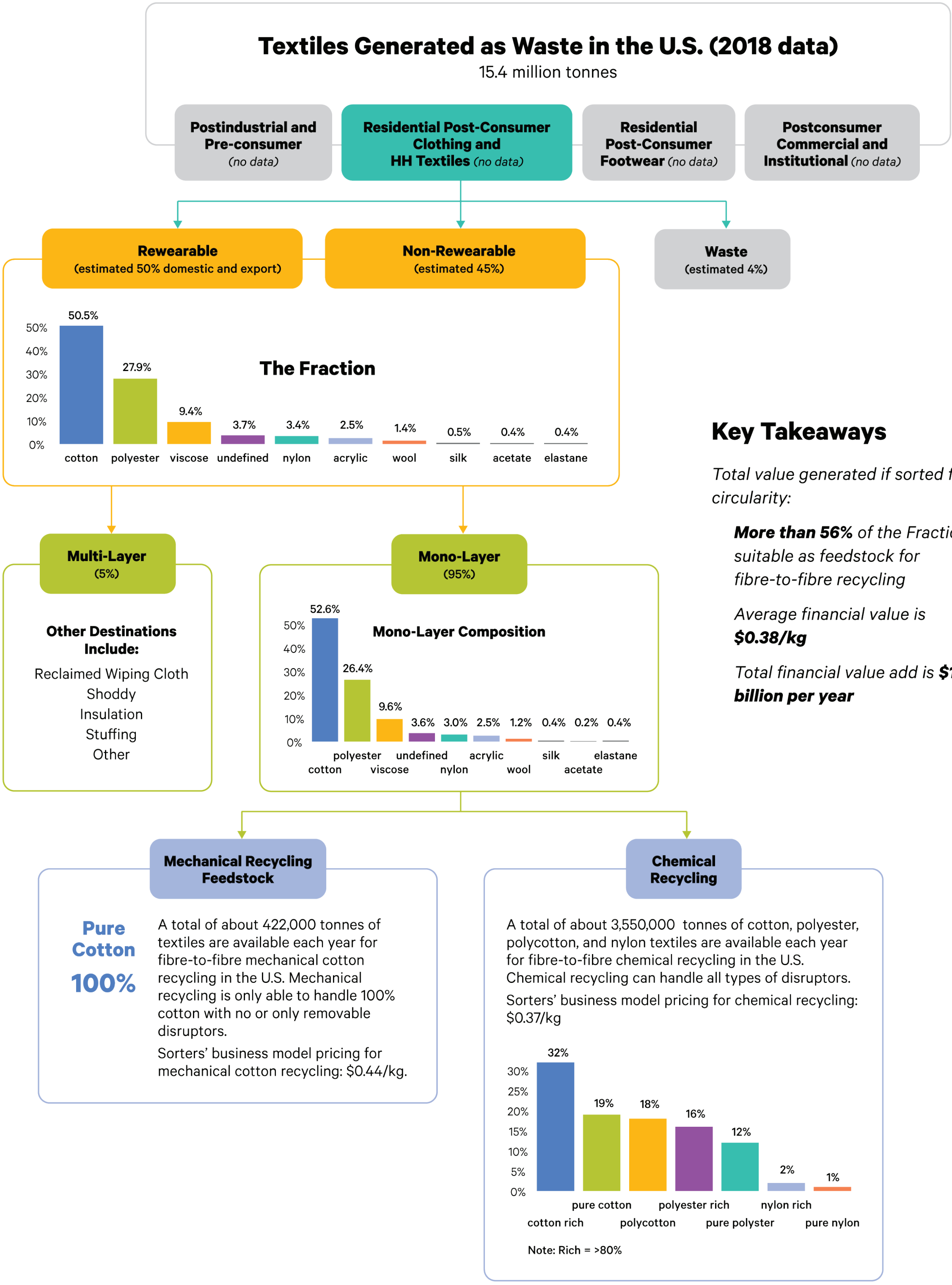
These findings suggest that a targeted public education campaign in conjunction with optimized program convenience could have the potential to increase recovery rates of residential post consumer textiles.

Decoding the Textile Recycling Potential

COMPOSITION ANALYSIS FINDS OVER 56% OF TEXTILES ARE SUITABLE FOR FIBER-TO-FIBER RECYCLING

NIR technology was used to determine garment composition. This Project analyzed a total of 14,884 kgs (14.84 tonnes) of post-consumer garments across 7 regions of the U.S. On-the-ground evaluations were conducted over two time periods, summer/spring 2023 and autumn/winter 2023, to account for seasonal differences in the garments entering sorting/grading facilities.

The composition analysis found that cotton is the most prevalent fiber type (51%) in the residential post consumer textile stream followed by polyester (28%) (Figure 2). When evaluated in terms of suitability for recycling, approximately 9% of residential post-consumer textiles are suitable for mechanical fiber-to-fiber cotton recycling and up to 56% are suitable for chemical fiber-to-fiber recycling. Given the scaling and development of recycling technologies, collection channels, sorting capacity, and pre-processing infrastructure, this research informs the business case for fiber-to-fiber recycling and the infrastructure and capacity needed to prepare post consumer textile feedstock for recycling.



Key Takeaways

Total value generated if sorted for circularity:

> ***More than 56%** of the Fraction is suitable as feedstock for fibre-to-fibre recycling*
>
> *Average financial value is **$0.38/kg***
>
> *Total financial value add is **$1.5 billion per year***

Figure 2: Composition Analysis of Textiles for Suitability for Fiber-to-Fiber Recycling.

Horizon for a Circular Textiles Future

There is a $1.5 billion value proposition for sorting for fiber-to-fiber recycling. This estimate represents the total recycled commodity value of the non-rewearable fraction of textiles currently discarded in landfills and incinerators across the U.S. each year. The new $1.5 billion value is unlocked by capturing textiles currently destined for disposal and channeling them into fiber-to-fiber recycling applications.

Introduction

Significance of Textile Waste in the U.S.

The U.S. is an important geography when it comes to aspirations for textile circularity, as it boasts the highest per-capita consumption of new textiles and apparel globally, with a market value of $251.8 billion.[5] While second only to China in absolute market share, this **excess consumption makes the U.S. a leading contributor to textile global waste** generation and one of the **largest sources of secondary raw materials for circular supply chains,** if collected, sorted, and pre-processed.[3]

According to the U.S. Environmental Protection Agency (EPA), approximately 15.4 million tonnes of textiles entered the waste stream in 2018, accounting for approximately 6% of the overall municipal solid waste stream by weight (Figure 3).[4] This signifies a staggering 46 kgs of textile waste per capita. Over the years, the annual amount of textile waste generated in the U.S. has tripled (Figure 1).[3] Between 2000 and 2018, textile waste generation was estimated by the EPA to have increased 80% by weight and 55% in weight per capita, making textiles one of the fastest growing categories of waste in the U.S. (Figure 4).[6]

Of the quantities of textiles generated as waste, the EPA estimates that **85% were disposed of in landfills and incinerators and only 15% were diverted** away from disposal.[4]

However, detailed data on used textiles is lacking (see Call Out Box: Current generation). Textile waste management is unregulated and neither generators nor collectors or sorters are required to report tonnage or composition data. Any data that may be collected by individual companies is not reported to a central oversight agency. As a result, there are no comprehensive estimates for used textile quantities, flows, final destinations, characteristics, or significance of different generator types (residential post consumer, commercial and institutional post consumer, pre consumer, and post industrial).

In addition, few textiles that are collected for reuse, repurposing, and recycling remain in the U.S. for sorting and grading. The majority of them are exported in aggregate to other countries where this categorization occurs. As a consequence, there is little to no visibility into how much is sort-

Current generation, disposal, and recovery estimates do not tell the whole story.

EPA tracks overall trends and changes over time. Its data is not intended to tell the whole story about textile generation, diversion, and disposal in the level of granularity needed to understand detailed material flows and inform recovery interventions. As such, the EPA uses a top-down material flow approach that aggregates data from industry associations and businesses, federal government studies, and state websites, supplemented by waste characterisations and other research reports.6 Generation quantities for textiles are calculated using national production data adjusted for imports and exports as well as assumptions about useful product lifespan. Disposal is calculated as the remainder of textiles generated but not recycled.

To develop textile flow data that can be used for interventions, several factors need to be addressed. First, lifespan assumptions must account for the fact that consumers do not always keep textiles as long as their true end of life. Changes in fit, style, and taste cause textiles to be turned over at higher frequencies than expected if they were kept until their true end-of-use.[8] So, while 15.4 million tonnes of textiles may have been projected to hit the municipal solid waste stream in 2018, the reality is that some unknown percentage of that stream flowed through disposal and diversion channels earlier than expected. Second, textile flow data needs to account for reuse. The EPA only tracks tonnage flows for materials in the municipal waste stream, which means that reused textiles are mostly unaccounted for. Reuse is considered part of the product's extended lifespan, not end-of-use. This is one reason why the EPA calls it a "recycling rate" and not a "recovery" or "diversion" rate. To accurately represent textile flows, the amount of textiles that flow through reuse channels (peer-to-peer or consumer-to-consumer) need to be quantified. Third, used textile export data needs to distinguish between reuse, repurposing, and recycling dispositions. Currently, EPA uses export data of used textiles in its recycling rate calculation but the majority of textiles exported are exported for reuse and repurposing, with only a very small fraction ultimately being recycled.

ed as rewearable versus non-rewearable. This is in contrast to Europe where regional sorting operations can provide an indication of the split between rewearable and non rewearable.

For interventions to be planned, data on textile waste generation and composition by generator type is necessary. Given that the U.S. is a high consuming country without a significant textile manufacturing industry, post-consumer textiles are likely the largest fraction of textile waste.

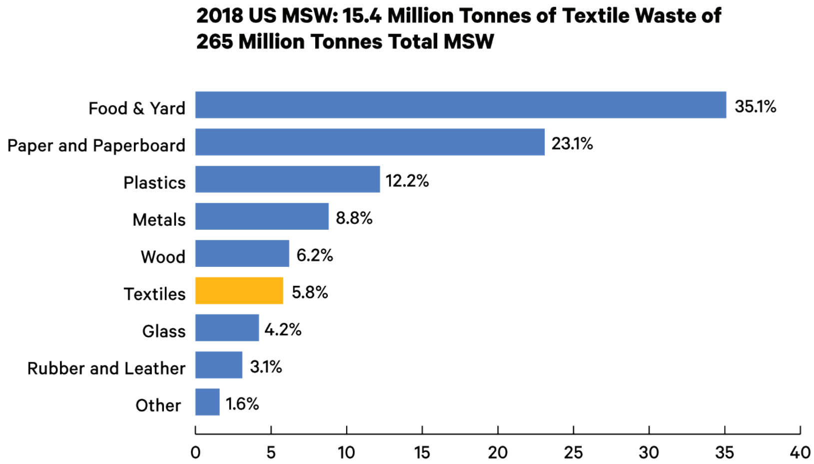


Figure 3: U.S. Waste Stream Composition (2018).[6]

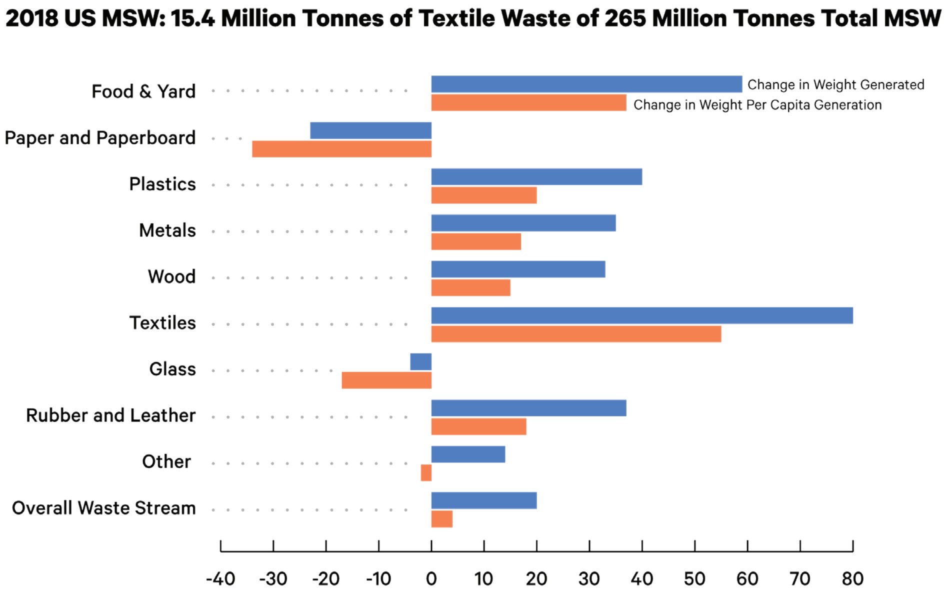


Figure 4: Percent Change in Absolute Tonnes and Tonnes per Capita Waste Generation, USA 2000-2018.[6]

MOVING TOWARD CIRCULARITY: SIX ELEMENTS OF EFFECTIVE RECOVERY SYSTEMS

A circular economy entails holistic solutions to keep materials circulating through different stages of use. An effective circular economy will use a coordinated system for end-of-use materials management. Developing an effective material management system starts with stakeholders across the value chain working together and committing to effect change across six key elements of the recovery value chain.[9]

Figure 5 illustrates the steps of an effective recovery system. The numbers start on the right side of the figure because the first step in textile recovery is widespread, convenient collection that is simple to use with pathways for textiles to re-enter the value chain. Regional textile aggregation and sorting facilities place materials into diverse commodity bales that flow into various reuse, repurposing, and recycling end markets, including mechanical and chemical recycling technologies. A strong and consistent demand from brands and manufacturers generates demand-pull through these recovery and processing systems. Education and outreach compliments the market development efforts to increase demand for reused, repurposed, and recycled textiles and promote responsible behavior at the end of the product's life. Thoughtful and supportive policies level the playing field and incentivise development of infrastructure in support of public-private partnerships crucial for scaling solutions.

Effective Materials Management is the Foundation of a Circular Economy

ELEMENTS OF EFFECTIVE RECOVERY SYSTEMS

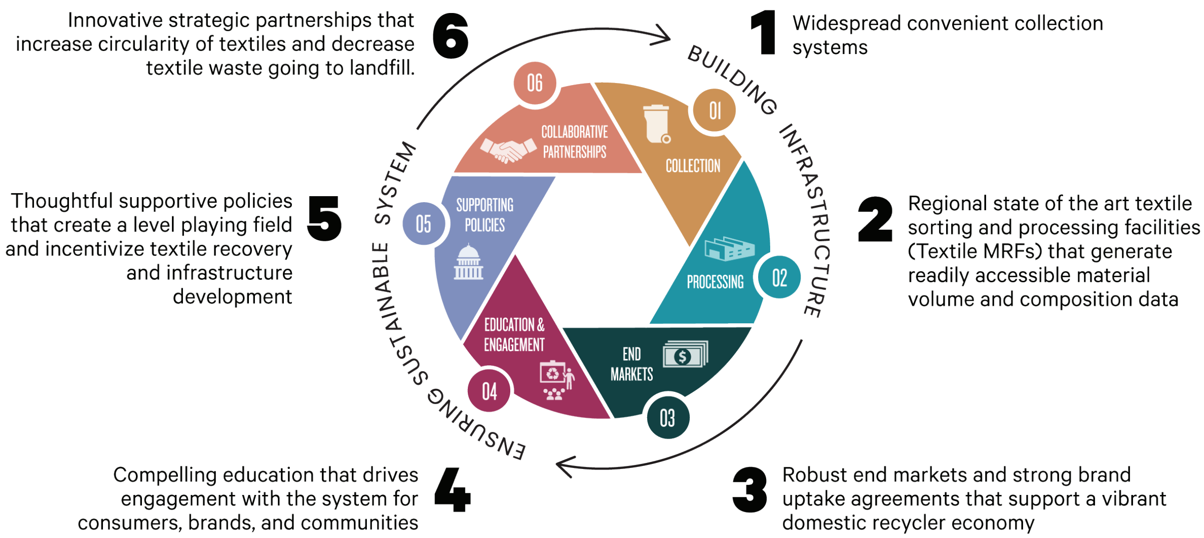


Figure 5: Six Elements of Effective Recovery Systems.

The Sorting for Circularity USA project explores the first two elements of this value chain in depth: #1 Collection (through a consumer survey) and #2 Recycling (through a textile composition analysis).

Project Goals

The primary objectives of the project are to identify potential improvements to collection systems to increase recovery of textiles for recycling and determine the availability of waste textiles suitable for fiber-to-fiber recycling. This project aims to provide data to address two primary challenges:

1. **Collection: Overcome limited data on consumer disposal and diversion behavior.** There is a lack of data on how consumers dispose and divert textile waste, including quantities of unwanted textiles generated, the utilization of different collection channels, and the underlying motivations behind consumer choices. Gaining insights into consumer behavior can inform the optimization of textile recovery programs, enabling maximum recovery and minimal disposal.
2. **Recycling: Address data gaps on fiber composition**. The scarcity of fiber composition data of textile waste is a significant limitation to building the value proposition of fiber-to-fiber recycling. Lack of data about the size of the addressable market hinders the commercialisation of recycling

technologies because this data can inform the investment and development of infrastructure and capacity of collection, sorting, pre-processing and recycling tech/processes. To establish viable business models and scale recycling efforts, innovators in mechanical and chemical recycling need access to data about the quantities and types of fibers suitable for their technologies, as well as insight into potential access to this feedstock.

Together, results from this research will inform access to residential post-consumer textiles for recycling and support efforts to scale fiber-to-fiber recycling. Future steps to build on the learnings from this report would aim to assess automated textile sorting solutions and determine a commercialisation and investment roadmap for scale.

Chapter 1. Textile Collection

PART 1.1. BACKGROUND AND CONTEXT: THE CURRENT STATE OF THE U.S. TEXTILE RECOVERY SYSTEM

The textile recovery landscape in the U.S. consists of a complex network of generators, collectors, brokers, sorters-graders, and end markets (Figure 6). Textiles do not take predictable paths through the reverse supply chain. Some supply chain actors play multiple roles, and materials may be transacted back and forth multiple times.

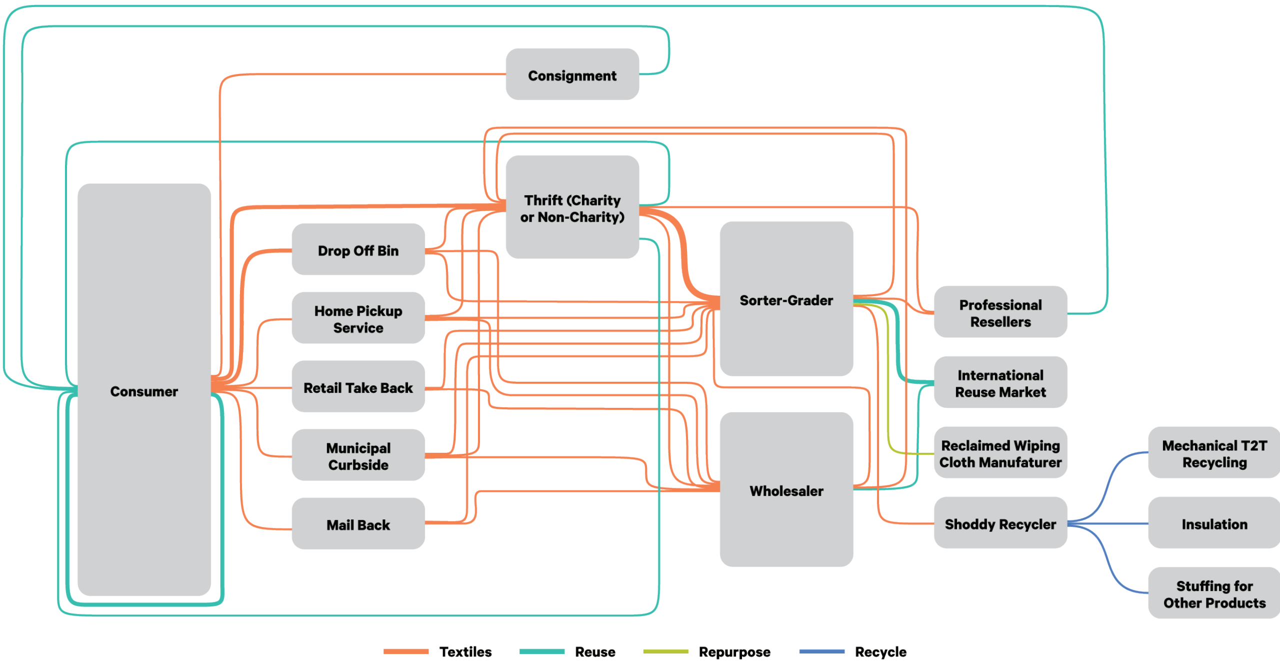


Figure 6: Pathways of Used Textiles Diverted From Disposal in the U.S.
(Note: Losses to landfill are not indicated here occur at each point in the recovery value chain)

A variety of supply chain actors including consumers, non-profits, and for profits, comprise the used textile economy, keeping materials flowing through various forms of use and ultimate disposition.

HOW TEXTILES ARE COLLECTED FROM THE CONSUMER

Textiles diverted from disposal travel diverse pathways. Collection channels, both formal and informal, are operated by a mix of for-profit and not-for-profit entities, but few are operated by municipalities. The reason most municipal recycling programs do not offer source-separated collection of textiles, is that as municipal recycling programs developed in the 1980's, textiles represented a relatively low percentage of municipal solid waste. In addition, while curbside recycling is undoubtedly convenient for consumers, it is a logistically challenging proposition for textiles because:

» There is a lack of data on the quantity of textiles generated at the household level.

» Textiles have episodic generation frequencies due to the cadence at which consumers clean out their closets or evaluate their textiles for donation or disposal, making efficient routing difficult (unlike paper and packaging, which are generated continuously and reliably).

» Textiles are susceptible to weather conditions and absorb liquids from other recyclables; once wet or soiled, textiles are no longer suitable for recovery.

Integrating textiles into existing municipal programs would require significant changes and investment. Many local government waste authorities currently rely on the reuse economy for their current collection partners.

The Reuse Economy

The reuse economy of charities, thrift shops, and peer-to-peer sharing channels, such as hand-me-downs, has historically served consumers even before the widespread adoption of municipal curbside and drop off recycling programs. For example, the Salvation Army (founded in 1865) used thrift to generate funds for its mission work and Goodwill (founded in 1902) created jobs and fought poverty using discarded consumer goods that needed mending from the wealthy while hiring underemployed populations to restore the items for resale.

Given the reuse and resale potential of textiles, textile recovery programs have evolved and expanded over the past decade, encompassing various collection methods such as collection bins, door-to-door collection services, retail take-back collection, branded recommerce, individual resellers, and specialty thrift and consignment stores. Informal peer-to-peer channels involve transactions between individuals, such as hand-me-downs, swapping, and garage sales. Formalized collection channels include charity donation, thrift stores, consignment shops, collection bins, municipal curbside collection, branded take-back programs, and recommerce. Once collected, the journey of textiles to their next use is far from straightforward. Textile commodities may change hands multiple times and be traded back and forth. Figure 6 illustrates the intricate nature of used textile flows in the U.S.

Certain collection channels (e.g., consignment, specialty thrift, customer to customer resale platforms, select charities, and some drop off bin operators) target high-quality or gently-used textiles because the economic value of these materials is higher than the non-rewearable fraction. In contrast, other channels accept textiles in any condition, with non-rewearable items directed to sorting facilities for ultimate repurposing or recycling. ***In general, rewearable textile products command higher market value and often subsidize the handling of non-rewearable textiles.*** Each collection

Goodwill

Goodwill is a social service enterprise comprising 154 Goodwill Organizations across the U.S. and Canada, each a separate 501(c)(3) nonprofit organization. Goodwill is tied together by a shared social mission under the Goodwill Industries International (GII) umbrella and is the largest nonprofit workforce developer in the U.S. providing job training and career services. In 2022, Goodwill recovered the value in more than 4 billion pounds of used goods, diverting them from landfills and giving them a second life. 83.4% of the 2023 U.S. population is within a 10-mile radius of a Goodwill location.

The typical process flow of textiles through Goodwill is first through the retail sales floor, then to an outlet center where items are typically sold by weight directly to consumers, and then to salvage markets where items are sold in bulk (Figure 7).

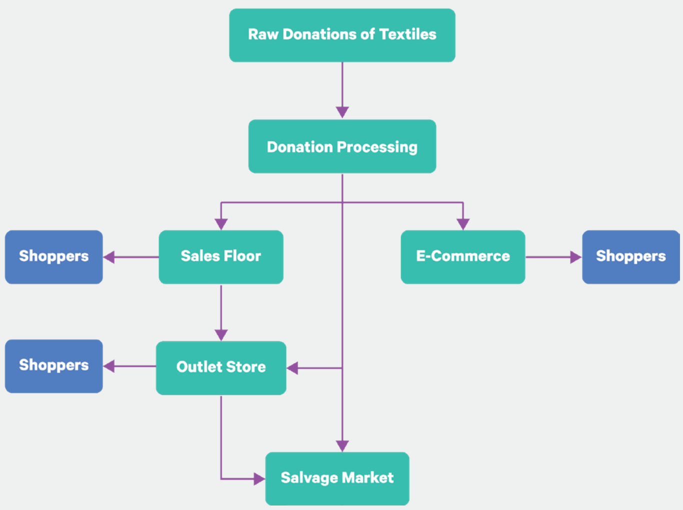


Figure 7: Process Flow of Textiles Through the Goodwill Network.

channel has a different business model, cost structure, target clientele, market niche, and profit margin (Table 1).

The amount of textiles processed through formal and informal collection programs is undocumented and quantities of textiles flowing through each respective channel is unknown. Given the scale of donation, thrift, and collection bins, it is a logical assumption that most textiles diverted from disposal flow through these channels.

Conversely, textiles discarded as refuse travel through municipal and commercial waste management systems, transported to disposal facilities without undergoing sorting or salvage. When consumers dispose of textiles as trash, the items follow a short and direct path to landfill and incineration.

Peer-To Peer. Peer-to-peer transactions in the secondhand textile industry refer to a model of exchange where individuals buy, sell, or trade textiles directly with each other, without the involvement of traditional intermediaries like organizations, service providers, brands, or retailers. This model has gained popularity with the emergence of online platforms to facilitate transactions, such as Craigslist, Facebook marketplace, eBay, and Nextdoor. Peer-to-peer transactions include activities like hand-me-downs, direct networks (e.g., sharing with friends, family, and neighbors), organized swap events, classifieds and community boards, social media forums, garage sales, and peer-to-peer marketplaces. Peer-to-peer transactions are highly decentralized and difficult to quantify.

Charities and Thrift. Charities and thrift stores are widely recognized as collection options for used textiles. The quantity of textiles that for-profit and not-for-profit thrift stores handle, however, remains uncertain. The charity and thrift network consists of various types of organizations, including large national charities, small independent thrift stores, specialty resale stores, and consignment stores. Each operates under different rules, with different capabilities, acceptance criteria, and business models. The independent operation of these organizations makes it challenging to track collection quantities. As a result, comprehensive data on the extent of the charity and thrift network for textile collection is scarce.

Drop-Off Bins. Drop-off bins are commonly found in communities across the U.S., providing the most accessible collection option for people living in urban and rural areas. These bins are typically located in public spaces such as shopping center parking lots and may be owned by charities, private companies, or be part of municipal-run programs.

Certain textile collection companies such as Helpsy, USAgain, Planet Aid, and St. Pauly's textiles collaborate with communities, municipalities, and other institutions like schools and nonprofits, which act as the hosts for the bins. The clothing and other textiles collected in these bins are aggregated, sorted, and directed to reuse, repurposing, or recycling pathways. The drop-off bin host site typically assumes responsibility for monitoring the bin and requesting a pick up when near full, often in exchange for a rental fee or revenue-share paid by the bin operator. The business model offers cost-efficiency compared to other collection channels like curbside collection and home pick ups, which require higher levels of service and less efficient routes.

Curbside Collection. Few U.S. cities offer curbside collection of source-separated textiles, but in recent years, public-private partnerships have emerged, wherein municipalities contract service providers to offer curbside collection of textiles. These contracts are typically no-cost contracts, meaning neither the municipality nor the resident pays for the service. Instead, the program operates based on the revenue generated from the sales of collected textiles. Municipal contracts can be attractive to service providers due to benefits such as first-right of refusal, exclusive access to textile waste, complementary municipal marketing, and the credibility associated with being the municipality's official service provider. However, the lack of base funding means that the viability of the service depends entirely on the market. As long as the market value of the recovered commodities exceeds the program's operational cost, the program will remain sustainable. If market values decline and persistently remain low, the program will be jeopardized.

Home Pick Up. Home pick up service offers a convenient solution for individuals who are unable to personally drop off textiles at designated locations and those who value the convenience of this service.

The service may require a minimum quantity of material, a minimum pre-assessed value, and/or a service charge. Various organizations offer home pickups for used textiles, facilitating their reuse and recycling, including select junk removal services, charities, community service organizations, clothing collectors, and specialty providers.

In-Store Retail Take Back. In-store take back programs encourage customers to return unwanted textiles and apparel at participating retail stores. In exchange for donating used clothing, customers may receive discounts on the purchase of new items. In-store collection operations are typically managed by the retailer, while downstream handling is contracted to collectors and sorter-graders for aggregation and management of the textiles.

Mail-Back. Mail-back programs are niche but growing. Some programs serve as an entry point for brands into the recommerce market whereas others are independently operated. Mail back programs typically involve a service provider such as Trashie, Retold Recycling, or Terracycle, sending a bag/box to the consumer, who then packs the textiles for shipment to a logistics provider. These providers evaluate, process, and resell the received textiles through a variety of outlets including recommerce, resellers, and salvage markets.

Table 1: Comparison of Textile Waste Diversion Channels.

Diversion Channel	Supply Chain Actors Involved	Program Scale	Funding Mechanism	Typical End Use	Bottom Line	Examples
Peer-to-Peer	Family, friends, neighbors, community (in person and online)	Widespread; Likely substantial quantities and; high number of transactions.	Peer-to-Peer financial transactions	Reuse	Effective method but informal system relies on consumer practices and are hard to track or quantify	Craigslist Ebay Facebook marketplace Mercari Nextdoor
Charities and Thrift	For profit and not-for-profit organizations	Widespread; Likely substantial quantities	Resale and Salvage revenue	Reuse	Effective method for reuse, but limited for low-value textiles	Goodwill Salvation Army St. Vincent de Paul Local churches
Drop-Off Bin	For profit or not for profit organization	Widespread; Likely substantial quantities	Commodity revenue	Reuse and Recycling	Low cost and efficient; well used, but little data tracking and some oversight challenges	Helpsy PlanetAid USAgain St. Pauly's
Curbside Collection	Municipally operated program with service typically contracted out to private or charity collectors	Limited; Likely small quantities	Commodity revenue	Reuse and Recycling	Convenient for consumers but high operational cost and challenging logistics	Helpsy Simple Recycling
Home Pick-Up	For profit or not for profit organization	Limited; Likely small quantities	Resale and Salvage revenue	Reuse	Convenient for consumers but high operational costs	Local charities Helpsy Simple Recycling
In-Store Retail Take-Back	Branded program with contracted service provider	Limited; Minimal quantities	Commodity revenue	Reuse and Recycling	High operational costs with minimal volumes collected	Soex

Diversion Channel	Supply Chain Actors Involved	Program Scale	Funding Mechanism	Typical End Use	Bottom Line	Examples
Mail-Back	Independent program or Branded program with contracted service provider	Limited; Likely small but growing quantities	Resale and Salvage revenue	Reuse and Recycling	Expensive program to operate with limited options for low-value textilesnes	Retold Recycling Trashie

AFTER COLLECTION

The path that recovered textiles take through the recovery system after collection is dependent upon which entry point the consumer chooses. A portion of collected textiles are directly resold or traded back to consumers through channels such as thrift stores, consignment and peer-to-peer sharing. The remaining textiles are sold to professional sorting and grading companies, where textiles are categorized into hundreds of fractions for reuse, repurposing, and current mechanical recycling end markets. Textiles may be sent to a final destination after sorting or they may change hands and go on for further sorting, grading, or processing.

Eventually, recovered textiles end up in a limited number of end uses: domestic or foreign reuse markets, reclaimed wiping cloth and rag production, or shoddy manufacturing. According to SMART, 45% of recovered textiles are sent to reuse markets, primarily the global secondhand market, while 30% is utilized in the reclaimed wiping cloth industry, and 20% is allocated to shoddy and open-loop recycling.[10] Less than 1% of recovered textiles are recycled into new textile fibers and the remainder is considered waste.[11]

Three Municipal Source-Separated Collection Case Studies

Municipal collection programs have mixed results in terms of success. They tend to work better in dense urban areas as opposed to suburban and rural areas.

San Francisco

Recology, the City of San Francisco's recycling service provider, piloted a consumer appointment-based curbside textile collection program starting in 2017. The initiative started by allowing textiles in the curbside recycling bin, but issues at the sorting site, the collection method changed to having residents schedule a pick up at no additional charge.[12] The program is funded through the regular residential waste bill.[13] Collected textiles were primarily reused through a partnership with St. Vincent de Paul. In the current pick up format, the program faces challenges primarily related to high collection costs. The at-home pickups incurred an expense of $61 per collection for Recology.[13] This cost exceeded the value of the materials being gathered, leading to the discontinuation of education and promotion of the program. The unsustainable economic model underscored the complexities associated with integrating textile recycling into curbside collection programs and highlighted the need for innovative approaches to address cost-effectiveness in such initiatives. Both Recology and San Francisco Environment have endorsed Extended Producer Responsibility (EPR) as the preferred program format, so the costs are equitably shared with producers and not burdened on local government and garbage rate payers.[14]

New York City

The ReFashionNYC initiative in New York City serves as an illustration of a source-separated textile collection program that is free of cost to residents and the City. The NYC Department of Sanitation (DSNY) contracts out the collection of textiles and apparel from multifamily apartment buildings using a bin-collection model. Notably, the contract for this initiative is exclusive to not-for-profit service providers. The program requires that a fixed price per pound from the sale of collected textiles is allocated to an outreach and education fund managed by the vendor. This outreach is designed to encourage resident participation in the program. Multifamily buildings can apply for textile collection bin placement, which is serviced when full. DSNY incurs no costs nor receives funds for the program. Although the initiative has encountered challenges, it has proven largely successful due to the proactive partnership between Housing Works and DSNY, their joint commitment to the program's success, downstream collaborations to manage the substantial influx of recovered textiles, and the operational efficiencies derived from the densely populated urban setting.

St. Paul, MN

In St. Paul, MN, Eureka Recycling included textiles in the residential recycling program for nearly two decades before discontinuing the initiative. During the program's operation, residents were instructed to place bagged textiles alongside other recyclables in their curbside blue bins, which contained loose items such as bottles and cans. Eureka Recycling, responsible for hauling and processing recycling in the city, collected bagged textiles in the same trucks used for recyclables. At the recycling facility, workers manually removed the bags of textiles at the beginning of the sorting process.

Several factors led to the eventual discontinuation of the program. A primary reason was disruptions in textile end markets in which offtakers that had been accepting textiles stopped accepting them, resulting in year-over-year commodity revenue losses that strained the program financially. The compactor trucks used for collecting textiles alongside recyclables caused contamination issues, as textiles easily absorbed moisture and residue, rendering them unsuitable for reuse markets.

Furthermore, the manual pre-sort at the front end of the Material Recovery Facility encountered challenges. Equipment damage and downtime were caused by textiles that hadn't been properly removed from the incoming stream of recyclables, tangling machinery. Textiles that did make it through the facility to commodity bales contaminated those bales, leading to a reduction in commodity prices. These complications collectively contributed to the decision to cease the textile collection program.

Eureka found that textiles can be collected for as little as $0.01/household/month using this co-collection approach. They also found that collecting textiles on designated recycling days resulted in 40% higher tonnage than a call-in program.

PART 1.2. CONSUMER BEHAVIOR

WHY CONSUMER ACTIONS MATTERS FOR TEXTILE CIRCULARITY

Effective collection is crucial in establishing a robust reverse supply chain that redirects materials for continued use. The fate of unwanted consumer textiles hinges on whether consumers opt for disposal pathways or recovery pathways. As discussed, American consumers have a wide range of recovery options available to them and as shown by the survey results, consumers are already making commendable efforts in utilizing diversion channels for rewearable items, but there remains ample room for improvement in augmenting the recovery of non-rewearable textiles for fiber-to-fiber recycling.

Note: Full survey findings and a review of the survey's methodology can be found in Appendix IV - Survey Methodology and Results.

HOW CONSUMERS CURRENTLY MANAGE TEXTILES AFTER USE

Most Consumers Utilize Diversion Channels. A 2023 survey of over 1,000 U.S. consumers show that once a consumer no longer wants a textile product, the most popular disposal method is *donation* (used by 77% of respondents), followed by it *giving away to family or friends* (55% of respondents), *repurposing* (39% of respondents), *discarding in the trash* (39% of respondents), *recycling* (27% of respondents), and *reselling* (25% of respondents).

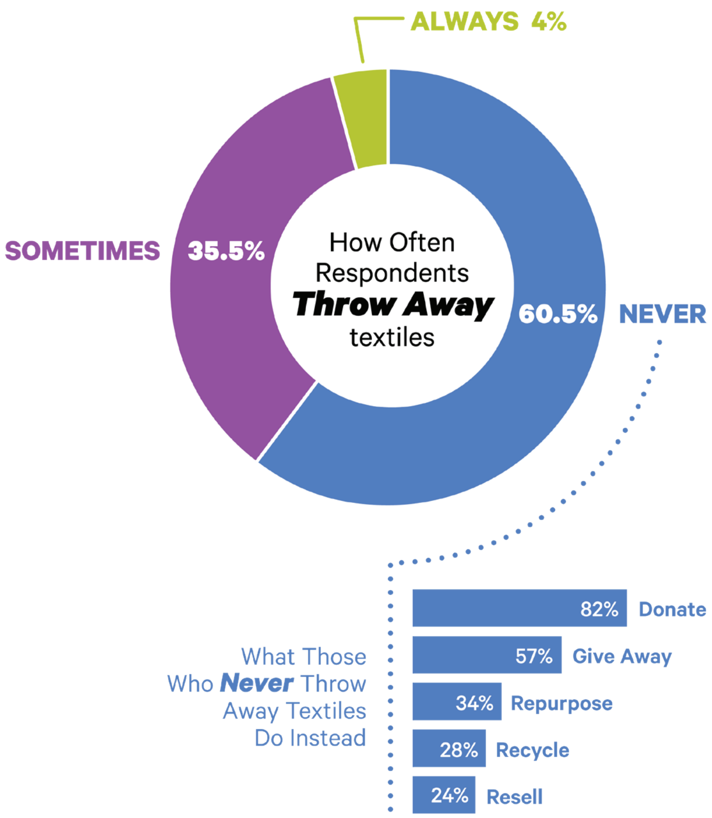


Figure 8: Most Popular Disposal Methods for Post-Consumer Textile Waste.

In terms of textile disposal, the survey found that 35.5% of respondents use both disposal and diversion methods, while 60.5% solely divert their unwanted textiles, and 4% exclusively throw them in the trash (Figure 8). Moreover, almost 83% of respondents feel that current diversion programs are convenient (Figure 9).

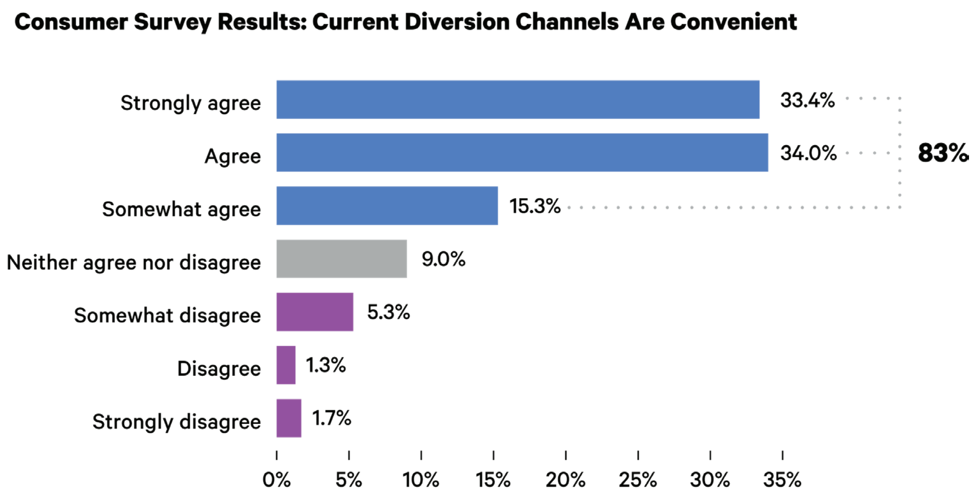


Figure 9: Perceived Level of Convenience of Using Current Diversion Channels for Textile Waste.

Consumers Divert "High-Value" Textiles and Dispose of "Low-Value" Textiles. There appears to be a logical pattern guiding the chosen methods of disposing textiles. When textiles are of "high" quality and in good condition, they are more likely to be resold or given to family and friends (Figure 10). Even when the quality is still considered "good," consumers may still consider resale and giving them away, but charity and donation become more viable options. For clothing of "fair" quality, it is most commonly taken to a charity/donation center. As soon as the perceived quality diminishes to "damaged," consumers are significantly more inclined to throw them in the trash or repurpose them as rags or for arts and crafts at home. Socks and underwear, in particular, are almost always discarded in the trash, while linens are more likely to be donated or repurposed for rags, for arts and crafts, or animal uses, depending on their quality. When it comes to kids' clothing, the most common behaviors include reselling, giving away, or donating to charity.

In Figure 11, "Consumer Survey Responses for Methods of Disposal for Various Types of Unwanted Textile Waste," depicts the ways in which consumers dispose (rows) of textiles of different types and qualities (columns). The larger the bar, the greater the number of consumers who choose that method of disposal for that textiles type/quality. Colored outlines indicate statistically significance either greater than or lower than other types/quality textiles in that row. For example, in the first row, the method Throw Away was used significantly more for damaged textiles than for textiles of fair, good, or new quality. Likewise, socks are significantly more likely to be thrown away than kids' clothing and linens.

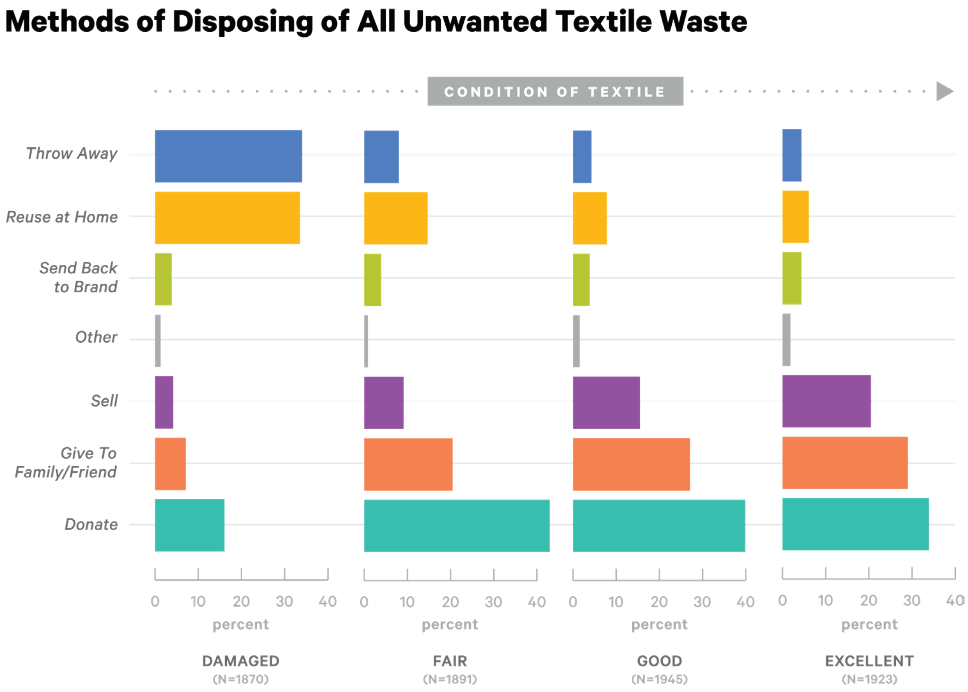


Figure 10: Methods of Disposal for Various Types of Unwanted Textile Waste.

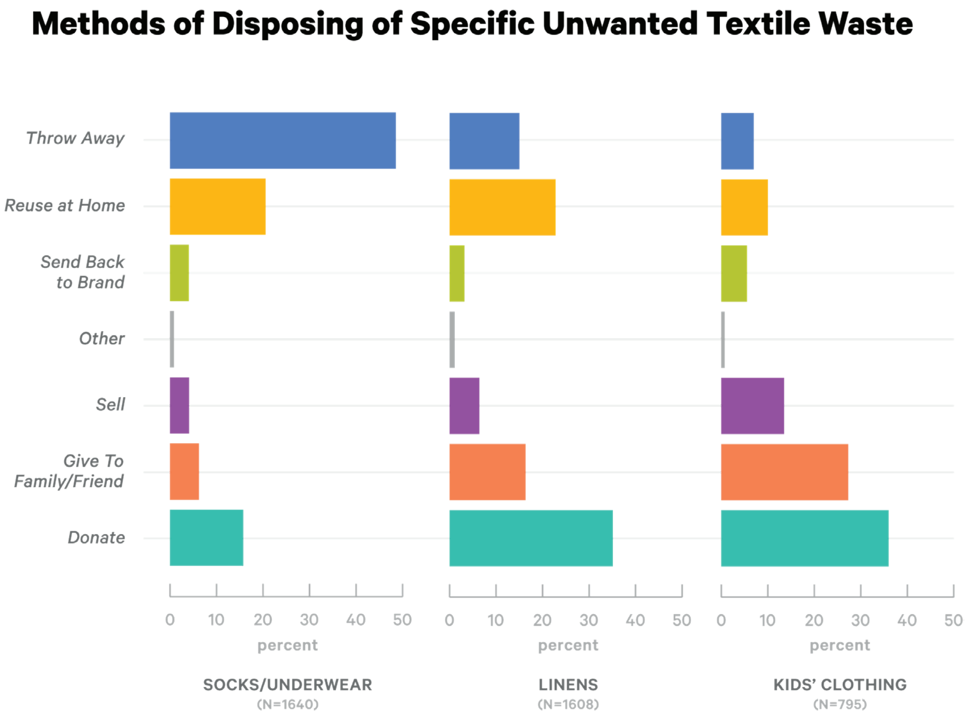


Figure 11: Methods of Disposal for Specific Types of Unwanted Textile Waste

Increasing Recovery Rates: Factors that Influence Consumer Behavior

Overall, consumers demonstrate a deliberate approach when it comes to deciding how to dispose of unwanted textiles. Understanding the motivations behind consumer textile disposal can provide valuable insights for developing strategies to increase recovery rates.

Condition and Fit are Primary Drivers of Textile Waste Generation. According to survey findings, the main drivers for consumers' decision to get rid of textiles are (1) the textiles being worn out, (2) the clothing not fitting properly, and (3) the textiles being damaged (Figure 12). A considerable 58% of respondents attribute the "poor condition" of the textiles as the primary factor for their disposal. This indicates a potentially substantial volume of post-consumer textiles from residential sources that could be directed towards non-reuse end markets such as fiber-to-fiber recycling.

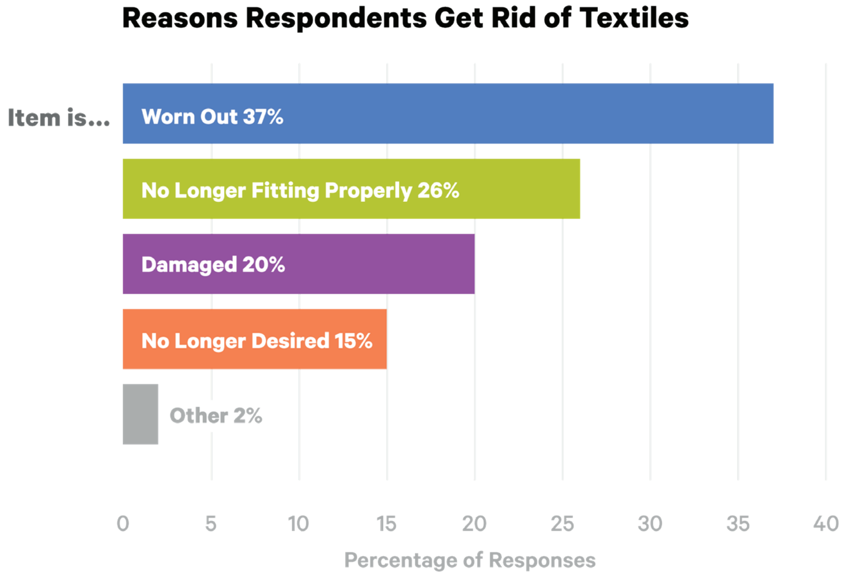


Figure 12: Top Reasons Consumers Get Rid of Textiles.

Consumers Choose Recovery and Disposal For Different Reasons.

Why Consumers Choose to Divert Textiles. The leading reason survey respondents choose to divert textiles is to help those in need (Figure 13). Supporting a charity is the most influential factor in determining the overall choice of textile disposition. These findings strongly suggest that (a) consumers recognize the inherent value in their unwanted textiles and that (b) charities play a well-known and influential role in the textile recovery value chain. Additionally, the results indicate that consumers generally divert rewearable items and discard non-rewearable items. Therefore, it can be inferred that ***appealing to a "feel-good" motive could be an effective way*** to encourage consumers to divert instead of discard their textiles.

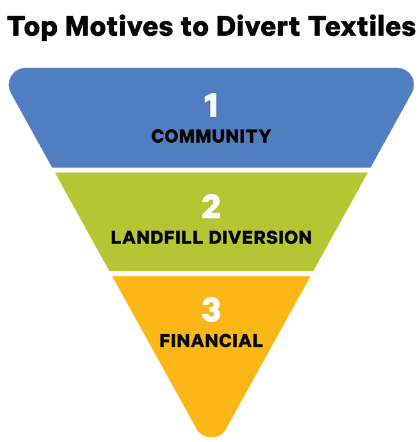


Figure 13: Top Motives for Diverting Textiles.

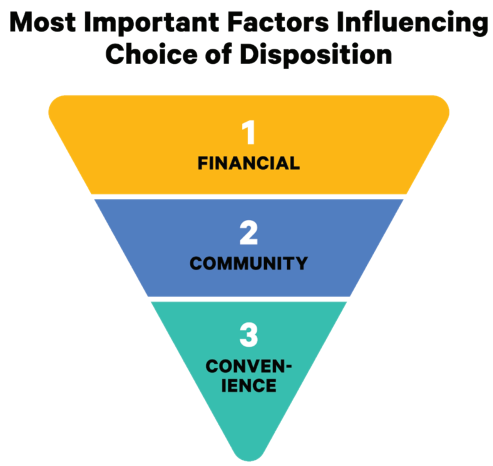


Figure 14: Most Important Factors Influencing Choice of Disposition.

Why Consumers Choose to Dispose of Textiles. Among the respondents who had unwanted textiles in the past year, 40% reported throwing at least some of them away (Figure 8). Of this group, 38% cited poor quality as the reason for not diverting the textiles, 37% mentioned convenience-related factors, 10% lacked confidence in knowing what is accepted for donation, reuse, or recycling, and 5% expressed skepticism as to whether textiles are actually reused or recycled (Figure 15). Less than one percent of respondents reported being aware of diversion options.

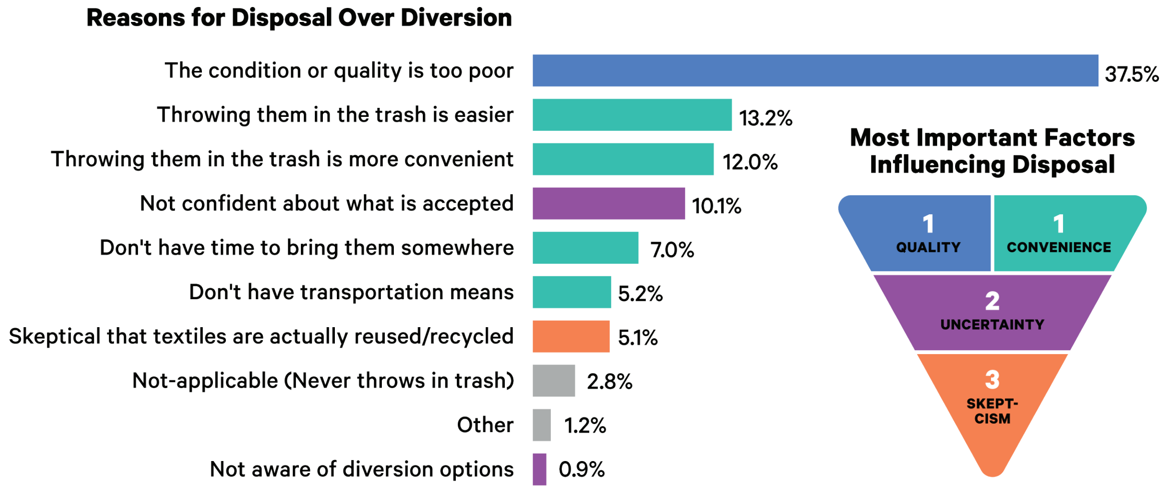


Figure 15: Reasons for Disposal Over Diversion.

ACTIONABLE STEPS TO INCREASE RECOVERY OF TEXTILES FOR FIBER-TO-FIBER RECYCLING

1. Educate consumers about recovery options for non-rewearable textiles.

The leading reason consumers discard textiles in the trash instead of diverting them for recovery is that they believe the condition or quality is too poor (Figure 12). In addition, 46% of all survey respondents discard underwear and socks in the trash (Figure 11) and another 30% usually discard ripped, torn, and stained items in the trash (Figure 10). Communicating information to consumers about diversion opportunities for non-rewearable textiles is important for maximizing capture of these items for fiber-to-fiber recycling, in addition to other uses, such as reclaimed wiper and shoddy). Education campaigns about diversion opportunities for low-quality and poor-condition items for recycling need to be clear and widespread.

2. Optimize program convenience.

Proximity is a well known determinant of participation in recycling programs. Research has shown that the closer a diversion option is, in terms of travel time or distance, the higher the participation rates. For instance, a study conducted in Michigan revealed that residents were willing to drive up to 25 minutes to recycle their household waste and 30 to 45 minutes to recycle specialty items (like electronic waste, paint, and motor oil).[15] Another study by Call2Recycle found that consumers were willing to travel up to 10 miles to recycle batteries, with the distances varying based on regional population density.[16] Similarly, research commissioned by the Carpet Recovery (CARE) stewardship organization in California discovered that 30% of respondents would recycle carpet if someone collected it from their home, 59% would be willing to travel at least 5 miles to recycle, and 29% would travel over 15 miles.[17]

The importance of proximity is evident in the actions taken by regulatory compliance organizations and legislative mandates. For example, PaintCare, the designated stewardship organization for paint collection programs in California, aims to have drop-off sites within 15 miles of 90% of the state's population. Similarly, in British Columbia, Canada, "convenient" access for electronics recycling is defined as a 30-minute drive or less to a drop off site in urban areas and 45-minutes or less for rural residents.[17]

For textiles, the majority of the American public has access to diversion programs that meet these convenience standards. Goodwill alone has locations within a 10-mile radius of 83.4% of the U.S. population.[18]

However, despite these efforts, convenience still remains a barrier for some individuals. In fact, 37% of survey respondents who dispose of textiles mentioned convenience-related factors as barriers to participating in textile recovery programs (Figure 15). This suggests that convenience should go beyond proximity and also consider factors such as the setting (urban, suburban, and rural), program timing (availability when needed), and effort (time-saving measures).

A. ***Tailored Offerings by Community Setting.*** The survey identified variations in willingness to travel based on community setting (urban, suburban, and rural). In urban areas, residents are more inclined to walk to a drop off point, whereas rural and suburban residents are more willing to drive. Additionally, the survey highlights that limited access to transportation is a barrier for some individuals when it comes to transporting unwanted textiles.

B. ***Coordinated Collection Options Based on Activation Events.*** Survey results show that textile generation is episodic. Over 60% of respondents remove unwanted textiles from their homes on a periodic basis or when motivated by an event (as opposed to a continuous basis) (Figure 16).

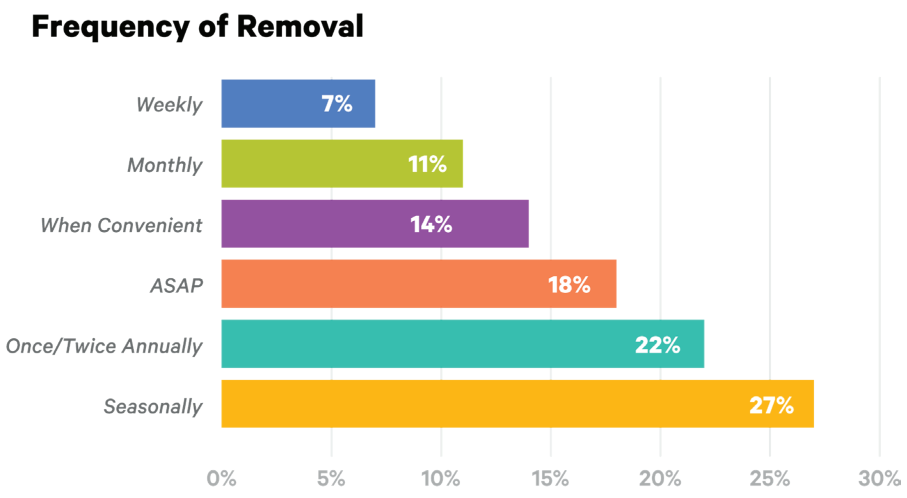


Figure 16: Frequency of Removing Unwanted Textiles from the Home.

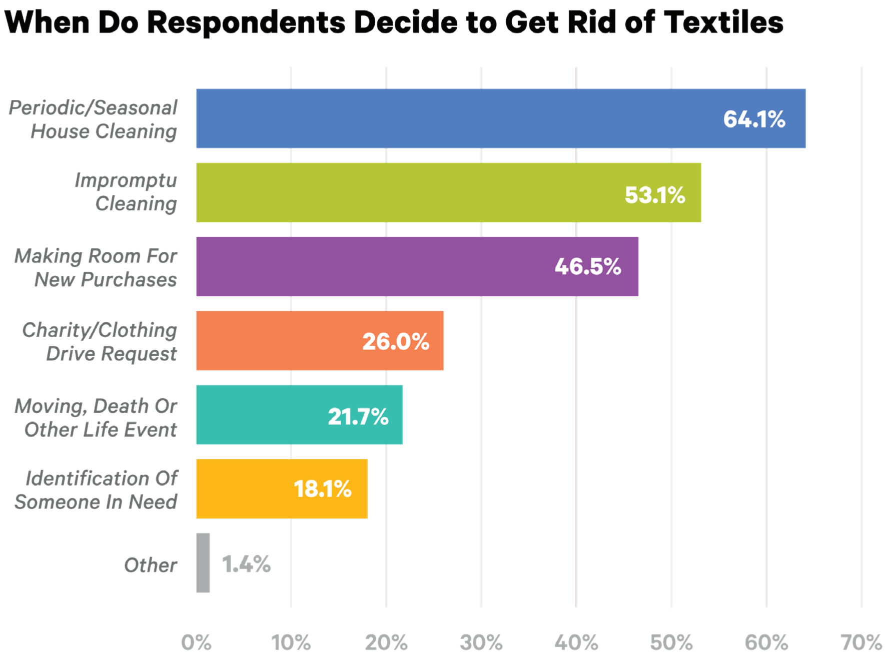


Figure 17: Activator Events That Prompt Removal of Unwanted Textiles from the Home.

Having collection programs aligned with activator events can help capture textiles that might otherwise be discarded. These activator events can include seasonal cleaning, significant life events such as the passing of a family member, moving out for college, or relocating homes (which tends to occur more frequently among urban respondents compared to those in rural and suburban areas) (Figure 17). In urban settings, collection programs implemented in shared living spaces like apartments can take advantage of the high frequency of moves. On the other hand, in rural and suburban areas, collection programs can be intensified during traditional "seasonal cleaning" periods, such as around New Year, early Spring, and back-to-school time.

Supporting the potential effectiveness of strategically timed collection initiatives is a survey finding that reveals 73% of respondents are willing to hold on to unwanted textiles for three months or even longer, if it means diverting them from the waste stream.

C. ***Reduced Participation Effort.*** A quarter of respondents who dispose of textiles in the trash mentioned that the time and effort required for diversion is a barrier. Establishing collection programs that are convenient and require minimal effort will encourage participation. Examples of such programs include home-pick ups, curbside collection, and mail-back services. However, these programs tend to be more expensive to operate compared to programs that rely on consumers bringing textiles to collection points. The additional costs associated with enhanced convenience may be passed on to consumers, as observed by some mailback programs like Terracycle and Retold Recycling, as well as doorstep collection programs like Retrievr.

When consumers were asked about their willingness to pay for added convenience, responses were divided. Approximately 42% expressed willingness to pay (no particular threshold was asked), 41% were unwilling to pay, and the remaining 17% of respondents were undecided (Figure 18). Individuals in urban areas are more likely to be open to paying for a convenient program, while those in a suburban area are more likely to express unwillingness to pay. It is important to understand that the perception of "convenience" is subjective to each respondent, based on their own interpretation of effort and time, and whether they are willing to pay for it. In the absence of convenience, residents find other pathways, such as increased disposal.

Willingness to Pay for Added Convenience

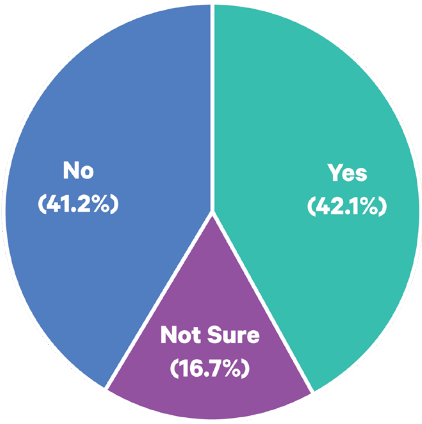


Figure 18: Consumer Willingness to Pay for Added Convenience to Collection Programs.

3. Increase Clarity About What Can Be Diverted

Ten percent of individuals who discard textiles instead of diverting them do so because they lack confidence in understanding what can be donated, reused, or recycled. This finding highlights the need for clearer and more comprehensive education about how consumers should handle their unwanted textiles. While it is difficult to create a unified message due to varying acceptance rules across programs, clarity and confidence can be enhanced through a well-planned and well-informed large-scale public outreach campaign. Moreover, there is a strong argument for streamlining acceptance policies across similar programs. A harmonized message about the recovery potential of low quality textiles could open access to an entirely new stream of materials for textile recyclers, one that does not compete with existing end markets, and result in fewer decision points for the consumer and presumably increase participation through greater clarity and less consumer confusion. In summary, a public education campaign should consider the following key points:

» Educate consumers about recovery options for non-rewearable textiles.

» Increase clarity about what can be diverted and where (e.g., provide guidance on what is rewearable versus non-rewearable).

» Reinforce the important roles that both for-profit and not-for-profit actors play in the textile recovery ecosystem.

» Provide high-level information about downstream pathways and ultimate disposition of diverted textiles.

4. Increase Trust Amongst Stakeholders

Five percent of individuals that discard textiles instead of diverting them do so because they are skeptical about the actual occurrence of reuse or recycling of textiles. Trust is an important cornerstone of recovery programs and consumers need assurance that their diversion efforts are worthwhile, have a positive impact, and that the items they donate or divert are actually used again and/or made into new things.[19, 20] Consumer confidence in the textile recovery system is eroded by news coverage of collection businesses (intentionally or unintentionally) obscuring for-profit status and media reports of textiles ending up in landfills and dumpsites across the globe.[21, 22, 23, 24, 25] To improve consumer trust, the public needs (1) better education about the role of for-profit and not-for-profit collectors and (2) increased transparency about the final destination of materials.

A. ***Better public education about collectors.*** While the public does not need to know all the inner workings of the textile recovery industry, it is important to convey the important roles that both for-profit and not-for-profit collectors play in the textile recovery ecosystem. To promote socially responsible practices and provide clear public messaging, the Secondary Materials and Recycled Textiles (SMART) Association, which includes textile collectors such as for-profit bin operators, established a Clothing Collection Bin Operator Code of Conduct. The code outlines a set of best practices that members are expected to follow, including refraining from using deceptive or ambiguous labels and logos on bins that falsely imply support for a specific cause without an actual affiliation with a charitable organization. The code of conduct also emphasizes the importance of clearly disclosing the for-profit nature of the business on the collection bin.[26]

Certain jurisdictions such as Chicago, New York City, and various localities in Massachusetts, have implemented regulations governing the permitting, placement, labeling, and management of collection bins for the purposes including improving public understanding and reducing misleading advertising.[27, 28, 29]

Charitable benefits of textile recovery

- Some domestic charities fund their social missions through the sale of donated textiles.
- Some for-profit collectors donate a portion of materials and/or profit to charity.
- Thrift stores (both not-for-profit and for-profit) provide access to low-cost textiles and apparel to local community members.
- The domestic secondhand clothing industry generates direct and indirect jobs.
- Exported textiles provide employment and access to affordable textiles abroad.

B. ***Increased Downstream Transparency.*** The public generally lacks awareness of where diverted textiles ultimately end up.[30, 31] To improve consumer trust in the textile recovery system and reduce risk, consumers need transparency into the fate of recovered textiles - especially the textiles they donate. An education campaign that communicates a simplified message of how the textile recovery industry works could help improve trust. Such a campaign might explain that textiles do not necessarily travel a straight-line path from generator to ultimate recipient and instead, many diverted textiles are sold by the collector (whether charity or otherwise) to sorters and graders that in turn sell separated textile commodities into various reuse, repurposing, and recycling end markets across global geographies.

Chapter 2. Textile Recycling

PART 2.1. BACKGROUND AND CONTEXT: THE STATE OF TEXTILE RECYCLING

RECYCLED CONTENT IN TEXTILES IS LOW AND MOST COMES FROM BOTTLES

The utilization of recycled content in the global textile production supply chain is minimal. In 2022, recycled inputs accounted for 7.9% of the global fiber market.[32] Based on 2023 data reported by Textile Exchange, the order of prominence (based on weight) for global recycled content begins with polyester and is trailed significantly by the other fiber types.[32] In addition, it is important to note that almost all recycled polyester is from recycled PET bottles. Recycled textiles contributed to less than one percent of the global fiber market (Figure 19).

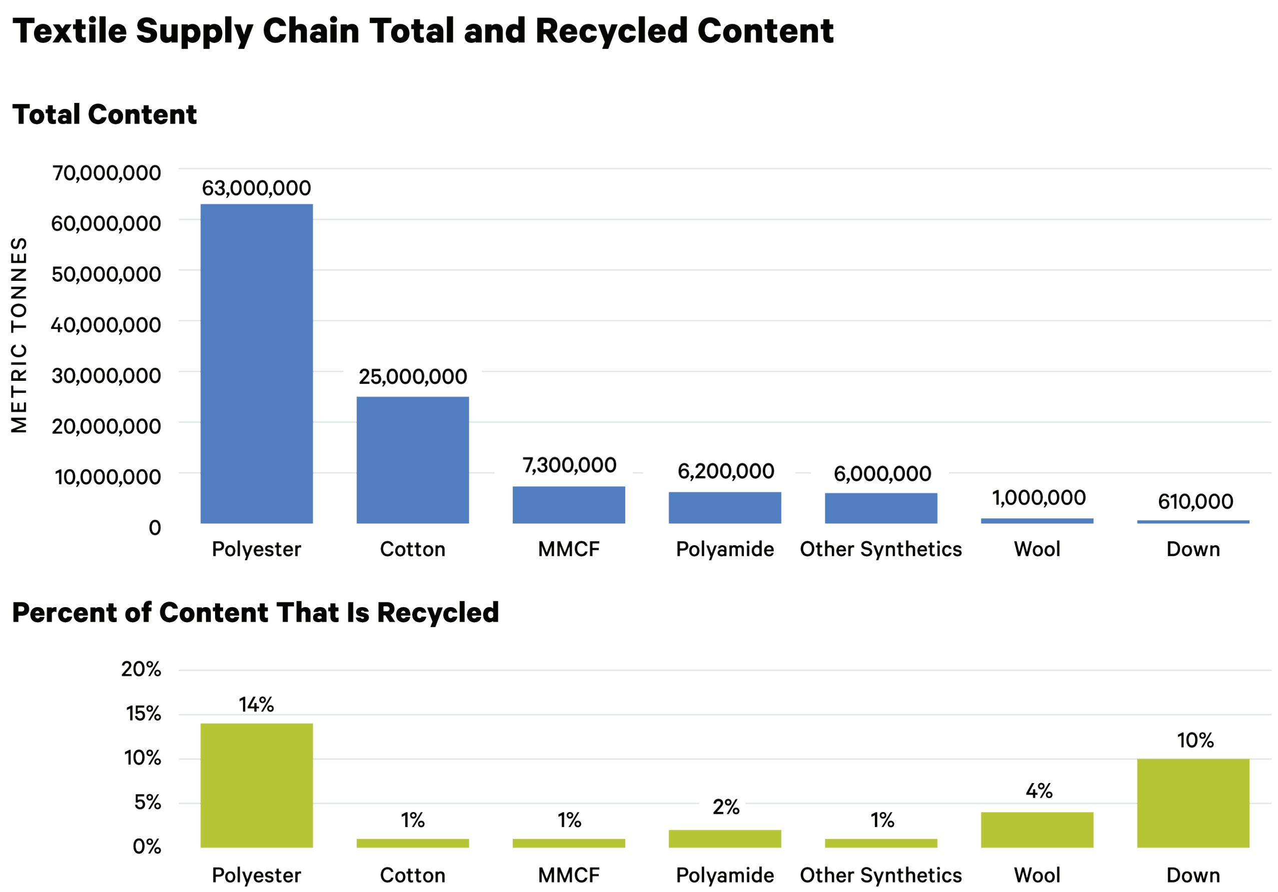


Figure 19: Recycled Content as a Fraction of Annual Global Production.[32]

BRAND DEMAND IS GROWING BUT STILL SOFT

In recent years, there has been a growing interest from brands to incorporate recycled content into their product portfolios. Leading brands in the textile and apparel sector have set ambitious goals to use recycled content. For instance, over 150 companies are signatories to the Textile Exchange's Recycled

Polyester Challenge, an initiative aimed at raising the market share of polyester that comes from recycled sources from 14% in 2019 (Figure 19) to 45% in 2025, and Textile Exchange's 2025 Sustainable Cotton Challenge aimed at catalyzing a shift to 100% sustainable cotton sourcing, including recycled content, by 2025.[33, 34] The shift towards recycled fibers is driven by various pressures, including the following:

Environmental Impact: By opting for recycled fibers, brands can mitigate the negative environmental consequences associated with virgin raw material resource extraction. A recent report by Textile Exchange and the UN Fashion Industry Charter for Climate Action (FICCA) demonstrates the potential of mechanically recycled PET from post-consumer bottles in reducing greenhouse gas (GHG) emissions.[35] Compared to virgin PET chips, recycled chips/pellets could achieve a 66% reduction in GHG emissions, while the production of Drawn Textured Yarn from recycled PET filament can result in a 27% reduction (Figure 20). Chemical recycling of PET may also offer benefits. Depending on the feedstock source, the technology, and the region of PET production, some studies show that chemically recycled PET has the potential to reduce GHG emissions by 5-27% when compared to virgin PET.[35] Recycled cotton may offer additional benefits in the areas of land use, water, and pesticide, although the variable nature of cotton growing across different geographies means that environmental impacts vary based on the region of production. One study looking at the use of recycled cotton compared to virgin found a 2.2–8.6% GHG emissions reduction, 0.6–24.5% lowered water footprint, 1.4–11.6% reduced air pollution, and 3.1–25.2% less land use impact replacing 30% of a garments virgin cotton with recycled cotton.[36] Another study found that a savings of about 0.5 ha of agricultural land, 6,600 kg CO_2 eq, and 2,783 cubic meters of irrigation water by replacing 1000 kg of virgin cotton with recycled cotton yarns.[37] Finally, a study by Ikea found that the impacts of recycled yarns are much lower than virgin yarns and the size of the impact is proportional to the percentage of recycled cotton used.[38]

Environmental Benefits of Recycling

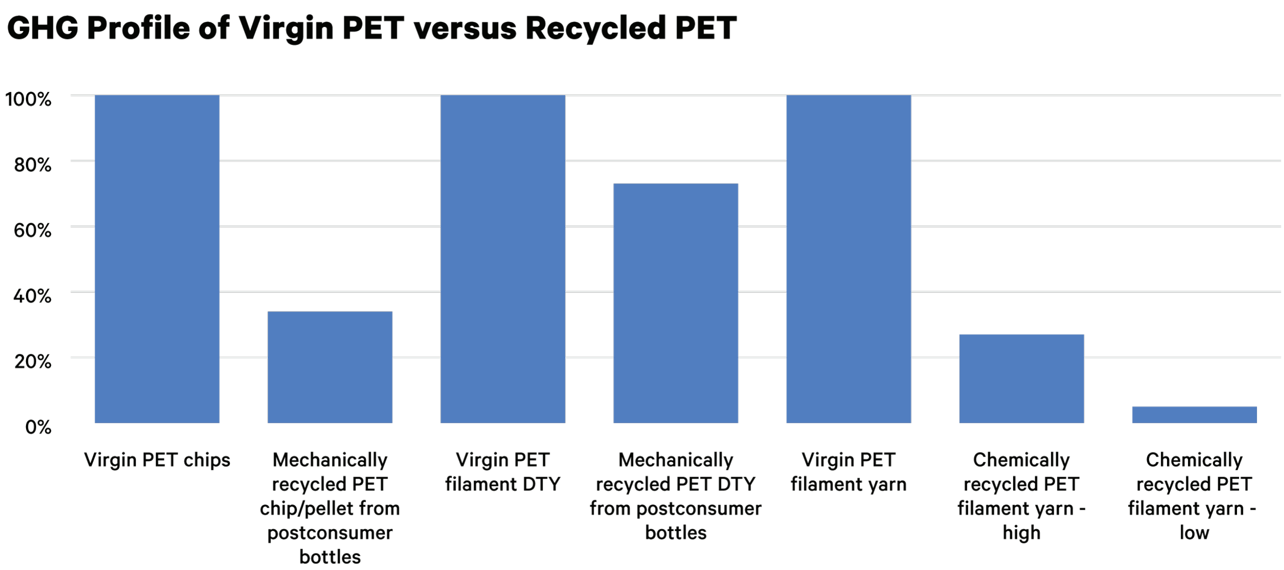


Figure 20: Greenhouse Gas Benefits of Recycled vs. Virgin PET.[35]

Consumers and NGO Influence. Increasingly, consumers and non-governmental organizations (NGOs) are exerting pressure on brands to adopt responsible or recycled material sourcing practices associated with calls for the reduction of virgin polyester. The public is becoming more aware of supply chain and end-of-use management issues, leading to a growing demand for more sustainable products. As a result, brands view textile recycling as a core part of their future materials strategy.

Market Advantage. Certain brands capitalize on their market leadership position to drive advancements in textile recycling and integrate recycled content into their supply chains. These brands actively explore approaches to future proof their businesses, such as market share expansion and investment into innovative technologies, exclusive benefits and business opportunities to which market laggards may not have access.

Supply Chain Risk Mitigation. A shift to secondary raw materials and recycled fibers is recognized as an effective risk mitigation strategy to combat challenges posed by fluctuating raw commodity prices, uncertain access to raw materials, and global supply chain disruptions.

Legislation. Regulators are taking action to address the textile waste crisis. Examples include the textile disposal ban in Massachusetts and proposed Extended Producer Responsibility (EPR) legislation for textiles in California (SB 707, Newman) and New York (S6654/A08078 Kavanagh/Kelles) which would place financial and operational responsibility for textile recycling onto producers. The European Union (EU) introduced the Waste Framework Directive, country-level textile collection mandates, and EPR regulations, creating a regulatory environment that adds momentum to the circular textiles movement.

THE BEVERAGE BOTTLE CONUNDRUM

PET bottles constitute the majority of recycled inputs for polyester, globally. However, in recent years, the demand for recycled bottle feedstock from the packaging industry in the U.S. has surpassed that of the textile industry. This shift can largely be attributed to legislation mandating minimum recycled content rates for packaging. In 2020, the consumption of recycled PET (rPET) in the Food/Beverage and Non-Food/Beverage Bottle categories exceeded the demand for rPET fibers in the U.S./Canada markets for the first time. This trend continued into 2022.[39]

Consequently, the U.S. rPET textile fiber industry has faced challenges due to higher prices and increased competition for limited supply. The shortage of rPET available to the textile industry has sparked interest in unlocking alternative sources of rPET, such as polyester-rich pre-consumer, post-industrial, and post-consumer textiles for fiber-to-fiber recycling.

A noteworthy mention is that chemical recycling of hard-to-recycle waste streams like PET thermoforms (e.g., clamshells, cups, tubs, lids, boxes, trays, egg cartons and similar rigid, non-bottle packaging made of PET plastic resin[40] and which are often not collected for recycling), carpeting, textiles, and other PET-rich streams are increasingly being eyed as sources for chemical recycling which can produce virgin-like polyester that may be suitable for textile applications. This is because they have a high percentage of polyester content making them an attractive feedstock.

THE TEXTILE RECYCLING MARKET'S PROJECTED GROWTH AND OFFTAKE COMMITMENTS WILL BOLSTER SUCCESS

The textile recycling market is projected to experience substantial growth over the next decade**.** According to market research firm Spherical Insights & Consulting, the "Global Textile Recycling Market Size" (specifically fiber-to-fiber recycling) was valued at $4.35 billion in 2021 and is expected to reach $6.13 billion by 2030 (Figure 21).[41,i]

During the forecast period, the cotton segment is anticipated to dominate the textile recycling market, with mechanical recycling outpacing chemical recycling in terms of growth. Although the textile recycling market is significantly smaller than the virgin apparel fiber production market, it is steadily expanding. The Ellen MacArthur Foundation estimates that 90% of textiles have the potential to be recycled, offering an economic opportunity worth $500 billion.[11] Additionally, a 2022 McKinsey analysis reveals that 70% of the textile waste considered 'available to recycling'[ii] in the EU-27 and Switzerland can be effectively converted into fiber-to-fiber recycled material. This represents 18-26% of the overall residential post-consumer textile waste stream and has the potential to generate an annual profit of $1.65 billion to $2.4 billion

i These estimates are based on research that includes companies like Worn Again Technologies, Lenzing Group, Birla Cellulose.

ii Material available to recycling includes the fraction that is collected but not suitable for a use higher in the waste hierarchy.

by 2030.[42] The Sorting for Circularity Europe project found that 74% of low value post-consumer textiles is readily available and suitable for closing the loop in the clothing and textiles sector across the six European countries in the study, representing a potential value increase of €74 million per year when sorted textiles are reintroduced into the textiles value chain.[43]

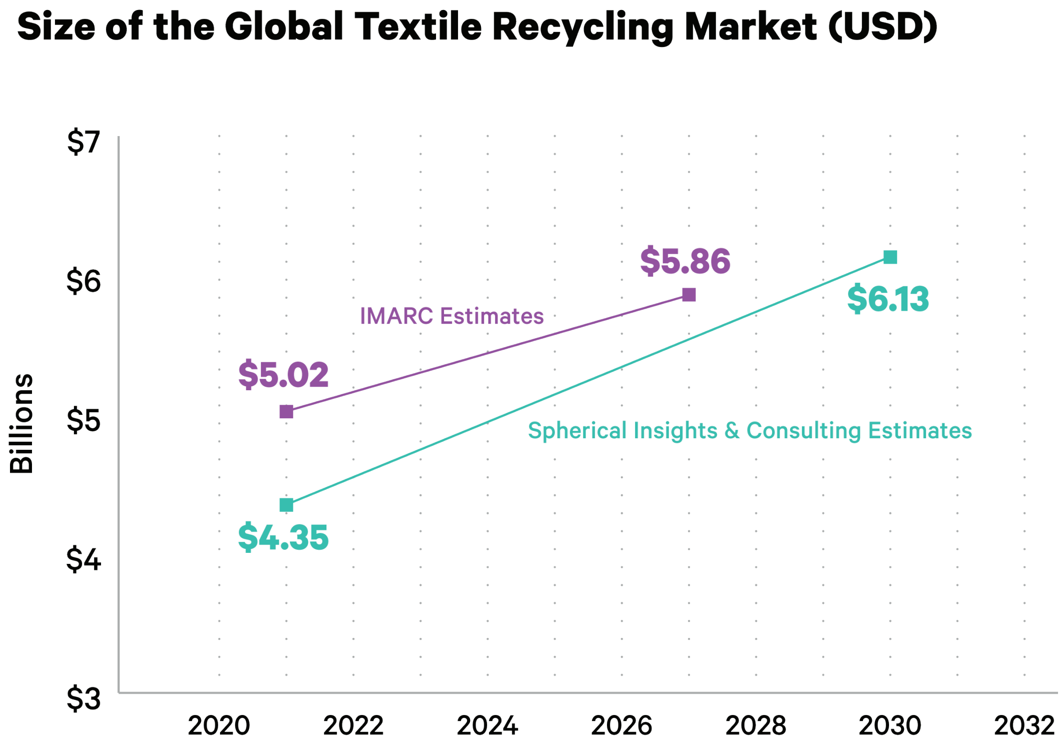


Figure 21: Size Of The Global Textile Recycling Market (USD).[44, 45]

Despite projections that textile recycling is poised for growth, chemical recycling in particular has high hurdles to clear to establish itself as a mainstream end-of-use solution in the marketplace. As a "first-of-a-kind" solution, chemical recycling relies on the carefully timed creation of a new ecosystem upstream (supply channels need to be restructured so that on-spec textile waste feedstocks can be supplied to chemical recyclers) and downstream (e.g., integrating recycled content into existing supply chains). Chemical recycling also has long lead times, and as a new approach to recycling, chemical recyclers must prove their business models, demonstrate their ability to move from lab scale to production scale, show that they can produce quality outputs that can be integrated into existing supply chains, and convince the public, regulators, and NGOs that their processes yield net positive environmental impact. Resulting high risk levels associated with chemical recycling causes investors to be extra cautious before financing these new technologies, especially in startups. There is an immense level of coordination with suppliers, offtakers, and financiers, while also working internally on the technology's capabilities and scaling plan. These challenges became evident in Renewcell's struggles and ultimate bankruptcy. To counteract these concerns, studies such as this one that demonstrate the availability of supply can help unlock capital for chemical recycling. Another important lever to support chemical recycling is for brands and manufacturers to signal strong demand for recycled content. Signaling market demand through contractual multi-year offtake agreements can drive investment and build confidence in this space.[46]

Simultaneously, it is important to recognize that setbacks and failure are inevitable components of innovation. Companies, technologies, processes, approaches, and go-to-market strategies will falter and some may ultimately fail. That does not mean that chemical recycling is flawed or futile. It simply means that change is hard. The industry at large has a responsibility to continue to ask the hard but fair questions and guide these new innovations into successful market positions. Working with supply chains to strengthen demand-pull for recycled textile fibers is one way that brands can support the development of chemical recycling as a new recovery pathway.

An Overview of Recycling Technologies and Input Specifications

INPUT SPECIFICATIONS ARE HIGHLY SPECIFIC TO FIBER-TO-FIBER RECYCLING PROCESSES

There are a variety of textile recycling technologies, each with its own set of feedstock input specifications for target fiber content, non-target fiber content, contaminants, material construction, disruptors, and size, and form. The prevalence of different fiber compositions (pure fibers, blends, and percentages of each) and color informs the amount of raw material that is available for recycling. Whether an item is single layer or multilayer informs whether the item can be accurately identified by automated fiber identification equipment, like NIR, which can presently only read the top layer. The prevalence and types of disruptors (buttons, zippers, sequins, etc.) informs the level of pre-processing that is required to prepare whole textile products for recycling (de-trimming, stripping, clipping, etc.).

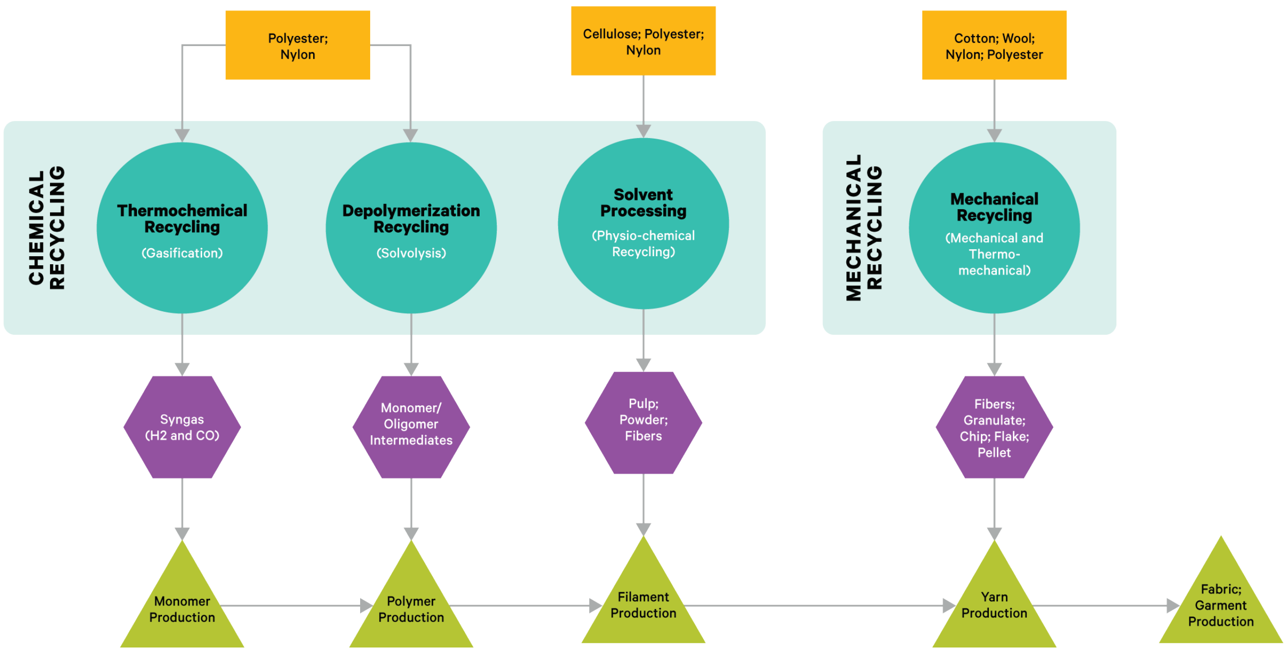


Figure 22: The Different Types of Textile Recycling.[47]

CLASSES OF TEXTILE RECYCLING TECHNOLOGIES

Textile recycling can be classified by the degree of processing and the products produced from the technology. Each class of recycling technology is typically suitable for a select suite of fiber types.

Mechanical recycling is most commonly used for cotton and wool and applies mechanical processes including cutting, shredding, garneting (i.e., combing) to recover fiber that can then be respun (Figure 22). Requiring pure inputs (near 100% cotton or wool), mechanical recycling has very low tolerance for non-target fibers and other contaminants. It cannot remove color or other chemicals. Mechanical recycling for cotton and wool is well established and there are several commercial operators. While it is a low-energy process, the resulting recycled fibers are shorter compared to virgin. Thermomechanical recycling uses a grinding process along with a melting and extrusion process to recover synthetic fibers for yarn spinning (nylon and polyester). After melting, melt spinning can be used to form a new filament (i.e., a fiber of infinite length). Thermomechanical recycling requires pure inputs (near 100%) and consumes more energy than mechanical recycling yet faces similar challenges with regard to the quality of the resulting fiber.[48] Thermomechanical recycling processes are applied in carpet recycling today, but few if any are used for non-carpet textile inputs. Due to the relatively low energy requirements for processing, mechanical recycling and thermomechanical recycling are positioned higher on the materials management hierarchy than chemical recycling.

Chemical recycling is an umbrella term describing a suite of recycling processes. One chemical recycling process, physio-chemical recycling, is used for natural polymer based fibers (i.e., cotton) and synthetic fibers (e.g., polyester) and relies on a solvent-based process to extract and regenerate constituent fibers (Figure 22). With physio-chemical recycling, the polymer molecules that make up the fibers remain intact but impurities such as inks and dyes are removed. Physio-chemical recycling requires higher energy inputs than mechanical recycling, but can achieve higher-quality outputs.[48] Physio-chemical recycling is less well established than mechanical recycling for the conversion of cotton and other cellulosics and it is nascent for synthetic textiles and blends. High thresholds of target-fiber content (>90%) are preferred in physio-chemical recycling processes to maintain optimal economic viability and technical quality of resulting recycled fibers.[49] There are some early commercial operations. As early-stage entrants to the market, the economics of these technologies are still being proven.

Depolymerization is another form of chemical recycling, which involves breaking down synthetic polymer based fibers (e.g., nylon and polyester) to recover oligomers and monomers that can be used to rebuild the polymer (Figure 22).[50] Depolymerization recycling uses a variety of chemical means to break polymers down into their constituent monomers that can then be reformed into the base polymer for the fiber or used in other applications such as fuel production, pharmaceuticals, packaging, durable goods, etc. Examples of chemical depolymerization approaches include methanolysis, glycolysis, and hydrolysis, as well as enzyme-catalyzed reactions. Depolymerization technologies are technologically and economically sensitive to inputs and therefore have low tolerances for non-target fibers. These systems typically specify feedstocks =>90% target fiber content. Depolymerization requires high levels of energy but can achieve virgin-like or close to virgin-like outputs.[48] The U.S. can expect a handful of commercial-scale operations for polyester depolymerisation technologies in the U.S. are scheduled to commence operations in the next few years and there are numerous lab scale and demonstration pilots for polyester and to a more limited extent other fibers underway.

Gasification is a chemical recycling process that converts hydrocarbon rich polymers to synthesis gas or "syngas," which is H2 and CO. These elemental building blocks can then be used in monomer and polymer production to create new raw materials for a variety of end uses, including new textiles. Syngas can be used in energy production, but this pathway is not generally accepted as recycling. Gasification plants are capital intensive but the process produces versatile outputs with little to no loss of quality.There is currently one gasification facility in operation in the U.S. and another one recently announced.

As technologies evolve and scale, it is hoped that their input specifications for target fiber content and their tolerance for non-target fibers, disruptors, and contaminants loosen so that more textiles can be recycled. Post-consumer textile waste is naturally heterogenous and contains a mix of product types, fiber blends, chemicals, and disruptors. However, post-consumer textiles are one of the largest components of the textile waste stream. Insufficient data exist on the characteristics of post-consumer textile waste in aggregate and their suitability for textile-to-textile recycling. For textile recyclers to scale, characteristics that define suitability of textiles for recycling must be known. Pursuit of data on textile composition was a primary objective of this project.

PART 2.2. COMPOSITION OF RESIDENTIAL POST-CONSUMER TEXTILES AND FRACTIONS SUITABLE FOR FIBER-TO-FIBER RECYCLING

The Sorting for Circularity USA project evaluated the composition of residential post-consumer textiles consisting primarily of ones that were diverted from landfill and sent to sorters and graders. The study also evaluated a small sample of textiles from a U.S. landfill. In total, 14,884 kgs (14.84 tonnes) of textiles from six recovery facilities and one landfill were analyzed.

The selected focus regions were California, Colorado, Texas, Florida and New York, representing a wide geographic distribution, a spread across climate zones (to test a hypothesis about fiber composition variability across climates); and near major population centers (Figure 23).

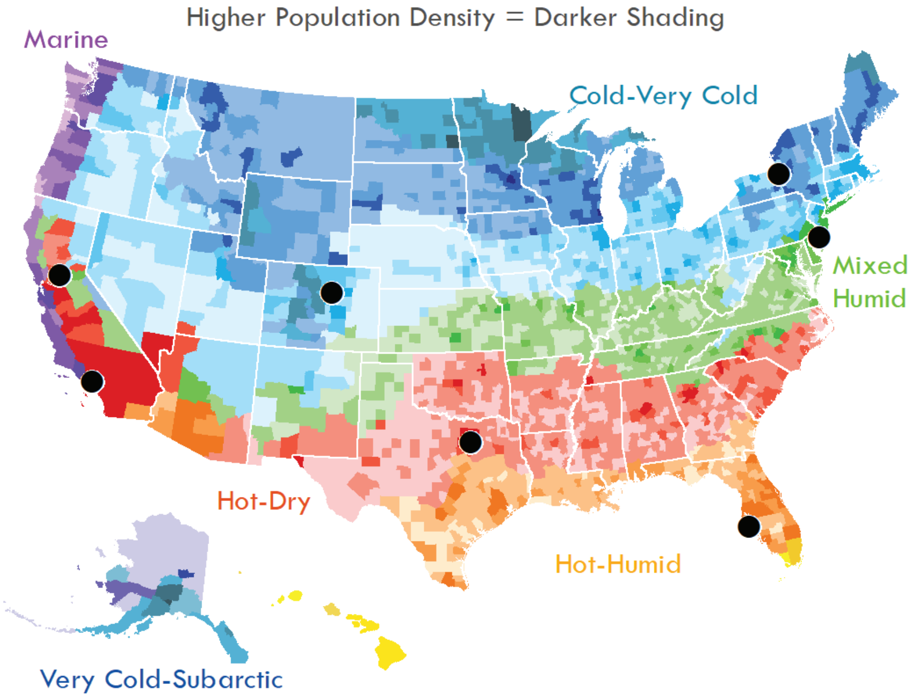


Figure 23: U.S. Focus Facilities.

The following facilities participated in this research study:

» Goodwill of the Finger Lakes

» Helpsy

» Goodwill Suncoast

» Goodwill of Colorado

» United Southern Waste

» Goodwill of the San Francisco Bay

» A west coast municipal landfill

A detailed methodology and full results can be found in Appendix I - Composition Analysis Methodology and Results.

Cotton is the Dominant fiber Type

Overall, cotton is the dominant fiber type found in residential post-consumer textiles and polyester is the second most prevalent, as shown by the overall fiber breakdown in Figure 24.

Total Composition Analysis Results

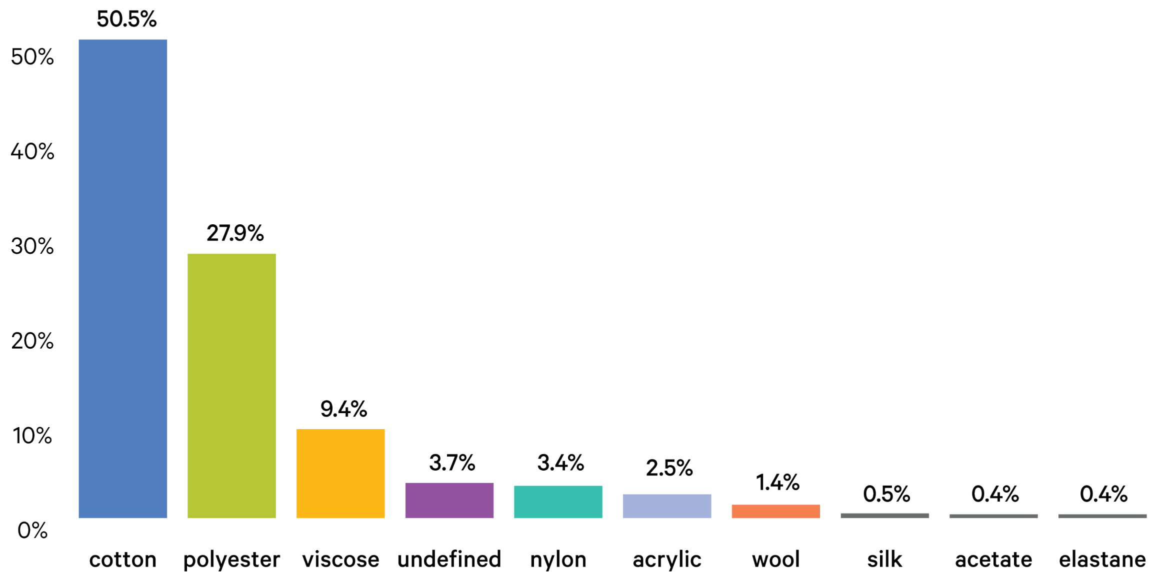


Figure 24: Fiber Composition of Sampled Residential Post-Consumer Textiles.

Interestingly, while cotton was found to be the dominant fiber present in the textiles analyzed, polyester is the dominant fiber produced on the global fiber market. A similar finding was seen in the Sorting for Circularity Europe project and the Sorting for Circularity India project. This disparity is attributed to the hypothesis that a significant portion of the polyester produced each year is used in non-apparel applications and non-consumer-facing textiles and hence not ending up in the same waste streams. For example, Textile Exchange estimates the following:[32]

» Around 30-60% of polyester fibers are used for apparel, 20-35% are used for home textiles, and the rest are used for other applications (such as automotive, agricultural, industrial, technical, etc.).

» In contrast, 60-70% of total cotton fiber production is used for apparel, while 20-30% is used for home textiles, and about 10% for other products.

Given the large estimated range of polyester fiber used for non-apparel and home textile applications (5-50%) globally,[51] more research is needed to hone the understanding of global polyester fiber flows to see if these applications are suitable for recovery and recycling.

Landfills display slightly different textile composition profiles

The analysis of waste textiles from samples taken from landfill yielded fairly similar findings with three exceptions. First, the landfill sample had a higher percentage of items that tend to be more frequently discarded after use by consumers, such as underwear, costumes, and linens, compared to rewearable items such as tops and bottoms. Second, while cotton was the dominant fiber type and polyester next (Figure 25), the gap between cotton and polyester was smaller in the landfill than the non-landfill sample (Figure 24). Finally, the landfill results exhibited a notably higher percentage of nylon compared to the non-landfill results (Figure 25).

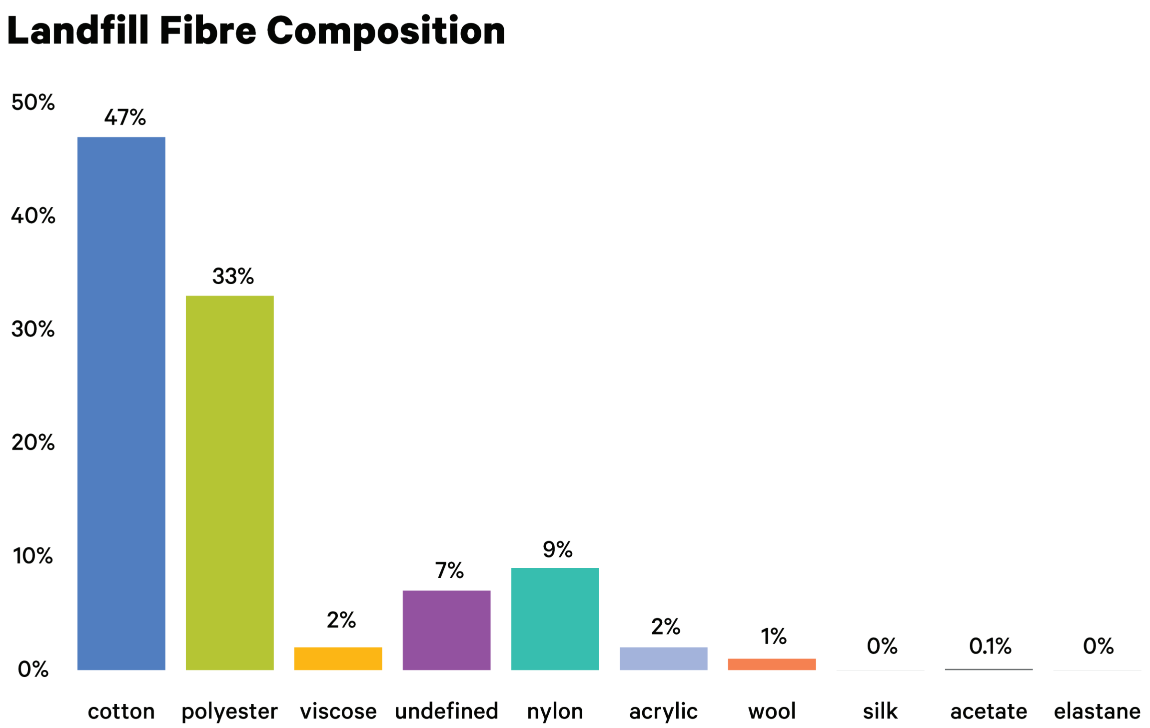


Figure 25: Landfill Fiber Composition.

It is important to exercise caution against broad extrapolation from the landfill results since the landfill sample size is not statistically representative and it is significantly smaller than the non-landfill sample.

Under 10% of Textiles Currently Meet Mechanical Recycling Standards for Cotton

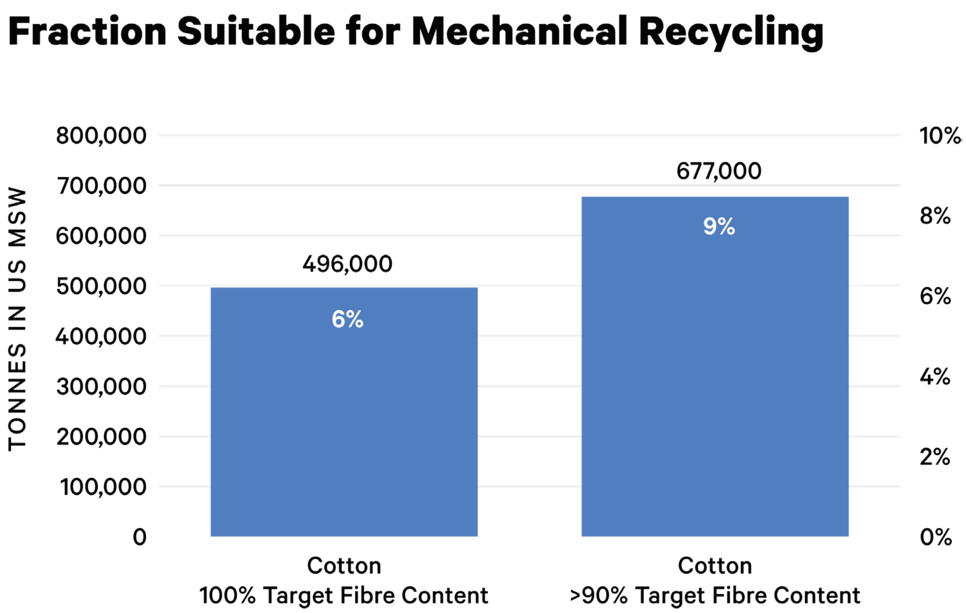


Figure 26: Share of Textiles Suitable for Mechanical Recycling for Cotton in U.S. MSW.

Analysis of textiles suitable for mechanical recycling in this study is limited to cotton.[iii] Mechanical recyclers usually need feedstock sorted by fiber type and color and require pure feedstocks that are pre-processed to remove disruptors.

Textiles suitable for mechanical recycling considered the following criteria:

- Cotton only
- 90% or higher target fiber composition
- Single-layer
- Single-color
- No disruptors or only removable disruptors

Under these conditions, findings reveal that up to 9% of residential post-consumer textiles are suitable for mechanical recycling (Figure 26). If input specifications require 100% pure fiber content, the fraction of textiles suitable for mechanical cotton recycling drops to 6%.

UP TO 56% OF POST-CONSUMER TEXTILES MAY BE SUITABLE FOR CHEMICAL RECYCLING

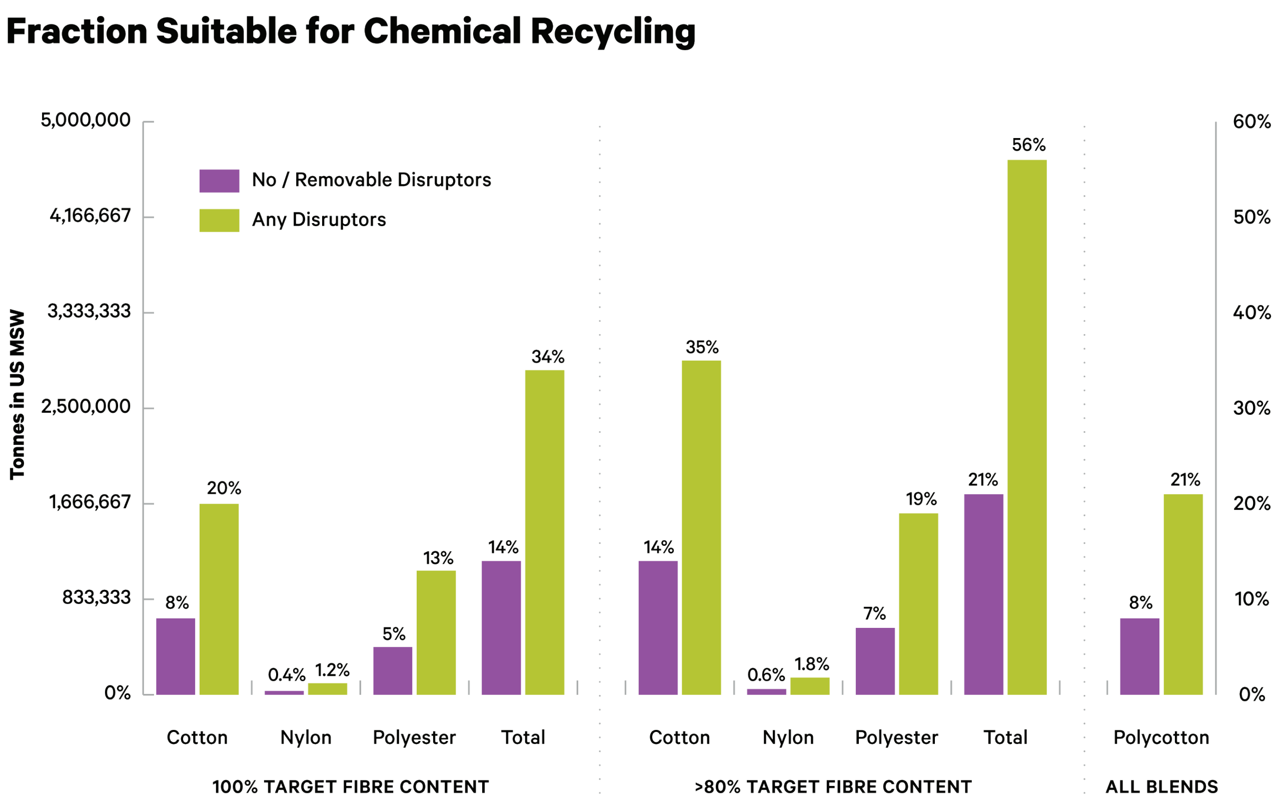


Figure 27: Fraction of Fiber Contents Suitable for Chemical Recycling in U.S. MSW.

iii Although mechanical recycling is available for wool, wool was not a focus of study. In addition, while mechanical recycling is theoretically possible for polyester and nylon, there is no practical recycling of these textiles at present, with the exception of carpet, which is a highly specialized process that cannot be easily adapted for post-consumer residential textiles. Note that the presence of elastane was not factored into calculations due to challenges detecting it. As well, material construction (knit versus woven) was not analyzed as part of this project but is an important factor for some mechanical recyclers. Further detail about the analysis of textiles for mechanical recycling can be found in Appendix I - Composition Analysis Methodology and Results.

Chemical recycling (solvent-based, depolymerization, and gasification recycling) is suitable for cotton, polyester, nylon[iv], and polycotton textiles. Chemical recyclers are generally agnostic to color but require feedstock sorted by fiber type and have strict thresholds regarding target fiber percentages. Some recyclers also have an intolerance for elastane.[v] That said, chemical recycling technologies for textiles are still in early stage development and input specifications are still being tested, refined, and optimized. This analysis evaluates feedstock suitability under the following criteria:

» Single-layer only

» 80% or higher purity of target fiber (cotton, polyester, and nylon)

» Any combination of polycotton and cottonpoly[vi]

» Any disruptors

Under these assumptions, findings reveal that over **56% of residential post-consumer textiles are suitable for chemical recycling** (up to 35% cotton, up to 19% polyester, 1.8% nylon, and up to 21% polycotton) (Figure 27). Note that there is overlap between the fractions suitable for cotton recycling, polyester recycling, and polycotton recycling.

If chemical recyclers were to require 100% pure materials plus polycotton blends, textiles suitable for chemical recycling would represent over 34% of the total residential post-consumer textile stream (20% cotton, 13% polyester, and 1.2% nylon, and the portion of the polycotton stream that excluded 100% cotton and 100% polyester) (Figure 27).

If the presence of non-removable disruptors is problematic for chemical recyclers, the feedstock for chemical recycling decreases to between 21% and 30% overall (up to 14% cotton recycling, up to 7% polyester, 0.6% nylon, and up to 8% polycotton) at an =>80% minimum fiber content threshold (including all polycotton) and between over 14% and 22% overall (up to 8% cotton, up to 5% polyester, 0.4% nylon, and up to 8% polycotton) at a 100% fiber content threshold (including all polycotton) (Figure 27).

More Data Will Hone Opportunities for Fiber-to-Fiber Recycling

UNDERSTANDING DISRUPTORS

Further investigate the presence and removability of disruptors. Data on the fiber composition of textiles is the first step toward evaluating the available supply of waste textiles for mechanical and chemical recycling. In addition, more research is needed to understand the prevalence of disruptors and their impact on recyclability. Different recycling technologies have different criteria and tolerances for disruptors. Disruptors include things like metal, plastic, fabric trims, embroidery, print, restricted substances, problematic chemicals (phthalates, PFAS), inks, dyes, coatings, laminations, anti-wrinkle agents, water repellents, fiber tracers, and more. The Sorting for Circularity project captured the presence and absence of certain disruptors, such as metal, plastic, print, fabric, and other. Additional research is needed to (1) investigate the presence of other forms of disruptors, (2) quantify disruptors to understand how prevalent they are and what percentage of the overall sample weight they are; and (3) determine how removable they are.

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iv Additional research is needed to determine how much Nylon is Nylon 6 versus Nylon 66, and efforts are needed to identify how to separate them because mechanical recycling technologies cannot accommodate mixed chemistries and most NIR spectroscopy is unable to differentiate these polymer variations.

v Elastane, a known prohibitive for some recyclers, is usually present in quantities under 10% and was therefore not detected by the NIR scanners. See Appendix for details.

vi For the purposes of this analysis, the polycotton fraction includes polyester-viscose and the cottonpoly fraction includes viscose-polyester since cotton and viscose appear similar to the NIR scanner when present in blends.

DETERMINING FIBER COMPOSITION VARIATIONS BETWEEN REWEARABLE AND NON-REWEARABLE TEXTILES

Research differences between rewearable and non-rewearable textiles. The textiles available for study in this project were a mixture of rewearable and non-rewearable from four Goodwill locations, two sorter-graders, and one landfill. These study fractions were an inherent limitation of this study given the limited activity of sorters and graders in the U.S. and the lack of sorted fractions of non-rewearable textiles for analysis. Given current industry estimates, it can be assumed that 40-60% of the items in the recovery stream are suitable for a reuse end market and another 30% currently have strong end market demand from the reclaimed wiping cloth industry.[10] That said, all textiles that are rewearable today eventually become non-rewearable and the data from this study show fiber composition across mixed post-consumer textiles collected for recovery.

BUILDING DATASETS ON LANDFILL TEXTILE COMPOSITION

Conduct additional landfill sampling to document the characteristics of disposed textiles. More research is needed to quantify and characterize discarded textiles. Landfill audits, municipal waste characterisation studies, bin audits, and other waste auditing methodologies can be used to document the quantity and composition of discarded textiles from various types of generators (single family residential, multi-family residential, industrial, commercial, institutional, retail, etc.). Research documenting the quantities of textiles from different types of generators and the composition profiles of each stream will help quantify the value proposition of fiber-to-fiber recycling, and therefore inform decisions and investments into building the necessary infrastructure and developing technological capacity.

QUANTIFYING TEXTILES BY GENERATOR TYPE

Track quantities and material flows of textiles generated by different classes of generators. Residential post-consumer textiles undoubtedly contribute to the global textile waste crisis, but a non-negligible portion of virgin fibers flow into non-consumer textile applications as well. Quantifying fiber flows to non-consumer textile applications and determining how accessible these products are for recovery and recycling is a worthwhile endeavor if the goal is textile circularity and resource conservation. Given significant gaps in textile waste generation and disposition data in the U.S. – overall and by generator type – there is a need for efforts to collect this data. A bottom up study would provide additional insights to compare and contextualize EPA's top down data. Such an approach could entail collecting, aggregating, and reconciling new and existing location-specific waste generation and diversion data. Sources of this data include landfill audits, hauler data, local waste characterization studies, brands, retailers, manufacturers, and other significant generators, collectors, thrift, resale marketplaces, and sorters and graders, as well as informed estimates to account for other forms of informal reuse. This data is needed to truly understand the generation, flow, and disposition of all unwanted textiles in the U.S. and plan comprehensive recovery systems.

TRACKING PRODUCT CHARACTERISTICS OVER TIME

Continue research over time to track changes as a result of evolving production trends, design choices, and consumer demand. Textile products are subject to continuous development as a result of evolving design, trends, taste, regulations, and material innovations. What's in the waste stream today may not reflect what is available for recycling once fiber-to-fiber recycling is commercial-ready. Continued assessment of textile products on the market, whether through waste composition studies such as this one, through feedback loops between the upstream and downstream supply chain, or through mandatory reporting or product tracing, is vital to understanding the value proposition for fiber-to-fiber recycling into the future. Textile waste composition data also informs where design change is needed to ensure that recyclers are able to adapt to the constantly changing nature of textile waste (i.e., the "evolving ton").

DISTINGUISHING FORMS OF NYLON

Evaluate methods for distinguishing Nylon 6 from Nylon 66. Today's NIR technology is unable to differentiate Nylon 6 from Nylon 66 yet recycling technologies are unable to process these two streams if mixed together. Additional research is needed to identify a reliable way to distinguish Nylon 6 from Nylon 66 and document which products use which form of Nylon.

DETECTING ELASTANE

Improve identification capabilities for elastane. Elastane poses a technical challenge for some recyclers and may be considered a prohibited fiber, even if present in low quantities, which elastane generally is (elastane is not usually present in proportions over 5%). Unfortunately, NIR is inefficient at identifying fibers present at low percentages which means that textiles with elastane are difficult to identify and remove. Additional focus should be placed on improving the capabilities of sorting technologies to detect elastane, alongside innovating recycling processes and technologies to tolerate or proactively recover elastane.

SORTING FOR MATERIAL CONSTRUCTION

Enhance identification of knit versus woven textiles for mechanical recycling. Some mechanical recycling processes have limitations on processing woven textiles. Knitted textiles are made with yarns in which the fibers are more loosely intertwined meaning that the fibers are more easily salvageable in a mechanical recycling process. In contrast, woven textiles are made of more compacted fibers causing the fibers to tear during the shredding process.[52] This results in low-quality yarns and reduced recycling efficiency. Current sorting technologies are not optimized to detect material construction (knit versus woven) and therefore are unable to sort by this characteristic. Additional research is warranted to develop sorting capacity by material construction so that textiles can be sorted appropriately for mechanical recycling.

IDENTIFYING PRE-PROCESSING NEEDS

Document pre-processing requirements and test technologies to prepare textiles for recycling. Pre-processing is a prerequisite step between sorting and recycling. It involves preparing sorted textiles for recycling such as removing disruptors and size-reducing materials (shredding/cutting into smaller pieces). Every recycler has unique pre-processing requirements. Efforts are needed to (1) identify where along the recovery value chain pre-processing is best situated (at the back end of a sorting facility, as a stand-alone intermediary, at the front-end of a recycler, as a combination of these options?), (2) identify, test, and optimize pre-processing technologies (such as shredders, metal detectors, magnets, eddy currents, density separators, etc.), and (3) determine the business case for the pre-processing step.

PART 2.3 THE MULTI-BILLION DOLLAR PROPOSITION

There is a $1.5 billion opportunity for sorting for fiber-to-fiber recycling. In Table 3, "Recycling Commodity Valuation," this estimate represents the total recycled commodity value of the non-rewearable fraction of textiles currently discarded in landfills and incinerators across the U.S. each year.[vii] ***Textiles currently recovered for reuse (domestic and international), repurposing (i.e., reclaimed wiping cloth), and recycling (shoddy) are assumed to continue to follow current pathways, unimpacted by fiber-to-fiber recycling.*** The new $1.5 billion value is unlocked by capturing textiles currently destined for disposal and channeling them into fiber-to-fiber recycling applications. This billion-dollar-plus valoriza-

vii (15.45 million tonnes textile waste generated in the U.S. annually) x (85% disposal rate) x (50% estimated to be non-rewearable) = 6.56 million tonnes available for fiber-to-fiber recycling.

tion assumes the high-end commodity revenue that a sorter and grader can expect to receive by sorting the following fractions for fiber-to-fiber recycling end markets as shown in Table 2.

Table 2: Feedstock Characteristics and End Markets for the Different Fiber Types.

Feedstock Fiber type	Feedstock Characteristics	Fiber-to-Fiber Recycling End Market
100% Cotton	Single Layer; Only removable or no disruptors	Mechanical recycling*
≥80% to ≤99% Cotton	Single layer; Any disruptors	Chemical recycling
≥80% Polyester	Single layer; Any disruptors	Chemical recycling
≥80% Nylon	Single layer; Any disruptors	Chemical recycling
Polycotton blends**	Single layer; Any disruptors	Chemical recycling

*Mechanical recycling sits above chemical recycling on the circular economy hierarchy

**Includes viscose-polyester and polyester-viscose and eliminating overlap with the chemical recycling fractions for cotton and polyester

Additional value can be created through wool recycling (not addressed in this analysis), as well as reuse of the rewearable 50% of textiles currently disposed of in landfills and incinerators.

Table 3: Recycling Commodity Valuation.

	Fraction	KG in US Waste Stream	Commodity Pricing Low	Commodity Pricing High	Commodity Calculation Low	Commodity Calculation High
Mechanical Recycling	Cotton (100%)	422,252,391	$0.44	$0.44	$185,791,052	$185,791,052
Chemical Recycling	Cotton (≥80% to ≤99%)	966,673,112	$0.11	$0.37	$106,334,042	$357,669,051
	Polyester (≥80%)	1,248,528,573	$0.11	$0.37	$137,338,143	$461,955,572
	Nylon (≥80%)	116,586,070	$0.11	$0.37	$12,824,468	$43,136,846
	Polycotton Blends*	1,347,682,246	$0.11	$0.37	$148,245,047	$498,642,431
	Total	***4,101,722,392***			***$590,532,752***	***$1,547,194,953***

*Distinct from Cotton (≥80% to ≤99%) and Polyester (≥90%)

Commodity pricing is based on input from recyclers, sorters, and graders for modeling purposes. Actual pricing may vary based on (1) a recycler's particular business model, (2) changing cost structures as technologies scale, (3) policy and market incentives

The $1.5B value can be monetized by collecting textiles that would have otherwise been disposed, sorting them, and selling sorted bales to recyclers, who in turn would process the textiles into recycled inputs for fiber and yarn spinners. Value is created by keeping in circulation textile materials that would have otherwise been discarded. Since this value represents the commodity value at the point of sale from a sorter/grader to a recycler, it accounts already for margins in the recovery value chain through the point of sorting. Additional value is added at the recycler in converting waste inputs into secondary raw materials, and customary added value onward through the textile production supply chain.

That said, ***the $1.5 billion figure does not represent net system gains.*** It does not account for ancillary funding required to build capability and capacity throughout the recovery system to collect, sort, pre-process, and recycle textiles. Significant funding is needed to carry the capital and operational costs of supporting infrastructure, as well as ongoing financial demand-pull for recycled commodities. ***Nor does it reflect an added $400M savings in waste disposal tip fees*** if the non-rewearable portion of textiles are diverted to recycling instead of landfilled and incinerated. This savings would benefit local government, taxpayers, and ratepayers.[viii] See Chapter 3 for further discussion on system economics and funding opportunities.

viii (15.45 million tonnes textile waste generated in the U.S. annually) x (85% disposal rate) x (50% estimated to be non-rewearable) x (average 2022 U.S. tip fee of $53.04/tonne[53]).

Chapter 3. Growth Opportunities for the U.S. Textile Recycling Industry

PART 3.1 BRIDGING THE SORTING INFRASTRUCTURE GAP

Sorting for recycling remains a critical gap in the reverse supply chain. For textile recycling to be economically sustainable and scalable, recyclers need affordable and reliable access to feedstock of known specification in required quantities.

Textile collectors, sorters, and graders are well-positioned to fill the market niche for fiber-sorting since they already have expertise handling the millions of tonnes of textiles that flow through recovery channels. That said, the largely off-shored sorting industry needs to be reshored if textile-to-textile recyclers are creating local demand for fiber-sorted textiles, and the sorting industry needs to transition from manual sorting to automated sorting.[ix] The establishment of even a handful of commercial-scale textile recycling plants in the U.S. can drive a revival of domestic sorting and grading, which has been offshored over the past few decades to countries with low labor rates and/or duty-free processing zones.[x]

Textile recyclers are encouraged to work hand in hand with sorters and graders to build sorting capacity. A carefully planned joint scaling effort will allow sorters and graders to adapt their business models in response to demand and will allow recyclers to grow in lock step with supply. A coordinated supply and demand effort will also allow for testing, iteration, and validation of the new first-of-a-kind systems and technologies that need to be implemented.

Ultimately, sorting for recycling will require tech-enabled sorting to reach minimum throughput volumes. However, sorters can enter this space with handheld and table-top devices NIR devices and scale from there. With scale, sorting for recycling will generate demand for skilled labor, prompt indirect job growth throughout the value chain from collection, aggregation, sortation, recycling, and even stimulate new fiber and yarn manufacturing opportunities, counteracting a recent trend of jobs losses reported by domestic mill closures.[56, 57]

Catalytic funding must be made available to activate the build out of a domestic sorting industry and overcome the steep financial barriers of capital-intensive equipment and facility buildout. **Support in the form of grants, loans, financing, and co-investment should be made accessible** (Figure 28).

Once established, automated sorting of textiles at high speed and high accuracy is expected to improve the unit economics of sorting for recycling compared with manual alternatives like label-reading and hand-held scanning devices. Sorting may become even more streamlined with upstream supply chain adoption of digital product passports.

ix Today's typical sorting facility employs sorters who manually evaluate items for downstream reuse, repurposing, and recycling end markets. Employees may specialize in specific attributes to facilitate the decision-making process and improve workflow and throughput. Considerable time and effort is invested in training individual employees and employee retention is a business priority.

x In 2021, the U.S. was the largest net exporter of secondhand clothing globally, exporting a value of $834 million, accounting for 16% of the $5.17 billion industry.[54] Top destinations for exported used clothing from the U.S. include Guatemala, Chile, Honduras, and India.[55]

An important next step is understanding the various business models for sorting textiles for recycling. Evaluating factors such as target feedstock, acquisition costs, technology and equipment, levels of automation, capital expenditures, operational expenditure, and revenue streams can inform policy, guide investment, and help prepare the industry for scaling.

PART 3.2 TECHNOLOGICAL ADVANCEMENT AND INNOVATION

In recent years, new technologies and innovations have emerged to sort textiles for recycling. Sorting technologies like NIR, hyperspectral imaging, artificial intelligence (AI), and machine learning are helping to make the sorting process quick, efficient, and accurate to meet end market requirements be it for reuse, recycling, or export.

Automated sorting for textile recycling is under development with several established equipment manufacturers and technology companies, such as Tomra Textiles, Valvan Baling Systems, Pellenc, PicVisa, Andritz, and Trinimax as well as new startups, such Matoha, Sortile, Refiberd, circular.fashion, HKRITA Sorting, and others exploring technologies that identify fiber type (through NIR, hyperspectral), detect color (RGB), remove disruptors (metal detection), and size-reduce textiles (shredders). Many of these technologies have been used in the recycling industry for decades (NIR, magnets, eddy currents, shredders, conveyors, pressurized air jets, balers, etc.), but to be technologically effective at sorting textiles, these technologies require further development and customization based on the material composition and physical characteristics of textiles. Pairing established sorting technologies with emerging technologies like visual image recognition, AI, and machine learning, some technology companies may be able to soon offer high-speed, high-accuracy solutions for sorting the recycling fraction of textile waste.

At the same time, further development of the recycling technologies themselves are needed. To date, chemical recyclers have been focused on testing, proving, and developing their technical capabilities, many of which are still at lab scale. As a result, input specifications for chemical recycling remain quite narrow. Recyclers rely on controlled feedstock streams like new fabrics and post-industrial feedstocks with known compositions to hone their technologies. There is a lot of work needed to develop the capabilities of chemical recycling technologies to process post consumer materials that are varied and complex. As chemical recycling technologies progress over time, it is hoped that recyclers' tolerance for non-pure textile feedstock expands and their input specifications widen.

PART 3.3 DESIGN FOR REUSE, REPAIR, AND RECYCLING

As sorting and recycling technologies develop, there should be a feedback loop established between recyclers and product designers. There is a delicate balance between design and recycling capabilities. Generally speaking, recycling technologies cannot adapt quickly enough to keep up with changes in product design because of the capital intensive nature of recycling equipment and facilities. This is referred to as the "evolving ton" paradox in the waste industry. Therefore, it is important that design considerations factor in "recyclability." Products designed to be compatible with existing and planned near-term sorting and recycling infrastructure is a best practice (Figure 28). Upstream design considerations today should account for fiber composition (mono-materials preferred), product construction (single-layer preferred), color (important for mechanical recycling), material construction (knit versus woven depending on preferred recycling treatment), and disruptors (fewer, removable, same fiber composition as primary product, non-toxic, restricted-substance compliant, and/or benign to the recycling process). Looking to the future, there's a role for innovation to develop recycling-compatible dyes, trims, finishes, prints, etc.

PART 3.4 FUNDING TO SHIFT SYSTEM ECONOMICS OF FIBER-TO-FIBER RECYCLING

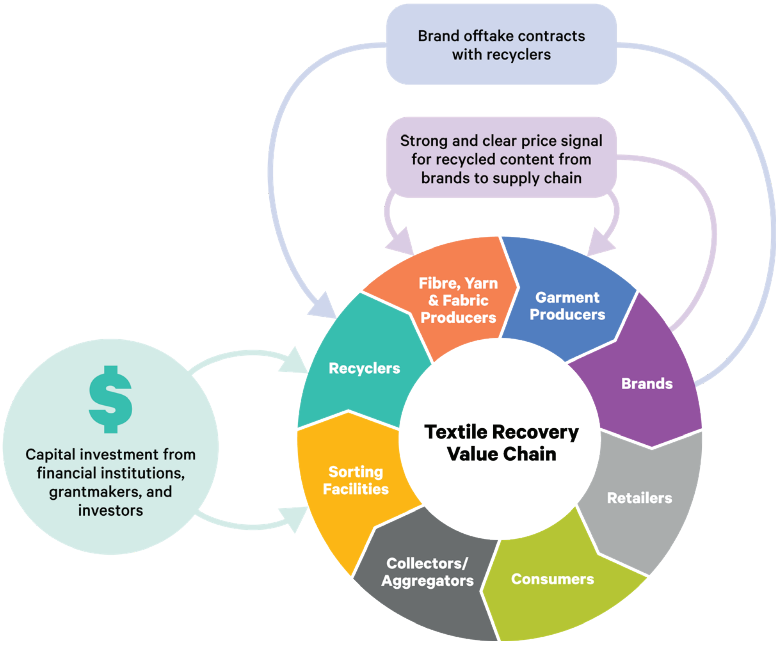

Figure 28: Near-Term Financial Investments Needed to Stimulate Fiber-to-Fiber Recycling Infrastructure in the U.S.

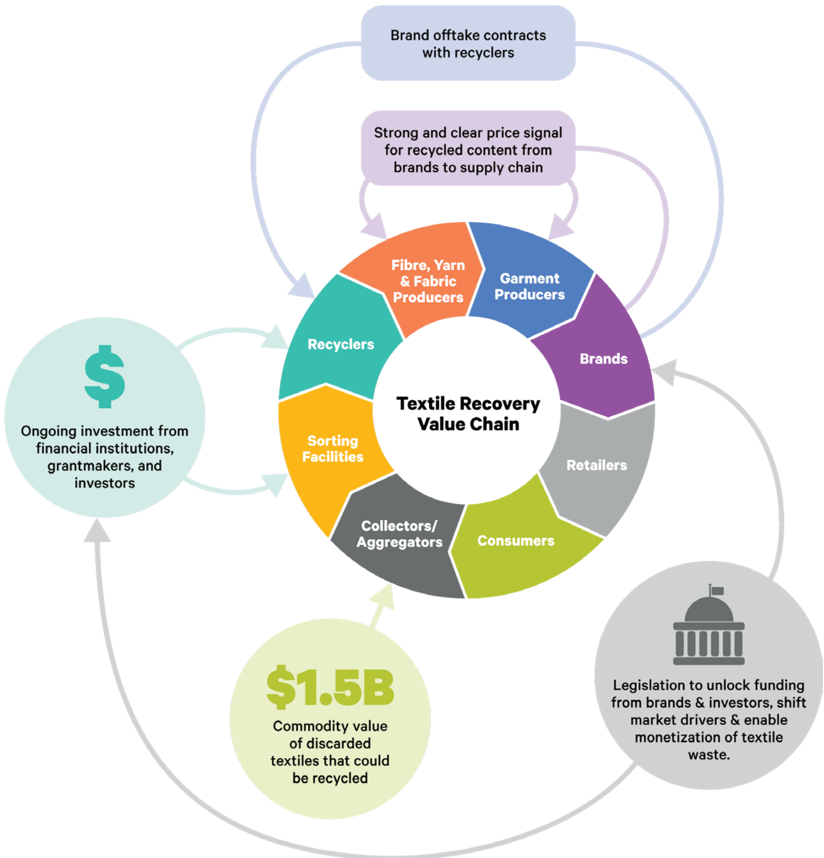

Figure 29: Long-Term Economic Drivers of Fiber-to-Fiber Recycling in the U.S.

To capitalize on the market opportunity that fiber-to-fiber recycling represents, the economics of the textile recovery system need to be addressed. There are needs for both short term and long term market interventions.

In the short term, there is a need for investment of low-cost capital to build sorting and recycling infrastructure. In the long term, there is a need to rewire market conditions around textile recovery to allow for circular supply chains to develop and be self-sustaining (Figure 29).

This means changing market signals to create recycling demand pull for non-rewearables through the recovery value chain. Today, there is a financial disincentive for collectors and sorters to accept non-rewearable and low-value rewearable textiles because the handling costs exceed commodity values and the addition of low-value materials to the mix dilutes the value. Focus instead is placed on new or gently used clothing and textiles that command a significantly higher price compared to recycling commodities.

Compounding this, there is overall negative price pressure on the reuse ecosystem. As textile waste volumes increase and overall product value declines, textile collectors and processors face a higher proportion of low-value textiles (Figure 30). The price difference between new and used items has become increasingly narrow, making used items less financially attractive to consumers than they once were. For recycling, the revenue from the reuse fraction is what subsidizes the collection and handling of the recycling fraction. Without resale revenue, recycling becomes less financially viable under current market conditions. The situation is exacerbated as high labor rates and escalating handling and transportation costs increase the cost of collecting used textiles. The result of these macroeconomic pressures is that end market demand is too weak to incentivize the additional activities needed for fiber-to-fiber recycling.

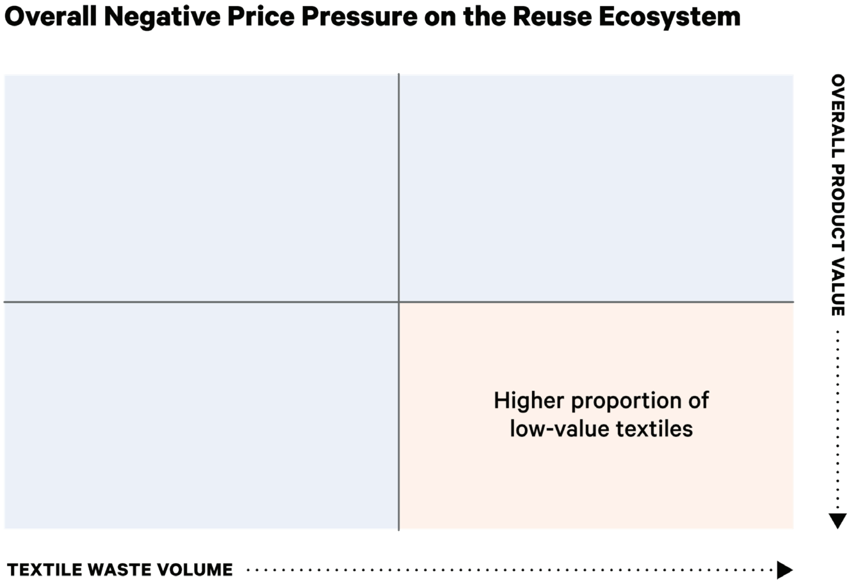

Figure 30: Effect of Increasing Textile Waste Volume and Overall Product Value Decline

To be commercially viable, the cost of textile collection and processing must come in line with the value of recovered textiles (or vice versa) and that is likely to only occur through funding and incentive-shifting policies like EPR.

The average commodity prices of existing end markets exceed the commodity prices that fiber-to-fiber recyclers are able and willing to pay (with the exception of wool recyclers, which is a very small fraction of fibers). Table 4 provides estimated low and high commodity prices for various commodities at the time of publication.[xi] The value of the downstream markets, ranked from highest to lowest, are reuse, reclaimed wiping cloth, shoddy, mechanical fiber-to-fiber recycling, chemical fiber-to-fiber recycling.

Table 4: Commodity Prices of Existing End Markets.

Fraction	Avg Commodity Price Low ($/kg FOB)	Avg Commodity Price High ($/kg FOB)
Highest Grade Rewearables	$4.41	$8.82
Mid-Grade Rewearable	$1.32	$3.31
Lowest Grade Rewearables	$0.44	$0.99
Wipers (white)	$0.99	$1.32
Wipers (colored)	$0.24	$0.46
Shoddy/Insulation	$0.33	$0.55
Mechanical F2F recycling - wool	$1.32	$1.32
Mechanical F2F recycling - cotton	$0.44	$0.44
Chemical recycling	$0.11	$0.37

In addition to procuring feedstock, recyclers are faced with the challenge of selling recycled fibers and yarns into the supply chain at price premiums over virgin to cover operational costs. The scale of the premium varies, but in almost all cases, recycled fibers prices exceed pricing of virgin feedstock. Virgin feedstock prices remain low due to factors such as:

» Entrenched petroleum and agricultural subsidies.

» Global manufacturing systems that have been optimized over decades to increase volume and minimize cost.

» Unaccounted cost of externalities (pollution, carbon emissions, resource extraction, unfair labor practices, etc.) that have not been internalized into pricing.

For meaningful uptake of recycled fibers, recycled fiber price points must either come in line with virgin pricing (unlikely, but exemplified at a high level by Table 5 *for demonstration purposes only*) or **policy that shifts system economics must be adopted**.

Table 5: Average Low and High Commodity Prices For Virgin fibers.

Virgin Fibers	Avg Commodity Price Low ($/kg)	Avg Commodity Price High ($/kg)
Cotton[58]	$1.70	$2.56
Polyester (PET granules)[59]	$0.86	$2.01
Nylon 6[59]	$2.12	$2.49

Long-term offtake agreements between recyclers and brands (or their manufacturers) are important levers to ensure a recycler's financial solvency and ability to attract ongoing investment especially during early commercialisation. Recycled fibers are up against deeply entrenched, highly subsidized

xi Pricing from personal interviews with collectors, sorters and graders.

and scaled commodity production systems making it difficult to reach price-parity. In addition, circularity requires a fundamental shift in production practices, which can be onerous. Long-term recycled content offtake agreements require changes to established supply chains and production practices and introduce new forms of risk and cost unfamiliar to brands. Brands today are unaccustomed to such supply chain relationships and struggle to modify current supply chain practices, sourcing agreements, impact to margin, profit earning profiles, and risk tolerance.

If the business case can be made for sorting for recycling, sorters and graders will respond to the market opportunity and textiles can more readily flow into fiber recycling end markets. Sorters and graders are aptly situated to take on the activity of sorting for recycling and becoming suppliers of fiber-sorted textiles for recyclers since sorter and graders are already handling one of the fractions of textiles that could become feedstock for recyclers. The addition of fiber-sorting to their services could expand their footprint further into the reverse supply chain, open new streams of revenue, and diversify the market solutions they offer. This kind of verticalization reduces the number of transactions between supply chain actors and hence prevents additive price markups for the handling textiles to supply recyclers.

Similarly, if the competitive playing field is leveled through policy, brands and manufacturers will make the switch from virgin inputs to recycled ones. That said, long-term offtake agreements for textile sorters will also be important as sorters look to expand into fiber-to-fiber recycling markets. Sorters will likely need a guaranteed offtake with a floor price and volume guarantee to help precipitate investment and interest.

PART 3.5: THE U.S. COMMERCIAL LANDSCAPE FOR SITING A TEXTILE RECYCLING FACILITY

For recyclers that are considering locations for new facilities, proximity to supply is crucial. Some existing sorting facilities may have the scale and interest to adopt fiber sorting capabilities to become a supplier, or there may be a value proposition in the idea of a new ecosystem of textile material recovery facilities (MRF).

As discussed, few sorting and grading activities occur within the U.S. Sorting activities that remain domestic are either small-scale and limited in scope or located in geographic regions with low minimum wage rates and/or close to ports to help offset costs. For these reasons, there is a concentration of sorting and grading along the Mexico/Texas border, as well as in southern Florida and the Carolinas.[60]

Local, state, and federal regulations also come into play. Some states regulate advanced recycling as a waste management activity while others regulate it as a manufacturing activity. The designation impacts siting, permitting, and reporting requirements. Chemical recycling facilities not categorized under “disposal” or “solid waste management facility” may be granted funding, taxed, and held to the environmental standards of manufacturing facilities, rather than waste-to-energy (WTE) facilities. Designated as manufacturers, facilities are permitted like any industrial source and are subject to Clean Air Act regulations, local regulations and all federal and state permits for water and waste.

At the time of publication, 25 states regulate “advanced recycling facilities” as manufacturing facilities. All 25 laws define pyrolysis and gasification facilities as advanced recycling. Some include depolymerization, catalytic cracking, reforming, hydrogenation, solvolysis, and other similar technologies. Several, though not all, explicitly exclude fuel from being considered a recycled product of advanced recycling. Most laws explicitly state that plastics produced by advanced recycling are considered recycled products, and some states (TX & LA) indicate that such plastics may legally be considered recycled content when remanufactured into new plastic products.

State or federal regulations may dictate the handling of recycled outputs based on whether the outputs are classified as a waste material or a commodity, which could influence the ability of recycled pellets/fibers to be openly traded/exported to certain countries across the world (Figure 31).

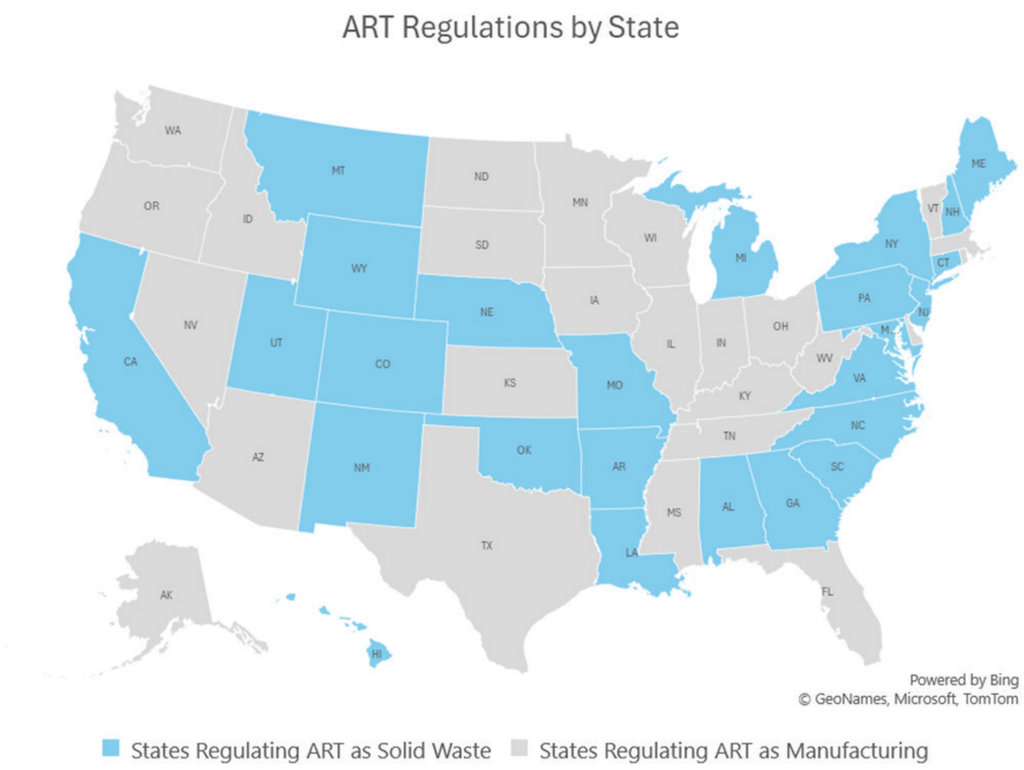

Figure 31: Map of U.S. States Regulating Advanced Recycling Technologies as Solid Waste or as Manufacturing.

Other important siting factors for recycling facilities include:

Proximity: Geographic location relative to complimentary value chain sectors:

» Parallel supplies of feedstock, such as commercial, post-industrial and pre-consumer textiles.

» Ports, for the export of recycled commodities.

» Yarn spinners for the conversion of recycled fibers into yarn.

Local Costs: Regional market costs relative to market availability:

» Local energy costs, especially for energy-intensive recycling processes.

» Landfill tipping fees, for disposal of wastes produced during the recycling process.

» Fair market labor costs and availability of skilled staff

Incentives: Location-based incentives come in many forms:

» Recycling infrastructure development incentives. An example is California's Recycling Market Development Zone (RMDZ) program, which offers low interest loans, technical assistance, and free product marketing to businesses that use materials from the waste stream to manufacture their products and are located in a designated zone.

» Favorable tax policies to encourage business growth (e.g., Texas, Florida, Indiana).

» State and local grants for market expansion, job development, public education, and research.

It is important to note that these conditions may change, and new policies or economic shifts can impact a state's attractiveness for industrial development. As the market evolves, as recycling scales, and as new policies such as EPR alter the economic incentives and viability of domestic sorting, reuse, and recycling, new geographies will emerge as attractive locations for recyclers.

PART 3.6 POLICIES TO SUPPORT FIBER-TO-FIBER RECYCLING AND INFRASTRUCTURE

Policy is a critical driver to ensure supportive market conditions for textile recovery. The economics of the circular supply chain can be shifted through policies and regulations that alter the cost-revenue dynamics of the recovery system, such as EPR, mandatory recycled content requirements, elimination of duty drawbacks on unsold inventory, revision of agricultural and oil subsidies on virgin inputs, virgin material taxes, eco-design requirements, disposal bans, carbon taxes, supply chain accountability regulations, market development grants and assistance (Table 6).

Policy is a long-game with some legislating taking more than five years from bill conception to bill adoption, and further time allowances for the regulatory process of rulemaking. In the U.S., most waste-related policy occurs at the state and local level and this is where efforts are normally focused for the most effective outcomes.

Table 6: Policies and Regulations Affecting Cost-Revenue Dynamics of the Textile Recovery System.

Policy	Economic Impact
Extended Producer Responsibility	Creates a dedicated financing stream to operate recovery programs Incorporates the cost of end of life management into the cost of the product, either internalized in the cost, or through a consumer fee Eco-modulated fees incentivize "greener" products and disincentive problematic products Reduces waste management costs to local government and businesses
Recycled content requirements	Creates demand-pull through the value chain for recycled content
Elimination of duty drawbacks for unsold inventory	Financially disincentivizes destruction of unsold inventory making it more attractive for reuse and recycling
Revision of virgin subsidies	Accounts for externalized costs in an effort to incentivize solutions which use recovered resources where costs are internalized.
Virgin material tax	Monetizes externalized costs in an effort to incentivize circular solutions Creates funds to address infrastructure, education deficits, and shift incentives for solutions that use recovered resources
Eco-design requirements	Set expectations, incentivize and reward products that meet specified environmental preferences Potential to level the competitive playing field and de-risk spend to produce "green" products
Disposal bans	Potential avoided disposal fees for municipalities, taxpayers and ratepayers Monetizes waste as a commodity, if paired with a demand-side policy
Carbon tax	Increases costs of products that have higher carbon impacts
Supply chain accountability regulations	Aims to ensure legal business dealings, fair margins and fair wages at each node of the supply chain, which translates into product pricing closer to "true cost".
Market development grants and assistance	Makes financing and possible tax incentives available to recovery value chain companies

POLICY HIGHLIGHT: EPR FOR TEXTILES

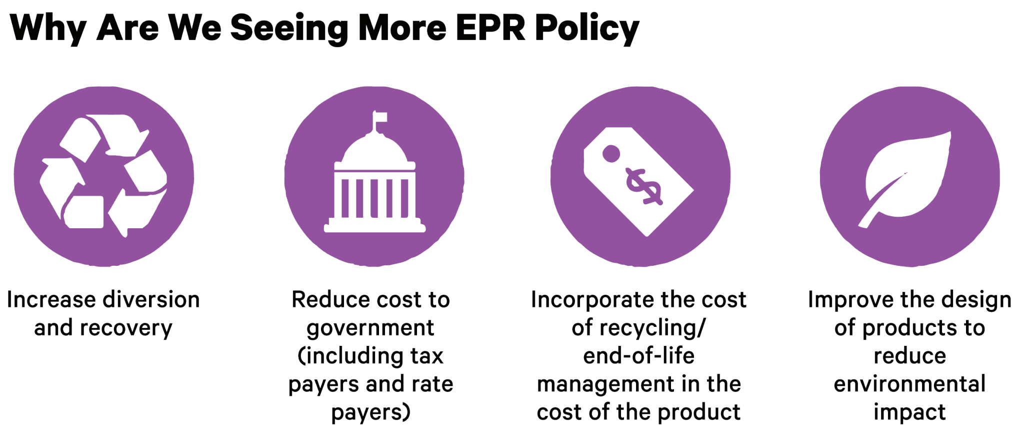

Figure 32: The Benefits of EPR.

Over the past few years, textile waste has increasingly been the subject of policy discussions, with a focus on EPR as a preferred regulatory approach. EPR is a policy approach in which producers take responsibility for management of the products and/or packaging they produce at the end of their useful life. Responsibility may be fiscal, operational, or a combination of the two. Typically, EPR programs assess a fee to the producers of the covered products to fully cover the costs for collection, gaps in sorting infrastructure, transportation, processing collected materials, consumer education, and transparent annual reporting (Figure 32). Producers are typically defined as whichever level of the supply chain brings the covered product to market, be it brand owners, importers, manufacturers, etc. EPR is created through legislation establishing rules and targets; managed by one or more Producer Responsibility Organizations (PROs); guided by a Program Plan, and enforced using the Annual Reports.

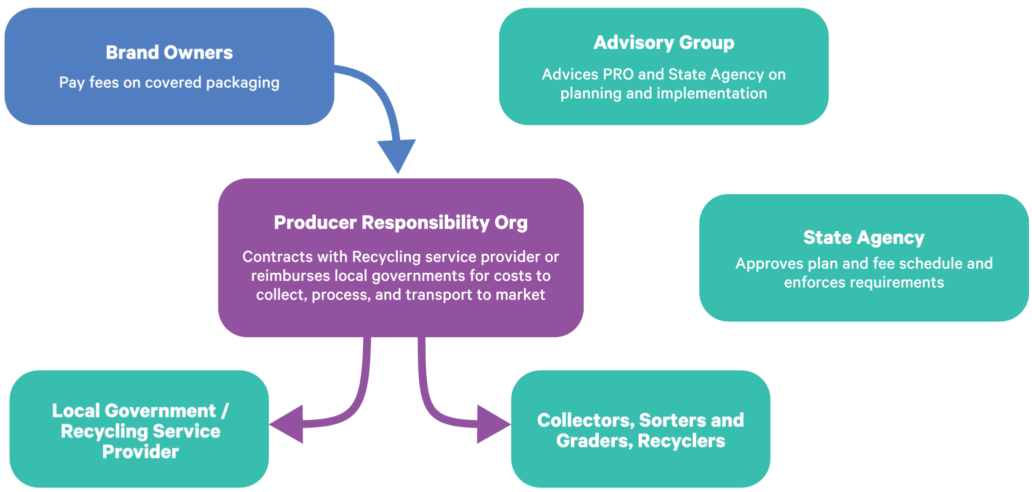

Figure 33: The Roles and Responsibilities in Textile EPR Programs.

EPR programs not only increase landfill diversion, they establish responsible management standards for hard to recycle products. Current practices rely on local government and public funds, but adding industry funding requirements equitably shifts the cost of end-of-use management into the cost of the product. By building the end-of-use costs into the upfront costs, producers can improve the design of products and reduce environmental impact to reduce their fees and improve program performance. EPR is a tool to overcome market failures impeding textile circularity. Examples of current market failures for textiles include: 1) insufficient local government funding for source separation and expanded sorting capabilities; 2) lack of transparency and accountability for end-markets; 3) broken financial feedback loops

Overview of EPR for Textiles Around the World

France has the longest standing EPR program for textiles (since 2008), while the Netherlands and Hungary EPR regulations will take effect in 2025.[63] Sweden, Spain, Bulgaria, Italy, Norway, Chile, and the UK are in the process of discussing and developing proposals, while Australia has a voluntary program that will become mandatory if performance measures are not met.[63] The European Commission proposed a waste framework directive that would create mandatory and harmonized EPR obligations for producers of textiles in the EU and the Ecodesign for Sustainable Products Regulation to mandate recycled content uptake.[64] The current status of EPR programs across the world is shown in Figure 34, "Global Status of Country-Level EPR Programs."

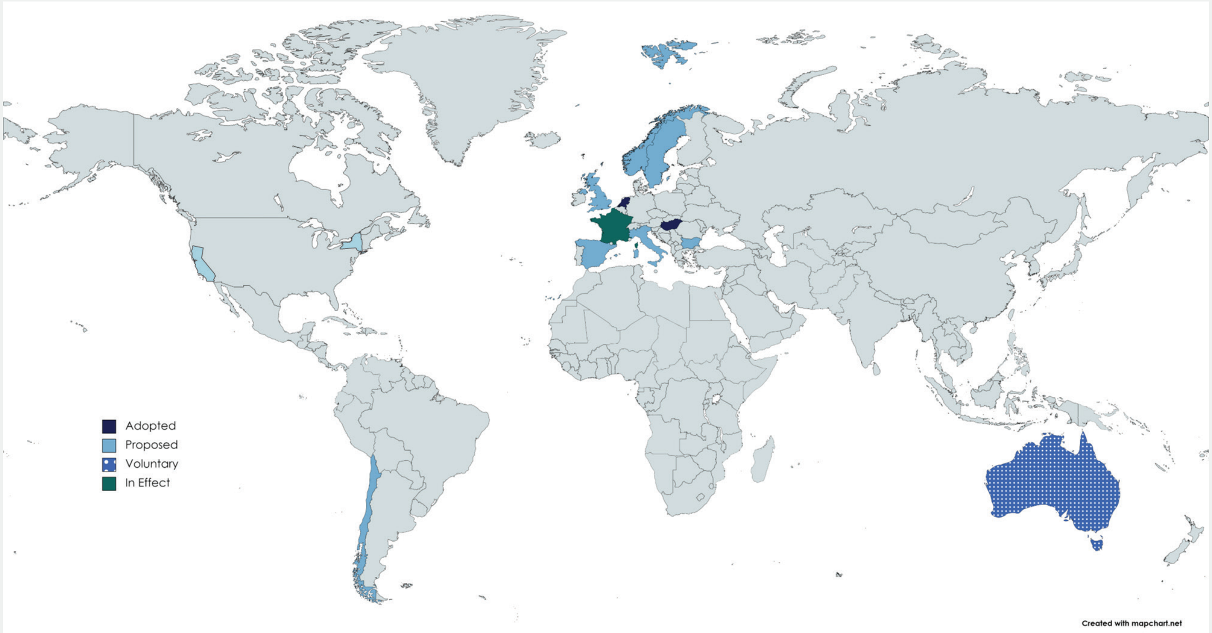

Figure 34: Global Status of Country-Level EPR Programs.

between consumers that generate the waste and municipal program operators that manage the waste; 4) commodity value fluctuations; and 5) underdeveloped supply chains to from recyclers back to yarn and fabric mills.

EPR provides pathways for producers to achieve circular economy goals, level the competitive playing field, unlock investment, and grow textile reuse and recycling systems.

In the U.S., California and New York legislatures are reviewing bills for textiles EPR (CA SB707 Newman,[61] and NY S6654/A8078 Kavanagh/Kelles,[62] respectively), and there is indication that other states may be introducing EPR bills for textiles as well.

Legislative discussions in Europe are more advanced than they are in the U.S. and learnings from these efforts can be used to inform development of EPR in the U.S. The EU is working with stakeholders, obtaining feedback, and setting precedents around issues like mandatory collection targets, timelines, products in and out of scope, fee-setting, export of textile waste, definitions of recycling, and harmonization of legislative requirements across jurisdictions, among many other topics. While the American market, political climate, and legal structures are notably different from the EU, the groundwork that has been laid with regard to the impacts of EPR and engagement from stakeholders across the value chain will inform bill language and policy approaches in the U.S.

EPR is a holistic policy approach that relieves the disparities between production and recovery systems. EPR can incorporate a host of supply and demand side regulations within them, such as disposal bans, eco-modulated fees to promote green design and other desirable producer behavior, recycled content mandates, reporting requirements, outreach and education mandates, and more. A list of policy considerations can be found in Appendix VI - Supportive Policy Mechanisms.

PART 3.7 PRODUCT AND PERFORMANCE STANDARDS TO SUPPORT FIBER-TO-FIBER RECYCLING

Standards facilitate the commercialisation of new business practices and remove barriers to business dealings. Standards regulate products, processes, and/or performance. Performance standards are common in EPR programs, but product and process standards can be standalone policies. Examples of process standards include standardizing commodity grades for reuse and recycling related to condition and quality and commodity price indices for reuse and recycling grades (Table 7).

Table 7: *Description and Benefits of Commodity Specifications and Price Indexes.*

Standard	Description	Benefits
Commodity Specifications	Commodity specifications provide industry-developed guidelines for market acceptance of various post-consumer recycled bales.	Provides a benchmark for producers of the commodity (e.g., sorters and graders) for the production of quality bale commodities Facilitates greater understanding of the products commonly accepted for reuse and recycling Provides clear specifications that help improve bale quality and contribute to higher reuse and recycling yields, cost effectiveness, and quality Facilitates communication between bale producers and purchasers (e.g., resellers; recyclers) Provides insight for the broader marketplace and value chain, from product developers to other stakeholders and decision makers
Price Index	A commodity price index is an index that tracks the price and returns on a given basket of commodities.	Provides insight into supply and demand trends and factors influencing price performance Allows for comparison against virgin counterparts and identify any correlations that may exist (such as market caps or floors) Allows for market predictions and forecasting Enables businesses to peg their own pricing against industry averages Allows for nimble adjustments in operations to respond to market changes Can be used in contracting, negotiations, and investment decisions

Today, textiles are sorted and graded into commodities according to buyer specifications and end market preferences. Different end markets have specific requirements and there is considerable variability in fractions produced. For instance, one sorter-grader may supply bales for buyers in Ghana where there is limited demand for cold weather clothing. Conversely, another sorter-grader may cater to buyers in Latin America, where tastes and needs differ. Subjectivity inevitably influences decisions regarding “rewearable/non-rewearable”, “quality” and “value.” Since there are no standardized trading grades, there are no industry price indices to track or benchmark trade. Instead, trust and reputation define relationships and serve as the foundation of the used clothing trade. However, the sector also attracts fly-by-night actors who do not abide by the formalized sector’s code of conduct. The consequences of illegitimate actors’ activities include artificial depression of market prices, potential improper management of materials, lack of visibility into business practices and tonnages, incidences of theft and criminal activities, along with the unauthorized exportation of textiles. The extent of these impacts is unknown.

Standardized end market grades facilitate collection by creating a common language, eliminating subjectivity, and aligning collection channels on which items have market value and which do not. Even if commodity standards do not cover every potential permutation of quality and condition, they serve as an industry benchmark for trade and pricing. Standards establish best practices and align baseline expectations for bale contents. Standardized grades would facilitate responsible international trade and provide an entry point for oversight of the content and quality of export bales (i.e., how much is really "reusable"). Standards allow the industry to track the market value of various grades of recovered textiles and how those commodity values change over time. In the end, collection channels that accept any and all types of textiles eliminates the need for consumers to execute their own judgment to determine quality and could offer the most simplistic solution, but standards are a step-wise approach to get there.

Commodity Specifications for Textile Reuse

- ✓ Objective condition criteria: sings of wear; damage
- ✓ Objective quality criteria (e.g., high fashion, vintage, luxury, mass market)
- ✓ Generator type (post-consumer, pre-consumer, etc.)

Commodity Specifications for Recycling

- ✓ Acceptable fibre compositions and colours
- ✓ Acceptable fabric construction (woven/knot/nonwoven)
- ✓ Acceptable ranges of contamination (percent by weight)
- ✓ Allowable or disallowable disruptors
- ✓ Necessary formats (shred size)
- ✓ Bale size, weight, and density
- ✓ Bale integrity and binding practices
- ✓ Storage requirements

Bale specifications should remain adaptable due to rapidly evolving textile design and the quickly evolving textile circularity market. Specs need to be responsive to evolving recycling technologies as well as the "evolving ton."

Definitions represent another important type of standard. Aligning on industry definitions enhance business dealings, allow for consistency across value chain partners and geographies, and serve as reputable references for regulators and organizational goal setting. Examples of terminology for which standardized definitions would be beneficial in relation to fiber-to-fiber recycling include: "recycling," "mechanical recycling," "chemical recycling," "advanced recycling," "molecular recycling," "secondary raw material," "contaminant," "recycled content," "waste," and "textile," among others. The International Organization for Standardization (ISO) already offers definitions for many of these terms as they relate to plastics.

Organizations important in the development and issuance of standards for textile circularity include, but are not limited to, the International Organization for Standardization (ISO), National Institute of Technology and Standards (NIST), ASTM International, American Association of Textile Chemists and Colorists (AATCC), Institute of Scrap Recycling Industries (ISRI), Textile Exchange, and Secondary Materials and Recycled Textiles (SMART) Association.

Conclusion and Recommendations

The U.S. is well positioned to leverage the millions of tonnes of textiles disposed of each year and channel them into circular markets.

Consumers are ready and willing to embrace new collection opportunities so long as they have adequate access to programs (i.e., close, convenient, and available when needed), with appropriate guidance about what can be diverted and where, and with assurances of where items are ending up and who is benefiting.

Detailed composition analysis of residential post-consumer textiles shows that **fiber-to-fiber recycling is a value-added solution to close the loop on over 56% of the non-rewearable textile stream** (i.e., after reuse and repurposing). Assuming the appropriate collection, sorting, and preprocessing infrastructure is in place, **fiber-to-fiber recycling has the potential to generate $1.5 billion in revenue** and keep materials that would have otherwise been discarded in circulation as well as replace virgin materials and reduce the environmental impact of textiles.

Growth Strategies for the U.S. Textile Recycling Industry

The opportunity that lies ahead is sizable, by any measure. To realize this opportunity, the financial value proposition of recovery needs to be improved. Economics of the system can be shifted through improved system efficiencies (i.e., scale and verticality), increased recycled commodity valuation, stronger demand pull, well-structured buying practices (such as long-term offtake agreements), combined with policy mechanisms like extended producer responsibilities, mandatory recycled content uptake, and better design of products that allow for the internalization of externalities.

In addition, **stakeholders across the recovery value chain have a role to play,** each of which interact with circularity differently in their day to day operations and have perspectives that are crucial in creating a feasible and holistic circularity approach for the industry (Figure 35).

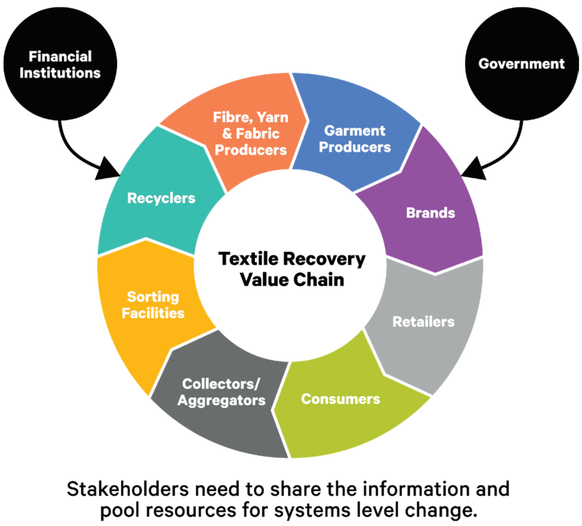

Figure 35: The Components of the Textile Recovery Value Chain.

What Stakeholders In the Value Chain Can Do

» Brands play a central role in the circular textile ecosystem. ***Brands set the bar for sustainable material sourcing practices,*** like sourcing safe, environmentally friendly, recycled materials, and recycling-compatible fibers, textiles, chemicals, prints, and dyes, and committing to longer term use of recycled content over virgin content. Brands are encouraged to map their supply chains, design for recycling (e.g., single-fiber textile products with minimal or easily removable and recoverable disruptors), adopt meaningful levels of recycled-content (testing, piloting, and scaling the use of recycled content in increasing percentages across their entire portfolio), integrate enabling technologies like digital passports that are compatible with sorting infrastructure and recycling processes, and embrace circular business models to prioritize the circular economy hierarchy (reuse before repair, before repurposing, before recycling). Importantly, brands can re-work their legal risk tolerance levels and develop long-term procurement strategies to allow for recycled content uptake commitments through their supply chain contracts. There is also a role for brands in providing clear and transparent information and end-of-use guidance and support to consumers. Brands can work to educate customers on conscious consumerism, proper use and care of products, and preferred end of life management activities.

» ***Government has a role to play in setting political agendas that prioritize equity and transparency to advance fiber-to-fiber recycling.*** Policy is the most likely driver to affect economic change. EPR for textiles, along with other synchronistic policy mechanisms, can alter the cost-revenue dynamics of the recovery system in favor of fiber-to-fiber recycling (see Appendix VI - Supportive Policy Mechanisms for a more comprehensive list of recommended policy approaches). Government can also provide funding for research, development, and scaling through grants and tax incentives. Federal agencies can support the development and adoption of standards such as commodity specifications and commodity price indices to facilitate commercialisation of new business practices and remove barriers to business dealings.

» ***Retailers can play a role in consumer education and consumer choice*** by carrying products that meet minimum environmental and sustainability standards and comply with local legislation like EPR. Retailers also have access to consumer behavior and purchasing data that can be used to inform product production and design.

» **Consumers have a role in being intentional and thoughtful about the products they buy,** following care labels and ensuring products are handled in the best possible manner when no longer wanted. Consumers can also organize grassroots efforts to advocate for positive change.

» **Collectors can begin tracking tonnages and collection markets,** tracing downstream flows, and providing transparency into services available, while tailoring collection methods to optimize consumer participation.

» **Sorters and pre-processors serve to bridge the sorting gap.** An important next step to prepare the industry for scaling is understanding business models for sorting textiles for recycling and evaluating factors such as feedstock costs, technology and equipment, capital expenditures, operational expenditure, and revenue streams. As demand for fiber-to-fiber recycling intensifies, advancements in technologies for sorting, pre-processing, and recycling are needed. Together with recyclers, the reverse supply chain stakeholders can agree upon a common language, definitions, classifications, industry tools, and standards.

» **Recyclers can conduct techno-economic and life cycle analyses of their processes and work hand in hand with the manufacturing supply chain** to ensure compatibility with existing production facilities and process flows to reduce friction and avoid parallel cost. Recyclers that are considering locations for new facilities in the U.S. should map market development opportunities, evaluating factors such as proximity to supply (e.g., sorters and graders), energy costs (especially for energy intensive processes), transport logistics for recycled commodities (i.e., access to multi-modal transport, proximity to ports), landfill tipping fees, availability of local financial incentives, and the local regulatory environment governing advanced recycling.

» **Financial institutions can unlock investment for collection and processing infrastructure** by working with government and industry to conduct due diligence studies and understand risk levels associated with different forms of innovations and technologies.

» Finally, **stakeholders are encouraged to work together** to share information and pool the resources needed to make systems level change. NGOs, academia, and trade associations play a critical role in organizing the industry, aggregating data, conducting research, advocating for change, supporting pilots and demonstration projects, and contributing new innovations and business models. These industry stakeholders can contribute to developing and lobbying for supportive policy and provide grant funding and other financial incentives to foster technological advancements and innovation.

Embracing textile circularity through these actions can transform the economics of the textile and waste industries to make fiber-to-fiber recycling profitable and prosperous, while reducing global environmental impacts, creating sustainable jobs, and fostering a culture of reuse and recycling.

That said, there is work to do to adjust market conditions, increase textile waste capture rates, prepare supply chains, test sorting, pre-processing, and recycling technologies, validate business models, encourage business partnerships, instill confidence in investors and financiers, guide grant funding, demonstrate system benefits for policy makers, educate consumers, shift production practices, and overcome the hurdle of moving from pilot-scale to full-scale so that the fiber-to-fiber recycling industry can flourish.

In the short term (next 5-10 years), the continuation of industry-led projects, research, and market development play an important role in fulfilling these needs, in conjunction with supportive policy to carry the industry forward in the longer-term. Of particular near-term importance is the need to demonstrate the commercial and technical feasibility of collecting and preparing U.S.-generated feedstock for fiber-to-fiber recycling both within the context of current global textile flows and within the context of future desired shifts that account for maximal social and environmental benefits.

The U.S. has an opportunity to be a global leader and set the bar for responsible consumption and production throughout the textile and apparel industry.

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Appendix I - Composition Analysis Methodology and Results

Target 2: Assessing Recyclability of Post-Consumer Textiles

» Assess the composition of post-consumer textile waste using NIR spectroscopy to inform the addressable market for recycling.

Objective

The purpose the textile composition analysis is to collect the textile waste composition data to understand the addressable market for fiber-to-fiber recycling

Methodology

The post-consumer textile waste characterization study collected information about product type, fiber composition, color, and disruptors using a combination of manual assessment and NIR technology. The research team collected the following data about post-consumer textiles.

» The prevalence and frequencies of different fiber compositions (pure fibers, blends, and percentages of each). This informs:
   - The amount of raw material is available for different recycling technologies.
   - The percentage of non-target fibers recyclers should expect and therefore how much yield loss they should expect (which impacts overall cost of the recycling process as well as what types of out throws and byproducts must be managed).
   - the types of non-target fibers to expect in feedstocks - some fibers (like elastane) can be problematic for certain processes (they disrupt the chemistry and/or biological process)

» Whether an item is single layer or multilayer
   - This informs whether the item can be accurately identified by automated fiber identification equipment, like NIR, which can presently only read the top layer

» Color
   - This informs feedstock available for mechanical recycling

» The prevalence and types of disruptors (buttons, zippers, sequins)
   - This informs the level of pre-processing that is required to prepare whole items and textiles for recycling (de-trimming, stipping, clipping, etc.

FOCUS FRACTION

This project is focused on residential post-consumer textiles, encompassing both single- and multi-family household textiles. Post-industrial, pre-consumer, and commercial post-consumer textiles were not in scope for this study.

Both rewearable and non-rewearable textiles were in scope for this study (Figure 36). While the desired feedstock for textile recycling is the non-rewearable fraction of recovered textiles (supporting the circular economy hierarchy where reuse is a more preferable materials management approach than recycling), the reality is that little sorting and grading happens in the U.S. and pre-sorted samples of non-rewearable textiles were not readily available. As a consequence, this study was unable to access pre-segregated non-rewearable textiles only for analysis.

That said, the sorting partners provided their lowest value textiles for analysis. For the Goodwill partners, that meant textiles that did not sell through the retail process, and were destined for salvage markets (i.e., those textiles designated for sale to brokers/traders). For the sorter/grader partners, that meant a mixture of fractions.

Figure 36: Focus Fractions for NIR Composition Analysis.

FACILITY SELECTION

The project team held an open application period to collect interest from sorters/waste aggregators. The application was distributed via Goodwill Industries International and the Secondary Materials and Recycling Textiles (SMART) Association. Participants were evaluated according to:

» Location (geographic distribution; climate zone; population representativeness)

» Willingness to provide space, labor, and resources to support the study

» Ability to segregate samples for analysis

» Ability to accommodate site visits within the project timeframe

» Overall support of the project goals

Following the application process, the research team selected seven textile waste aggregators, including four Goodwill organizations; two sorters/graders; and one municipal landfill. Goodwill is a significant charity thrift operator in the U.S. and Canada (see Call Out Box: Goodwill), while the two sorters/graders are operators in the for-profit textile collection and sorting sector. With an estimated 85% of textiles destined for disposal in the U.S. (predominantly in landfills), sampling textiles from the landfill was of high importance. The municipal sort was conducted at a municipal solid waste landfill on the West coast, serving a population of 1+ million residents.

The selected focus regions were California, Colorado, Texas, Florida and New York, representing a wide geographic distribution, a spread across climate zones (to test a hypothesis about fiber composition variability across climates); and near major population centers (Figure 37).

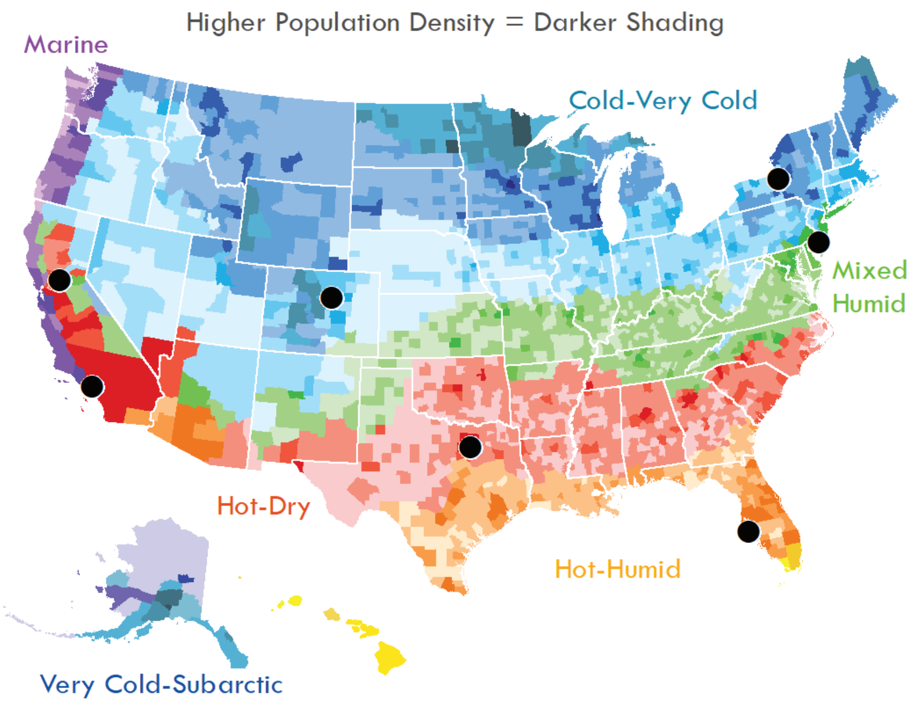

Figure 37: U.S. Focus Facilities.

The following facilities participated in this research study:

1. Goodwill of the Finger Lakes
2. Helpsy
3. Goodwill Suncoast
4. Goodwill of Colorado
5. United Southern Waste
6. Goodwill of the San Francisco Bay
7. A west coast municipal landfill

Interviews were conducted with each sorter/waste aggregator to understand process flows, feedstock streams, material handling activities, and downstream markets.

SAMPLE SIZE

Sample size was determined by the Sorting for Circularity Europe study which found that the average productivity of professional sorters was 41 seconds per scan[66] leading the U.S. project to set a target of 2,993 kgs per facility, with the exception of the landfill. The sampling methodology at the landfill was based on standard landfill auditing methodology. RRS planned to analyze textiles collected from ten 90.7 kgs residential refuse samples over five days, for a total target sample size of approximately 54.4 kgs (assuming textiles comprise 6% of the residential refuse stream). Between the six textile facilities and the landfill, the total target tonnage was 18,016 kgs.

Results

Results were fairly consistent between study rounds (seasonal) and across facilities (facility type, climate zone, and geography). Such consistency of composition suggests a level of reliability and predictability in the results.

TONNAGES ANALYZED

In all, RRS analyzed 14,844 kgs of textiles, 3,172 kgs short of the 18,016 kg goal.

PRODUCT TYPE

Age Category

Out of the total tonnage analyzed, 69% was made up of adult-sized garments while children and baby clothing made up 15% of the total sample weight (Figure 38). The "other" category consisted of items not assigned to a defined age group, including household items and general accessories, for example.

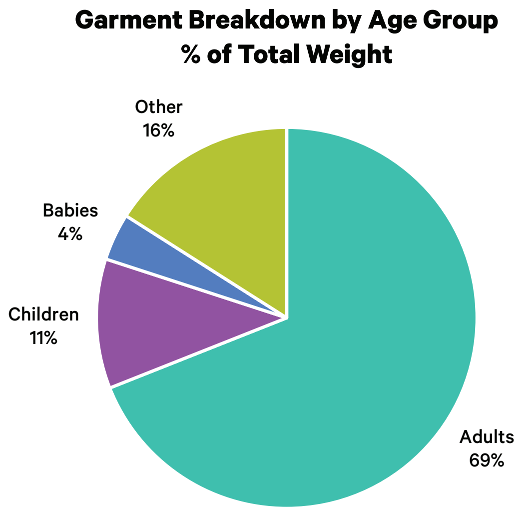

Figure 38: Distribution of Garments by Age Group.

Product Category

Tops were the most prevalent item type analyzed, accounting for 45% of the total sample weight with bottoms following for 27%. The most common combination for age and item type were adult tops, totaling 41% of the total weight analyzed.

FIBER COMPOSITION

Half of the overall sample was made up of cotton (50% by weight), while polyester was the next dominant fiber at 28% of overall sample weight (Figure 39). Some of that cotton and polyester presented in pure form (e.g., 100% cotton or 100% polyester) while the rest was found in blended items. Pure 100% cotton items comprised 21% of all of the textiles analyzed by weight while pure polyester made up 15% of the sample weight. Items that were a blend of polyester and cotton made up 16% of the total sample weight.

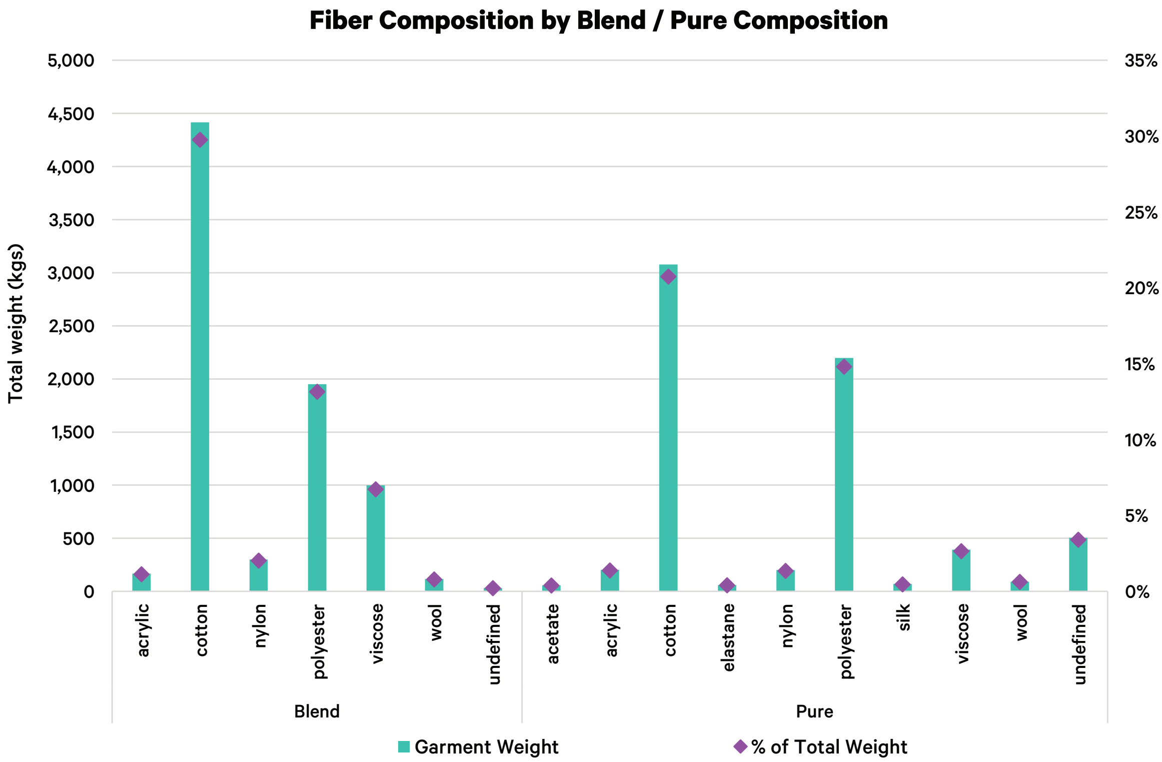

Figure 39: Fiber Composition By Blend/Pure Composition.

SINGLE-LAYER VS MULTI-LAYER

Multi-layer items accounted for approximately 5% of the total sample by weight, while the remaining 95% of the sample weight were single-layer items (Figure 40). Items most frequently identified as multi-layer included coats and jackets, accounting for 57% of the total multi-layer sample weight.

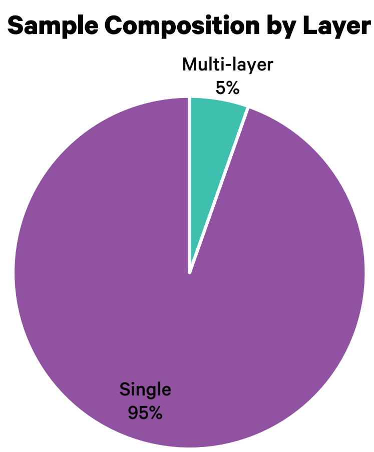

Figure 40: Distribution of Single-Layer vs. Multi-Layer Garments in the Sample.

DISRUPTORS

Disruptors were present in approximately 71% of the sample, while 29% of the sample had no disruptors. Out of the items containing disruptors, 26% of items counted had more than one type of disruptor present. The most common disruptor overall was fabric, with fabric disruptors appearing on 28,869 out of the 73,140 items collected (Figure 41).

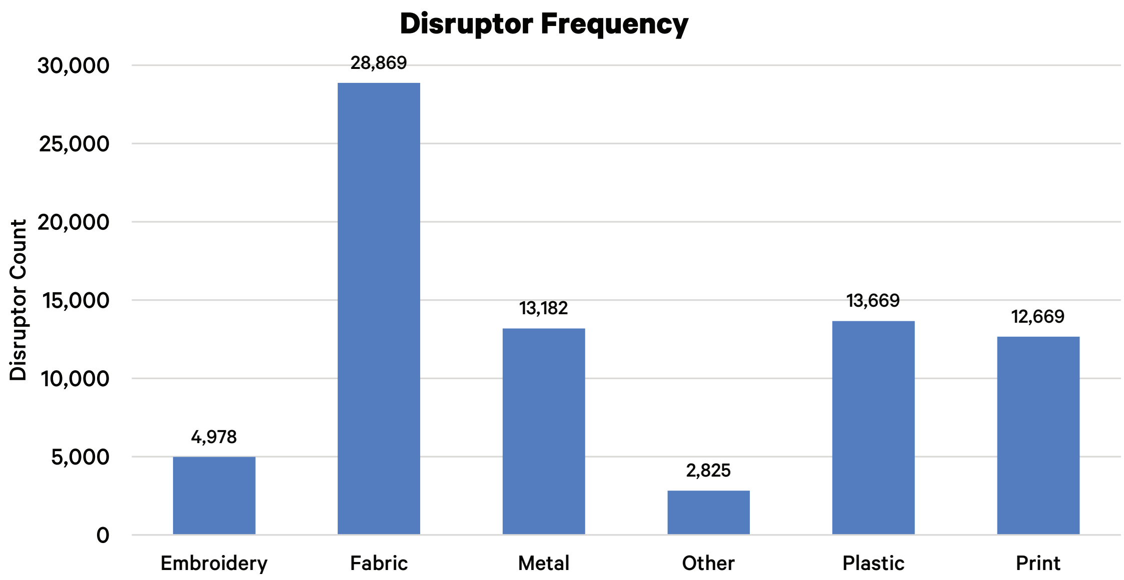

Figure 41: Composition and Count of Disruptors Found in the Sample.

SEASONAL / GEOGRAPHIC VARIATION

Segmentation analysis for season, climate, and geography factors yielded no significant differences or trends based on product type or fiber composition. This suggests that fiber composition may not be a determining factor in the siting of recycling facilities.

Seasonal Comparison: Item Type

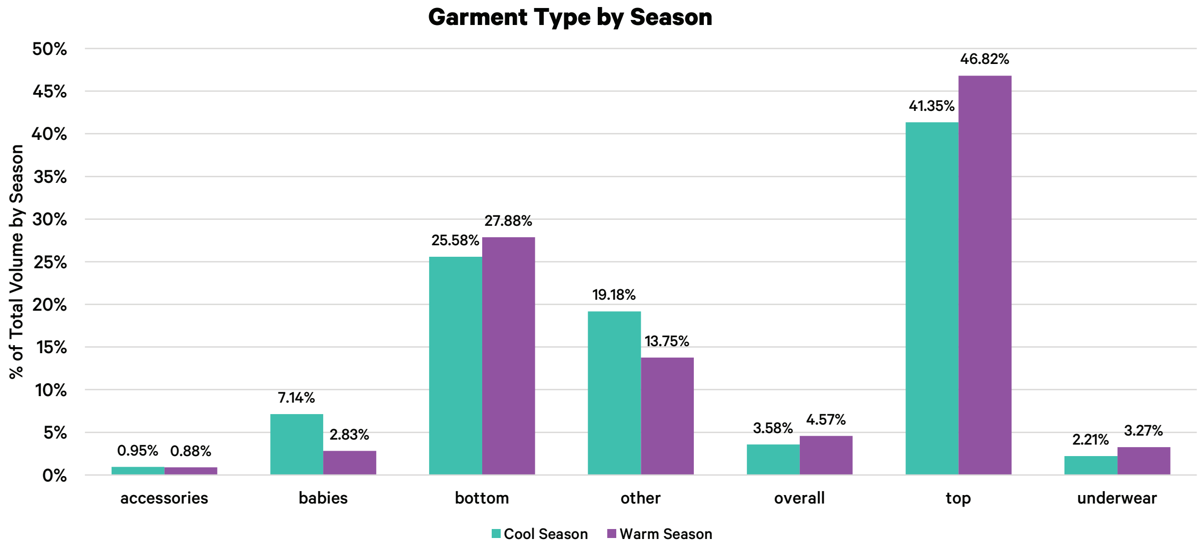

Figure 42: Composition of Garment Types by Season.

Seasonal Comparison: Primary Material Type

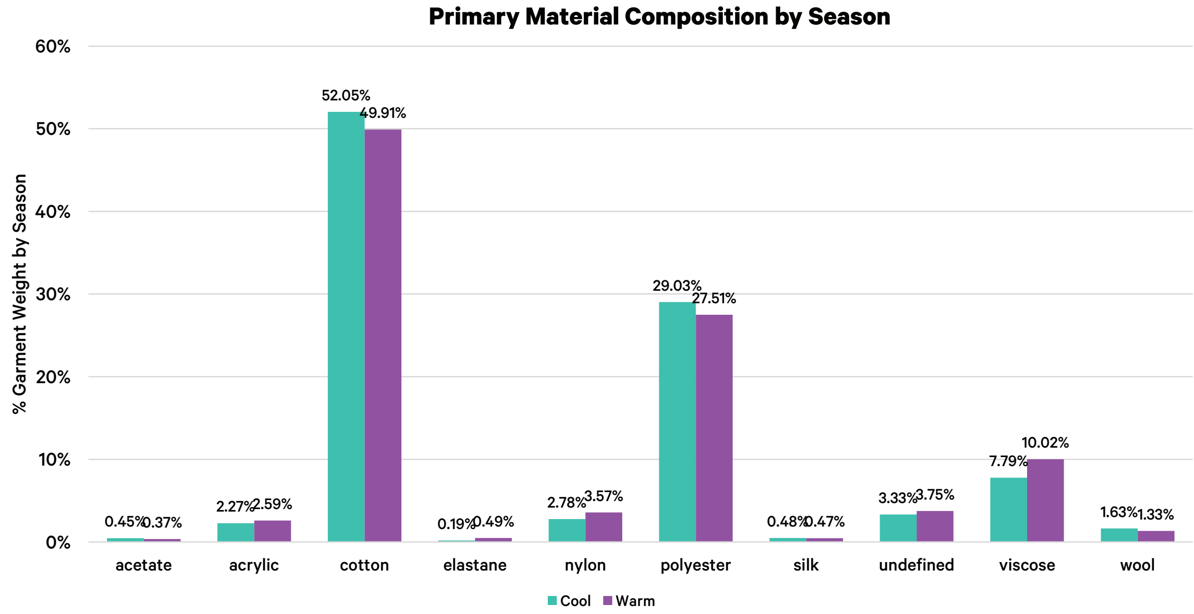

Figure 43: Primary Material Composition by Season.

LANDFILL RESULTS[XII]

Landfill Results: Product Type

The "other" category was dominant in the landfill sample. "Other" textiles, including products such as fabric, household linens, stuffed animals, tents, backpacks, and other non-apparel items) accounted for 51% of the total sample weight for the landfill site, compared to 15% at non-landfill facilities (Figure 44). From this category, 31% of the sample weight from the landfill were household linens.

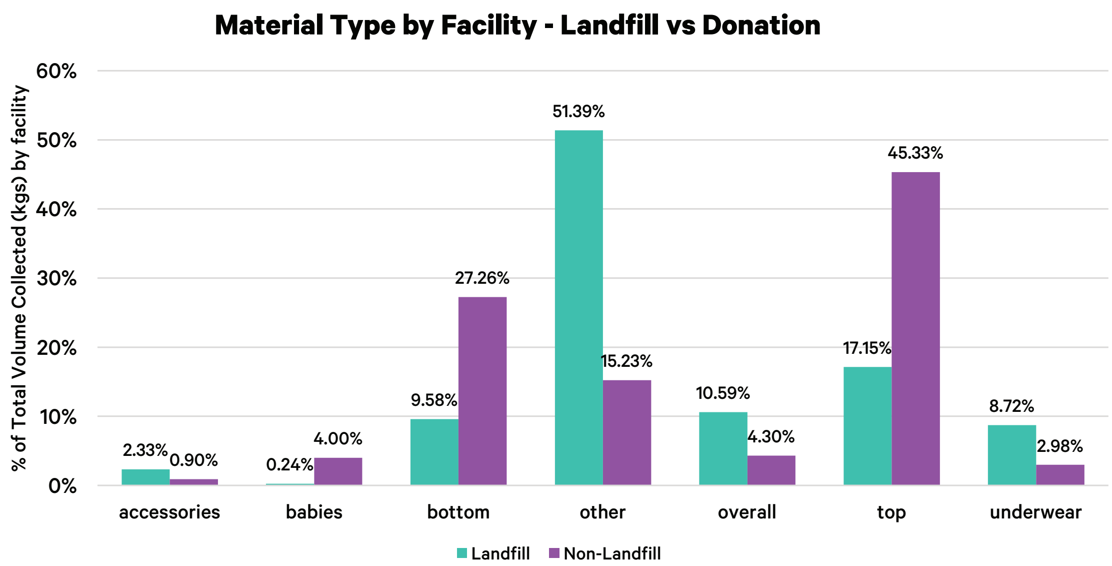

Figure 44: Distribution of Materials Collected by Facility Type.

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xii Disclaimer: Landfill sample is not statistically representative

Landfill Results: Fiber Composition

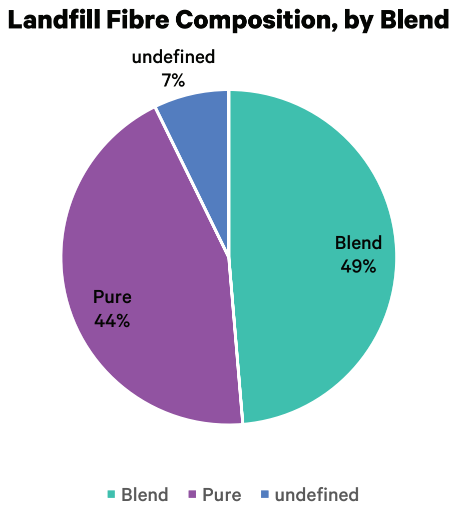


Figure 45: Composition of Fibers From Landfill.

The blend analysis yielded comparable results for landfill and non-landfill sites. The main difference is that the landfill sample contained twice the proportion of "undefined" fiber types as the non-landfill sample (7.2% and 3.6% respectively) (Figure 46). An "undefined" reading occurs when the machine cannot read the material type. An undefined reading is usually the result of excessive dirt, coatings, or blends of three or more fiber types.

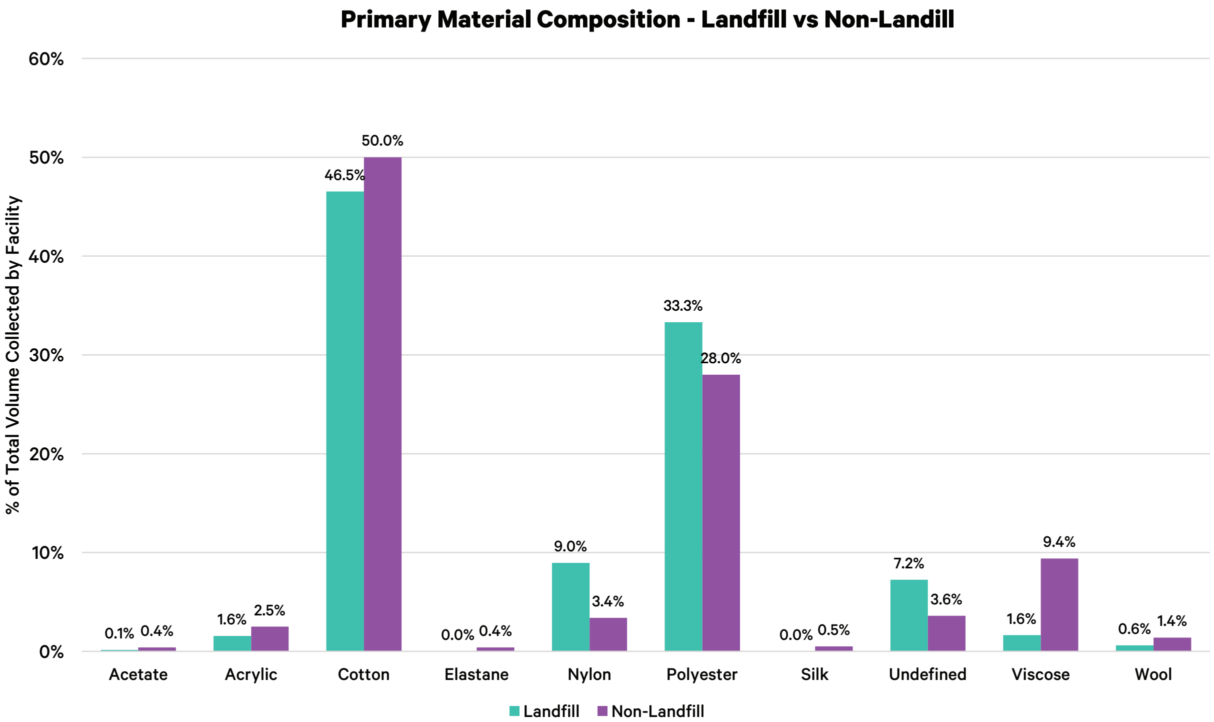


Figure 46: Primary Material Composition by Facility Type.

Both the landfill and non-landfill sites found cotton to be the most prominent primary material with polyester being the second. That said, the gap between cotton and polyester was smaller in the landfill sample than the non-landfill sample (Figure 46). In addition, there was a notably higher percentage of nylon in the landfill sample compared to the non-landfill sample.

The higher percentage of polyester in the landfill sample compared to the non-landfill sample became more notable in pure materials. Pure polyester comprised 22% of the landfill sample weight whereas in the non-landfill sample pure polyester accounted for 15% of the total weight.

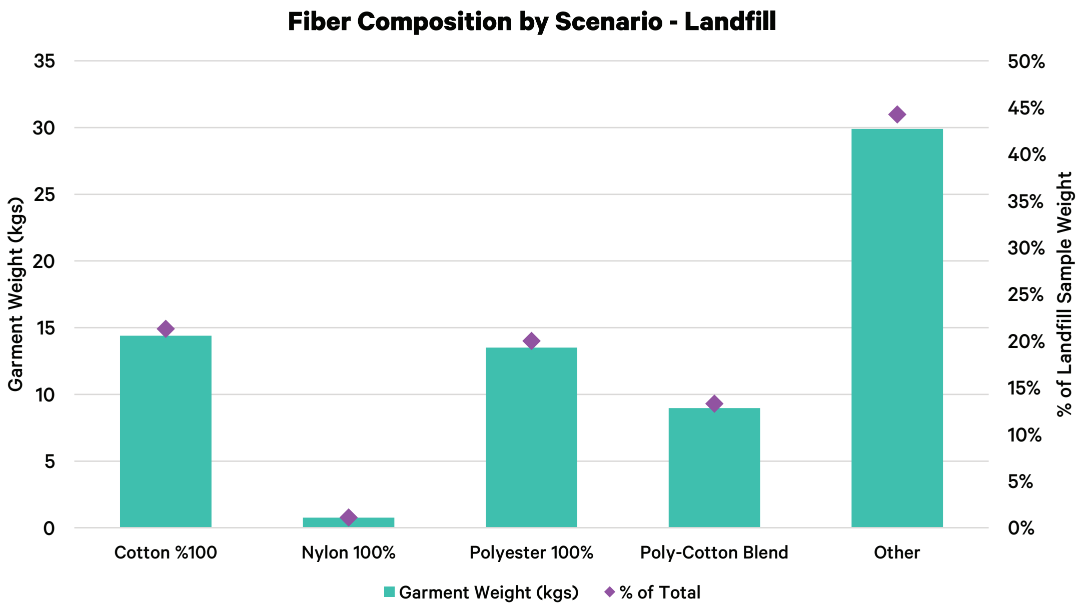


Figure 47: Garment Fiber Composition by Scenario (Landfill).

Landfill Results: Disruptors

Disruptor-free items accounted for 52% of the total weight sampled at the landfill site, compared to 30% at non-landfill facilities. Fabric remained the dominant disruptor with a fabric disruptor present on 114 out of the 254 items analyzed.

Landfill Results: Product Layers

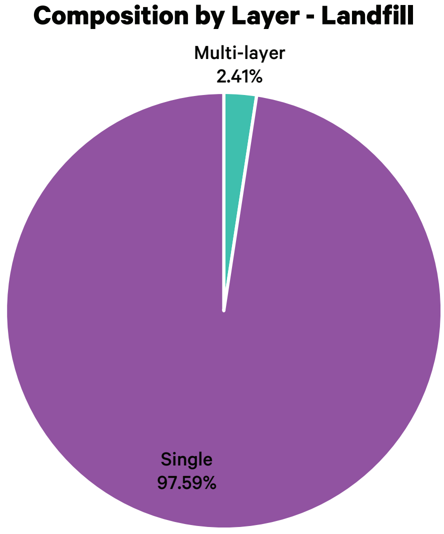


Figure 48: Single vs. Multi-Layer Fiber Item Composition (Landfill).

Of the total items analyzed, 97.6% of the total sample weight at the landfill were single-layered items, compared to 95.6% for the non-landfill facilities (Figure 48). The remaining 2.41% of landfilled items were multi-layered.

FIBER-TO-FIBER RECYCLING ANALYSIS

The research team calculated quantities of textiles suitable for fiber-to-fiber recycling using results of the composition analysis combined with knowledge of sorting technology capabilities and input specifications of varying recycling technologies. The resulting methodology:

» Eliminated multilayer items from analysis since sorting technologies cannot accurately sort multilayer items;

» Filtered items by color (for mechanical recycling);

» Evaluated feedstock with and without disruptors, since capabilities to identify and remove disruptors are quickly evolving;

- Metal and plastic disruptors were categorized as removable while other forms of disruptors were considered non-removable.

» Assessed various fiber composition scenarios.

Mechanical Recycling Scenario Analysis

The following criteria were applied for the mechanical recycling scenario analysis:

» Layers: Single layer only; excluded multi-layered items

» Color: Single colored items - excluded multi-color items as well as items where the color was marked 'undefined', meaning the scanner was unable to properly assign an item color.

» Fiber Composition: Focused on fiber compositions with potential mechanical recycling markets: cotton. Wool is excluded as it is not a focus of this study.

- Cotton: ≥90%, 100%

» Disruptors: Only with removable disruptors or no disruptors

Table 8: Available Feedstock for Mechanical Recycling.

Mechanical Recycling Feedstock	Total Weight (kgs)	% of Total Sampled	Nationwide Conversion (tonnes)*
≥ 90% Cotton Target Fibre Content (No Disruptors/Removable Disruptors)	1,304	9%	1,354,000

Note: tonnes rounded to nearest thousandth for consistency.
* Estimation uses 2018 EPA value of 15.45 million tonnes generated[4]

Primary Composition Analysis

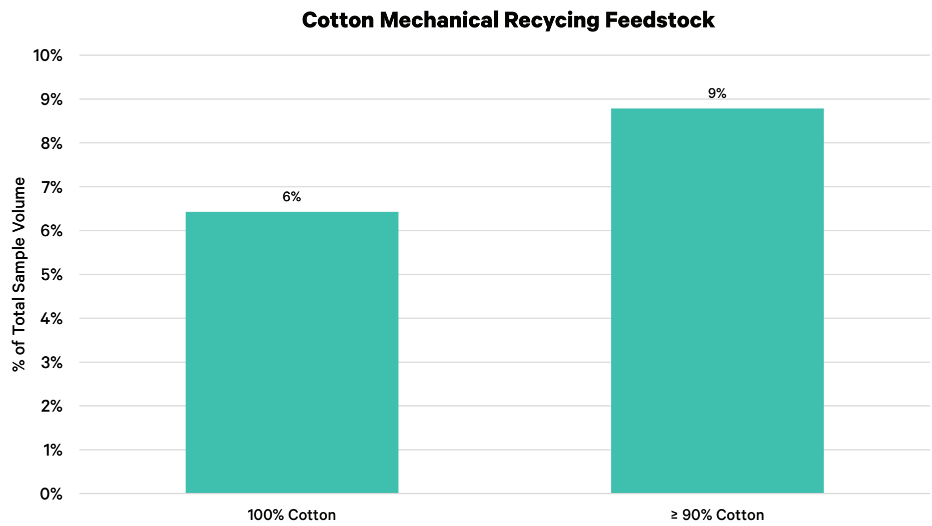


Figure 49: Cotton Feedstock Available for Mechanical Recycling.
Note: Sample volumes are cumulative.

The available feedstock for mechanical recycling based on the composition criterias for this feedstock is shown in Figure 49. Pure cotton items suitable for mechanical recycling account for 6% of the total sample weight. This volume increases to 9% when composition requirements are lessend to ≥90% cotton items.

Disruptor Analysis

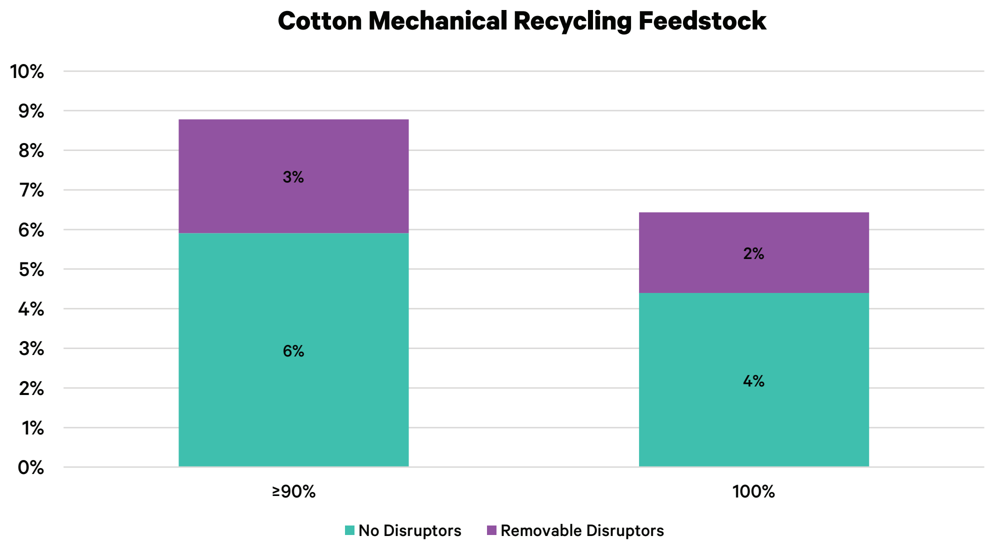


Figure 50: Cotton Feedstock Available for Mechanical Recycling by Disruptor Type.
Note: Sample volumes are cumulative.

Since mechanical recycling cannot account for non-removable disruptors, only those items with removable or no disruptors were totaled for the feedstock volume. For the 100% cotton scenario, 4% of the total volume had no disruptors present, which increased slightly to 6% for the ≥90% cotton feedstock (Figure 50).

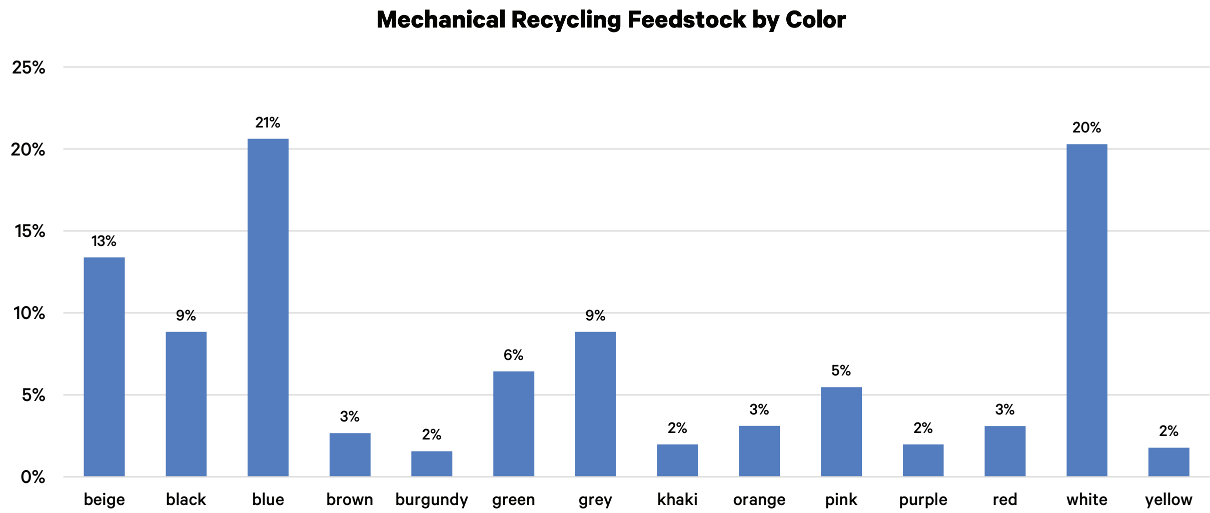


Figure 51: Suitable Mechanical Recycling Feedstock by Color.

Out of the feedstock suitable for mechanical recycling, blue single layered items were the most prominent at 21% of the total feedstock weight, with white following at 20% (Figure 51).

Chemical Recycling Analysis

The following criteria were applied for the chemical recycling scenario analysis:

» Chemical recycling includes physio-chemical and depolymerization recycling technologies

» Layers: Single layer only; excluded multi-layered items

» Color: All

» Fiber Composition

- Cotton: ≥80%, ≥90%, 100%
- Nylon: ≥80%, ≥90%, 100%
- Polyester: ≥80%, ≥90%, 100%
- Polycotton Blends*:
    - 50/50 polycotton
    - 60/40 polycotton
    - 65/35 polycotton
    - 70/30 polycotton
    - 80/20 polycotton
    - 65/35 cottonpoly
    - 80/20 cottonpoly
    - All polycotton - total value includes any items with primary material of polyester and secondary material of cotton or viscose (to account for similarities in cotton and viscose when scanning).

**A +/- 3% was accounted for when calculating all blend ratios*

» Disruptors: with disruptors; only with removable disruptors

Table 9: Available Feedstock For Chemical Recycling.

Chemical Recycling Feedstock	Total Weight (kgs)	% of Total Sampled	Nationwide Conversion (tonnes)*
≥ 80% Cotton Target Fibre Content			
All Disruptors	5,220	35%	5,423,000
No or Removable Disruptors	2,042	14%	2,122,000
≥ 80% Nylon Target Fibre Content			
All Disruptors	264	2%	274,000
No or Removable Disruptors	94	1%	98,000
≥ 80% Polyester Target Fibre Content			
All Disruptors	2,823	19%	2,933,000
No or Removable Disruptors	1,049	7%	1,090,000
All Polyester Blends Target Fibre Content**			
All Disruptors	3,047	21%	3,165,000
No or Removable Disruptors	1,151	8%	1,196,000

Note: tonnes rounded to nearest thousandth for consistency.

* Estimation uses 2018 EPA value of 15.45 million tonnes generated

** All Polycotton will account for all polyester/cotton blends. Due to this, there will be some overlap with cotton and polyester ≥ scenarios.

Primary Composition Analysis

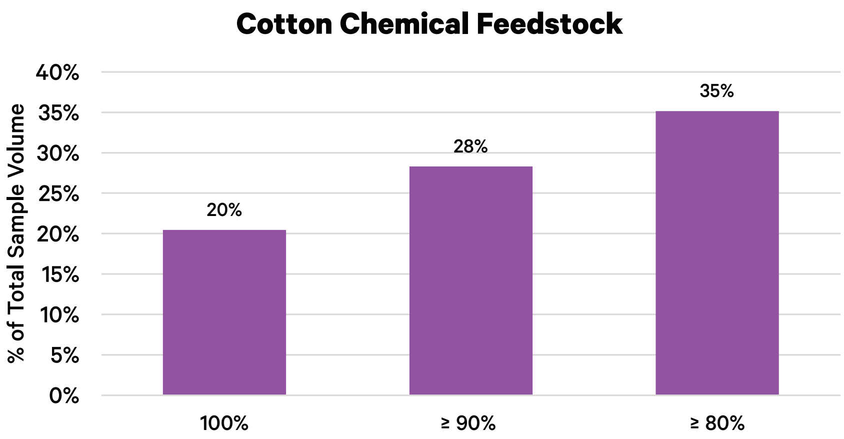


Figure 52: Single-Layer Cotton Feedstock Available for Chemical Recycling.
Note: Sample volumes are cumulative. Cotton volume includes any polycotton blends that contain ≥80% cotton.

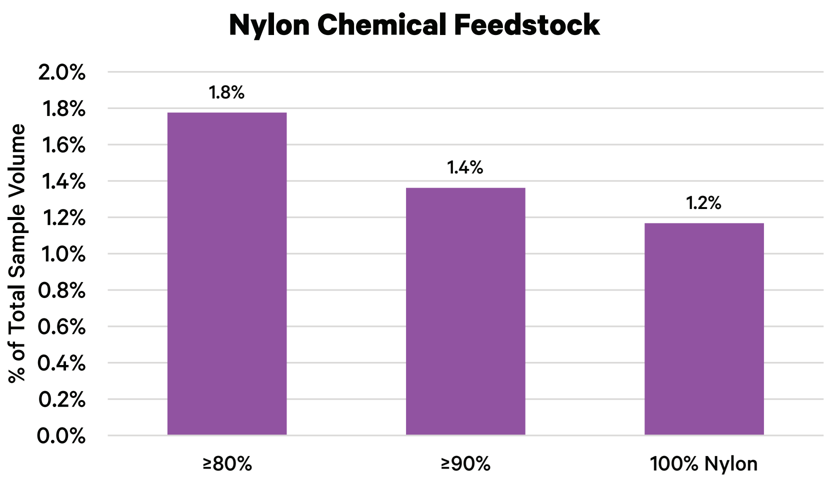


Figure 53: Single-Layer Nylon Feedstock Available for Chemical Recycling.
Note: Sample volumes are cumulative.

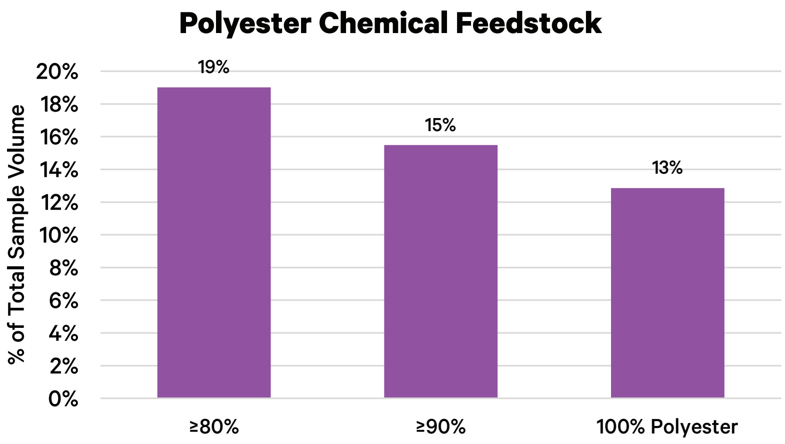


Figure 54: Single-Layer Polyester Feedstock Available for Chemical Recycling.
Note: Sample volumes are cumulative. Polyester volume includes any polycotton blends that contain ≥80% polyester.

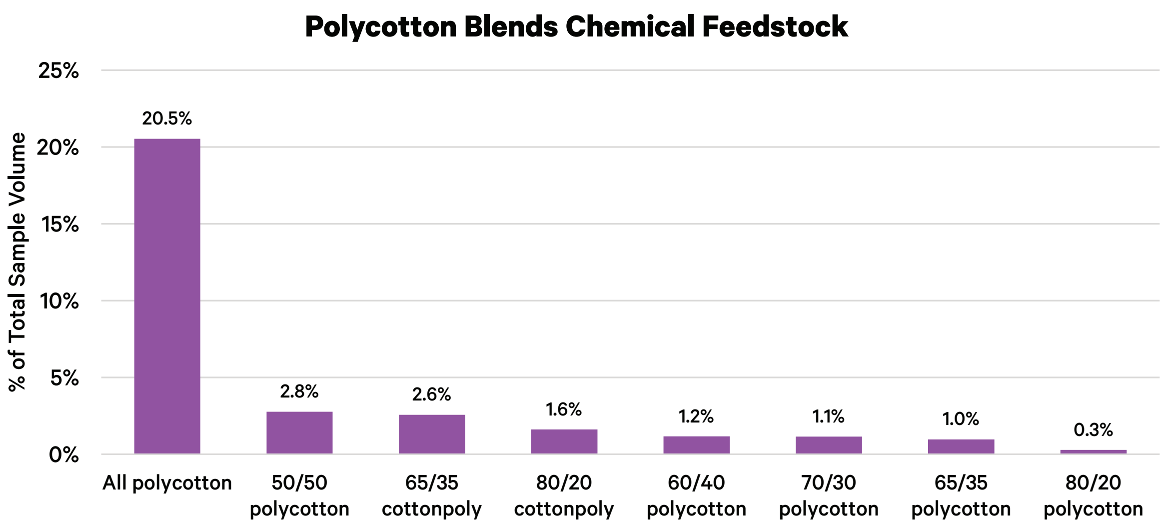


Figure 55: Single-Layer Polyester/Cotton Blend Feedstock Available for Chemical Recycling.

Out of the total sample weight, 35% of items are suitable for chemical cotton recycling with 20% of the total being pure cotton items (Figure 52). Pure nylon items were seen in a much smaller quantity, accounting for around 1% of the total sample weight (Figure 53). Polyester remained the second most prominent material, with 19% of items analyzed being classified as suitable for chemical recycling (Figure 54). When looking at polycotton blends as a whole, it was determined that 21% of the total sample weight was a polycotton blend, with the most prominent blend consisting of 65/35 cottonpoly (Figure 55).

Disruptor Analysis

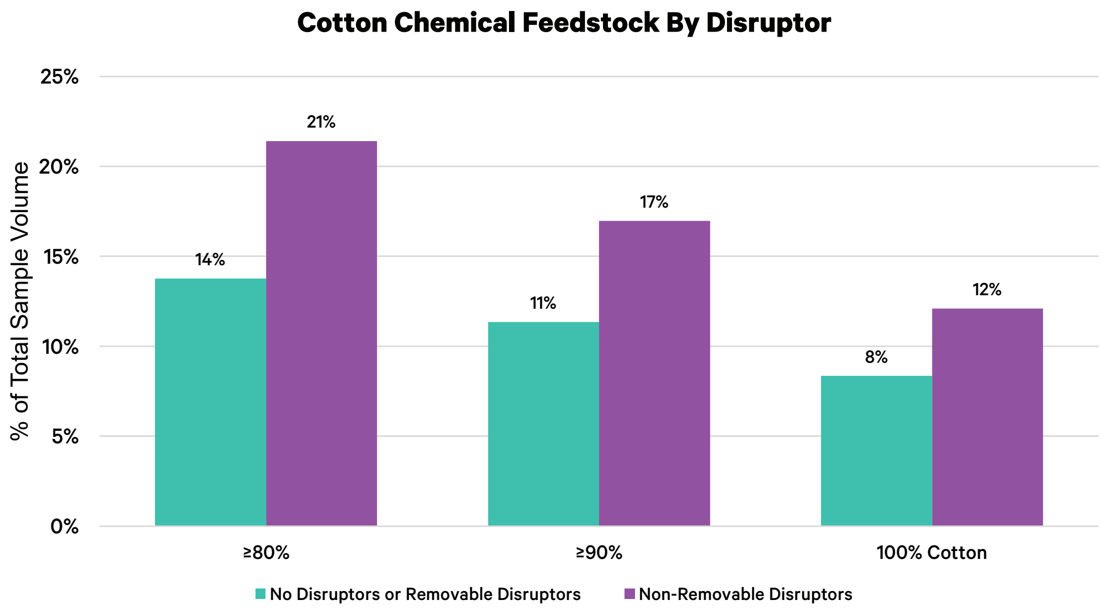


Figure 56: Single-Layer Cotton Feedstock Available for Chemical Recycling With Disruptors Factored In.

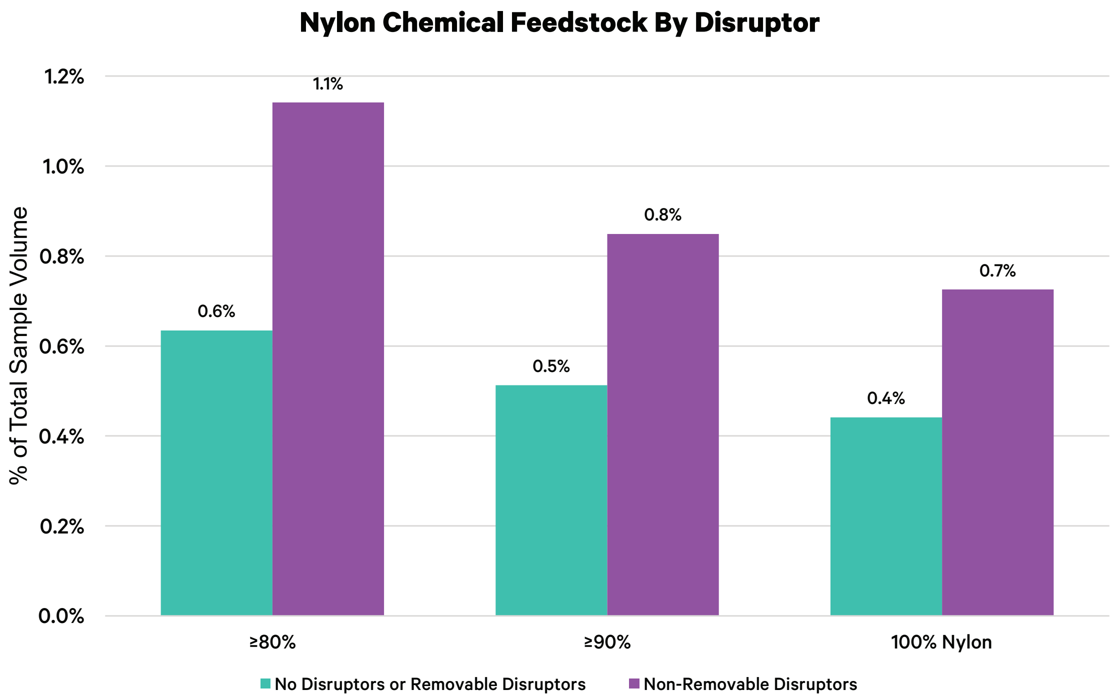


Figure 57: Single-Layer Nylon Feedstock Available for Chemical Recycling With Disruptors Factored In.

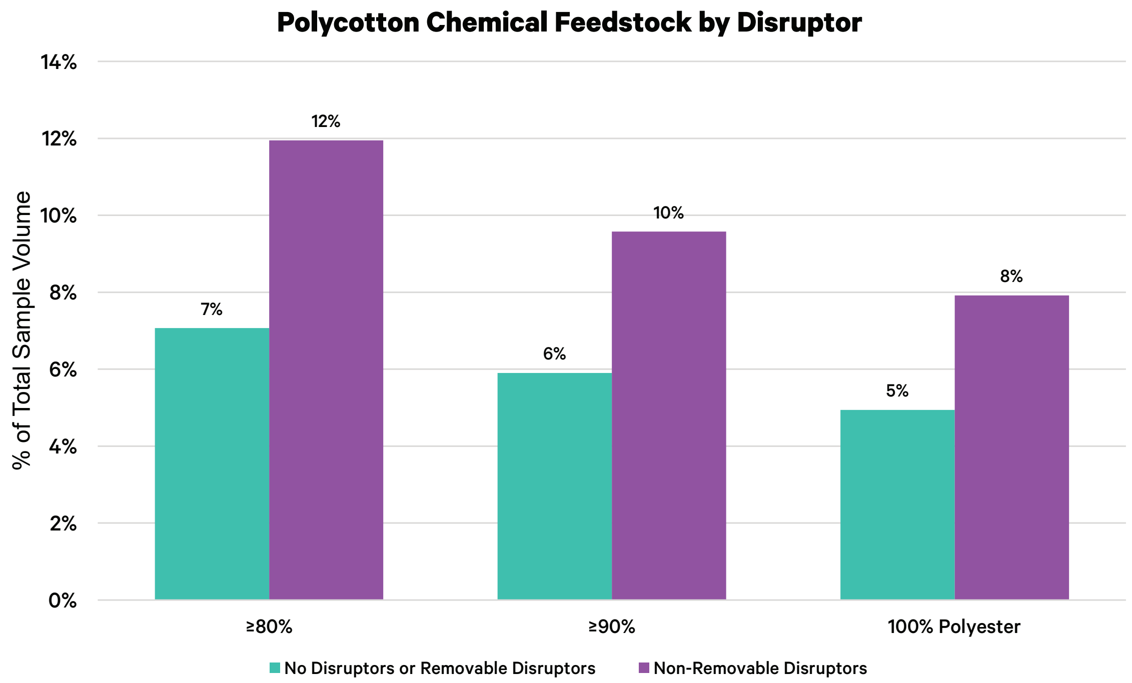


Figure 58: Single-Layer Polyester Feedstock Available for Chemical Recycling With Disruptors Factored In.

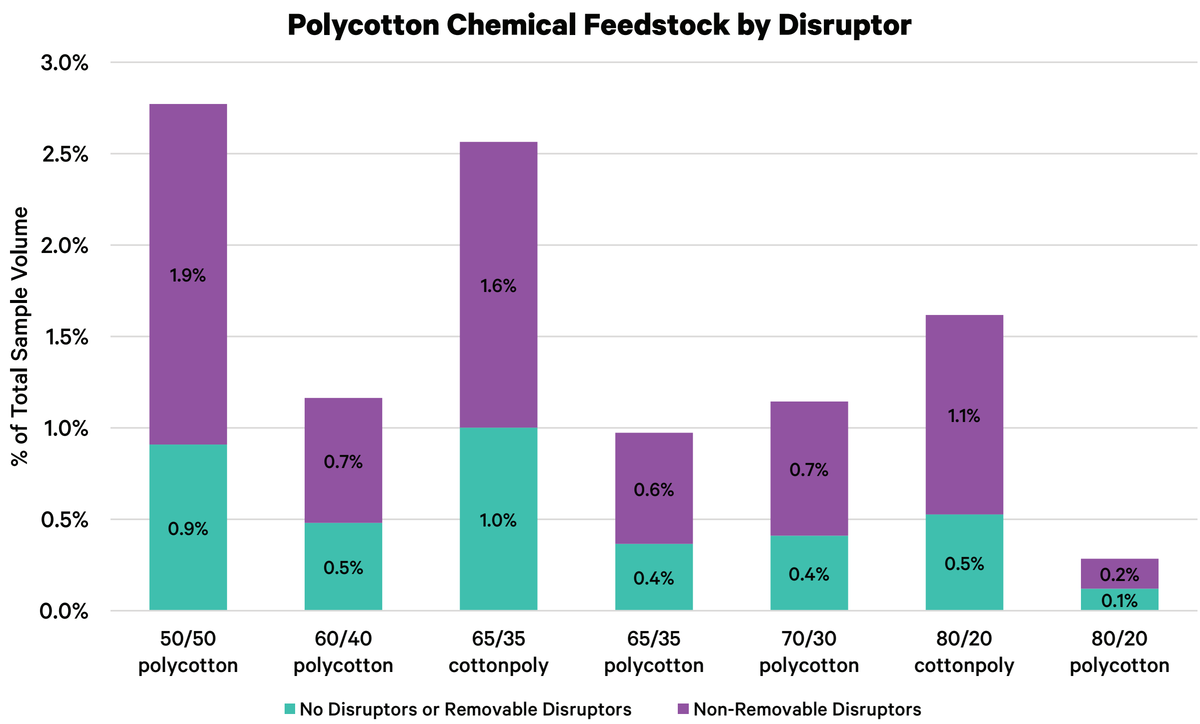


Figure 59: Single-Layer Polyester/Cotton Blend Feedstock Available for Chemical Recycling With Disruptors Factored In.

Similar to the findings for mechanical recycling, the presence of non-removable disruptors greatly reduces the feedstock for chemical recycling. For all the listed scenarios for cotton (Figure 56), nylon (Figure 57), polyester (Figure 58), and polycotton (Figure 59), a non-removable disruptor accounts for at least the majority of the potential feedstock for chemical recycling.

Appendix II - Composition Analysis Limitations

NIR Limitations

Spectroscopic technology is used across multiple industries to analyze composition. It works as follows:

1. An electromagnetic wave is sent to the sample to be analyzed.
2. The wave and the sample's chemical structure interact.
3. The wave is measured having interacted with the sample, and a spectrum is produced.

This spectrum represents the sample's 'chemical signature' and can be compared with spectra from pre-recorded samples to determine the composition of the item.[67]

The pre-recorded samples are otherwise known as a 'Materials Library', which act as a reference point of comparison for the textile being analyzed. Fashion for Good will benefit from the work of Refashion with Terra and Matoha to obtain a robust Materials Library that contains all major fiber types, including the most common blends found in textiles. Refashion will develop several identical physical sets of the reference materials library.

Whilst it is the most commonly used technology, it is still in the development stage for textiles and thus has some key considerations, as follows:

1. NIR technology performs to a high degree of accuracy in pure materials, and commonly-used blends (e.g., polycotton).
2. NIR technology is less accurate for multi-blended items (e.g., using 3 or more fiber types), or less common blends - given the lack of reliable pre-recorded samples which the spectrum can be compared against.
3. The NIR technology used for this study is unable to confidently identify fibers under 15%. If fibers are present in quantities under 15%, the machine returns a "contaminant" reading. This is an especially relevant limitation for elastane considering the frequent presence of elastane in textiles in low percentages and the problematic nature of elastane in many recycling processes.
4. NIR technology analyzes a material's surface - therefore multi-layered items that contain different materials (e.g., jackets) can cause difficulty in identification. Some fabrics and textiles are constructed so that different fibers protrude on the surface (front or back). Therefore, fiber compositions are uneven with some fibers "showing" more on the surface of the item, while others are "hidden". A good example of this is terry cloth. Similarly, some items contain plating on one side of the fabric but not the other. Elastane on the inside of jeans is an example of one type of common plating application. Plating may not be visible if only the outside of the item is scanned, and plating is not always uniform throughout the item; it is sometimes applied only in certain spots.The thickness and color of fabric scanned as well as presence of coatings and finishes can reduce the accuracy of the composition analysis of NIR scanners.
5. NIR has been reported to be less effective at identifying material composition on dark colored items. NIR is unable to detect composition when textiles are dyed with pigments that have high light-absorbing properties and low light reflectance. NIR detection uses reflectance spectroscopy, meaning it detects the unique light spectrum reflected off of the item. Certain pigments, like true black, do not reflect enough light to generate a reading, causing the item to appear invisible to the scanner.

"Invisible" textiles were segregated, weighed and cataloged separately; however, no fiber composition readings were possible.

6. fiber types that are similar in chemical structure may not be distinguished accurately. For example, viscose and cotton have similar chemical structure, as do animal proteins like wool, silk, and leather. In this analysis, fabrics consisting of leather, wool, silk, and linen were not detected reliably by the NIR scanners.
7. For different reasons, synthetic leather and PU coated fabric were not recognized.

Inherent limitations of NIR are included in the built in margins of error. Margins of error are caused by natural variations in spectrum readings and the quality of the material library that is referenced in producing results. fiber composition results may contain a few percentage point variance in accuracy. The more common and pure the fiber composition is, the more accurate results generally are.

NIR works by acquiring a unique wavelength based on the light reflected off of the fibers. The fiber percentages shown by the scanner are based on the surface area of fibers present on the surface of the item scanned. These percentages were then converted to weights using the same proportions, even though in reality the weight of different types of fibers vary. For example, cellulosic fibers are generally heavier than synthetic fibers. That said, dyes and other treatments impact the true weight of fibers (sometimes disproportionately) and determining an accurate breakdown of fiber weight by percentage is not possible using the methodology employed by this study.

Data on the fabric structure (knitted, woven, nonwoven) was not captured in this study. As mechanical recyclers mostly process knitted textiles and denim trousers, feedstock estimates for mechanical recycling in this report are higher than the actual quantities available. Based on product categories, around 14% the estimated feedstock weight for mechanical recycling consists of products with woven fabric structures like trousers (non-denim), jackets and coats.

NIR is unable to identify chemicals such as PFAS or other restricted substances.

Despite these considerations, NIR is still one of the most suitable technologies for textile composition analysis as it provides significantly more accuracy into composition than manual sorting (the status quo) and is less expensive than alternative technologies.

Human Error

While NIR scanners allow for the automated recognition of the composition of textiles, the outcomes of this Project have been prone to human error. Data from the scanners were complemented with information of other characteristics of the textile product using an app. Errors in human judgment may have resulted in incorrect decisions for attributes such as the classification of an item type, the precise color of the item, the type of disruptor, and/or missed disruptors if not seen by the person sorting. Classification of multilayer items was particularly prone to human error because of the two-step process involved in recording the data affiliated with each layer.

The study methodology also limited the distinction of disruptors to present or absent for a specific set of disruptor types (metal, plastic, fabric, embroidery, print, and other). The methodology did not allow for a quantification of the prevalence of the disruptor by weight or surface area.

On-the-ground quality controllers were available to ensure data was inserted adequately or corrected afterwards, but human errors certainly occurred throughout the data collection.

Weights

The conversion item to weight was based on average weight per product type (Table 10), instead of each item's actual weight. To maximize the volume that could be scanned in the time available for this Project, scanned items were not weighed individually. The product type and age group was captured per item using the App. The items were translated to a weight based on average weight per product type and per age group. The average weights used were based on estimates received from textile retailers and data from Refashion, resulting in the average weight per product type shown in Appendix III - Average Weights Per Product Type.

Saved items without a product type or age group were deleted from the sample as no reliable weight could be associated with the product. The weight of multi-layered items was equally attributed to both layers. Since multi-layered items were excluded from the sample used to calculate feedstock availability this limitation does not affect the study outcomes.

Representativeness

Data collected through the Sorting for Circularity USA project provides a novel glimpse into residential post-consumer textile waste in the U.S. at sampled locations during two seasons in 2023. Data does not reflect a representative sample. To understand the textile waste stream at a statistically significant level, a sampling approach that includes a larger geographic representation and significantly greater sampled tonnage over multiple seasons is required; a larger sampling effort than was achievable during this project.

Appendix III - Average Weights Per Product Type

Table 10: *Post-Consumer Textile Composition Analysis Estimates on Average Weights Per Product Type.*

Product Age Group	Product Name	Average weight (kgs)
Adults	Bra-Lingerie	0.09
Adults	Coat	1.06
Adults	Costume	0.43
Adults	Costume	0.215
Adults	Denim-Jacket	0.71
Adults	Denim-Overall	0.67
Adults	Denim-Shorts	0.32
Adults	Denim-Skirts	0.34
Adults	Denim-Trousers	0.51
Adults	Dress	0.18
Adults	Heavy-Jacket	0.75
Adults	Home-Wear	0.31
Adults	Jumpsuit-Overall	0.36
Adults	Light-Jacket	0.31
Adults	Polo-Shirt	0.25
Adults	Waterproof-Rainwear	0.8
Adults	Reflective-Safety	0.58
Adults	Shirt-Blouse	0.16
Adults	Shorts	0.2
Adults	Skirts	0.24
Adults	Socks-Hosiery	0.03
Adults	Sport-Trousers	0.21
Adults	Sweaters-Hoodie	0.31
Adults	Swimwear	0.12
Adults	Trousers	0.36
Adults	T-Shirt	0.16
Adults	Underwear-Bottoms	0.09
Babies	Baby-Clothes	0.16
Babies	Baby-Underwear	0.16
Children	Bra-Lingerie	0.03

Product Age Group	Product Name	Average weight (kgs)
Children	Coat	0.59
Children	Costume	0.26
Children	Denim-Jacket	0.45
Children	Denim-Overall	0.19
Children	Denim-Shorts	0.23
Children	Denim-Skirts	0.22
Children	Denim-Trousers	0.28
Children	Dress	0.22
Children	Heavy-Jacket	0.45
Children	Home-Wear	0.34
Children	Jumpsuit-Overall	0.21
Children	Light-Jacket	0.35
Children	Polo-Shirt	0.1
Children	Waterproof-Rainwear	0.53
Children	Reflective-Safety	0.35
Children	Shirt-Blouse	0.1
Children	Shorts	0.15
Children	Skirts	0.18
Children	Socks-Hosiery	0.02
Children	Sport-Trousers	0.22
Children	Sweaters-Hoodie	0.17
Children	Swimwear	0.06
Children	Trousers	0.22
Children	T-Shirt	0.1
Children	Underwear-Bottoms	0.03
Other	Fabrics	0.25
Other	Gloves	0.04
Other	Headwear	0.1
Other	Household-Linen	0.35
Other	Medium-Accessory	0.07
Other	Other	0.35
Other	Small-Accessory	0.03
Undefined	Undefined	0.28

*Weight shown is for single layer garments

Appendix IV - Survey Methodology and Results

Goal 1 | Target 1: Understanding Consumer Disposal behavior

» Identify and understand consumer textile disposal and diversion behavior to inform collection programs and infrastructure needs by surveying a representative sample of the U.S. population.

Objective

Target 1: Collection Channel Research was aimed at understanding consumer behaviors and attitudes related to the disposal of unwanted textiles. The research sought to leverage consumer insights through a national survey to inform recommendations for optimizing collection pathways and driving increased participation in textile recovery programs.

Survey Methodology

The project team developed an online survey to collect data regarding consumer textile disposal habits. The survey sought insights about:

» Textile purchasing behavior

» Textile waste storage, disposal, and diversion habits

» Origin of and ideology behind disposal practices

» Willingness to participate in textile collection programs

» Attitudes, perceptions, and motivations that influence how individuals dispose of textiles.

The research also takes a discrete look at urban, suburban, and rural environments because community density often dictates the types of collection programs that are feasible. For example, low population density makes centralized facilities and frequent collection practices less economical, whereas densely populated areas can offer economies of scale and higher quantities of material for collection.

The survey targeted a representative population of 1,200 U.S. adult (18+) consumers across several demographics, including age, gender, and community type (rural, urban, and suburban).

Textiles were defined as items made from fiber, yarn, or fabric, such as clothing, apparel, and household linens, such as blankets, curtains, bedding, towels, napkins, and tablecloths. Not included in the definition for the purpose of this survey are carpets, shoes, stuffed animals, accessories, and mattresses.

The survey was issued via Qualtrics on August 7, 2023 and remained open until quotas were filled. The form was open for 59 days and collected 1,108 responses after quality control review and cleaning for faulty respondents. Respondents were removed or terminated for hitting more than four of our quality control logic flags, or for presenting incomprehensible responses across all questions.

Survey Questions

Informed Consent:

The purpose of the following survey is to research attitudes and behavior around post-consumer textile waste diversion in New York State and nationally. Feedback gathered through this survey will assist in identifying opportunities for solution development regarding the sustainable management of textiles.

Your participation in this survey is voluntary. You may choose not to participate. If you decide to participate in this research survey, you may withdraw at any time without penalty. Please complete the questions to the best of your ability. Individual responses will remain confidential. Aggregated findings from this survey will be anonymized.

By taking this survey, you attest that you are at least 18 years old.

The survey is expected to take approximately 15 minutes to complete.

Gift Card Drawing

At the end of the survey, you can add your contact information to be entered to win one of three $50 gift cards. The winners will be selected at random.

Data Privacy

We will do everything we can to protect your privacy. Your identity and personal information will not be disclosed in any publication that may result from the survey. Individual responses will remain confidential. Aggregated findings from this survey will be anonymized.

Whenever one works with email or the internet, there is always the risk of compromising privacy, confidentiality, and/or anonymity. Your confidentiality will be maintained to the degree permitted by the technology being used. It is important for you to understand that no guarantees can be made regarding the interception of data sent via the internet by third parties.

*** In the context of this survey, the word “textile” means items made from fiber, yarn, or fabric, such as clothing, apparel, and household linens, such as blankets, curtains, bedding, towels, nakins, and tablecloths. Not included in the definition for the purpose of this survey are carpets, shoes, stuffed animals, accessories, and mattresses.

To what extent do you determine what happens with unwanted textiles in your home? *Select one response.*

_____ I have final say over what happens with unwanted textiles in my home
_____ I share influence over what happens with unwanted textiles with someone else in my home
_____ I am not involved in what happens with unwanted textiles in my home

1. How many bags of unwanted textiles does your household generate annually? Estimate in terms of medium-sized kitchen trash bags. *Select one response.*

   _____ <1
   _____ 1-5
   _____ 6-10
   _____ 11-15
   _____ 16-20
   _____ More than 20

2. What kinds of unwanted textiles does your household generate? *Select all that apply.*

   _____ Women's clothing
   _____ Men's clothing
   _____ Children's clothing
   _____ Household linens (e.g., blankets, linens, curtains, bedding, towels, napkins, tablecloths, etc.)

3. What are the main reasons you no longer want or need textiles? *By dragging and dropping, please rank each reason from 1-5 in order of importance, with 1 being the most important.*

   _____ Worn out
   _____ Damaged
   _____ Poor fit or size
   _____ Out of fashion/taste/lost interest in item
   _____ Other (please specify)

4. About how often do you remove unwanted textiles from your home? *Select one response.*

   _____ I get rid of each item as soon as I/others in my household decide I/they no longer want it
   _____ Weekly
   _____ Monthly
   _____ Seasonally
   _____ Once or twice a year
   _____ When I get around to it

5. At what point(s) do you identify textiles that you no longer want or need? *Select all that apply.*

   _____ Periodic clean out (e.g., seasonal/spring cleaning, back to school, etc.)
   _____ Impromptu decluttering/noticed an item I no longer want/need
   _____ To make room for the purchase of new items
   _____ Request from charity/clothing drive
   _____ Identification of a recipient in need
   _____ Life event (moving/bereavement)
   _____ Other (please specify)

The next section asks about your recent behaviors with unwanted textiles.

6. In what way(s) do you get rid of textiles that you no longer want or need? *Select all that apply.*

   _____ Put them in the trash/throw them away (1)
   _____ Donate them (e.g., give to a non-profit organization) (2)
   _____ Recycle them (3)
   _____ Resell them (e.g., receive money or store credit in return for items) (4)
   _____ Repurpose them (e.g., turn into rags, use for arts and crafts) (5)
   _____ Give away (e.g., to friends/family, swap event, for-profit collection bin) (6)

7. Within the ***past 12 months***, did you get rid of textiles that you no longer wanted? *Select one response.*

_____ Yes, within the past year, I got rid of textiles that I no longer wanted (1)
_____ I had unwanted textiles, but did not get rid of them within the past year (2)
_____ I did not have any unwanted textiles within the past year (3)

8. In the ***past 12 months***, what percentages of your unwanted textiles were disposed through each of the following? *Percentages must sum to 100.*

_____ Put them in the trash/threw them away : _______ (7)
_____ Donated them (e.g., gave them to a non-profit organization) : _______ (8)
_____ Recycled them : _______ (9)
_____ Resold them (e.g., received money or store credit in return for items) : _______ (10)
_____ Repurposed them (e.g., turned into rags, used for arts and crafts) : _______ (11)
_____ Gave away (e.g., to friends/family, swap event, for-profit collection bins) : _______ (12)
_____ Total : ________

9. Which textile donation/reuse/recycling/resale options have you participated in during the ***past 12 months***? *Select all that apply.*

_____ I gave my unwanted textiles to family, friends, neighbors (e.g., hand-me-downs, swap events)
_____ I dropped my unwanted textiles in a nearby textile collection bin (e.g., in a store parking lot)
_____ I brought my unwanted textiles to a community textile collection event or recycling depot
_____ I dropped off my unwanted textiles at a charity/donation center
_____ I brought my unwanted textiles back to an in-store retail collection bin
_____ I utilized a brand take-back program (i.e., when a fashion brand takes or buys back products)
_____ I scheduled a home pick-up (through a charity or local service provider) for my unwanted textiles
_____ I used my municipality's curbside clothing collection or pickup service
_____ I placed my unwanted textiles in my regular curbside recycling bin (bottles, cans, paper, etc.)
_____ I sold my unwanted textiles through brick and mortar consignment stores
_____ I dropped off or resold my unwanted textiles at a vintage or thrift store
_____ I gave away or resold my unwanted textiles online through a peer-to-peer platform (e.g., Facebook Marketplace, Craigslist, NextDoor, Mercari, eBay, etc.)
_____ I resold my unwanted textiles online through a resale platform (e.g., ThredUp, Poshmark, Recurate, The RealReal, etc.)
_____ I used my unwanted textiles for cleaning around my home
_____ I used my unwanted textiles for arts and crafts
_____ Other (please specify)

10. In the ***past 12 months***, what was the maximum distance you traveled to donate/ reuse/ recycle your unwanted textiles? *Select one response.*

_____ Walked more than 10 minutes to a drop off point (1)
_____ Walked 6 to 10 minutes to a drop off point (2)
_____ Walked 1 to 5 minutes to a drop off point (3)
_____ Drove more than 15 minutes to a drop off point (4)
_____ Drove 6 to 15 minutes to a drop off point (5)
_____ Drove 1 to 5 minutes to a drop off point (6)
_____ I went to a drop off point only because it was on the way to another destination (7)
_____ My unwanted textiles were **picked up from my home** (e.g., curbside pickup or door-to-door service) (8)

11. What do you usually do with unwanted textiles that are ***ripped, torn, or stained***? *Select all that apply.*

_____ Put them in the trash/throw them away (1)
_____ Take them to a charity/donation center (2)

_____ Use a non-charity reuse/recycling program (3)
_____ Use them at home for rags (4)
_____ Use them for arts and crafts (5)
_____ Use a branded take-back program (6)
_____ Sell them (7)
_____ Give them to family or friends (8)
_____ Other (please specify) (9)

12. What do you usually do with unwanted textiles that are in ***fair condition?*** *Select all that apply.*

_____ Put them in the trash/throw them away (1)
_____ Take them to a charity/donation center (2)
_____ Use a non-charity reuse/recycling program (3)
_____ Use them at home for rags (4)
_____ Use them for arts and crafts (5)
_____ Use a branded take-back program (6)
_____ Sell them (7)
_____ Give them to family or friends (8)
_____ Other (please specify) (9)

13. What do you usually do with unwanted textiles that are in ***good or very good condition***? *Select all that apply.*

_____ Put them in the trash/throw them away (1)
_____ Take them to a charity/donation center (2)
_____ Use a non-charity reuse/recycling program (3)
_____ Use them at home for rags (4)
_____ Use them for arts and crafts (5)
_____ Use a branded take-back program (6)
_____ Sell them (7)
_____ Give them to family or friends (8)
_____ Other (please specify) (9)

14. What do you usually do with unwanted textiles that are in ***new and unused condition***? *Select all that apply.*

_____ Put them in the trash/throw them away (1)
_____ Take them to a charity/donation center (2)
_____ Use a non-charity reuse/recycling program (3)
_____ Use them at home for rags (4)
_____ Use them for arts and crafts (5)
_____ Use a branded take-back program (6)
_____ Sell them (7)
_____ Give them to family or friends (8)
_____ Other (please specify) (9)

15. What do you usually do with **used underwear and socks** that you no longer want or need? *Select all that apply.*

_____ Put them in the trash/throw them away (1)
_____ Take them to a charity/donation center (2)
_____ Use a non-charity reuse/recycling program (3)
_____ Use them at home for rags (4)
_____ Use them for arts and crafts (5)
_____ Use a branded take-back program (6)

_____ Sell them (7)
_____ Give them to family or friends (8)
_____ Other (please specify) (9)

16. What do you usually do with ***kid's clothing*** that you no longer want or need? *Select all that apply.*

_____ Put them in the trash/throw them away (1)
_____ Take them to a charity/donation center (2)
_____ Use a non-charity reuse/recycling program (3)
_____ Use them at home for rags (4)
_____ Use them for arts and crafts (5)
_____ Use a branded take-back program (6)
_____ Sell them (7)
_____ Give them to family or friends (8)
_____ Other (please specify) (9)

17. What do you usually do with ***household linens (e.g., blankets, sheets, curtains, bedding, towels, napkins, tablecloths, etc.)*** that you no longer want or need? *Select all that apply.*

_____ Put them in the trash/throw them away (1)
_____ Take them to a charity/donation center (2)
_____ Use a non-charity reuse/recycling program (3)
_____ Use them at home for rags (4)
_____ Use them for arts and crafts (5)
_____ Use a branded take-back program (6)
_____ Sell them (7)
_____ Give them to family or friends (8)
_____ Other (please specify) (9)

The next section asks about your perspectives on available services for unwanted textiles.

18. To what extent do you agree or disagree with the following statement? *Select one response.*

"**Reusing/recycling** textiles is convenient."

_____ Strongly agree (1)
_____ Agree (2)
_____ Somewhat agree (3)
_____ Neither agree nor disagree (4)
_____ Somewhat disagree (5)
_____ Disagree (6)
_____ Strongly disagree (7)

19. To what extent do you agree or disagree with the following statement? *Select one response.*

"I have convenient access to **repair services** for textiles."

_____ Strongly agree (1)
_____ Agree (2)
_____ Somewhat agree (3)
_____ Neither agree nor disagree (4)
_____ Somewhat disagree (5)
_____ Disagree (6)
_____ Strongly disagree (7)

20. What motivates you to donate/sell/give away your unwanted textiles? *Select up to 3.*

____ To help those in need (1)
____ To receive a tax receipt (2)
____ To generate income (3)
____ To prevent something with value from going to landfill/incineration (4)
____ To decrease my environmental impact (5)
____ It makes me feel good (6)
____ It is a practice that has been passed down to me (7)
____ Other (please specify) (8)
____ I do not donate/sell/give away my textiles (9)

21. For what reasons do you throw away unwanted textiles in the trash instead of donating/reusing/recycling/reselling them? *Select up to 3.*

____ I am not aware of options to donate/reuse/recycle/resell them (1)
____ I am not confident about what's accepted for donation/reuse/recycling (2)
____ Throwing them away in the trash is easier (3)
____ Throwing them away in the trash is more convenient (4)
____ I do not have the time to bring my unwanted textiles somewhere or to donate/reuse/recycle (5)
____ The condition or quality is too poor (i.e., damaged, stained, etc.) (6)
____ I do not get rid of enough textiles to warrant the effort (7)
____ I do not have the means to transport my unwanted textiles (8)
____ I am skeptical that textiles are actually reused or recycled (9)
____ Other (please specify) (10)
____ I do not believe in donating/reusing/recycling textiles (11)
____ I always donate/reuse/recycle my textiles (12)

22. How long do you hold onto unwanted textiles before donating/selling/recycling/giving them away? *Select one response.*

____ I would not be willing to or am unable to keep unwanted textiles for any length of time
____ 1 week
____ 1 month
____ 3 months
____ 6 months
____ 1 year
____ More than one year

23. What are the most important factors when considering how to dispose of your unwanted textiles? *Select and rank up to 3.*

Rank 1	***Rank 2***	***Rank 3***
_____ Free of cost (1)	_____ Free of cost (1)	_____ Free of cost (1)
_____ Receive a tax receipt (2)	_____ Receive a tax receipt (2)	_____ Receive a tax receipt (2)
_____ Support a charity (3)	_____ Support a charity (3)	_____ Support a charity (3)
_____ Receive a payback (4)	_____ Receive a payback (4)	_____ Receive a payback (4)
_____ Get discounts on new purchases or store credit (5)	_____ Get discounts on new purchases or store credit (5)	_____ Get discounts on new purchases or store credit (5)
_____ Distance (11)	_____ Distance (11)	_____ Distance (11)
_____ Earn Cash (12)	_____ Earn Cash (12)	_____ Earn Cash (12)

24. What is the maximum distance you are willing to travel to participate in a collection program to donate/reuse/recycle your unwanted textiles? *Select one response.*

    ____ **Walk more than 10 minutes** to a drop off point (1)
    ____ **Walk 6 to 10 minutes** to a drop off point (2)
    ____ **Walk 1 to 5 minutes** to a drop off point (3)
    ____ **Drive more than 15 minutes** to a drop off point (4)
    ____ **Drive 6 to 15 minutes** to a drop off point (5)
    ____ **Drive 1 to 5 minutes** to a drop off point (6)
    ____ I would go to a drop off point **only if it were along the way to another destination** (7)
    ____ I would participate only if the unwanted textiles were **picked up from my home** (e.g., curbside pick-up or door-to-door service) (8)
    ____ I **would not participate** regardless of how close by the program is (9)

25. To what extent do you agree or disagree with the following statement? *Select one response.*

    "I would be willing to pay for a **convenient** donation/reuse/recycling program"

    ____ Strongly agree (1)
    ____ Agree (2)
    ____ Somewhat agree (3)
    ____ Neither agree nor disagree (4)
    ____ Somewhat disagree (5)
    ____ Disagree (6)
    ____ Strongly disagree (7)

26. In an average month, how many items of clothing does your household buy (not including socks or underwear)? *Select one response.*

    ____ More than 15 (1)
    ____ 11-15 (2)
    ____ 6-10 (3)
    ____ 3-5 (4)
    ____ 1-2 (5)
    ____ <1 (6)

27. Is there anything else about unwanted textiles that you would like to share?

Demographic Information. Individual responses will remain confidential.

28. What is your age? *Select one response.*

    ____ Younger than 18 years old (1)
    ____ 18-24 (2)
    ____ 25-34 (3)
    ____ 35-44 (4)
    ____ 45-54 (5)
    ____ 55-64 (6)
    ____ 65 or older (7)
    ____ I prefer not to answer (8)

29. What is your gender identity? *Select one response.*

    ____ Male (1)

_____ Female (2)
_____ Non-Binary (3)
_____ Other (4)
_____ I prefer not to answer (5)

30. What is your ethnic identity? *Select all that apply.*

_____ African American (1)
_____ Alaska Native (2)
_____ American Indian (3)
_____ Asian (4)
_____ Black (5)
_____ Hispanic (6)
_____ Latino/a (7)
_____ Native Hawaiian (8)
_____ Pacific Islander (9)
_____ White (10)
_____ Other (11)
_____ I prefer not to answer (12)

31. How many people (adults and kids under 18) live in your household? *Please provide a response for each. If it is just you, please enter 1 for adults and 0 for kids.*

_____ Adults (1)
_____ Kids (2)

32. In what type of home do you live? *Select one response.*

_____ A one-family house, detached from any other houses (1)
_____ A one-family house, attached to one or more houses (2)
_____ An apartment building under 5 stories (3)
_____ An apartment building with 5-10 stories (4)
_____ An apartment building over 10 stories (5)
_____ A mobile home (6)
_____ Other (please specify) (7)

33. What is your annual household income before taxes? *Select one response.*

_____ Not currently employed (1)
_____ Less than $20,000 (2)
_____ $20,000 to $44,999 (3)
_____ $45,000 to $74,999 (8)
_____ $75,000 to $99,999 (9)
_____ $100,000 to $149,999 (4)
_____ More than $150,000 (6)
_____ I prefer not to answer (7)

34. What is your U.S. Zip Code?

35. In what type of community do you live?

_____ Rural (1)
_____ Urban (2)
_____ Suburban (3)

36. If you would like to be entered for the gift card drawing, please provide the following information:

Name (1) ____

Email (2) ____

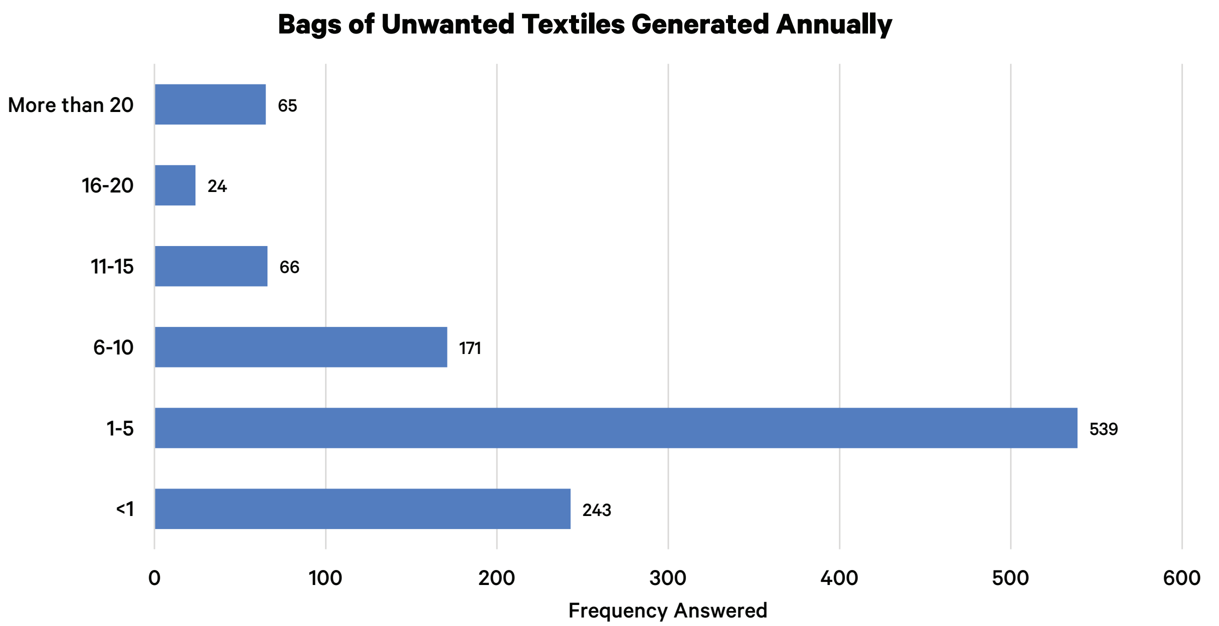
Thank you for completing this survey. Your responses will play an important role in reducing textile waste. If you entered for the gift card drawing, you will be notified if your name is drawn. Please allow 3-4 weeks for processing.

 Funding provided by the Environmental Protection Fund administered by the New York State Department of Environmental Conservation.

Survey Results

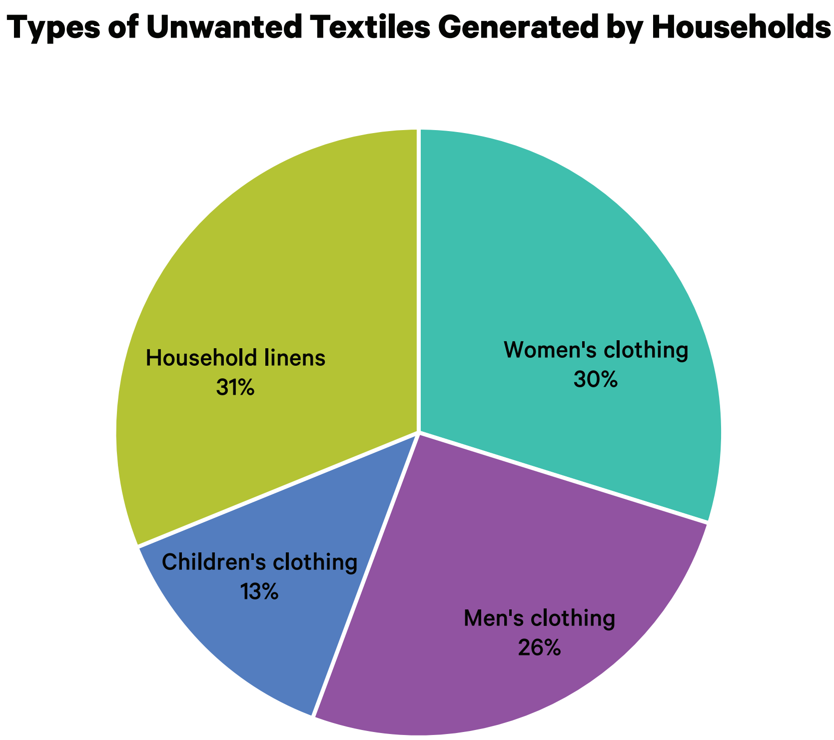
1. How many bags of unwanted textiles does your household generate annually? Estimate in terms of medium-sized kitchen trash bags. Select one response.

Bags of Unwanted Textiles Generated Annually	Total Answered	Answer Percentage
<1	243	21.9%
1-5	539	48.6%
6-10	171	15.4%
11-15	66	6.0%
16-20	24	2.2%
More than 20	65	5.9%



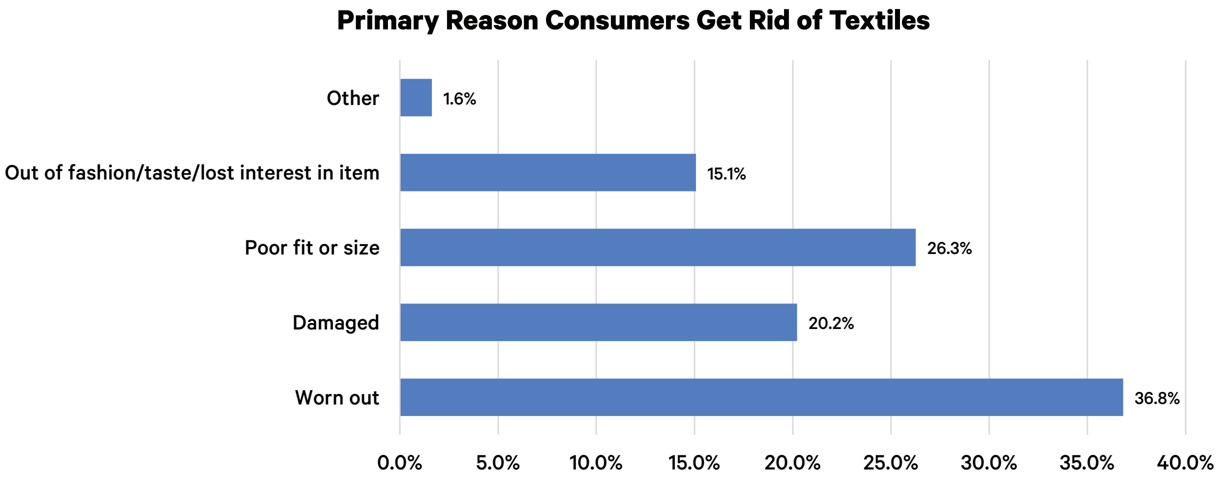
2. What kinds of unwanted textiles does your household generate? Select all that apply.

Types of Unwanted Textiles Generated	Total Answered	Answer Percentage
Women's clothing	760	29.8%
Men's clothing	659	25.9%
Children's clothing	336	13.2%
Household linens (e.g., blankets, linens, curtains, bedding, towels, napkins, tablecloths, etc.)	794	31.1%



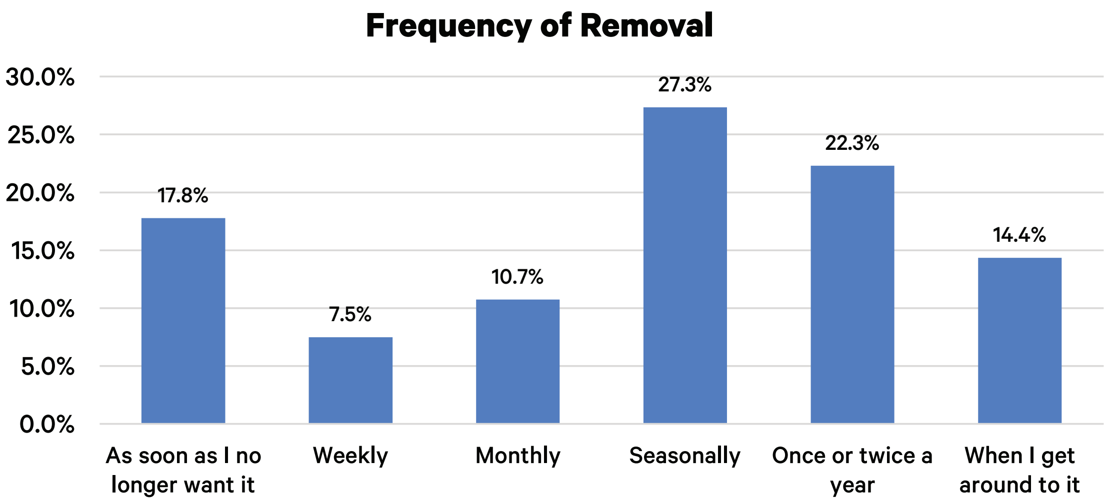
3. What are the main reasons you no longer want or need textiles? Please rank each reason from 1-5 in order of importance, with 1 being the most important.

Reason for unwanted textiles	Primary Reason Total Answered	Secondary Reason Total Answered	Primary Reason %	Secondary Reason %
Worn out	408	330	36.8%	29.8%
Damaged	224	320	20.2%	28.9%
Poor fit or size	291	270	26.3%	24.4%
Out of fashion/taste/lost interest in item	167	181	15.1%	16.3%
Other	18	7	1.6%	0.6%



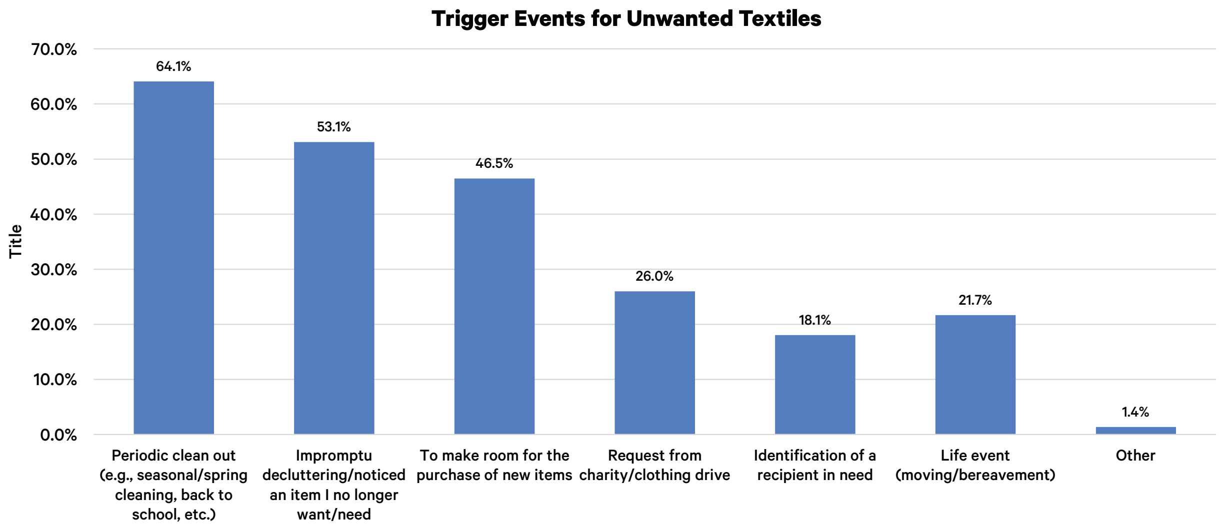
4. About how often do you remove unwanted textiles from your home? Select one response.

Frequency for Textile Removal from Home	Total Answered	Answer Percentage
As soon as I no longer want it	197	17.8%
Weekly	83	7.5%
Monthly	119	10.7%
Seasonally	303	27.3%
Once or twice a year	247	22.3%
When I get around to it	159	14.4%



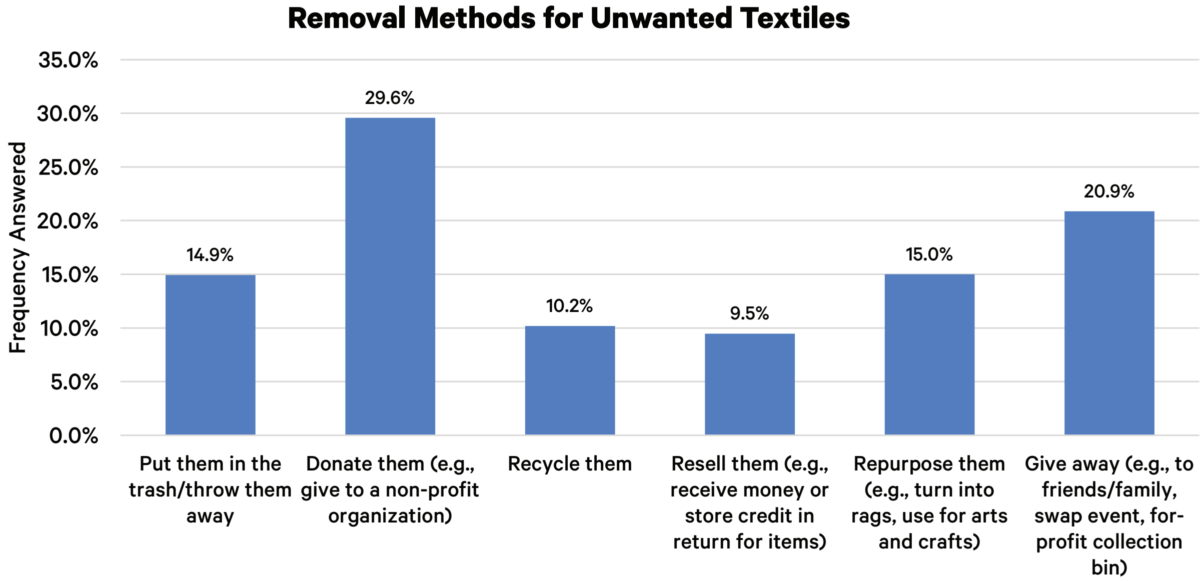
5. At what point(s) do you identify textiles that you no longer want or need? Select all that apply.

Activator Events for Unwanted Textiles	Total Answered	Answer Percentage
Periodic clean out (e.g., seasonal/spring cleaning, back to school, etc.)	710	27.8%
Impromptu decluttering/noticed an item I no longer want/need	588	23.0%
To make room for the purchase of new items	515	20.1%
Request from charity/clothing drive	288	11.3%
Identification of a recipient in need	200	7.8%
Life event (moving/bereavement)	240	9.4%
Other	15	0.6%



6. In what way(s) do you get rid of textiles that you no longer want or need? Select all that apply.

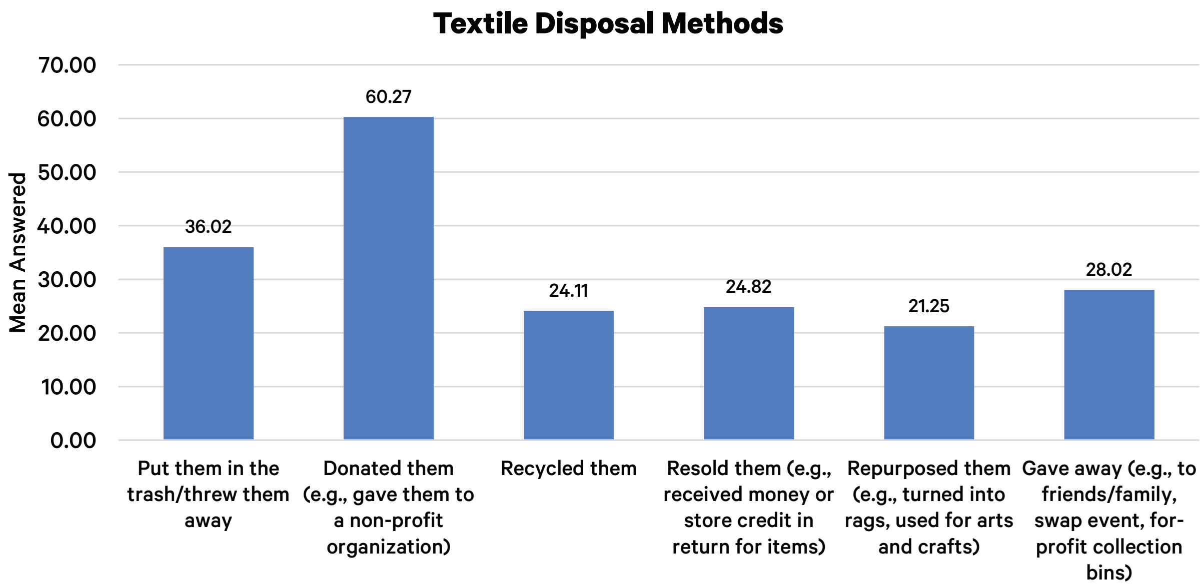
Removal Methods for Unwanted Textiles	Total Answered	Answer Percentage
Put them in the trash/throw them away	432	14.9%
Donate them (e.g., give to a non-profit organization)	856	29.6%
Recycle them	295	10.2%
Resell them (e.g., receive money or store credit in return for items)	274	9.5%
Repurpose them (e.g., turn into rags, use for arts and crafts)	434	15.0%
Give away (e.g., to friends/family, swap event, for-profit collection bin)	604	20.9%



7. No Question 7?

8. In the past 12 months, what percentages of your unwanted textiles were disposed through each of the following? Percentages must sum to 100.

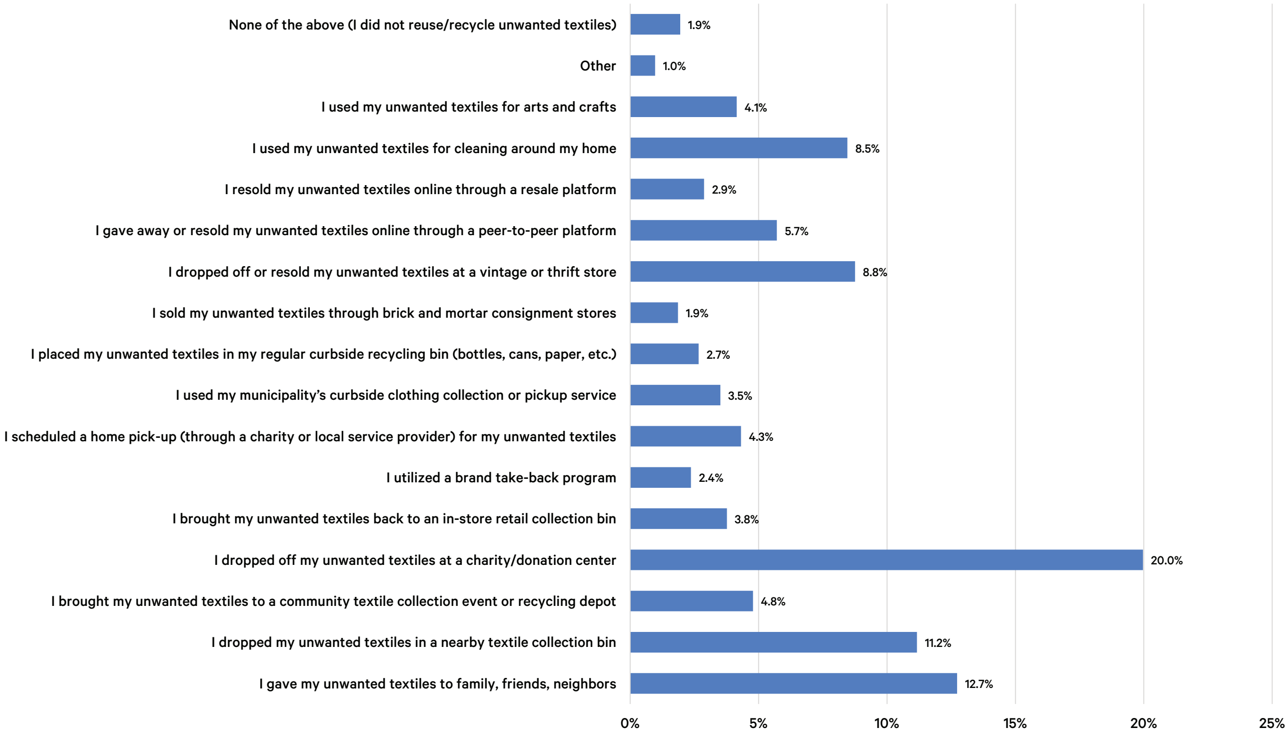
Textile Disposal Methods	Mean Answer
Put them in the trash/threw them away	36.02
Donated them (e.g., gave them to a non-profit organization)	60.27
Recycled them	24.11
Resold them (e.g., received money or store credit in return for items)	24.82
Repurposed them (e.g., turned into rags, used for arts and crafts)	21.25
Gave away (e.g., to friends/family, swap event, for-profit collection bins)	28.02



9. Which textile donation/reuse/recycling/resale options have you participated in during the past 12 months? Select all that apply.

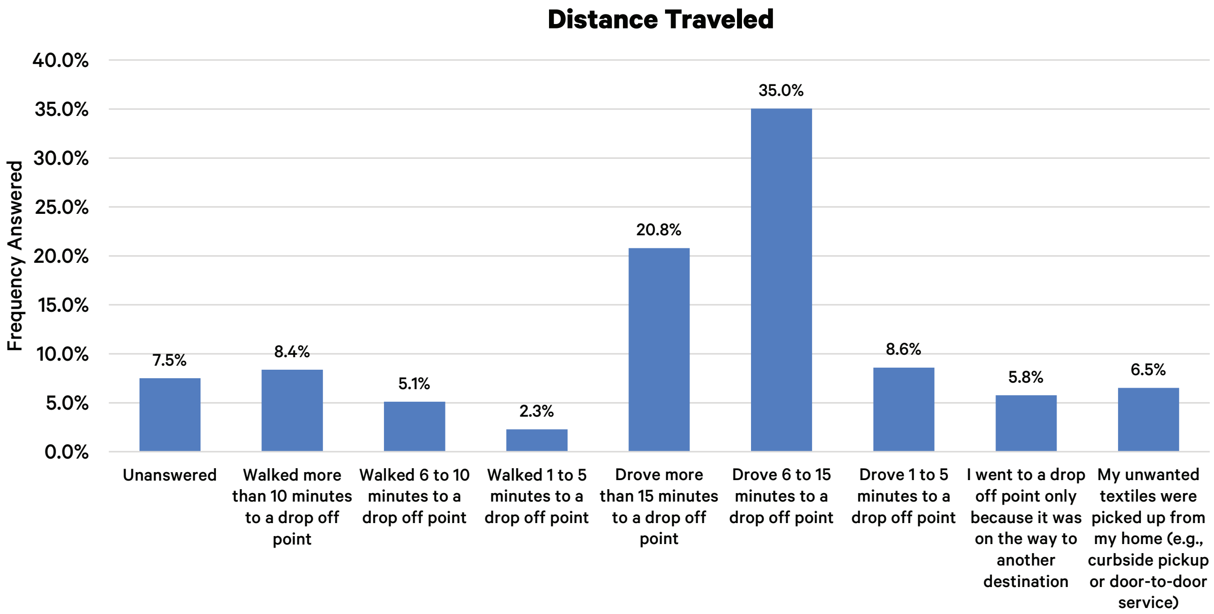
Textile Donation Methods	Total Answered	Answer Percentage
I gave my unwanted textiles to family, friends, neighbors (e.g., hand-me-downs, swap events)	301	12.7%
I dropped my unwanted textiles in a nearby textile collection bin (e.g., in a store parking lot)	264	11.2%
I brought my unwanted textiles to a community textile collection event or recycling depot	113	4.8%
I dropped off my unwanted textiles at a charity/donation center	472	20.0%
I brought my unwanted textiles back to an in-store retail collection bin	89	3.8%
I utilized a brand take-back program (i.e., when a fashion brand takes or buys back garments)	56	2.4%
I scheduled a home pick-up (through a charity or local service provider) for my unwanted textiles	102	4.3%
I used my municipality's curbside clothing collection or pickup service	83	3.5%
I placed my unwanted textiles in my regular curbside recycling bin (bottles, cans, paper, etc.)	63	2.7%
I sold my unwanted textiles through brick and mortar consignment stores	44	1.9%
I dropped off or resold my unwanted textiles at a vintage or thrift store	207	8.8%
I gave away or resold my unwanted textiles online through a peer-to-peer platform (e.g., Facebook Marketplace, Craigslist, NextDoor, Mercari, eBay, etc.)	135	5.7%
I resold my unwanted textiles online through a resale platform (e.g., ThredUp, Poshmark, Recurate, The RealReal, etc.)	68	2.9%
I used my unwanted textiles for cleaning around my home	200	8.5%
I used my unwanted textiles for arts and crafts	98	4.1%
Other	23	1.0%
None of the above (I did not reuse/recycle unwanted textiles)	46	1.9%

Textile Donation Methods



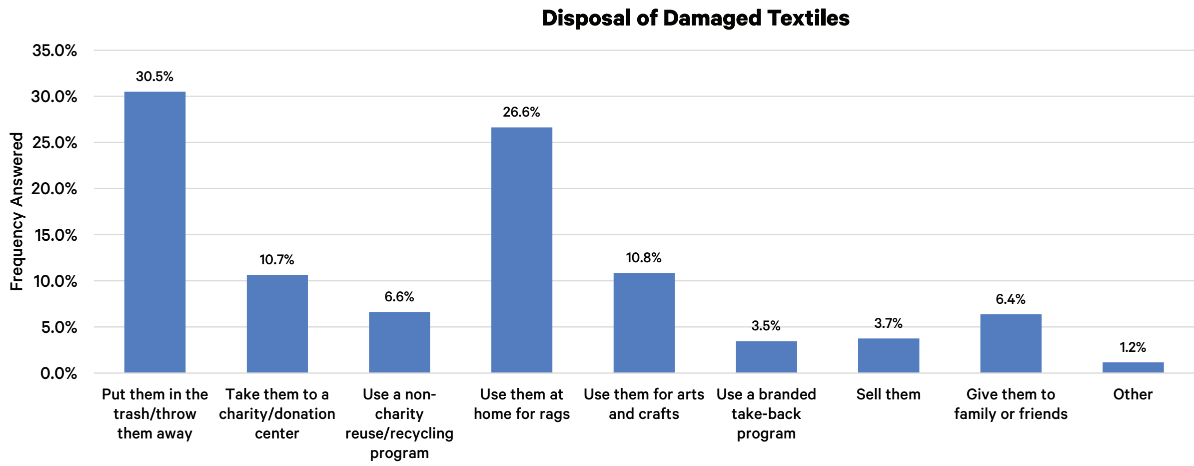
10. In the past 12 months, what was the maximum distance you traveled to donate/ reuse/ recycle your unwanted textiles? Select one response.

Distance Traveled	Total Answered	Answer Percentage
Unanswered	69	7.5%
Walked more than 10 minutes to a drop off point	77	8.4%
Walked 6 to 10 minutes to a drop off point	47	5.1%
Walked 1 to 5 minutes to a drop off point	21	2.3%
Drove more than 15 minutes to a drop off point	191	20.8%
Drove 6 to 15 minutes to a drop off point	322	35.0%
Drove 1 to 5 minutes to a drop off point	79	8.6%
I went to a drop off point only because it was on the way to another destination	53	5.8%
My unwanted textiles were picked up from my home (e.g., curbside pickup or door-to-door service)	60	6.5%



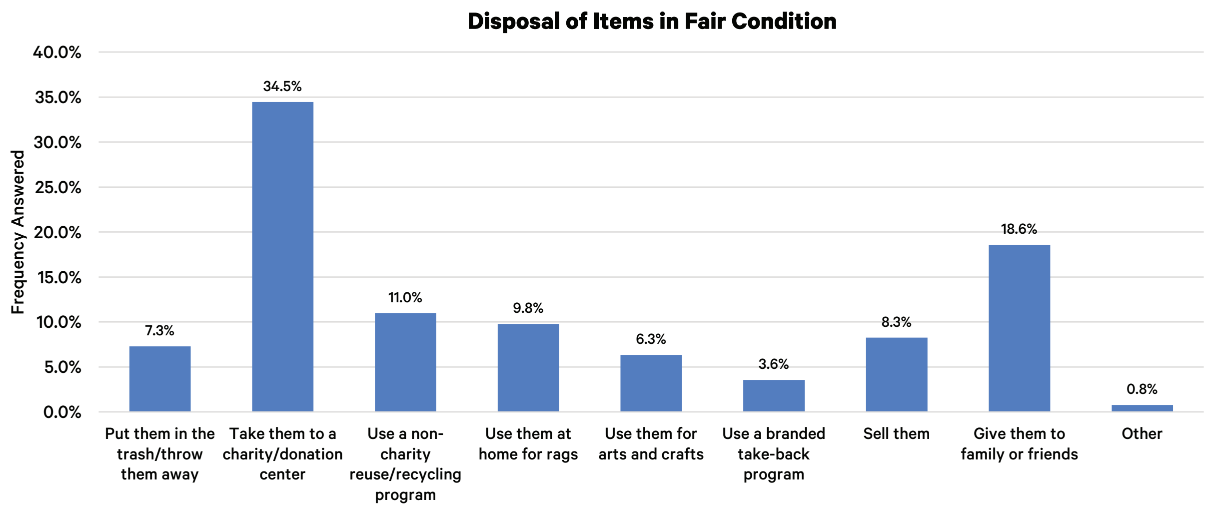
11. What do you usually do with unwanted textiles that are ripped, torn, or stained? Select all that apply.

Disposal of Damaged Textiles	Total Answered	Answer Percentage
Put them in the trash/throw them away	636	30.5%
Take them to a charity/donation center	222	10.7%
Use a non-charity reuse/recycling program	138	6.6%
Use them at home for rags	555	26.6%
Use them for arts and crafts	226	10.8%
Use a branded take-back program	72	3.5%
Sell them	78	3.7%
Give them to family or friends	133	6.4%
Other	24	1.2%



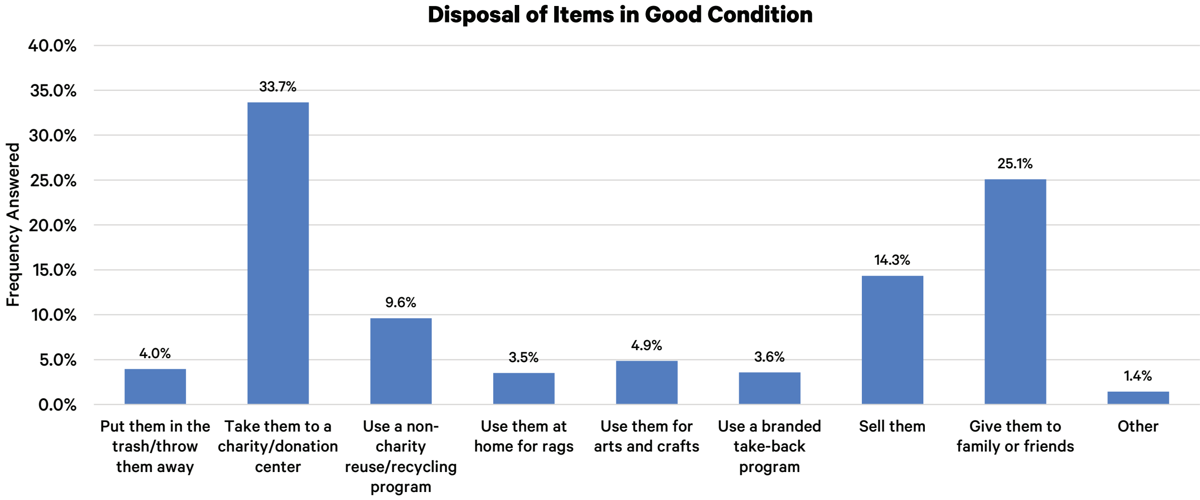
12. What do you usually do with unwanted textiles that are in fair condition? Select all that apply.

Disposal of Textiles in Fair Condition	Total Answered	Answer Percentage
Put them in the trash/throw them away	152	7.3%
Take them to a charity/donation center	718	34.5%
Use a non-charity reuse/recycling program	229	11.0%
Use them at home for rags	204	9.8%
Use them for arts and crafts	132	6.3%
Use a branded take-back program	74	3.6%
Sell them	172	8.3%
Give them to family or friends	387	18.6%
Other	16	0.8%



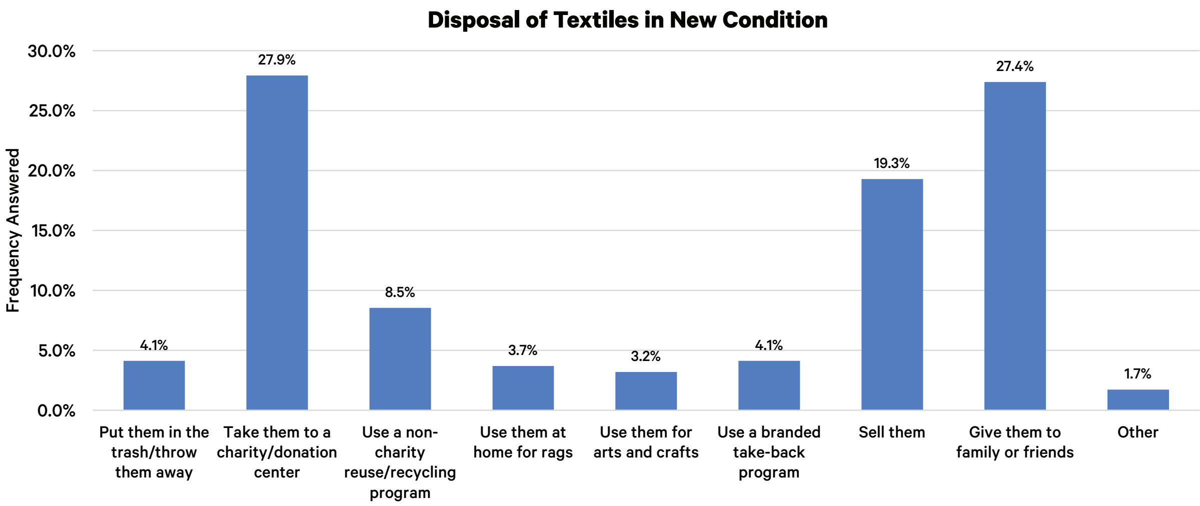
13. What do you usually do with unwanted textiles that are in good or very good condition? Select all that apply.

Disposal of Textiles in Good Condition	Total Answered	Answer Percentage
Put them in the trash/throw them away	83	4.0%
Take them to a charity/donation center	707	33.7%
Use a non-charity reuse/recycling program	202	9.6%
Use them at home for rags	74	3.5%
Use them for arts and crafts	102	4.9%
Use a branded take-back program	75	3.6%
Sell them	301	14.3%
Give them to family or friends	527	25.1%
Other	30	1.4%



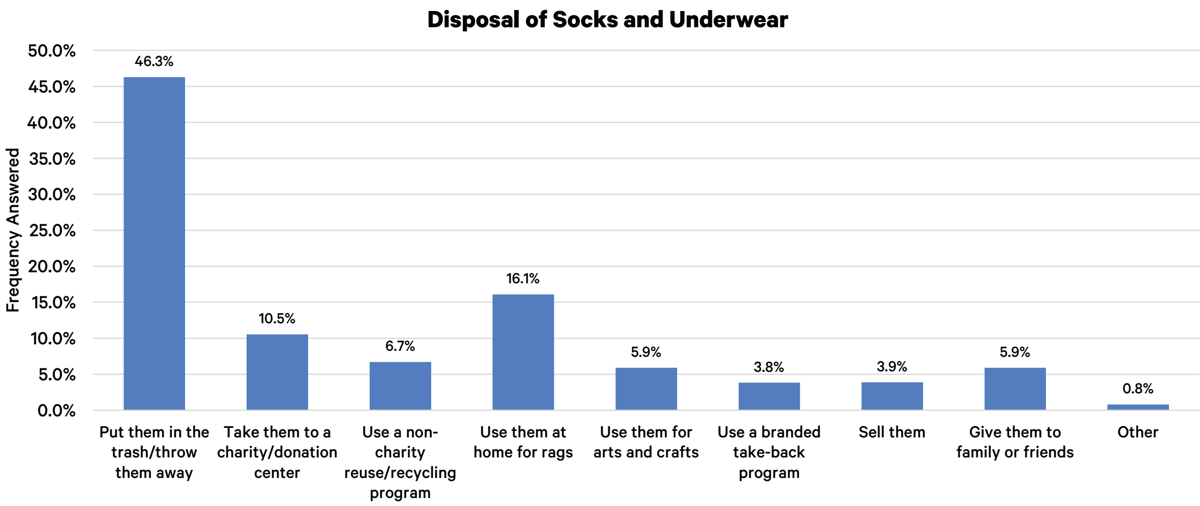
14. What do you usually do with unwanted textiles that are in new and unused condition? Select all that apply.

Disposal of Textiles in New Condition	Total Answered	Answer Percentage
Put them in the trash/throw them away	84	4%
Take them to a charity/donation center	569	28%
Use a non-charity reuse/recycling program	174	9%
Use them at home for rags	75	4%
Use them for arts and crafts	65	3%
Use a branded take-back program	84	4%
Sell them	393	19%
Give them to family or friends	558	27%
Other	35	2%



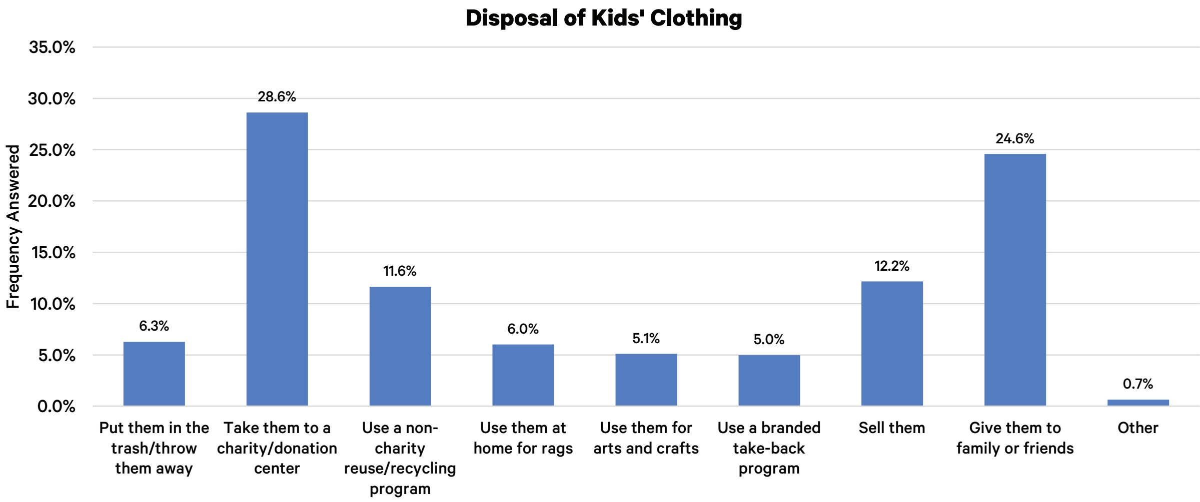
15. What do you usually do with used underwear and socks that you no longer want or need? Select all that apply.

Disposal of Socks and Underwear	Total Answered	Answer Percentage
Put them in the trash/throw them away	759	46.3%
Take them to a charity/donation center	173	10.5%
Use a non-charity reuse/recycling program	110	6.7%
Use them at home for rags	264	16.1%
Use them for arts and crafts	97	5.9%
Use a branded take-back program	63	3.8%
Sell them	64	3.9%
Give them to family or friends	97	5.9%
Other	13	0.8%



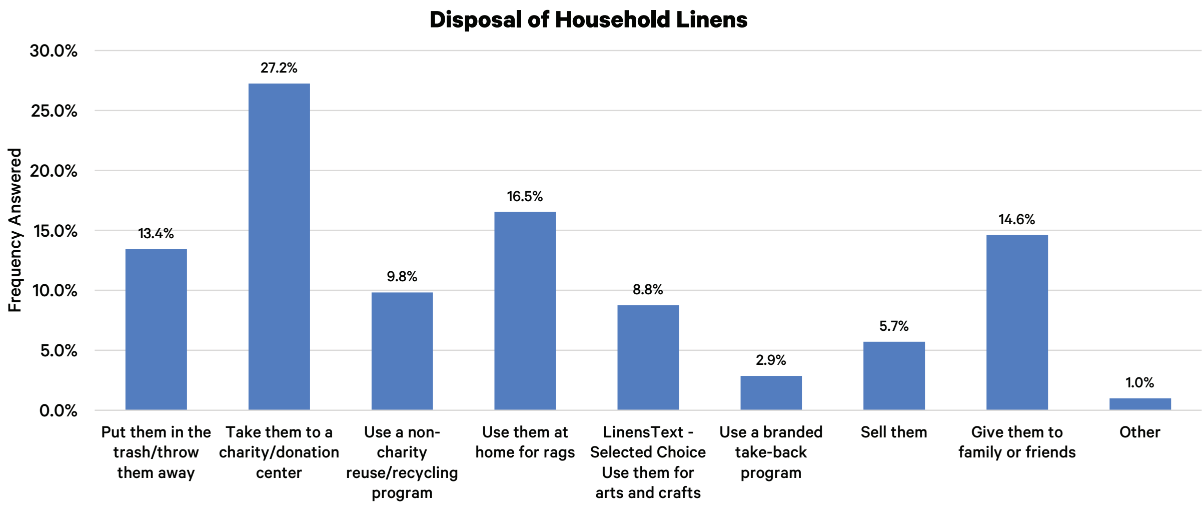
16. What do you usually do with kid's clothing that you no longer want or need? Select all that apply.

Disposal of Kid's Clothing	Total Answered	Answer Percentage
Put them in the trash/throw them away	48	6.3%
Take them to a charity/donation center	219	28.6%
Use a non-charity reuse/recycling program	89	11.6%
Use them at home for rags	46	6.0%
Use them for arts and crafts	39	5.1%
Use a branded take-back program	38	5.0%
Sell them	93	12.2%
Give them to family or friends	188	24.6%
Other	5	0.7%



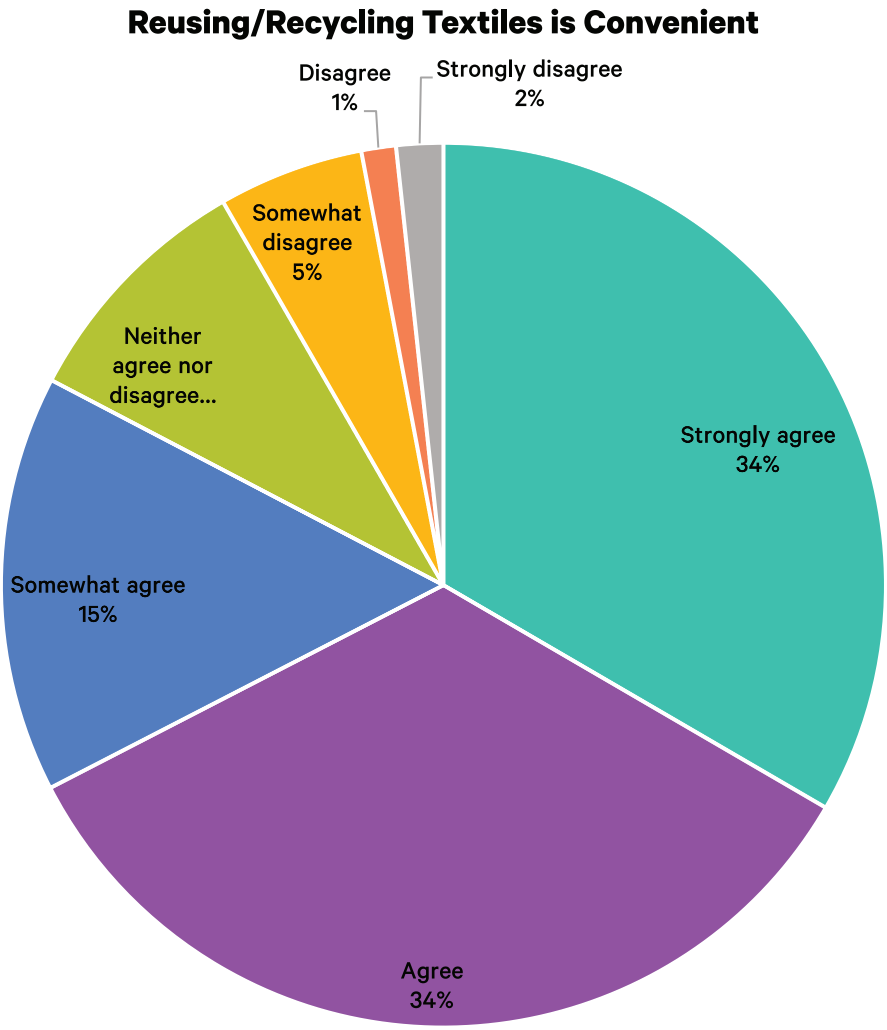
17. What do you usually do with household linens (e.g., blankets, sheets, curtains, bedding, towels, napkins, tablecloths, etc.) that you no longer want or need? Select all that apply.

Disposal of Household Linens	Total Answered	Answer Percentage
Put them in the trash/throw them away	216	13.4%
Take them to a charity/donation center	438	27.2%
Use a non-charity reuse/recycling program	158	9.8%
Use them at home for rags	266	16.5%
LinensText - Selected Choice Use them for arts and crafts	141	8.8%
Use a branded take-back program	46	2.9%
Sell them	92	5.7%
Give them to family or friends	235	14.6%
Other	16	1.0%



18. To what extent do you agree or disagree with the following statement? Select one response. "Reusing/recycling textiles is convenient."

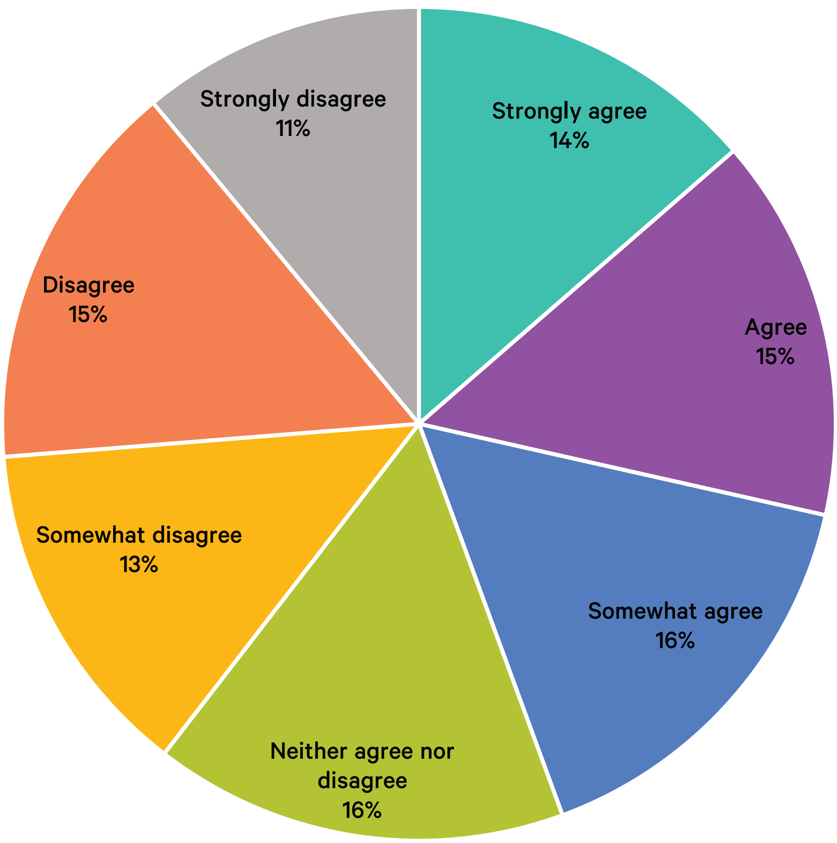
Reusing/recycling textiles is convenient	Total Answered	Answer Percentage
Strongly agree	370	33.4%
Agree	377	34.0%
Somewhat agree	169	15.3%
Neither agree nor disagree	100	9.0%
Somewhat disagree	59	5.3%
Disagree	14	1.3%
Strongly disagree	19	1.7%



19. To what extent do you agree or disagree with the following statement? Select one response. “I have convenient access to repair services for textiles.”

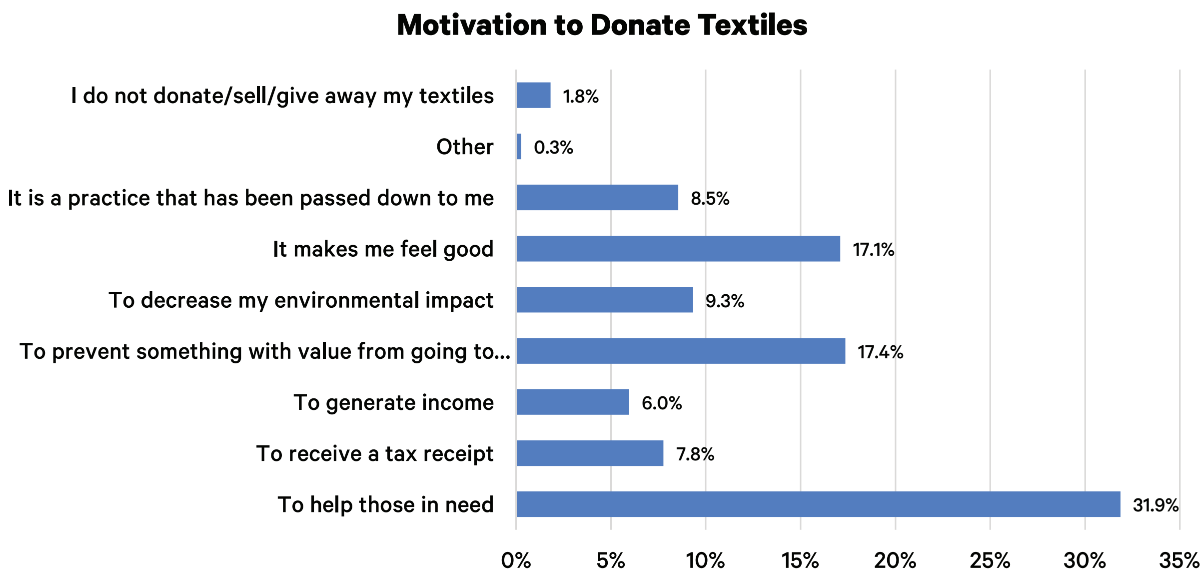
I have convenient access to repair services for textiles	Total Answered	Answer Percentage
Strongly agree	151	13.6%
Agree	165	14.9%
Somewhat agree	176	15.9%
Neither agree nor disagree	178	16.1%
Somewhat disagree	147	13.3%
Disagree	169	15.3%
Strongly disagree	122	11.0%

I have convenient access to repair services for textiles



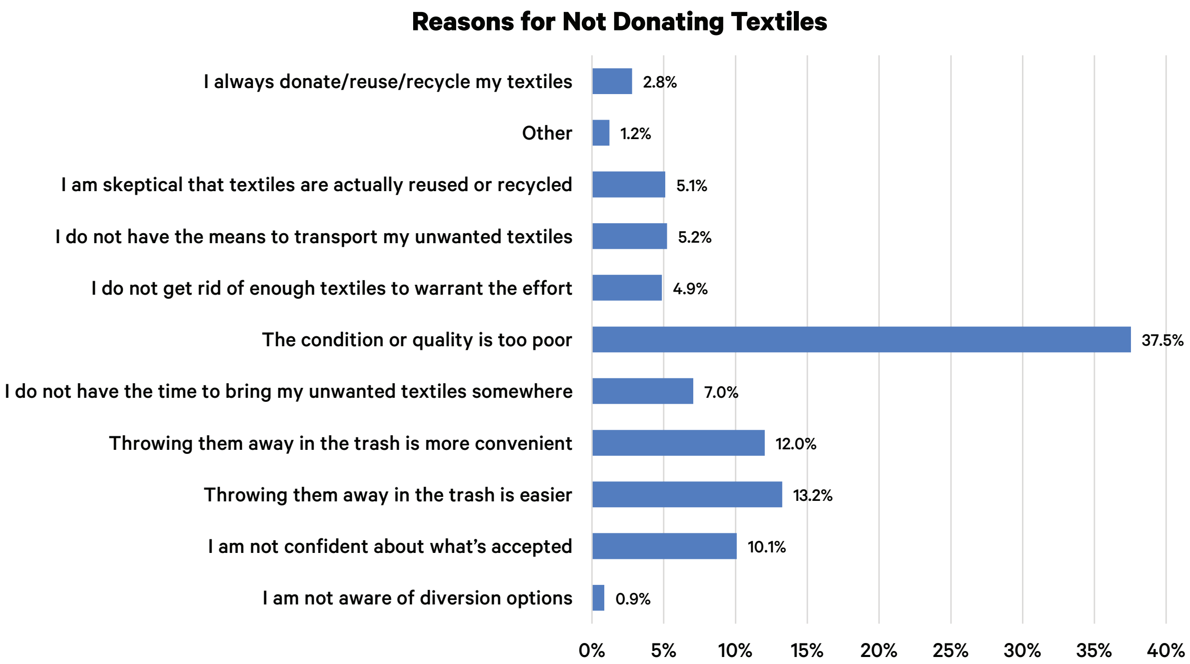
20. What motivates you to donate/sell/give away your unwanted textiles? Select up to 3.

Motivation to Donate Textiles	Total Answered	Answer Percentage
To help those in need	123	31.9%
To receive a tax receipt	30	7.8%
To generate income	23	6.0%
To prevent something with value from going to landfill/incineration	67	17.4%
To decrease my environmental impact	36	9.3%
It makes me feel good	66	17.1%
It is a practice that has been passed down to me	33	8.5%
Other	1	0.3%
I do not donate/sell/give away my textiles	7	1.8%



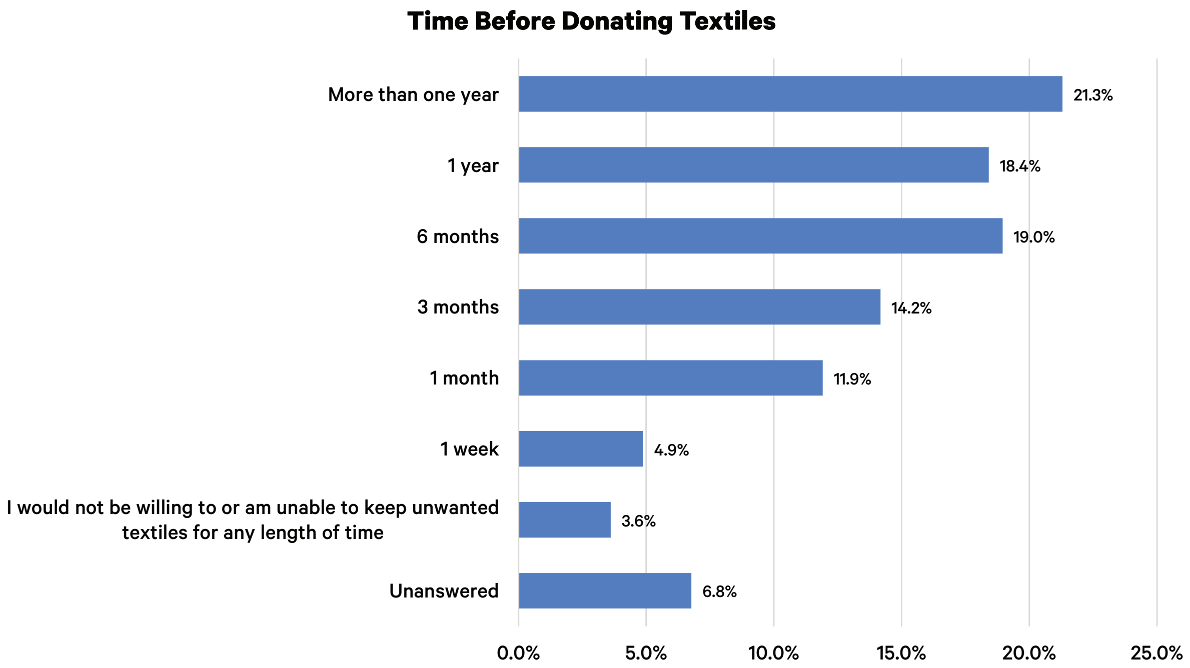
21. For what reasons do you throw away unwanted textiles in the trash instead of donating/reusing/recycling/reselling them? Select up to 3.

Reasons for Not Donating Textiles	Total Answered	Answer Percentage
I am not aware of diversion options	0.9%	7
I am not confident about what's accepted	10.1%	83
Throwing them away in the trash is easier	13.2%	109
Throwing them away in the trash is more convenient	12.0%	99
I do not have the time to bring my unwanted textiles somewhere	7.0%	58
The condition or quality is too poor	37.5%	309
I do not get rid of enough textiles to warrant the effort	4.9%	40
I do not have the means to transport my unwanted textiles	5.2%	43
I am skeptical that textiles are actually reused or recycled	5.1%	42
Other	1.2%	10
I always donate/reuse/recycle my textiles	2.8%	23



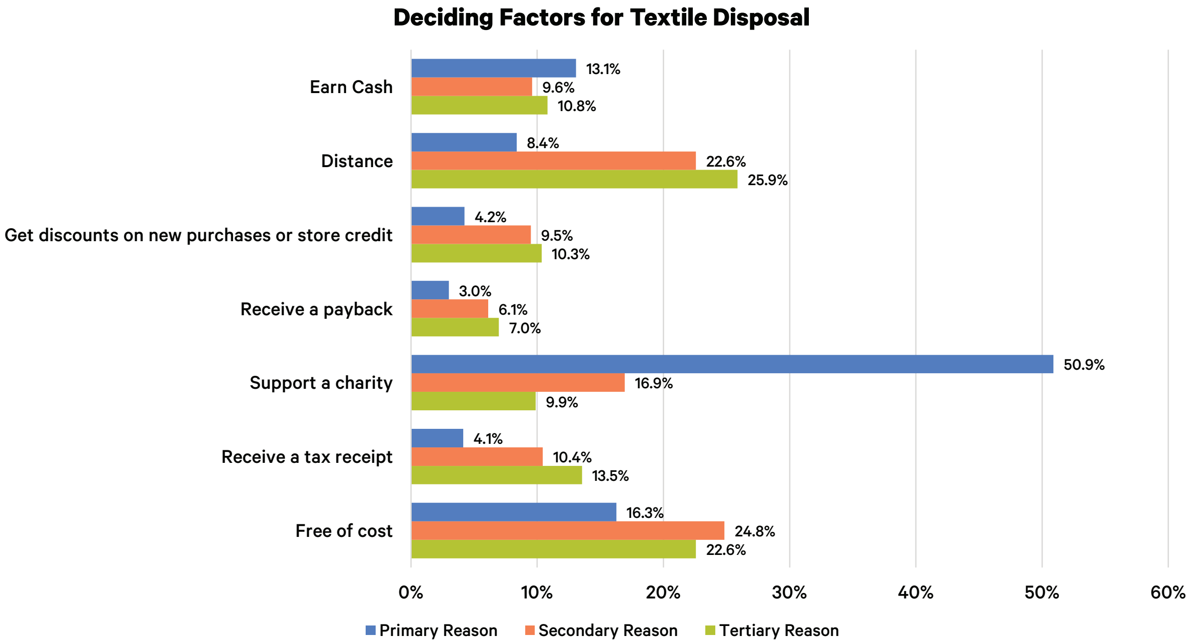
22. How long do you hold onto unwanted textiles before donating/selling/recycling/giving them away? Select one response.

Time Before Donating Textiles	Total Answered	Answer Percentage
Unanswered	75	6.8%
I would not be willing to or am unable to keep unwanted textiles for any length of time	40	3.6%
1 week	54	4.9%
1 month	132	11.9%
3 months	157	14.2%
6 months	210	19.0%
1 year	204	18.4%
More than one year	236	21.3%



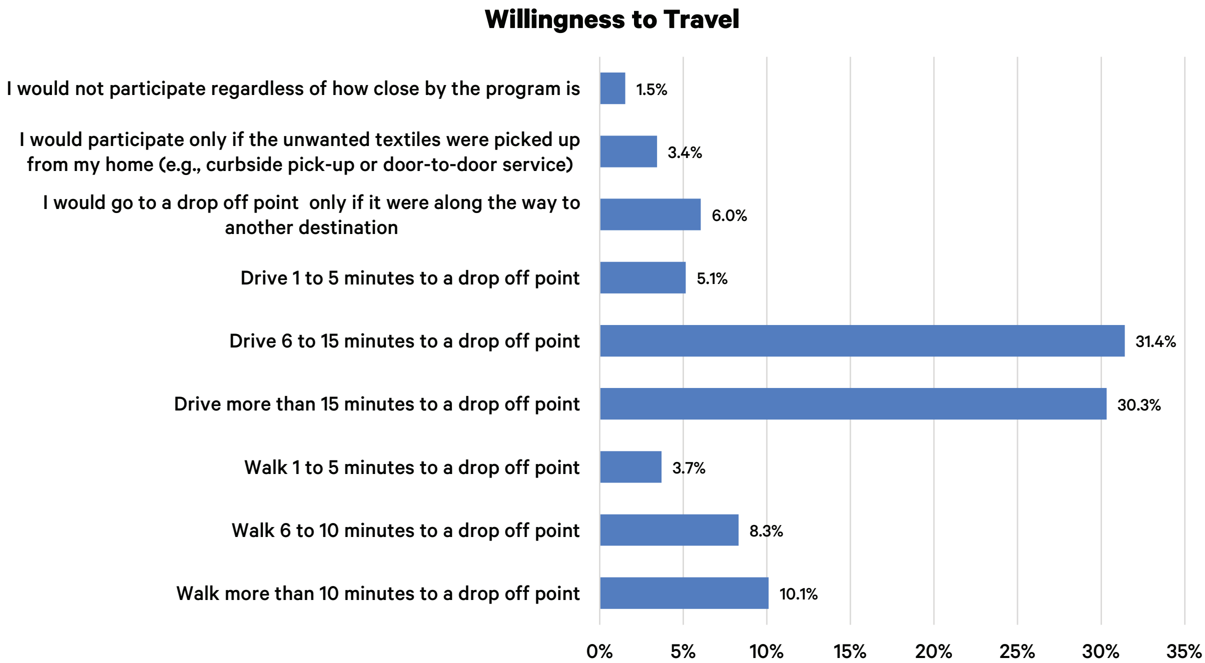
23. What are the most important factors when considering how to dispose of your unwanted textiles? Select and rank up to 3.

Deciding Factors for Textile Disposal	Primary Reason	Secondary Reason	Tertiary Reason
Free of cost	16%	25%	22.6%
Receive a tax receipt	4%	10%	13.5%
Support a charity	51%	17%	9.9%
Receive a payback	3%	6%	7.0%
Get discounts on new purchases or store credit	4%	10%	10.3%
Distance	8%	23%	25.9%
Earn Cash	13%	10%	10.8%



24. What is the maximum distance you are willing to travel to participate in a collection program to donate/reuse/recycle your unwanted textiles? Select one response.

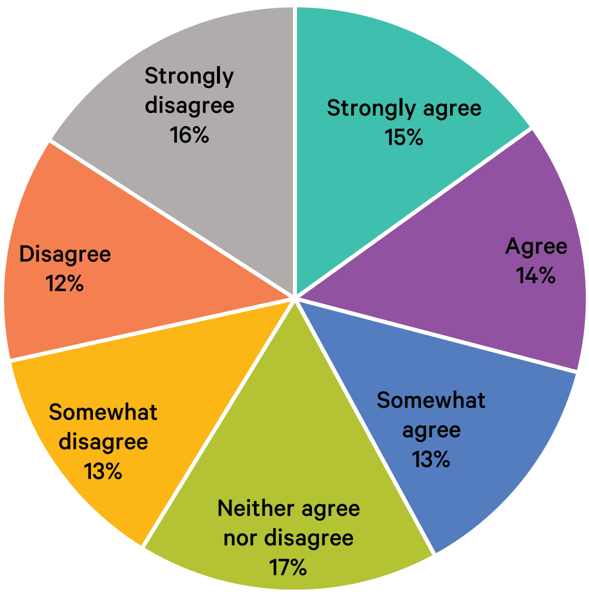
Willingness to Travel	Total Answered	Answer Percentage
Walk more than 10 minutes to a drop off point	112	10.1%
Walk 6 to 10 minutes to a drop off point	92	8.3%
Walk 1 to 5 minutes to a drop off point	41	3.7%
Drive more than 15 minutes to a drop off point	336	30.3%
Drive 6 to 15 minutes to a drop off point	348	31.4%
Drive 1 to 5 minutes to a drop off point	57	5.1%
I would go to a drop off point only if it were along the way to another destination	67	6.0%
I would participate only if the unwanted textiles were picked up from my home (e.g., curbside pick-up or door-to-door service)	38	3.4%
I would not participate regardless of how close by the program is	17	1.5%



25. To what extent do you agree or disagree with the following statement? Select one response. “I would be willing to pay for a convenient donation/reuse/recycling program”

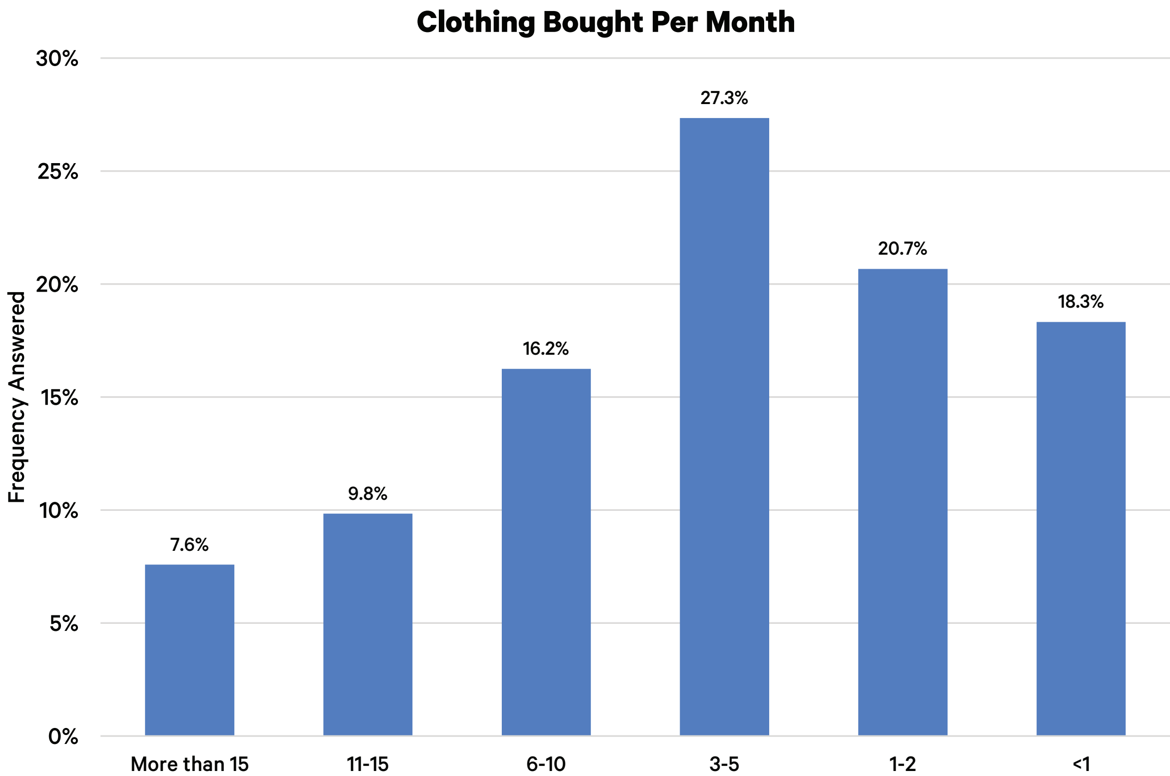
I would be willing to pay for a convenient donation/reuse/recycling program	Total Answered	Answer Percentage
Strongly agree	167	15.1%
Agree	155	14.0%
Somewhat agree	144	13.0%
Neither agree nor disagree	185	16.7%
Somewhat disagree	142	12.8%
Disagree	139	12.5%
Strongly disagree	176	15.9%

I would be willing to pay for a convenient donation/reuse/recycling program

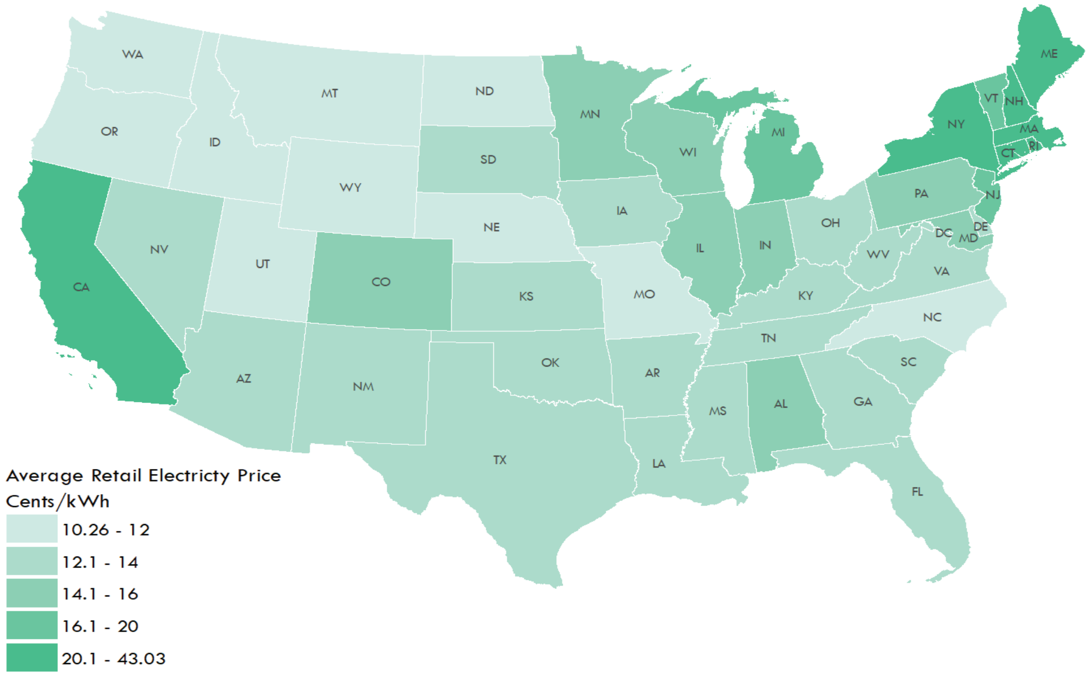


26. In an average month, how many items of clothing does your household buy (not including socks or underwear)? Select one response.

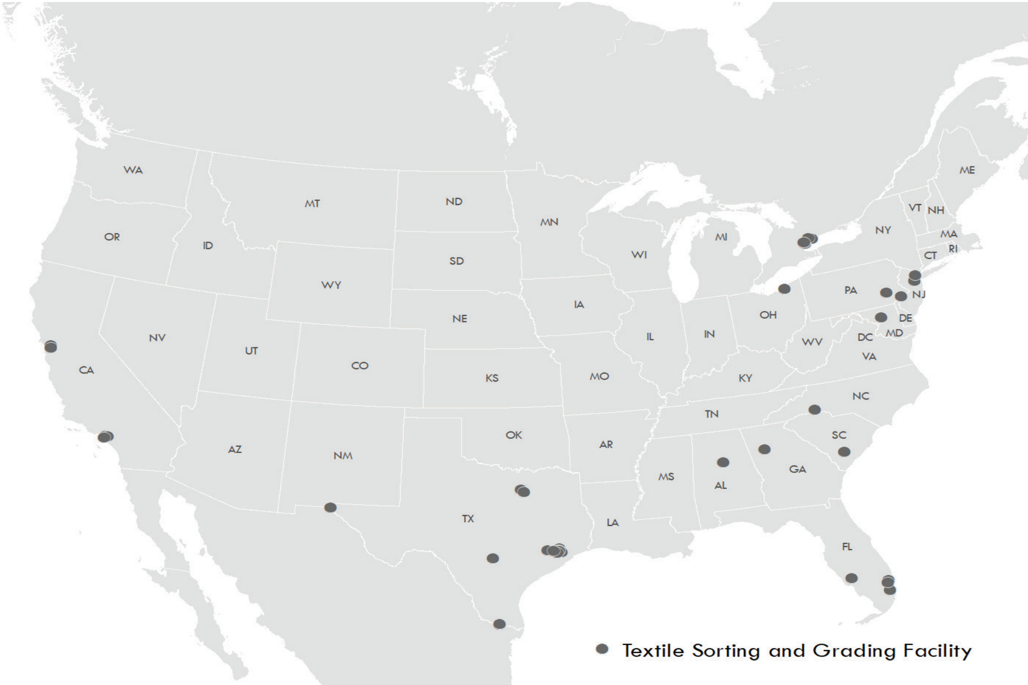
Clothing Bought per Month	Total Answered	Answer Percentage
More than 15	84	7.6%
11-15	109	9.8%
6-10	180	16.2%
3-5	303	27.3%
1-2	229	20.7%
<1	203	18.3%



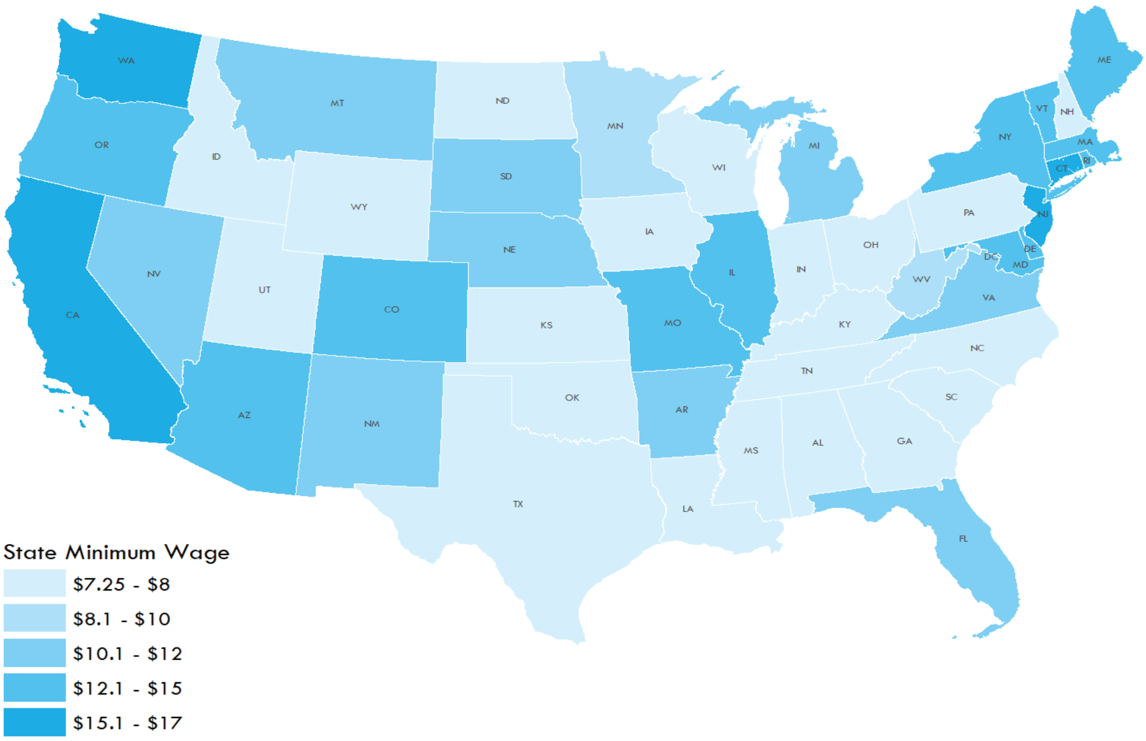
Appendix V - Commercial Landscape Factors Influencing the Siting of Recycling Facilities



U.S. Electricity Rates (2022)



U.S. Sorter and Grader Distribution (Note: Map is not comprehensive)



State Minimum Wage (2024)

Appendix VI - Supportive Policy Mechanisms

Accountability & Reporting

- Supply chain accountability regulations
- Large company disclosure of production and product disposal and destruction
- Mandatory end-of-use tracking and reporting

Standards and Definitions

- Reuse and recycling commodity standards
- Standardized definition of reuse, repurpose, and recycle
- Standardized definition of preparation for reuse and recycling
- Price indices
- Certifications
- Best practices for recycled content offtake agreements
- Model contract language

Waste Management Regulations

- Disposal bans
- Used textile export restrictions
- Mandatory collection

Infrastructure

- Market development grants and technical assistance
- Infrastructure grants
- Advanced recycling regulations and permitting rules

Studies & Education

- State-level textile recovery task force creation
- Research grants
- Needs assessment funding
- Consumer educations campaigns
- Public database of service providers

Product Stewardship

- Extended Producer Responsibility
- Eco-modulated fees
- Design for longevity/durability
- Labeling laws
- Mandatory Digital Passports
- Minimum warranty periods
- Requirement for certain percent of products offered for sale to include reused garments
- Offset growth with reuse

Taxes Incentives and Disincentives

- Revision of agricultural and oil subsidies on virgin inputs
- Virgin material taxes/duties
- Carbon taxes
- Reversal of duty drawbacks on destroyed products
- Discounted shipping rates for used textiles headed to a recovery destination
- Sales tax elimination or reduction for second hand clothing
- Corporate tax credits for brands and retailers that adopt reuse and recycling business models
- Sales tax on mass market products

Product Design

- Mandatory recycled content requirements
- Eco-design requirements

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