










ACCELERATING WORKFORCE DEVELOPMENT IN THE U.S. CIRCULAR TEXTILE ECONOMY

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SUMMARY

As the U.S. textile recycling business shifts from a linear to a circular model, industry stakeholders will face a variety of challenges: technological, structural, and resource-related. Utilizing available data and qualitative elements, this resource provides knowledge and ideas of use to businesspeople, investors, policy planners, and social services with strategic interests in meeting the U.S. workforce challenge now coming into view

This White Paper examines the landscape of workforce development, as related to how textile reuse/recycling jobs will affect the sector's future growth and success, with a focus on textile-to-textile recycling's job creation potential.

—Shelly Gottschamer, Treadletree

I. INTRODUCTION

The purpose of this White Paper is to survey the future employment possibilities for U.S. textile and reuse/recycling workers, as associated industries shift from a linear model to a circular one. This shift to a circular economy (CE) requires the adoption of new technology, but more importantly, to advance decent work opportunities, “sustainable industrial policies and actions will have to be comprehensive, integrated and inclusive.”¹⁴ A textile industry based on circularity will not only optimize resource consumption but will minimize the high environmental costs which the textile industry has identified and taken initial steps to mitigate.¹⁵ How the U.S. workforce can participate in this transition is the entry point for this exploratory White Paper. Through research and stakeholder participation, we take the view that the textile/recycling business is on the cusp of its greatest sea change since the power loom launched the Industrial Revolution.

As with any industry which is disrupted, both winners and losers will result from the transition to a new way of doing business. This report aims to show how our workforce can emerge stronger, while the entities investing in textile circularity can take advantage now of an evolving industry “... in which the material demands of economic growth are recovered from existing human activities”⁴⁷ and waste “can often be seen as valuable resources.”⁵⁷

Research reveals gaps in data, tracking metrics, and cooperative structures within the U.S. recycling/textile industry which would support a more formal analytic framework. Foundational data analytics which other major industries have long employed (banking, healthcare, manufacturing) are under-utilized. Of the top ten U.S. industries identified as employing data science practices, none are associated with recycling/reuse/textiles in the United States⁴⁵. Circularity, and the job creation that goes with it, will depend on improving data capture and exchange. As one stakeholder said, “We are just beginning down the road to data formation.”^H

For example, the EPA’s annual Recycling Economic Information Report 2020 does not break out recycled textile collections. Reported employment of 681,000 reflects the general category and was last updated in 2012⁴². At the time this represented about .5% of total U.S. jobs. Applied to 2021 reported total employment (153 million) this percentage translates into about 765,000 total recycling jobs in the U.S. today.

Solid European data sources make clear the potential for new job creation in a comparable circular economy transition in this country.¹⁰ This transition is gaining strength as public concern puts a spotlight on the facts about textile waste, its disposal, and the complex industry which produces it⁶; **an industry now on its way to viewing its waste stream as a strategic feedstock, and a circular model as “the best long-term solution to securing raw materials for textile manufacturing.”³ Driving this reframing of textile waste’s untapped value is breakthrough technology now coming online. A COO observes, “The opportunity is massive,” along with the potential for massive job**



growth.^A Once processing at scale, this renewed industry will require “the creation of new jobs and skills in relation to the preparation of these textiles for recycling.”⁶²

Operational plants are now confirming that textile-to-textile recycling technologies are ready to compete on price and quality with virgin resource-based textiles. A two-year trial encompassing 22 US companies – from yarn spinner and fabric producers to major retail brands – is “about to demonstrate some real products made in circular systems.”⁶¹

Currently over 13 million tons of U.S. textile waste are landfilled/incinerated annually⁹; part of the “... \$500 billion lost globally each year to clothing underutilization and lack of recycling.”⁶ The need for the textile industry to act differently is clear. “We have to change the way money is invested and spent; we have to shop with brands whose values reflect our own; and we have to change the way we assign value to what we buy and wear.”⁴⁹

Meanwhile the primary driver for our marketplace economy – the U.S. consumer – has already made plain its support for an eco-minded ethos, with a Global Fashion Agenda report showing that 75% of consumers view sustainability as “extremely or very important,”²⁶ while “nearly half of U.S. consumers say they would definitely or probably change their consumption habits to reduce their impact on the environment.”⁴⁵ From 2015-2019, the total market share of “sustainably-marketed products” grew by 54.7%, and continues to gain cross-category strength.⁹

This rise in “ethical consumerism” will help stimulate the transition from the current “take/make/waste” structure, and its related problems (i.e., child labor, resource destruction) to a CE, with its ethical, sustainable advantages.⁵⁰ Along the way, yielding critical environmental benefits which media watchdogs now focus on⁷, and a solution to job force creation in the next chapter in the history of the U.S. textile industry.

Review of available knowledge resources reveals that at this time “... social aspects [including employment] are not considered in current circular economy theory.”³ By adjusting the focus on CE to include the many people who do the work of recycling and reusing textiles now, we present a picture of what the future holds for job growth in this category.

METHODOLOGY

By gathering available data, the author presents a quantitative picture of textile recycling employment where possible, and underlying economic data where available. Otherwise the methodology employed is qualitative and interpretive by design.

Two separate surveys (one statistical and one interview-based) were conducted with textile reuse/recycle industry stakeholders, which focus on future employment trends and challenges. (Appendix A and Appendix B) Pilot Projects and Partnerships of interest are listed in Appendix C. Note: units of measure and data specified herein are provided as reported by the original Sources cited in the text.



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DEFINITIONS AND TERMS

As they apply to textile workforce development, some useful definitions follow:

- **Collection** – the recovery of textile waste for reuse, recycling or disposal
- **Feedstock** – Raw textile material supplied to a manufacturer
- **Materials Recovery Facility (MRF)** – industrial space for collected waste
- **Post-Consumer Textile Waste (PCTW)** – any natural or synthetic textile used and discarded by a consumer
- **Post-Industrial Textile Waste (PITW)** – unused floor waste, off cuts, and other leftover textiles recovered from the textile manufacturing process
- **Recycle** – to reprocess recovered textiles into useful material
- **Reuse** – the repurposing/reselling of second-hand garments
- **Shoddy** – a low quality non-woven material or stuffing made from shredded fiber waste, cloth or clippings
- **Sorting** – the process of separating PCTW and PITW into value-based grades
- **Textiles** – any fiber-based cloth or woven/knitted fabric, including felt, carpet, upholstery
- **Textile-to-Textile Recycling** – the circular process of material recovery, reprocessing it into new textile products, then repeating the cycle as these are again discarded
- **Waste Stream** – unwanted textiles, collected and channeled for recycling or disposal
- **Wipers** – recovered low-value textiles converted to industrial wiping cloths

II. TEXTILE WASTE STREAMS: EMPLOYMENT DRIVER

Creation of new textile recycling jobs, first and foremost, is based on simple asset utilization. The EPA reports that 3.8B pounds of post-consumer textile waste (PCTW) are recycled in the U.S. each year – only 13.8% of this total available feedstock.²⁴ The remaining 86.2% goes into landfills or is incinerated. Capturing the value of this wasted asset is the foundation of a highly profitable textile CE.

Secondly, by improving the current PCTW collection rate, we come closer to a CE model that “if managed well... presents opportunities for labor markets, as well as tackling climate change.”¹¹ “It feels like an exciting time for the textile sector ... we’re starting to focus on what needs to change, much greater collections and recycling. I’m sure jobs will be created through that.”^F



III. VALUE CHAIN LANDSCAPE: A DISCONNECTED PICTURE

Versions of the current value chain utilized by the textile sector are based on a legacy structure, which is linear, yet “disconnected,”²⁰ and “highly globalized.”¹⁰ Fashion industry ambition calling for a transitioning to a CE model remains a “new concept yet to be clearly defined.”²⁰

To address this disconnection, two textile value chains (Diagram A and Diagram B) bring all stakeholders into alignment for circular functionality. Both represent supply chain innovation that creates value through the diversion of “huge volumes of waste”⁶.

Value Chain A, the Textile Reuse/Resale model, functions today but does not accommodate the massive stream of PCTW that is considered low value, i.e., fast fashion.³ Revenue and workforce development in the Reuse model will depend on changing consumer behavior, i.e., breaking the habit of trashing unwanted garments and making them available for collection (see Diagram A: Section IV).

“Growth is about changing the mindset of consumers.”^H It’s a set of behaviors that needs to be normalized, and they’re becoming normalized rapidly.”^D

Value Chain B, the Textile-to-Textile Recycle model, incorporates innovative technology which, while yet to be fully commercialized, offers definite advantages that textile reuse does not (see Diagram B: Section V). Its economic advantage is based on the revaluing of vast feedstocks of unwanted and unexploited textile waste. “To achieve a circular system, a new end-market for non-reusable textiles is required.” (Fashion for Good). A business development engineer for a major recycling platform emphasizes their “...focus on the waste textile stream that is not reusable, not rewearable.”^F Other recycling projects (see Pilot Programs) address what the Ellen MacArthur Foundation views as a major challenge: “Existing recycling technology for common materials need to drastically improve their economics and output quality to capture the full value of the materials in recovered clothing.”⁶

Both versions of the current value chain begin with three basic operations, each with associated jobs. Their functions include:

- 1. Collections** – the physical gathering and delivery of textile waste to a Materials Recovery Facility (MRF) domestic or otherwise.
- 2. Sorting** – the separation of textile waste into useful grades
- 3. Distribution** – the graded material is channeled for either reuse or recycling

After distribution, waste textiles are either reused/resold or separated and processed into feedstocks for recycling. Processing this old material into new textile products closes the proposed Textile-to-Textile circular value chain (Diagram B). Exactly how



emerging technology can innovate this process, and lead to robust new job creation, is now on the horizon.

For now, the Reuse circular value chain model, as applied in Diagram A, is not only climate positive, it is already functioning, profitable, and growing fast.

IV. TEXTILE REUSE/RESALE BUSINESS MODEL

Making sense of how these two supply chain models can lead to the creation of new jobs is not strictly a matter of CE theory waiting to be applied. The Year Zero: Circular Fashion Report 2020 forecasts that the U.S. reuse/second-hand apparel market will double within the next five years.²⁰ A collector/upcycler who reports quadrupling their staff in 2021 (to 200 employees) confirms: “Actually textile reuse is ideal for job creation.”^D

The Textile Reuse/Resale model is one of today’s most dynamic apparel business channels, as fundamentally **“reusing an item is considerably more valuable than recycling, based on waste hierarchy.”⁴ Impact of vintage and second-hand garment resale on the fashion industry is already clear. Now growing 25 times faster than overall retail³³, this category juggernaut “... might be the industry’s most potent chance to keep its sustainable promise.” (NowFashion Magazine).**

Confirming this “mainstream phenomena,”⁴⁰ publicly held ETSY (1598 employees) paid \$1.63 billion for the vintage online reseller Depop (400 employees) in fall 2021. Another Wall Street start-up, Rent the Runway (1800 employees) launched as a publicly held entity at the same time (NASDAQ:RENT). According to TechCrunch, its IPO pricing indicates a “bullish market” for growth opportunities like Rent the Runway’s subscription-based used apparel platform.

Wall Street is investing in the U.S. second-hand resale market because its business fundamentals are strong and growing:

- Valued at \$28 billion in 2020
- Forecast to grow to \$64 billion by 2025
- Estimated 64 million unique customers in 2019

Source: (33) ThredUP/Boston Consulting Group

- Retail locations = 19,200+
- Workforce = 201,000+
- Payroll = \$4.18B+

Source: 41 U.S. Census Bureau 2019

As the primary channel for used garment resale, this retail base already employs about 237,000 U.S. workers (DataSource). One of the largest retailers in this sector, Sal-



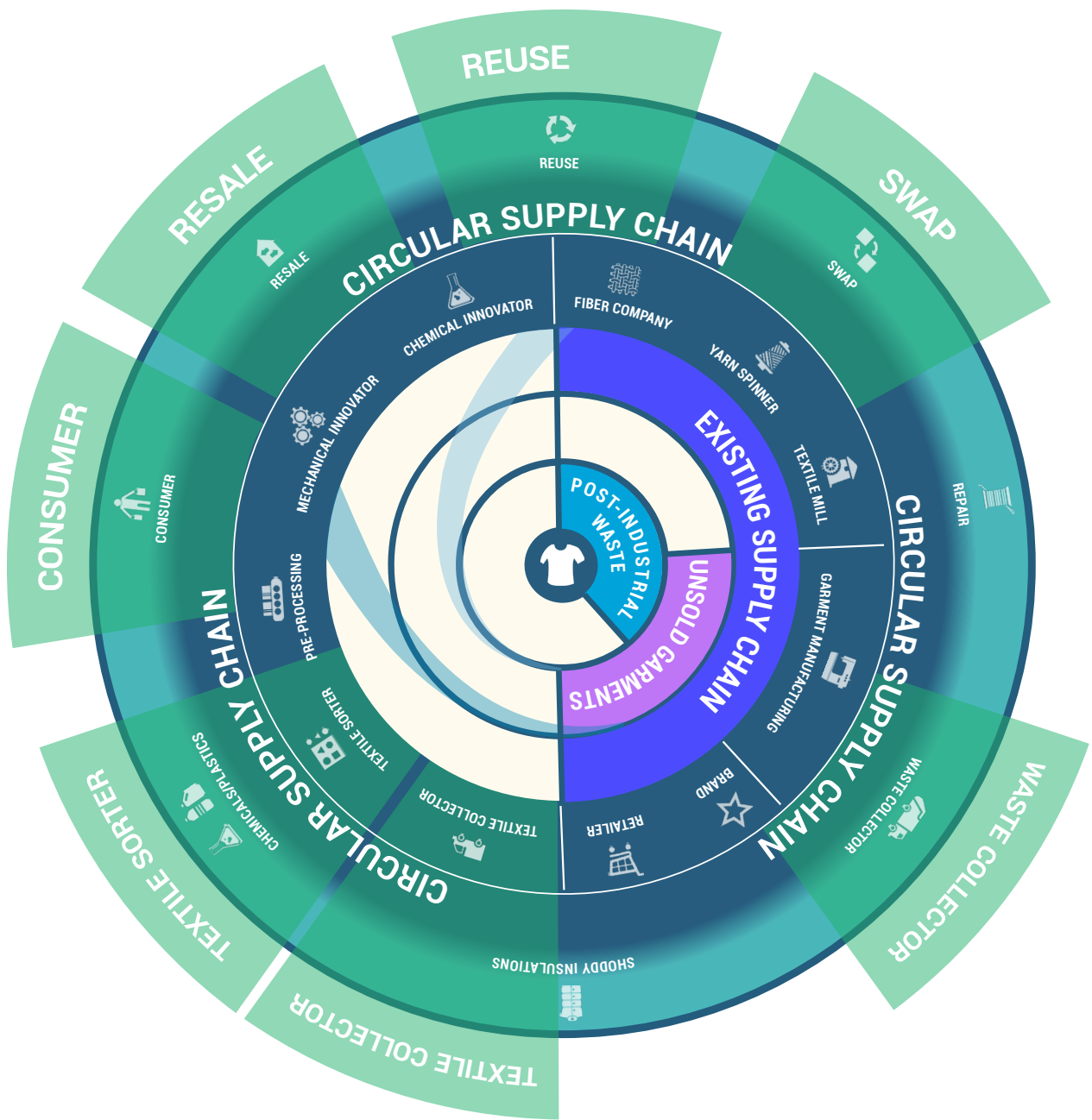


Diagram A Segments critical to Textile Reuse/Resale are highlighted:

Waste Collection → Textile Collection → Sorting →
 Reuse/Resale/Swap/Repair → Consumer → Waste Collection

vation Army (8,000+ North American stores/35,000+ employees) reports that about 60% of their thrift revenue in Canada comes from garment/textile resale.^F

Used merchandise stores have adapted to a changing retail landscape, COVID, and the shift to online channels⁴⁸. Strong community ties and a unique live experience that reflect today’s retail shopping preferences allow smaller resale shops to grow and



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thrive, while employing more people in the diverse communities they serve. Of the coveted Generation Z consumers (+67M) about 40% reported purchasing at least one item of used apparel in 2019, double the transactions of Generation X and Baby Boomers.³³

As a working model, garment resale is one of the few retail categories today that demonstrates CE's promise for growing profits and jobs while "... creating a virtuous circle."⁴⁰

V. TEXTILE-TO-TEXTILE RECYCLING: NEW SOLUTIONS, NEW JOBS

The used garment/textile industry is a resilient, adaptable business model with clearly defined costs. It is a proven solution for how some unwanted textiles in the U.S. can drive a profitable category.²⁰ One clean-tech textile stakeholder confirmed: "On the recommerce and circularity side, in the last two years, growth has been really mad [excellent]."^c

By contrast, the potential for textile-to-textile recycling (Diagram B) presents a more complicated picture, with many challenges, leading to the academic view that commercial "textile recycling is not economically beneficial at this time."³

Emerging platforms have helped changed the conversation about textile recycling's potential for profitability over the past five years. The most critical driver of a scalable textile-to-textile CE exists right now: access to the +13M tons of U.S textile waste currently landfilled/incinerated each year, at a lost value estimated to reach \$4B by 2030 (GFA/BCG); making it a sustainable solution for "optimizing [fashion] business practices to limit their negative impact" and "address its environmental and social footprint."²⁵

A Netherlands study of recycling job creation shows a potential increase of 14% compared to 25% for the resale/reuse model.¹⁰ However, textile-to-textile recycling offers many long-term strategic advantages that reuse/resale does not:

- No competition with new fashion retail sector/employment⁶
- A job-based strategy to decouple from virgin material resources¹⁰
- Onshore supply chain to reduce strategic volatility¹⁵
- Opportunity for upskilling of existing workforce¹⁶
- Massive jobs creation required to meet \$40.3B global eco-fiber demand by 2027²⁰
- Can incorporate +340,000 jobs from the U.S. legacy textile industry into the CE²²



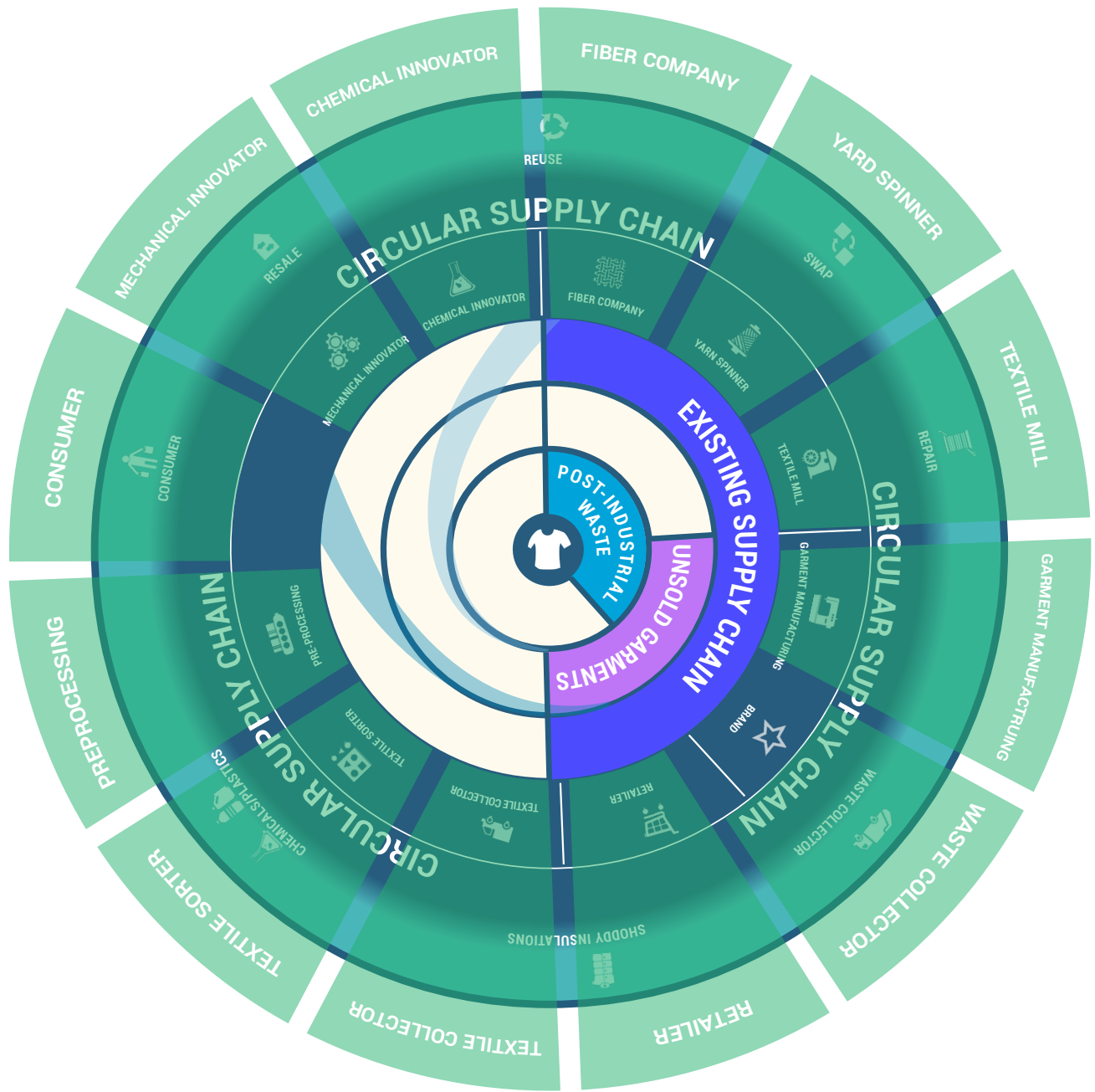


Diagram B Segments critical to Textile-to-Textile value chain are highlighted:

Waste Collection → Textile Collection → Sorting → Preprocessing → Recycle; Mechanical & Chemical Innovator → Fiber Company/Yarn Spinner/Textile Mill → Garment Manufacturing → Brand/Retailer → Consumer → Waste Collection

Three different recycling platforms are available for processing textile waste, with details for prospective investors to consider:

1/ **Mechanical Recycling** is a proven technology and currently the only recycling platform that is commercialized and profitable. PITW with some heavily sorted PCTW is



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processed into fibers by shredding, chopping and fraying. The wool recyclers of Prato, Italy have employed it to create fine woolens since the 19th-century.⁵⁴ The Boer Group of Germany also uses PITW mechanical recycling to produce high-value woolens.¹⁹

- Strengths: proven technology; low environmental impact; upscale market position.
- Drawbacks: fiber loss up to 46% during processing; fiber shortening and strength; limited feedstocks.

2/ Chemical Recycling – innovative solution for creating value from textile waste. Utilizes chemistry and water/heat to break down and reconstitute cotton/polyester feedstocks into raw cellulose and/or polyester.

- Strengths: Transformative technology; solves landfilling crisis; closes loop in circular textile economy; supports near-shoring strategy; addresses cotton ag water crisis.
- Drawbacks: Not operating at commercial scale; major capital investment required; environmental impacts vary.

3/ Thermoplastic Recycling – proven commercialized technology for processing of polymer waste through heat. Raw material produced in the form of granules ready for extrusion or injection. 82% of polypropylene purchased by the textile sector today is recycled granules.⁸

- Strengths: high demand for product (60% of fashion textiles use polyester); may apply to PCTW stream; markets include injection molding and 3-D printing.
- Drawbacks: focused on using PITW feedstocks; separation of blended fabrics into constituent products; granules recycled from post-consumer clothing are 20-30% more expensive than virgin sources.⁶

VI. WORKFORCE CREATION: NEW JOBS FROM OLD TEXTILES

Understanding how CE employment can apply to textile recycling in the future is central to creating a launch pad for new job creation. Over the next 20 years, “recyclable sectors benefit from large increases in employment,” according to the Organization for Economic Cooperation and Development.¹⁵ The fact that + 750,000 people are already employed in the U.S. recycling/reuse category⁴² speaks to a powerful job sector that textile recycling stakeholders and investors can expect to yield strong growth in the coming business cycle. **As the textile recycling sector grows, “more workers will be needed to collect, sort and process recyclables,” including both jobs that require “few specific skills” as well as “highly skilled” jobs.**³⁷



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COMPETITION FOR WORKERS

In the unsettled post-Covid business environment, “having a workforce that’s fit for the future and is capable of responding to evolving business demands will be key to strategic success.”¹⁶ Media headlines from the last quarter of 2021 highlight the fierce competition for lower-wage hourly workers: “Starbucks and Costco raise wages in the nationwide competition for workers” (NPR); and “HR experts say that more must be done to stay competitive in the labor market beyond just increasing pay.” (CNBC) The U.S. Bureau of Labor Statistics reports the number of low-wage workers actually declined in 2020, by 25%, to an available workforce of 1.1 million.²⁸ Compounding the hiring puzzle is an aging U.S. textile workforce, making “recruitment of new talent a priority.”²²

Like many industries, textile recycling is exposed to this generational shift in competition for workers, described by one stakeholder as, “the great challenge of the next business cycle.”^A Other stakeholders confirm the difficulty in finding workers:

“We would hire probably a third more people but can’t find anybody” even at \$3 over minimum wage. “We get applications, set up interviews, and nobody shows up. It’s weird, like nothing I’ve ever seen before.”^C

Not all views align. A major employer in the charity resale sector states: “The workforce is available if we pay them more.”^E The primary competitor for workers? “Amazon. They’re paying crazy, taking a lot of labor away from us.”^E **One stakeholder ties value and hiring together: “The most important thing is to find sufficient value in end products, that can justify paying people living wages to do this (sorting).”^D** An eco-ethos also influences the hiring process: “We will not hire anyone who has zero motivation in terms of changing the future ... I’m not interested in employees who are only interested in their pay per hour and benefits.”^G

The elephant in the hiring hall is sorting. U.S. Bureau of Labor Statistics describes this job: “textile sorters work along conveyor belts to manually separate unwanted textiles into specific material grades at MRFs. Qualifications: Entry level / physically demanding.”³⁸ The reuse/resale market depends on intense sorting to generate income through the grading of reusable items. (Fashion for Good) Every textile-to-textile recycling platform today incorporates manual sorting into their operations.¹⁹ “We still need manual sorting for the first step, separating the re-wearable garments” before processing at an operational textile-to-textile recycling plant in Sweden, confirms one stakeholder.^F

Sorting is generally regarded as unskilled entry level work, with minimum compensation to match.³⁸ **About “six months” of training is required to train a sorter, confirms one stakeholder, saying: “I would say this is a high skill type of job and requires a lot of experience. It’s not necessarily high wage, for whatever reason.”^D** **The managing director/U.S. division of a large international reuse enterprise, states: “When it comes to quality grading, no machine can do what a human eye can do. If I had all the money in the world I would still continue to use human beings to sort.”^B**



The collections workforce is under similar pressure. Reclaiming the +86% of textiles lost to landfilling is critical to a textile-to-textile CE strategy and associated job growth.²⁰ The Solid Waste Association of North America (SWANA) helps do the work of collecting and diverting textile waste, and converting it into valuable feedstocks. Their executive director states that, “recruiting and retaining workers is perhaps the biggest challenge” facing their +10,000 membership (New York Times 2021).

Effective and profitable implementation of a new workforce is a non-issue if the needed workers cannot be hired and retained. Average length of employment is “under a year for [resale/sorting] workers” who “find it’s more physically taxing than they anticipated. That’s the number one reason they don’t end up staying.”^E

Retaining higher-skilled apparel workers, such as engineers and plant operators, is a challenge that can be met through reskilling and retraining. Yet the MOTIF 2020 apparel industry survey finds an “overall dissatisfaction with training provided in companies. Only 34% of respondents across all levels and functions say they are satisfied;” and “for workers in technical roles, there is not enough mid-career development.”¹⁶ Utilizing vocational training and education (VET) is an international approach for “lifelong upskilling” while “driving the uptake in of circular strategies;”¹¹ which, if adopted, will strengthen the U.S. textile/recycling industry’s efforts to retain its workforce.

VII. INNOVATION: FROM TECHNOLOGY TO INFRASTRUCTURE

The next chapter in textile-to-textile recycling remains to be written. How innovation will disrupt the current reliance on low-wage jobs lends drama to this plot. For the story of CE textile recycling to have a happy ending for workers, their families, and the investors writing the checks, **a view prevails that, “the sorting process needs to be automated.”³ Accelerated innovation has brought the industry closer than ever to making this technological goal a practical reality. “Automated optical sorting technologies play a critical role in scaling up recycling and making it cost competitive with virgin resources.”⁶**

For example:

- An innovative system for conveyor sorting developed by Siptex uses Near Infrared (NIR) technology to analyze PCTW. Demonstration research establishes its “great potential for sorting textile waste by fiber, composition, and color.”¹⁹
- RFID (radio frequency identification) technology can be applied to thread to support automation of the sorting/grading process. This “digital thread” can connect to databases, and reveal the origin, material, and history of a garment.⁶³



Innovations like these are the next steps in full automation of PCTW sorting. When questioned about it, stakeholders with everyday experience in sorting textiles for profit expressed interest – and skepticism. “I think it’s going to be a combination (including manual sorting) for the foreseeable future. It’s ten years down the line before we see full automation.”^C One focuses in on RFID-type innovation: “What would be the best technology would be something like a barcode on each garment. That would radically change what we do. It would certainly boost the value of everything we do.”^D A major charity reseller observes: “It’s very romantic to think of new technologies, tracking devices in all the clothing. That’s great innovation. But it’s not helping us right now.”^E The U.S. development engineer for a European recycling platform: “With (our technology) we focus on a waste textile stream that is not reusable, not re-wearable. At the moment we wouldn’t take away from the manual sorting for re-wearables.”^B Another recycling stakeholder says: **“Building and operating plants means a blue-collar profile. It’s a bit of a crystal ball question, but we see lots of jobs, really good jobs.”^A**

INFRASTRUCTURE

Just as ripe for innovation is the challenge of “creating infrastructure for used garments”³ in the U.S. While not as glamorous as technology innovation, infrastructure is essential to diversion rate improvement for recovering unwanted textiles now discarded and landfilled. Innovating the collections infrastructure supports “the business case for circularity,” and can help shift jobs back to the U.S. from the “Global South.”⁹ Recovery of PCTW takes many forms in the U.S., encompassing both private and public organizations. Legacy collectors, such as Goodwill and Salvation Army, use retail bricks-and-mortar locations as collection points for used clothing and other textiles, and household goods. The charity-based channel collects about 30% of all donated clothing in the U.S. (RETEX) Building out the U.S. collections infrastructure is taking a variety of innovative forms, making it more convenient for the consumer to donate unwanted clothing and improve diversion rates:

- Partnerships, led by ThredUp, between J.C. Penney, Macy’s, Stage, and Madewell, to sell and collect used apparel in-store.²⁹ H & M’s similar in-store drop-off system for unwanted garments captured 20.6K metric tons of textile waste in 2018.
- The Give Back Box platform innovates donations via the reuse of shipping boxes to channel unwanted merchandise back to charities. Return shipping is paid by major brand partners, including Amazon, REI, Levi’s, Asics, Ann Taylor, Nordstrom, Viva Terra, and many others.
- The donation bin for-profit business model is making an impact, led by Helpsy (200 employees) in the Northeast, a collector/upcycler (25M pounds 2020). American Textile Recycling Services (112 employees) is the “fastest growing” donation bin business in the U.S., with 10,000 neighborhood bins deployed in 15 regions.



Their innovation – to build volume through “special events,” a volunteer network of +3500 and partnerships with local service entities such as the Humane Society – puts a public/private stamp on donations (+300M pounds 2021).

- Curbside pickup of unwanted textiles is a logical infrastructure innovation that faces a region-by-region challenge, with “hyperlocal providers” succeeding while others are on pause due to Covid, and relatively high operating expenses. Category leader Simple Recycling (79 employees/for profit) partners with charities, colleges, businesses and communities in “denser urban centers” to drive collections with “an easy and convenient option to divert” unwanted clothes and shoes.⁵⁶

A stakeholder with boots on the ground points out the drawbacks to the bin donation business: “The perceived legitimacy is very low, which means people steal stuff from your bins, or that someone dumps a bunch of garbage in your bin. On a given night we will have 50 or 60 dumping incidents. The police don’t come; that’s our problem.” He adds, “We are moving more and more into the curbside collection model. Even though it’s far less efficient by weight than the bin model, we get higher quality goods, and you don’t have to deal with the nonsense.”^D

VIII. THE WORLD RESPONDS: VIEWS AND TOOLS

Up to 70% of the world’s population depends on the global trade in second-hand textiles as a source for clothing, jobs and/or both.¹⁹ By aligning major U.S. stakeholders, a profitable CE model can work on our shores, ushering in a new era in textile-related employment. Bringing along small players from emerging market economies is another matter. In Kenya, for example, over 2 million people are directly or indirectly employed in the reused garment business, making it a major employer. Today 91.5% of Kenyan households buy their clothing second-hand. If their U.S. source for used garments stays here for reuse/recycling, the diversion could impact millions of poor families there.¹⁷ The need to act wisely on behalf of resource allocation must consider such hidden costs, both material and human. By learning from other countries and their people, we can together create “interconnected solutions” for good jobs that do not exploit workers and harm our planet (Fashion Revolution).

Following is a snapshot of how other nations are using cooperation and partnerships to address the textile recycling employment challenge:

- **Belgium and France** – established large re-use centers with networks that cover entire countries and regions, which are “well placed to provide jobs and training opportunities for a range of people of all skill levels.”³²



- **Netherlands** – set an “ambitious goal” for full circularity by 2050, with 50% reduced resource consumption by 2030. A case study provided “valuable insights and recommendations” for how to develop skills and jobs needed for a circular value chain, with a forecast of 6.6 jobs created/1000 metric tons of textiles processed by either chemical or mechanical recycling platforms.¹⁰
- **Australia** – sustainable denim brand Outland has pivoted from seasonal to capsule collections, with a “positive effect on workers” due to a “more consistent workflow and structure to the work week, allowing for more consistent training and education programs.”⁵
- **Nordic Countries** – a study sponsored by the Nordic Council of Ministries identified the “vast potential for job creation” within the textile reuse sector, with over 4,400 new jobs and 30,000 additional work training opportunities and internships created through the doubling of waste collections.
- **Pakistan** – has established a huge centralized textile MRF within the Karachi Export Processing Zone (KEPZ). With over 10,000 employees this +\$516M global powerhouse can process over 1.5B pieces per year. Highly-trained staff (50% female) sorts waste textiles into +300 different grades. (By comparison, Trans-America Trading Company is one of North America’s larger processors of PCTW and second-hand/vintage clothing. It has 85 employees, and processes about 500K pieces per year).
- **India** – recognized “three best ragpickers and three associations involved in innovation of best practices” with cash prizes. The Environment Minister stated: “This informal sector has saved the country.”⁵⁸
- **France** – the Emmaus shops employ primarily disadvantaged workers, collecting 100K metric tons of textiles per year, and generating 25 jobs/1000 metric tons collected.³²
- **Euratex** – aka the European Apparel and Textile Confederation, represents 21 nations spanning Portugal to Finland and Turkey, reporting on +160,000 textile and clothing firms in the Eurozone. It works across borders to develop “the image of the EU textile and clothing industry as an attractive employer providing high quality jobs and interesting career opportunities,” including training and reskilling. Their 2020 ReHubs initiative, which focuses on upcycling textile waste, finds it possible to create up to 120,000 new jobs in the European Union. (20 jobs/1000 metric tons of PCTW processed).



POLICY AND LEGISLATION

Of the levers identified in the New York Circular City Initiative, “regulatory and economic policies are the two most powerful job-creating policy instruments for city governments.”⁴ Public policy is a proven solution for US textile job creation; since 1941 the Berry Amendment has mandated the manufacturing of our military uniforms and other military textiles take place on U.S. soil, worth \$2.5B in 2019.³⁴ The Pulse of the Fashion Industry report identifies “Two of the key players in the [CE] eco-systems are governments and policymakers” and “increased momentum to create supportive regulatory framework” which can enable recycling job creation.²⁵ “In comparison to voluntary schemes, mandatory policies have the advantage of targeting the entire industry equally,” according to the Ellen MacArthur Foundation, which also offers some examples of how other countries utilize public policy to impact textile recycling and associated job creation.⁶

- **France** – passed a 2006 law holding manufacturer’s responsible for their product’s end of life use, channeling discarded textiles out of landfills and into feedstocks.
- **Holland** – has specified the use of recycled fibers as a “beneficial criterion” for sourcing of government workwear, part of a procurement program worth \$120M.

Stakeholder interviews mainly confirm the primacy of policy over other available levers (i.e. private investment, education, marketing) to empower job creation. A COO states, “We’re seeing more recycling legislation pop up ... we anticipate it will continue to increase in the coming years in ways that support the circular economy and this [textile recycling] industry.”^A The Managing Director (U.S. division) of a large European firm: “I’m from Germany, where there’s much more government influence in the recycling industry. A lot of things are mandated by the government, for example, responsibility of the manufacturer to take back its clothing. If the U.S. would go in that direction, it would create many more jobs, more opportunities, more feedstocks.”^B A charity reseller’s view: “Government policy is number one.”^E Stakeholder^F, with Swedish technology roots, concurs: “Between the four levers on textile reuse, government first, then private investment.” Not everyone agreed: “Private investment first... I don’t believe the government helps, we should do it ourselves.”^G

IX. THE ENVIRONMENT, JOBS, AND THE WORKPLACE CHALLENGE

To place job creation within the context of a textile CE model, we must address environmental issues, including worker safety and community impacts. A mindful regard for the environment is an established pillar of CE theory.⁶ But how extraction and depletion of finite earth resources relates to job loss and gain is a subject still advancing



in the study of circular economy theory³ A major OECD study into jobs, resource efficiency and the transition to a CE model does not include the textile recycling sector *per se*; it finds a CE transition overall proves “very effective in fulfilling its environmental objectives along with marginal but positive employment impacts for most countries. Only a few countries will be negatively affected.”¹⁵

Yet it is established that “factory workers in the textile industry have a higher-than-average prevalence of respiratory diseases and allergies,” and poor wastewater management “affects not only the health of textile workers, but also the communities living nearby.”⁶³ Fragmentation translates into a global textile supply base where “there are hundreds of thousands of factories using relatively small amounts of chemicals,” many of which can “cause severe harm to workers”³¹, compromising land, water, and air quality and putting at risk regional eco-systems where workers and their families live. By designing next-generation facilities that control environmental impacts, that are safe and employee-centric, we empower workforce development. Good places to work attract good workers.

Some facts and trends about resource depletion and climate change which may affect future employment in the textile recycling sector:

- Textile production represents 4% of global freshwater withdrawal (EMF/World Bank, FAO, AQUASTATCirc).
- Only agriculture surpasses the textile industry’s consumption and pollution of clean water.⁶⁴
- By 2040, hotter temperatures will likely shorten the cotton growing season by 40%, with drought affecting 50% of global cotton output; “some areas will become unsuitable for growing cotton in the near future.”¹⁸
- Cotton will be replaced by food crops as future water supply problems impact farmers.³
- Apparel/home textile production globally requires around 10M metric tons of chemicals each year,³¹ using over 15,000 different chemicals, some of which enter the food chain after discharge into the environment⁶³
- By 2050, if trends persist, the textile sector will take up +25% of the world’s carbon budget⁶⁴
- The fashion/textile industry is estimated to account for 4-to-10% of human-made global greenhouse gas emissions (ClimateScience 2021).
- An estimated 30% of viscose rayon is sourced from endangered forests.⁵⁹

How we respond to the challenge of these looming issues, both climate and workplace related, offers a clear opportunity to address the “numerous health and safety issues associated with the textile industry” (O.S.H.A./U.S. Dept. of Labor). A useful reframing of this challenge calls for us to reduce our many views of the recycled textile industry’s future to



a solution-based focus. For example, “chemical circularity” encompasses forward-looking concepts such as chemical leasing and the CURE (chemical user responsibility) model. As a component of CE strategy, chemical circularity can help control the release of greenhouse gases, while shifting the industry view of chemicals from “single-use disposable substances to valuable resources that should be used sparingly, reused or recycled where practicable and, as a last resort, discharged responsibly.”⁵¹ Innovative tools such as block-chain tracing are now coming online, making full fabric traceability possible, and supporting water-wise and renewable sourcing.⁵⁹ Advancements in low-water agriculture are helping improve U.S. cotton crops, producing domestic plants with “a stronger resilience to water shortages in later growth stages and increased cotton yields.”⁶⁶ And recycled cotton uptake will increase as preferential benchmarking tools are onboarded by more fashion/textile firms.¹

In transforming the climate-based strategies we employ, textile CE players not only demonstrate leadership, but can put into place a durable foundation for financial and environmental success.

X. CLOSING STATEMENT

It is tempting to look back at history to understand the present. A recent news article states, “As an industry, textile recycling is in its infancy.” (Washington Post 2021) Yet over 140 years ago, the job of the *chiffonier* – the ragpicker – was central to the functioning of Paris’ population of 2 million). Up to 40,000 ragpickers worked in Paris at this “honest occupation” and were regulated by law.⁵¹ The ragpicker Vargouleme in *Les Misérables* “considers himself fortunate, because ... he has a profession.” (51) Legislation beginning in 1883 spelled the end for the ragpickers of Paris. They became a “marginalized people,” and disappeared by the early 20th century.⁶⁰

As the U.S. textile recycling industry builds its next generation workforce, may we remember the chiffonier, and seek to make the jobs we create decent, respectable, and worth the human investment so called for.

SIX KEY SUGGESTIONS FOR TEXTILE CE JOB GROWTH

1. Start by collecting more textile waste to create more jobs.

Textile waste in the U.S. has increased by 900% since 1960.²⁴ Boosting our waste diversion rate through collections takes advantage of this trend and is the simplest way to create more reuse/recycling jobs.⁴ The U.S. PCTW collection rate is about 13.7%. (EPA 2018) Germany currently collects up to 75% of its textile waste for reuse and recycling.⁶ The Next Wear campaign in New York City increased their collection rate volume to 30%, supporting the concept that similar projects will create jobs.⁴ A 2020 study by the European Apparel and Textile Confederation (EURATEX) estimates that about 20 jobs can be created for every 1000 metric tons of textiles collected, sorted, and recycled in the European Union.⁶⁵



2. Standardize industry reporting and build a culture of collaboration.

Workforce creation requires collaboration between many stakeholders, with “standardized reporting frameworks” missing from the fashion industry at this time.²⁵ For example, the legacy textile supply chain in the U.S. employs 594,147 workers (2019) but the industry does not formally report on recycled feedstocks or possible CE assets.²² “To create a new supply of recycled textiles [with associated employment], large and small companies must work together.”³

3. Focus on big cities and expand to smaller population centers.

A McKinsey study reports that “large cities will account for 81% of global consumption and 91% of consumption growth between 2015 and 2030.”⁴ Concentrating CE policy/education/collection efforts in major urban areas will therefore yield the most jobs for the least investment. Programs proven to work can be rolled out strategically to the rest of the country as budgets allow.

4. Simplify where possible, and zero-in on resource efficiency.

The OECD finds a “direct impact” on employment comes with more efficient resource use.¹⁵ To commercialize mass textile-to-textile recycling, and build its associated workforce, the textile industry must “reduce material and products’ complexity.”²² Simplification must begin at the concept stage, Ellen MacArthur says, requiring that fashion designers of the future work “... in a way whereby that product comes back into the system: the components are recovered, the materials are recovered.” (Dezeen) A stakeholder interview points to, “The need for education in fashion schools that issue fashion certificates: the unsexy side of fashion.”^H

5. Pull policy levers to create jobs faster in the recycled textile category.

For long-term impact on textile CE job creation, “regulatory and economic policies are the two most powerful job-creating instruments.”⁴ The OECD states, “Allocation of revenues from taxes on materials use can substantially influence the final employment outcomes” in CE transition models.¹⁵ Textile and apparel shipments comprise 40% of all tariffs collected by U.S. customs in 2018; over \$13B in revenue.²²

Since 1941 the Berry Amendment has mandated that U.S. military uniforms, apparel, and other government textiles be manufactured on U.S. soil (procurement value of \$2.5B in 2019). Berry and similar legislation (Kissell Amendment) could specify recycled content in all government-ordered textiles.³⁴ Two Extended Producer Responsibility (EPR) bills have passed in the U.S. (Maine and Massachusetts), and nine more are pending in other states. 30 EPRs, although aimed at “only improving recycling rates”³², also generate recyclable textile waste and associated jobs.

6. Meet the growing demand for recycled polymers first.

A RETEX survey of 28 industry stakeholders shows demand for recycled polymers far exceeds (73%) that of recycled cotton (10%); currently 82% of feedstock polypropylene is purchased from recycled sources for textile production, compared to .53% for cotton.⁸ Recycled polyester, in the form of PET chips, is also in demand outside the textile sector, as a material in engineered resins, thermoformed plastics, and feedstock in 3D printing. At the decision stage, prioritizing polymer recycling first will support faster job creation at associated facilities.

APPENDICES

Appendix A – Survey

In addition to the desktop research conducted to inform this white paper, an exploratory survey was distributed to over twenty Accelerating Circularity members and a handful of industry stakeholders.

The surveys, distributed electronically, included approximately thirty questions investigating topics such as circular textiles jobs, textile waste streams, EDI practices, and future looking questions on the types of jobs and job development potential for circular textiles.

While the number of responses collected from the surveys and the low response across several questions make the survey insufficient to meet response rate expectations for quantitative research, the responses generated important insights building on our investigation.

Firstly, when prompting ACP members and stakeholders about number of jobs created with the circular economy, only one in five taking the survey responded to the question, which confirms a gap of information on the topic.

Among those who responded to the question, there was consistency that the job creation potential from circular textiles was between 3-10 jobs per 1000 tons of textiles recycled, which is consistent with our desktop research indicating between 5.73 – 8.58 jobs in the United States context.

Secondly, the response rate among ACP members and stakeholders to questions related to circular jobs breakdown, EDI and waste streams questions was also significantly low, about one in five, which prompted our team to follow up with qualitative interviews to further understand the causes behind the low response.

Thirdly, the surveys helped confirm that sorting, collection, and transportation are identified by ACP members and industry stakeholders as top job creation areas; while quality, cutting and warehousing are falling slightly behind.

Finally, on the questions of EDI practices implemented today across the organizations surveyed and need to address EDI issues into the future, the response rate was also relatively low indicating this is an area that is worth further examination to ensure that the future of circular textiles accounts, tracks and sets targets for EDI issues.



Appendix B – Stakeholder Interview Key

- (A) Chief Operating Officer – CIRC –Textile recycling technology
- (B) Managing Director – Texaid (U.S.A. Division) –Textile Reuse/Collections
- (C) Founder and Chief Technical Officer – Tersus Solutions –Textile Cleantech/Upcycler
- (D) Co-founder – Helpsy – Collector/Sorter Bin Network
- (E) National Director, Business Development – The Salvation Army National Recycling Operations Canada – Reuse Retailer
- (F) Business Development Engineer – TOMRA Sorting Recycling – Sorting/Collection Technology
- (G) Chief Executive Officer – Give Back Box – Collector/sorter/reseller
- (H) Director of Education – Fashion Revolution – Fashion Activist Organization

Appendix C – Pilot Programs and Partnerships

- Saxcell – chemical recycling platform / regenerated cellulose / Sweden
- Sorting for Circularity Project – textile sorting partnership / with I:CO, JMP Wilcox, Boer, Texaid / North-west Europe
- Evrnu – chemical recycling platform / regenerated cellulose / Washington
- Terracycle – closed loop “hard-to-recycle” solutions / polymers, more / New Jersey
- Retex – partnership for recycling PITW/PCTW / Utexbel recycled yarns / Euroregion
- Pure Nature Project – process chain for biobased yarns and materials / collaborators include Texperium, HemCell, Centexbel, Maastricht Universtiy et al / Netherlands
- Egyptian Cotton Project – PITW mechanical recycling pilot /blended yarns / T + C garments, Marzoli Textile Engineering, Albini Group, Filmar SpA *et al* / Egypt and Italy
- BlockTexx – chemical recycling platform / rPet pellets and cellulose from mixed waste textiles / Australia
- Sysav Industries – automated PITW/PCTW sorting platform / Tomra and Stadler partnership / Sweden
- Circ – hydrothermal chemical PITW/PCTW recycling platform / polymers and cellulose / Virginia



SOURCES

1. Circle Economy, *Environmental and economic assessment of post-industrial cotton waste recycling* (2020)
2. Kessler, Lisa, et al, “The contribution of material circularity to sustainability – Recycling and reuse of textiles,” *Current Opinion in Green and Sustainable Chemistry* Vol. 32 (December 2021)
3. Sandvik, I. M. & Stubbs, W., “Circular Fashion Supply Chain through Textile-to-Textile Recycling,” *Journal of Fashion Marketing and Management* Vol. 23 No. 3 (2019)
4. van Heel, O.D. et al, *Complex Challenges. Circular Solutions*. New York Circular City Initiative, Freshfields (2021)
5. Outland Denim, *Sustainability Report 2020* (2020)
6. Ellen MacArthur Foundation (EMF), *A new textiles economy: Redesigning fashion’s future* (2017)
7. Svoboda, Michael, “Media coverage of climate change in 2019 got bigger – and better,” *Yale Climate Connections* (March 10, 2020)
8. RETEX, *Annual Report*, Interreg (2021)
9. Accelerating Circularity Project (ACP), *Putting Textiles to Good Use* (2020)
10. Circle Economy, *Putting Circular Textiles to Work* (2021)
11. Circle Economy, *Closing the Skills Gap* (2021)
12. Dobberstein, John, “Less Water, Same Cotton Yields: Yes, It’s Possible,” *No-Till Farmer* (Nov. 28, 2019)
13. World Economic Forum (WEF), *Net Zero Challenge: The Supply Chain Opportunity* (2021)
14. International Labor Organization (ILO), *The Future of Work in Textiles, Clothing, Leather and Footwear* (2019)
15. Organization for Economic Cooperation and Development (OECD), *Labour market consequences of a transition to a circular economy* (2020)
16. MOTIF, *The State of Skills in the Apparel Industry* (2021)
17. Secondary Materials And Recycled Textiles (SMART) Association, *Discover the Truths about the Used Clothing Industry* (2021)
18. Robinson, Noah, “Cotton industry unprepared for climate change threat to crop and farmers,” *Thomson Reuters* (June 23, 2021)
19. Boer Group, Boer Group Recycling Website (2021)
20. Circular Fashion Summit, *Circular Fashion Report 2020: Year Zero* (2020)
21. SMART, *Data Collection Survey 2018* (2018)
22. Moran, Marty, “2019 State of the U.S. Textile Industry,” *Textile World* (May 15, 2019)
23. Allied Market Research, “Recycled Textile Market to Reach \$8 Billion,” *Globe Newswire* (May 13, 2020)



24. Environmental Protection Agency (EPA), *Advancing Sustainable Materials Management: 2018 Fact Sheet* (2020)
25. Kerr, J. & Landry, J., *Pulse of the Fashion Industry*, Global Fashion Agenda (GFA) & Boston Consulting Group (BCG) (2017)
26. Lehman, M. et al, *Pulse of the Fashion Industry: 2019 Update*, GFA, BCG, & Sustainable Apparel Coalition (2019)
27. Texperium, *Pure Nature: 100% Biobased*, Interreg (2020)
28. U.S. Bureau of Labor Statistics, *Characteristics of Minimum Wage Workers* (2020)
29. Resource Recycling Systems, *Textile Recovery in the U.S.: a Roadmap for Circularity* (2021)
30. Okie, Suzi, “The FAQs of EPR,” *Greenbiz* (Aug. 9, 2021)
31. Patterson, Phil, *Chemical Circularity in Fashion*, Laudes Foundation (2020)
32. RREUSE, *Briefing on Job Creation Potential in the Re-use Sector* (2015)
33. ThredUp, *2020 Resale Report* (2020)
34. U.S. Department of Commerce (OTEXA), *The Berry Amendment* (2021)
35. Congressional Research Service, *Buying American: The Berry and Kissell Amendments* (2020)
36. BioBoost, *A Strategy for Accelerating Sustainable Valorisation of Unused Crops and Co-products*, Interreg (2020)
37. Sandin, G. & Peters, G., “Environmental Impact of Textile Reuse and Recycling,” *Journal of Cleaner Production*, Vol. 184 (May 20, 2018)
38. Liming, Drew, *Careers in Recycling*, U.S. Bureau of Labor Statistics (2010)
39. Armstrong, C. & Park, H., *Online Clothing Resale: A Practical Approach to Evaluate Sustainable Consumption Gains*, Oklahoma State University (2020)
40. Kapner, Suzanne, “The Rise of Hand-Me-Down Inc.,” *Wall Street Journal* (Aug. 16, 2019)
41. U.S. Census Bureau, *All Sectors: County Business Patterns, including ZIP Code Business Patterns, by Legal Form of Organization and Employment Size Class for the U.S., States, and Selected Geographies* (2019)
42. U.S. Environmental Protection Agency (EPA), *Recycling Economic Information (REI) Report* (2020)
43. BusinessWire, *Insights on the Recycled Textile Global Market to 2027*, Berkshire Hathaway (2020)
44. Circ, Website, (2021)
45. NielsenIQ, *Was 2018 the year of the influential sustainable consumer?* (2018)
46. Maruti Techlabs, “Top 10 Sectors Making Use of Data Analytics,” *Towards Data Science* (July 25, 2017)
47. Savini, Federico, “The Economy that Runs on Waste: Accumulation in the Circular City,” *Journal of Environmental Policy & Planning* Vol. 21, Issue 6 (2019)
48. Kenoun, Sabrina, “Thrift shops and sustainable fashion outlets thrive during the pandemic,” *Cronkite News* (March 18, 2021)

49. Farra, Emily, “The Future of Fashion is Circular: Why the 2020s Will Be About Making New Clothes Out of Old Ones,” *Vogue* (Dec. 19, 2019)
50. World Vision Canada, *A Guide to Ethical Consumerism* (2021)
51. “Ragpicker,” Wikipedia, Wikipedia Foundation (Oct. 6, 2021)
52. Smee, Ben, “Recycling Textile Waste: A Solution Exists, We Can’t Go Backwards,” *Guardian* (May 29, 2021)
53. Sandvik, Ida, “Applying circular economy to the fashion industry in Scandinavia through textile-to-textile recycling,” Monash University (Oct. 23, 2017)
54. Badiani, Marco, “Rags Are Tomorrow’s Riches,” *The Florentine* (June 11, 2019)
55. Tubito, Christian, et al, “Applied DDMI,” Trash-2-Cash Project (2018-2020)
56. Vann, Karine, “As dozens of curbside textile recycling programs pause, others launch anew,” *WasteDive* (Dec. 7, 2020)
57. Le Moigne, Remy, “Waste watchers: How industries transform waste into resources,” Ellen MacArthur Foundation (Aug. 16, 2021)
58. Press Trust of India, “Now, a National Award for Ragpickers,” *The Hindu Press* (Aug. 16, 2015)
59. Fashion for Good, *From Fiber to Finish to Scale: Tracing Viscose And Beyond* (June 22, 2021)
60. Heidenreich, Claire, “Chiffoniers in the Periphery,” *Nineteenth-Century Art Worldwide* Vol. 18, Issue 2 (2019)
61. Mowbray, John, “U.S. circularity trial kicks off,” *Ecotextile News* Issue 105 (Oct.-Nov. 2021)
62. van Duijn, Hilde, et al, “Unwanted clothes, happy workers: exploring the potential for circular textiles to have a positive impact on work and workers,” *Circle Economy* (Jan. 15, 2020)
63. Palacios-Mateo, Cristina, et al, “Analysis of the polyester clothing value chain to identify key intervention points for sustainability” *Environmental Sciences Europe* Vol. 33 (2021)
64. Utebay, Burcin, et al, *Textile Wastes: Status and Perspectives*, IntechOpen (2020)
65. EURATEX, *ReHubs: A joint initiative for industrial upcycling of textile waste & circular materials* (2020)