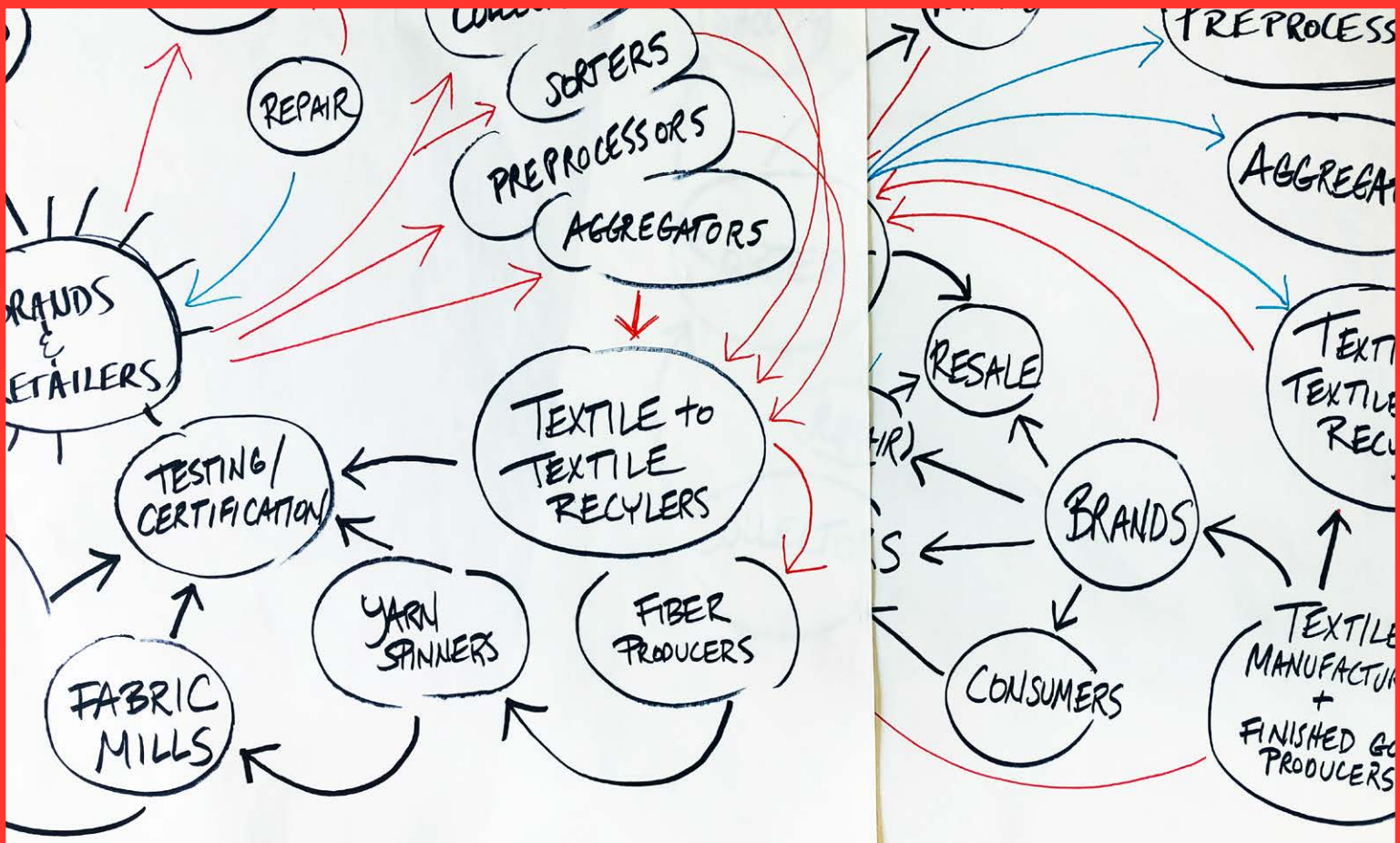
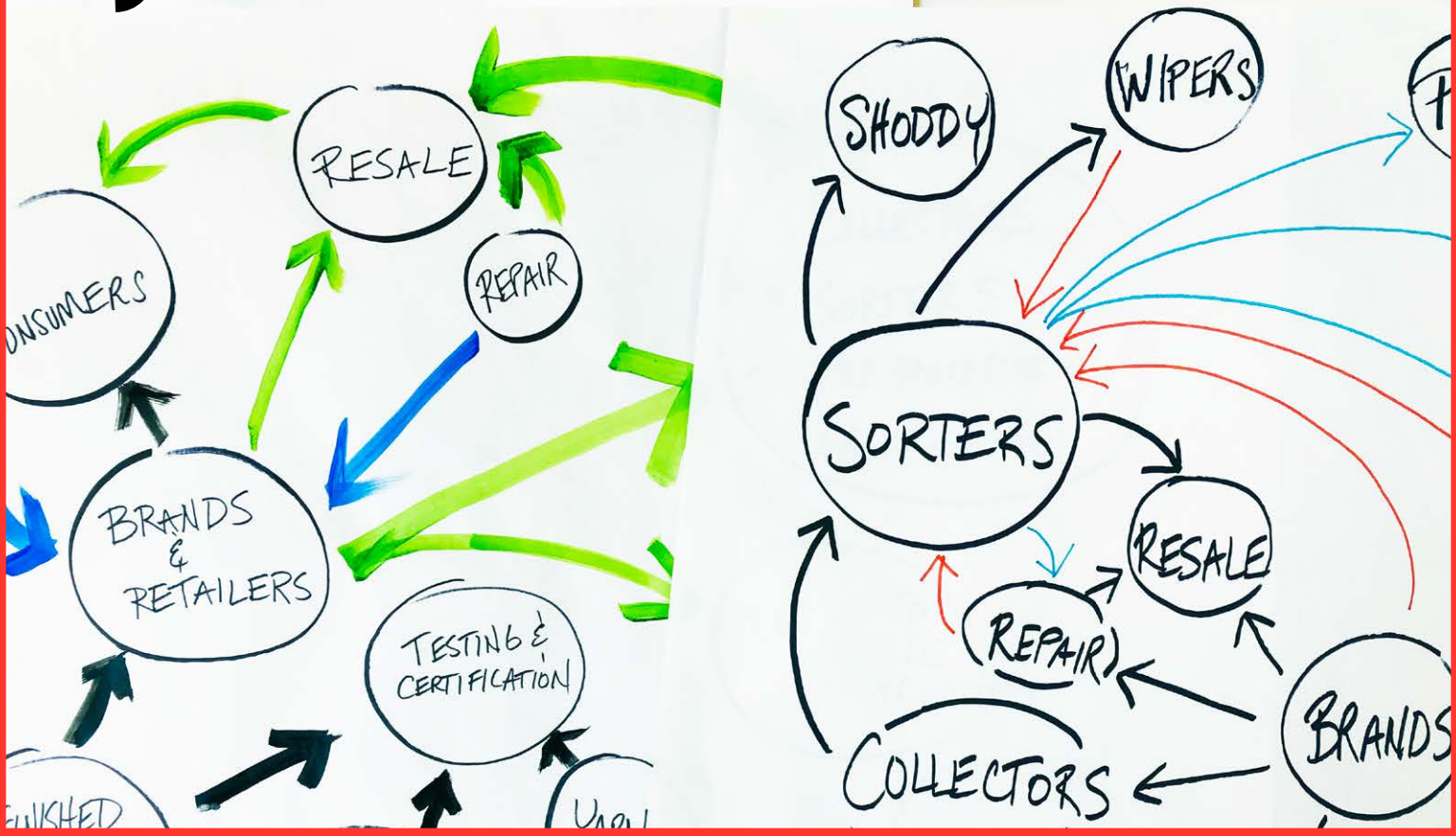


MODELING AND LINKING REPORT

ACCELERATING® CIRCULARITY

SPRING 2021



"The concept of circularity comes from our need to reduce our carbon footprint. It's not about having cost-neutral recycled materials. It's about saving ourselves!"

—Accelerating Circularity

"We can't reach our Climate Positive goal without going circular."

—Pernilla Halldin, Public Affairs, Sustainability H&M Group

We can not be satisfied until tens of thousands of companies are serving hundreds of million of customers really doing circular. As long as it remains in the lab we struggling.

—Mike Barry, Director of Sustainability (Plan A) Marks & Spencer, *Closing the Loop*, 2018.

"Cultivate a sense of collective vigilance for every act of consumption, evaluating its energy footprint. Learn about the production methods of everyday things, how to recycle them, and their planetary impact."

—Dalai Lama, *A Call for Revolution: A Vision for the Future, 2018*

Modeling & Linking Report

This report is designed to model textile-to-textile circular supply systems and highlight links required to make the system work.

The models will be used to formulate our upcoming textile-to-textile circular trials. Next steps are briefly discussed at the end of this report.

The textile industry has made ambitious commitments for carbon reduction. Textile-to-textile circular systems will be one solution among several that are required to meet those commitments. The carbon reduction potential of these systems must be validated. The trials imagined in this Modeling and Linking Report are critical to developing this knowledge.

Both before and after the trials, Accelerating Circularity will facilitate the formation of the required links.

All tools, intelligence, and know-how developed by or in collaboration with Accelerating Circularity will be made public in order to support the transition of the entire industry towards making circularity a reality.

Parameters:

- **Circular Strategy:** textile-to-textile recycling (resale and reuse are outside our scope)
- **Our definition of recycling:** using spent textiles as the feedstock for new fibers and yarns (Accelerating Circularity. Modeling and Linking Report. October 2020. pp. 40-41).
- **Feedstock bookkeeping:** material flows will be traced using the mass balance approach to enable scaled uptake of spent textile feedstocks
- **Geographies:**
  - **Feedstock (Spent Textiles) Sourcing:** East Coast USA
  - **Processing and Manufacturing (Recyclers, Yarn Mfg, Fabric Mills, and CMT):** North America
- **Products:** Apparel & Home Textiles
- **Fibers:** Cotton, Polyester, Manmade Cellulosic Fiber (MMCF)
- **Minimum Recycled Content:** 40% Post-consumer or Post-industrial spent textile inputs.
- **Participants:** Collectors, Sorters, Aggregators, Preprocessors, Recyclers, Fiber Manufacturers, Yarn Manufacturers, Fabric Mills, Dyer & Finishers, CMT, Brands & Retailers, Traceability Systems, Testing Facilities, and Shippers.
- **Goal:** Net zero carbon emissions, to meet the targets in the 2015 Paris Agreement on Climate Change (to limit global temperature rise to well below two degrees Celsius above pre-industrial levels as outlined in the UNFCCC FICCA: https://unfccc.int/climate-action/sectoral-engagement/global-climate-action-in-fashion/about-the-fashion-industry-charter-for-climate-action).
- **Approach:** Divert textiles from landfill and transform diverted material into circular textile feedstock.

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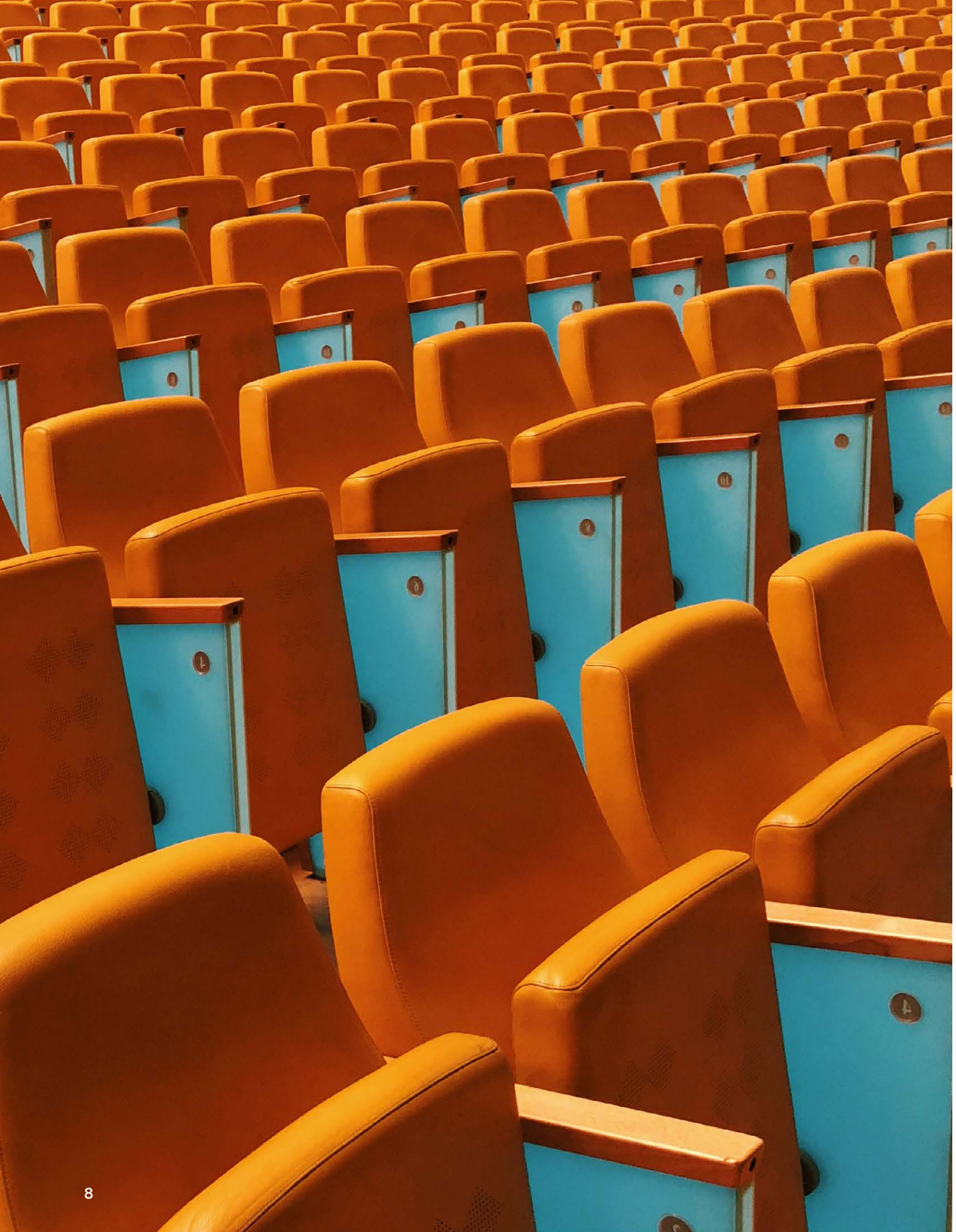


Organizational Structure

BOARD OF DIRECTORS

- CORPORATE GOVERNANCE
- ORGANIZATIONAL STRUCTURE
- FISCAL & LEGAL COMPLIANCE
- MISSION & VISION ADHERENCE

STEERING COMMITTEE

- STRATEGIC PLANNING
- TRIAL GUIDANCE & PARTICIPATION
- POTENTIAL BOARD CANDIDATES

ACP STAFF

- PROJECT IMPLEMENTATION AND ADMINISTRATION

SYSTEM PARTNERS

- COLLABORATE WITH ACP & GROUPS
- SHARED EXPERTISE IN SYSTEM SEGMENT
- TRIAL PARTICIPATION

SORTING SPECIFICATION WORKING GROUP

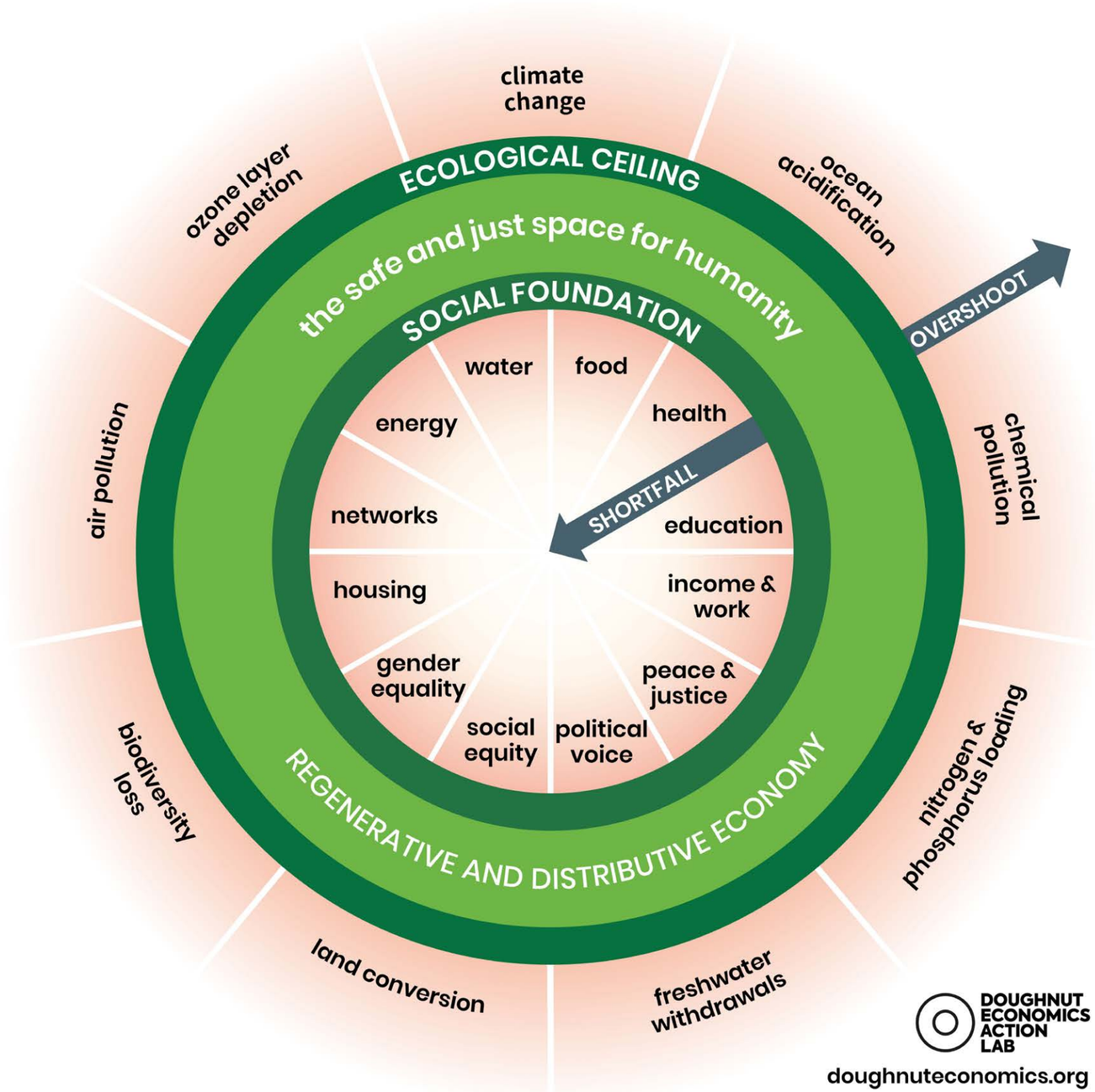
- POST-CONSUMER HIERARCHY
- MECHANICAL & CHEMICAL SORTING MATRIX
- SORTING CATEGORIES & AGGREGATION
- RECYCLER CATEGORIZATION
- SYSTEM PARTNER TRANSITION

BRAND & RETAILER WORKING GROUP

- TAKE-BACK PROGRAMS
- PROOF OF CONCEPT - FINISHED
- PRODUCT RECOMMENDATIONS
- SYSTEM PARTNER TRANSITION
- TRIMS
- OTHER TECHNICAL ISSUES

AD HOC WORKING GROUPS

- TRIMS
- OTHER TECHNICAL ISSUES



Circular Textile-to-Textile System Resource Boundaries

- The development of circular textile-to-textile supply systems must recognize the interconnectedness of our planet's systems. At Accelerating Circularity, we have been influenced by the work of Kate Raworth and her theory of Doughnut Economics. Her focus on an awareness of the ecological ceiling, social foundation, and regenerative and distributive economy are required for all businesses, but are closely aligned to the needs of a healthy textile industry.

- Each bounded area of activity has inherent limits that, in combination, make a system that either supports or depletes our social, environmental, or economic welfare.

KEY CONSIDERATIONS

- **Ecological:** Carbon, chemical, water and energy use must not exceed the nine planetary boundaries.
- **Technical:** Circular systems must meet minimum quality and volume requirements.
- **Logistics:** Material and processing locations must adapt to become circular.
- **Business Case:** Circularity is about improving our social and environmental profile, so our economic models must account for these factors. Without positive social and environmental impact, there is no reason to change from business as usual.

Textile Use Case Hierarchy

In collaboration with a wide variety of actors in the textile-to-textile circular system, Accelerating Circularity is developing a Textile Use Case Hierarchy for spent textiles that is accountable to social, environmental, and economic interests.

Goals

- Define circulation pathways for spent textiles.
- Identify best or highest-value use for collected materials (e.g. reuse, resale, recycler, wiper or shoddy) to establish a viable circular systems marketplace. In this framework:
    - Collectors establish the availability of volumes and types of materials
    - Sorters know what is available and how it needs to be sorted
    - Aggregators know likely bale specifications
    - Preprocessors know what services are required (e.g. trim removal, right sizing)
    - Recyclers know what volumes and types of materials available
    - Brands and retailers are fluent in design for recycling
- Incorporate all textile-related industries (e.g., apparel, home textiles, and hospitality, uniforms, and industrial laundry).

Next Steps

- Create knowledge and tools that support scaling and replication.
- Support infrastructure and knowledge development to prevent loss of material intelligence.
    - Educate consumers to avoid the municipal solid waste stream, which is a textile dead-end.
- Establish metrics and collect data to evaluate the availability and direction of flows for spent textiles from all current sources (e.g., landfill, secondhand market, consumers, brands and retailers, manufacturing).
- Develop sorting hierarchies for materials identified as textile-to-textile recycling feedstocks.

Textile Use Case Hierarchy

Material Segment	EPA 2017 14% Diverted	EPA 2017 Millions of Tons	2019 Exports Million of Tons	Notes
Domestic Reuse/Resale	7%	0.90	0	Must measure growth, resale brands, platforms, 2nd hand market
Repair				New sorting requirements
Int'l Reuse/Resale* (6309)			0.84	Issues with bans and trans shipments
Recycle - Mechanical	2.5 w/Shoddy	0.3 w/Shoddy		Growth for commercial entities in post-industrial & move into post-consumer feedstocks
Recycle - Chemical				Commercialization and scaling required
Wipers Domestic	3.5	0.4		Have we found a solution to clean and re-use? Clarify target materials.
Wipers (6310.9000/6310.10.00)** International			0.09	Mechanization support to maintain material domestically
Shoddy	2.5 with Recycling	0.3 with Recycling		Clarify target materials
Landfill	68%	9		Primary target for reduction – diversion tool
Incineration	19%	2.5		Secondary target for reduction – diversion tool
Total	100%	13.1 million tons	0.93	

Our Focus Areas of Influence Out of Our Scope

Mechanical Recycling Matrix

Feedstock Fibers	Acceptable for:		Can include:							Must Consider:			
	Textile-to-Textile	Wipers, Shoddy & Insulation	Elastane	Trims		Pigments/ Prints	Coatings/ Films		Chemistry/ Dyes	Fabric Construc-tion	Color	Full Garments v. Parts	Fabric Scraps
				Plastic	Metal		PET	Other					
100% Cotton	Y	Y	N	N	N	N	N	N	Y	Y	Y	Y	Y
98% Cotton/ 2% Elastane	Y	Y	Y	N	N	N	N	N	Y	Y	Y	Y	Y
90% Cotton/ 10% Other	Y	Y	Y	N	N	N	N	N	Y	Y	Y	Y	Y
60% Cotton/ 40% Polyester	N	Y	N	N	N	N	N	N	Y	Y	Y	Y	Y
60% Cotton/ 40% Other	N	Y	Y	N	N	N	N	N	Y	Y	Y	Y	Y
100% Polyester	Y	Y	N	N	N	N	Y	N	Y	Y	Y	Y	Y
98% Polyester/ 2% Elastane	Y	Y	Y	N	N	N	Y	N	Y	Y	Y	Y	Y
80% Polyester/ 20% Other	N	Y	N	N	N	N	N	N	N	N	N	N	N
60% Polyester/ 40% Cotton	N	Y	N	N	N	N	N	N	N	N	N	N	N
60% Polyester/ 40% Other	N	Y	N	N	N	N	N	N	N	N	N	N	N
100% Viscose	?	?	?	?	?	?	?	?	?	?	?	?	?
60% Viscose/ 40% Other	?	?	?	?	?	?	?	?	?	?	?	?	?

Textile to Textile Recycling Wiper/Shoddy

Chemical Recycling Matrix

Feedstock Fibers	Can Include:						Must Consider:					
	Elastane	Trim		Pigment/ Prints	Coatings/Films		Chemistry/ Dyes	Fabric Construction	Color	White	Full Garments v. Parts	Fabric Scraps
		Plastic	Metal		PET	Other	Y	Y				
100% Cotton	N	N	N	N	N	N	Y	Y	Y	Y	Y	Y
98% Cotton/ 2% Elastane	Y	N	N	N	N	N	Y	Y	Y	Y	Y	Y
90% Cotton/ 10% Other	Y	N	N	N	N	N	Y	N	N	N	Y	Y
60% Cotton/ 40% Polyester	N	Y	N	N	Y	N	Y	N	N	N	Y	Y
60% Cotton/ 40% Other	Y	Y	N	N	Y	N	Y	N	N	N	Y	Y
100% Polyester	N	N	N	N	Y	N	Y	N	N	N	Y	Y
98% Polyester/ 2% Elastane	Y	N	N	N	Y	N	Y	N	N	N	Y	Y
80% Polyester/ 20% Other	Y	N	N	N	Y	N	Y	N	N	N	Y	Y
60% Polyester/ 40% Cotton	N	Y	N	N	Y	N	Y	N	N	N	Y	Y
60% Polyester/ 40% Other	Y	Y	N	N	Y	N	Y	N	N	N	Y	Y
100% Viscose	?	?	?	?	?	?	?	?	?		?	?
60% Viscose/ 40% Other	?	?	?	?	?	?	?	?	?		?	?
Other												

NEW LINKS

Brand & Retailer Perspective

Resale and repair come to mind when we talk about circular business models. These strategies are opportunities to engage and deepen customer relationships.

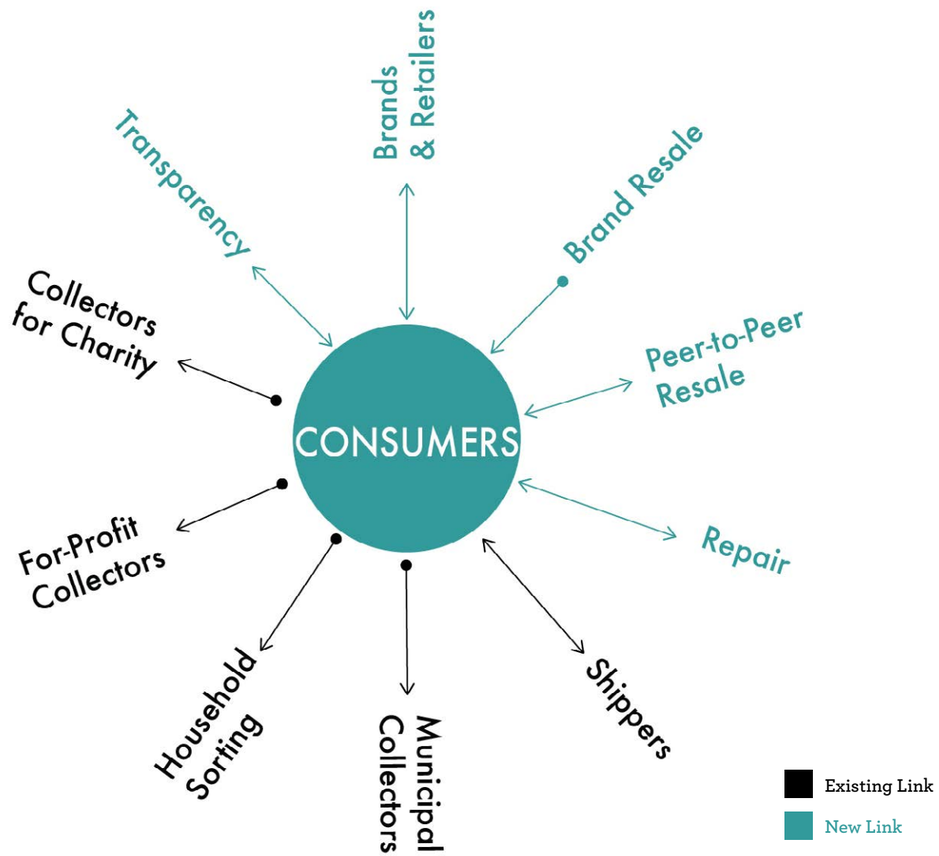
Transparency and traceability systems will be critical for brands to develop consumer connections, validate new material systems and make circularity claims.

Collector relationships will be essential to the new business models. They may be the first point of contact for take-back and resale programs.

Recyclers will be knowledge providers when it comes to circular design requirements.

NEW LINKS

Consumer Perspective



The consumer goes from being a spectator to an active participant in the new system.

Consumers become the new raw material suppliers. They send products back to brands and retailers or directly to collectors. Consumers have an opportunity to facilitate entry into the circular system through better sorting.

Purchasing is possible through multiple channels, from the traditional in-store or online marketplace to newer options of recommerce, repaired, and the growing thrift market.

Engaged consumers can dive further into the supply chain through participation in digital traceability schemes.

NEW LINKS

Collector Perspective

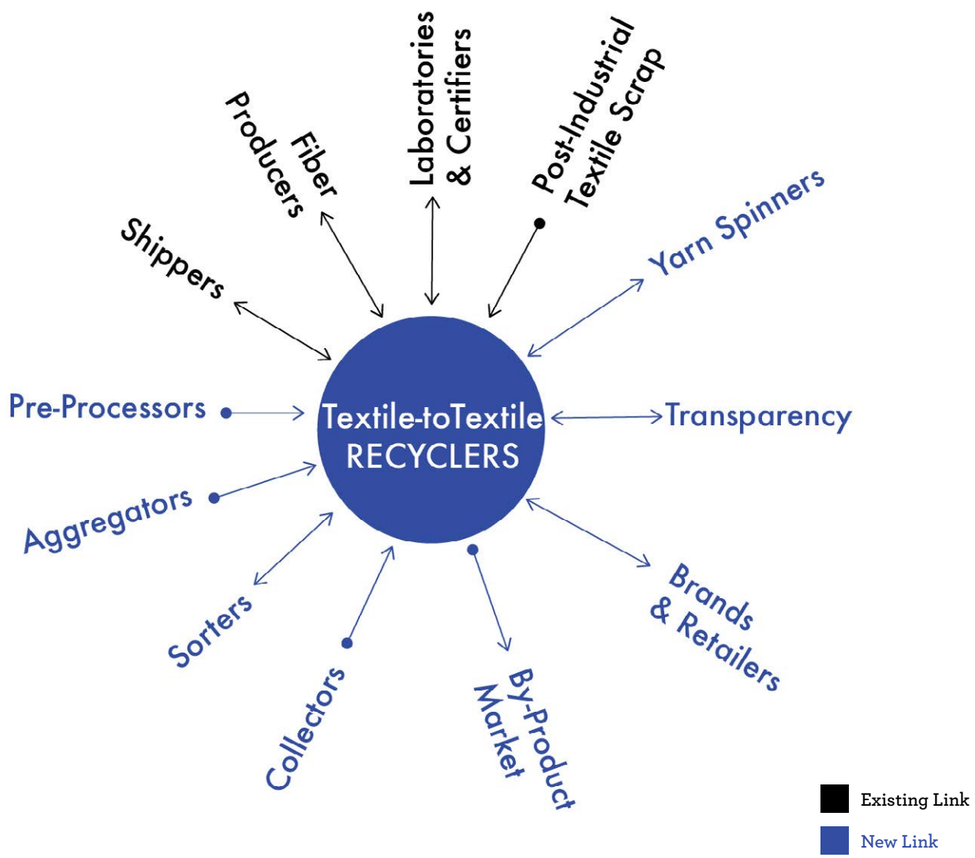
In a circular supply system, traditional relationships will be joined by newly formed and recently established links.

Some new links represent a shift in an existing relationship. For example, collectors and brands will seek active, rather than passive, relationships with traditional actors in the collection and resale sectors.

Other links are about new services and technologies that augment existing business and infrastructure, such as specialized sorting, preprocessing, and robust aggregation facilities to produce high value feedstocks for textile-to-textile recyclers.

NEW LINKS

Recycler Perspective

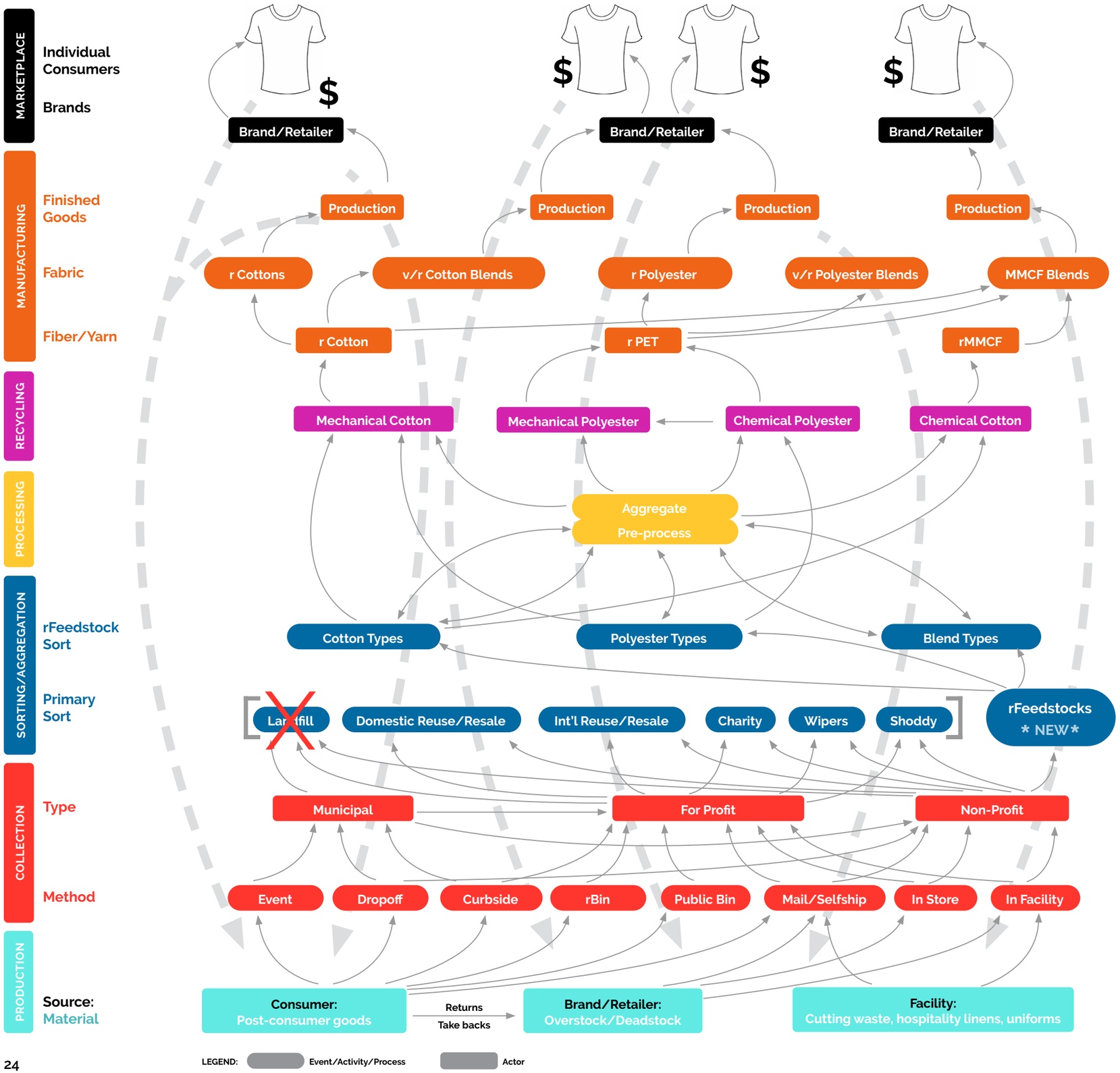


Links to and from recyclers are generally new.

Chemical recyclers are just getting into the game. This requires identifying the required sorting fractions and volumes to aggregate.

Mechanical recyclers, while commercial in post-industrial materials, are working to incorporate post-consumer feedstocks.

Recyclers can establish relationships to help brands and retailers understand how to design products that can be recycled through commercial technologies.



System Ecology

The Textile-to-Textile Circular System Ecology encompasses a wide variety of interconnected actors. Direct relationships between multiple actors are required for the system to work.

- Current systems have limited players within certain categories (e.g. sorters and aggregators).
- Materials are touched multiple times, creating inefficiencies (e.g. aggregators).
- Chemical recyclers are in the development phase and need to be commercialized.

COLLECTORS
For-profit
Charities
Municipalities

SORTERS
Garment
Fabric Construction
Color
Fiber Content

AGGREGATORS
Garments
Color
Fiber content
Restrictions

PRE-PROCESSORS
Right-Sizing
Trim removal
Deconstruction

FIBER TYPES
Polyester
Cotton
Blends
Elastane

RESTRICTIONS
Trims
Chemicals

BRAND & RETAILER
Independent Brands
Brand Groups
Branded Retailers
Direct to Consumer
Brand-Retailers
General Retailers

RECYCLER TYPES
Mechanical Cotton
Semi-chemical Cotton
Chemical Cotton
Mechanical Polyester
Chemical Polyester

SUPPLY CHAIN
Fiber Mfg
Yarn Mfg
Fabric Mill
Finisher/dyer
CMT

AUXILIARIES
Trims
Thread
Labels
Transparency & traceability systems

LABORATORIES/ CERTIFIERS
Commercial labs
Universities
Certifying Bodies

SHIPPERS
Planes
Trains
Truck
Boats
Handcarts

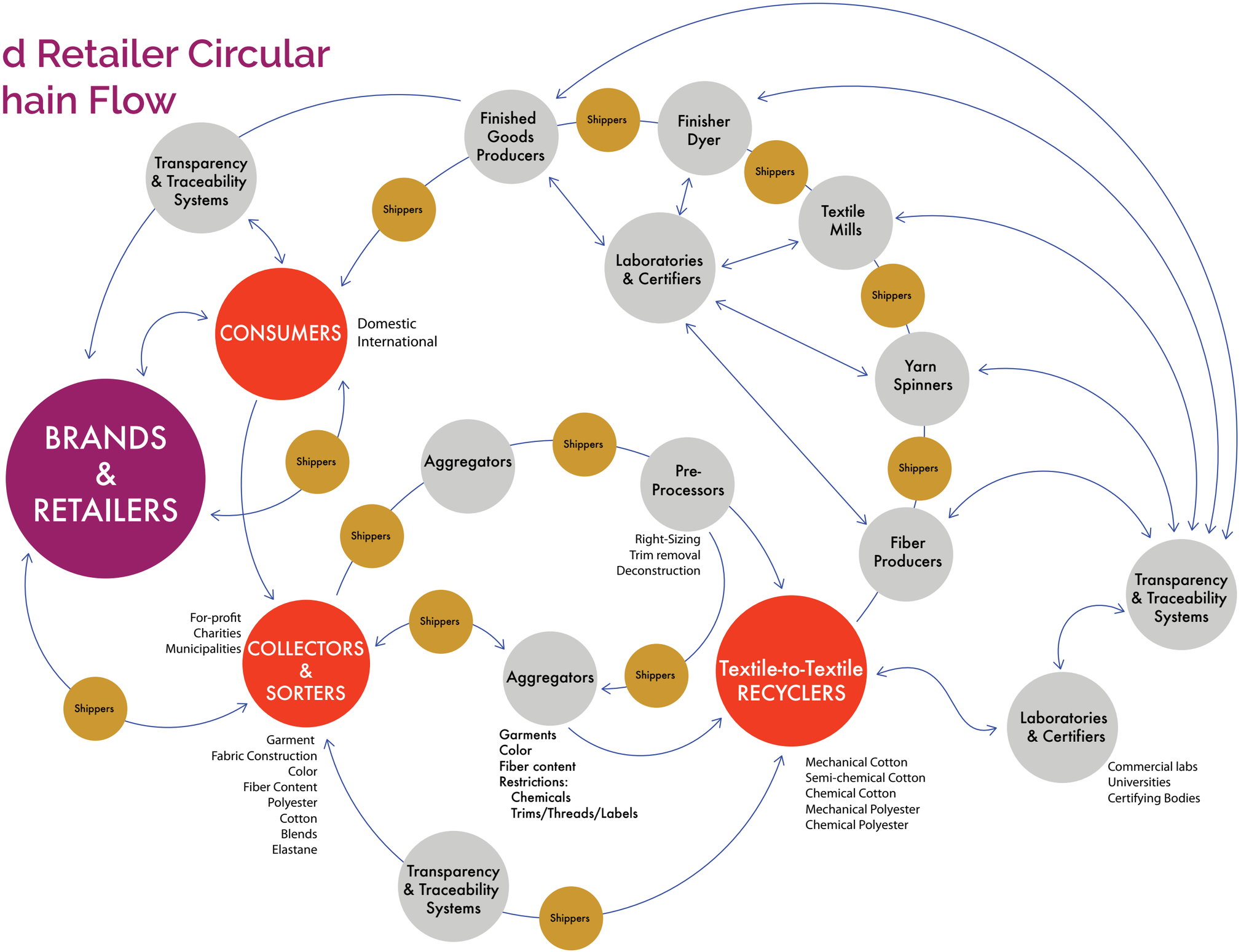
CONSUMER
Domestic
International

PARTICIPANTS
Collectors
Sorters
Aggregators
Preprocessors
Mechanical Recyclers
Chemical Recyclers
Fiber Manufacturers
Yarn Manufacturers
Fabric Mills
CMT Manufacturers
Brands
Retailers
Labs
Traceability Companies
Trim Suppliers
Shippers

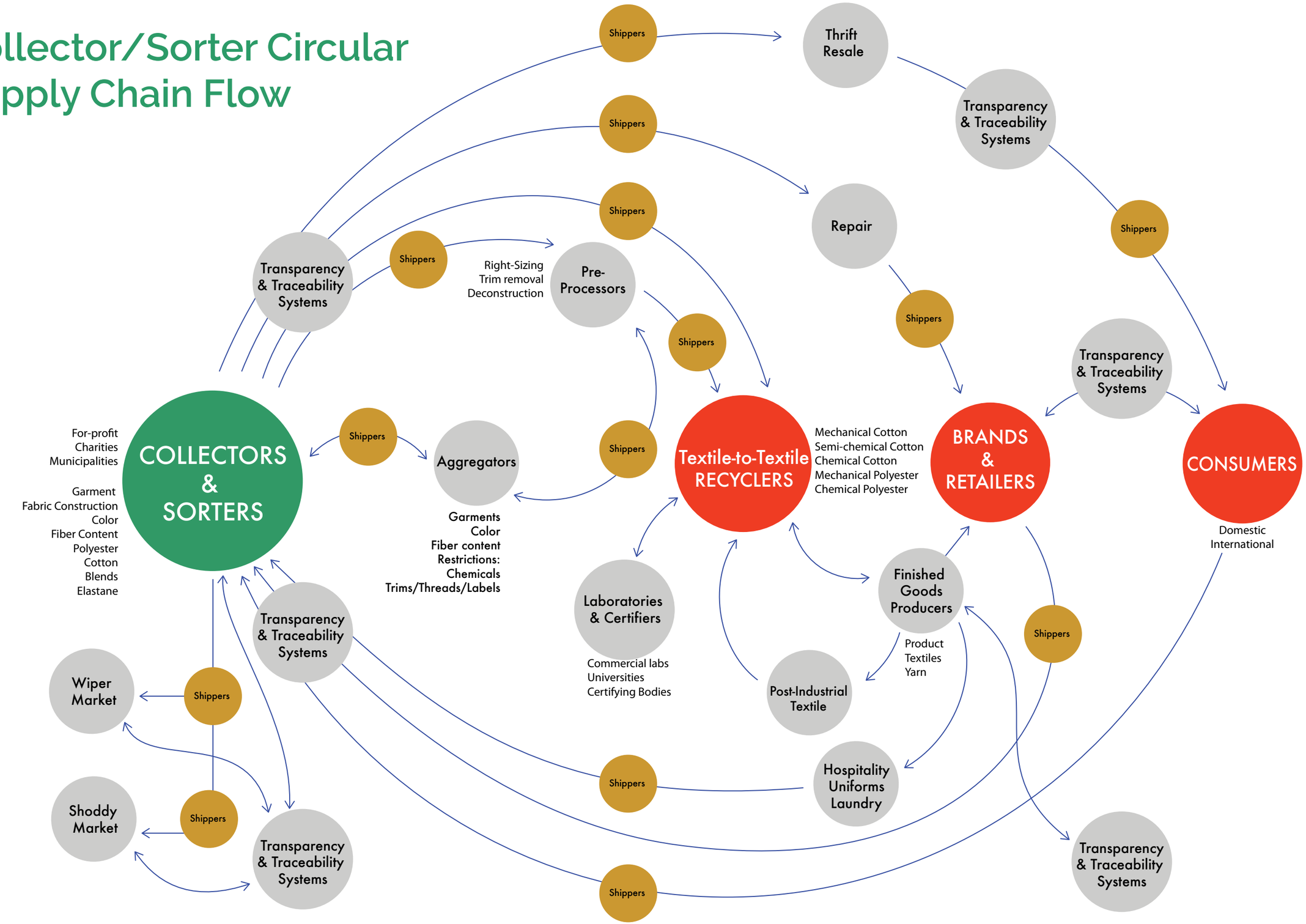
INPUTS
Virgin materials
Spent textiles
Human capital
Financial resources
Water, energy, chemicals

OUTPUTS
Products
Byproducts: waster, materials, chemicals, CO_2

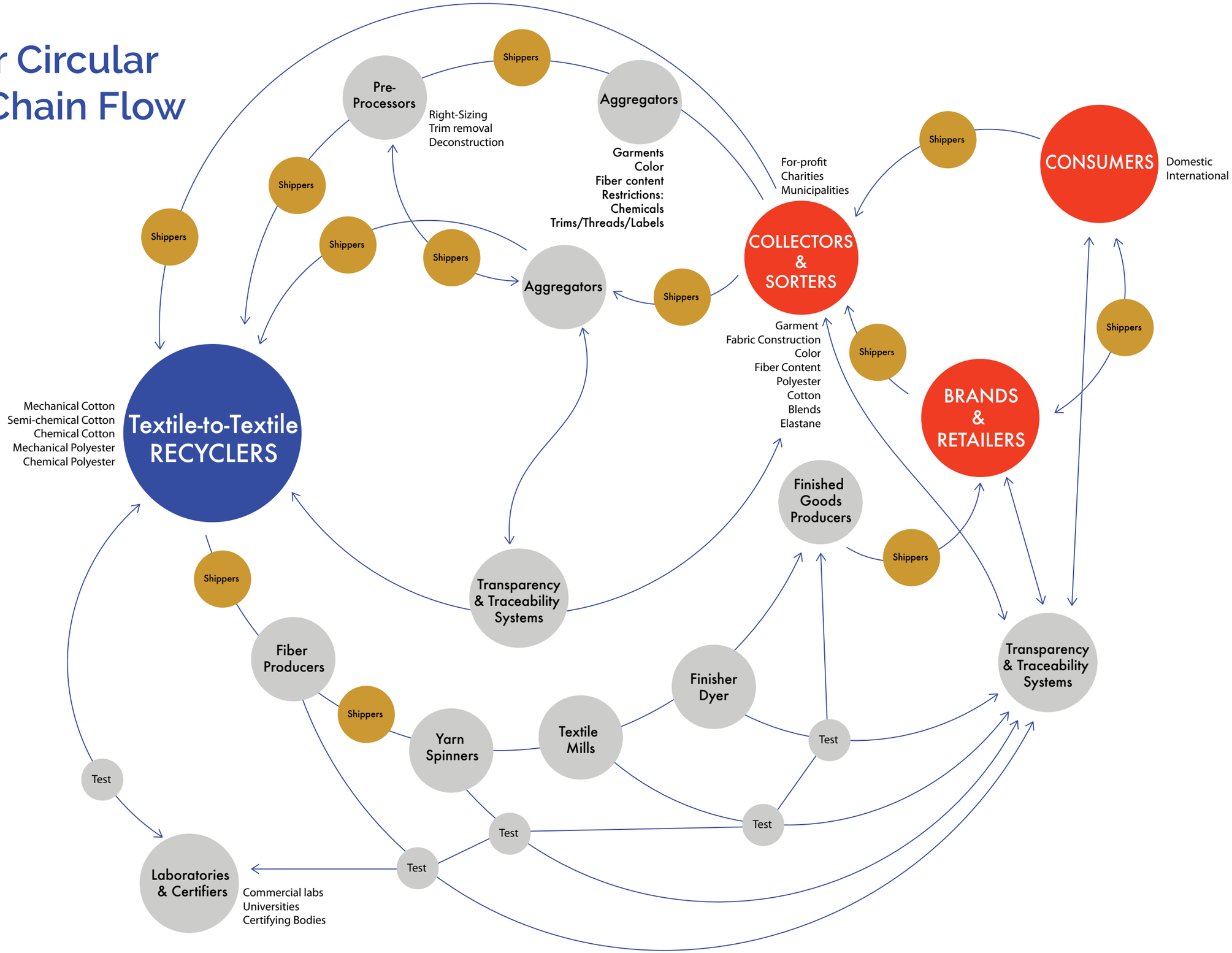
Brand and Retailer Circular Supply Chain Flow



Collector/Sorter Circular Supply Chain Flow



Recycler Circular Supply Chain Flow



ACP Product Models

Circular systems — like today's linear supply chain — include a multitude of pathways. Each is unique and can be simple or complex, driven by the quantity and quality of available material, technical capabilities, and demand. We need to transition from the current system to circularity quickly.

The current system must quickly reduce carbon emissions if we are to meet the goals of the Paris Agreement.

We believe in using the mass balance approach to material accounting to support this rapid transition. This approach allows collectors to aggregate spent textiles from a number of sources in order to supply dependable flows of quality feedstocks to the required specifications at commercial scale.

The hypothetical models outlined in the following pages are based on our research and conversation with industry actors.

Textile-to-Textile Towel Story

50% rCotton / 50% rPET

Hotels rotate towels on a regular basis, creating feedstocks for the recycling process. The only preprocessing required to transform towels to recycling feedstocks is laundering, which is done on site. The towels need to be aggregated to create commercial quantities of feedstocks. In this model, spent towels from The Breakers in Palm Beach can be shipped to Mexico to be garnetted, blended with rPET, and spun into yarn. The yarn is then shipped to Georgia and woven into new towels, which can then be procured by The Breakers or other hotels.

Circular Towel Flow

1. Collectors: The Breakers, Palm Beach, FL - collection on site
2. Sorters: The Breakers, Palm Beach, FL - Sorting on site
3. Pre-processors: The Breakers, Palm Beach, FL - Laundry on site
4. Aggregators: Southeast
5. Recycler: Giotex Merida, Mexico
6. Fiber Manufacturer: Giotex, Merida, Mexico
7. Yarn Spinner: Giotex, Merida, Mexico
8. Fabric Mill: 1888 Mills, Griffin, GA
9. Finished Goods Maker: 1888 Mills, Griffin, GA
10. Brands: The Breakers, Palm Beach, FL

Textile-to-Textile T-Shirt Story

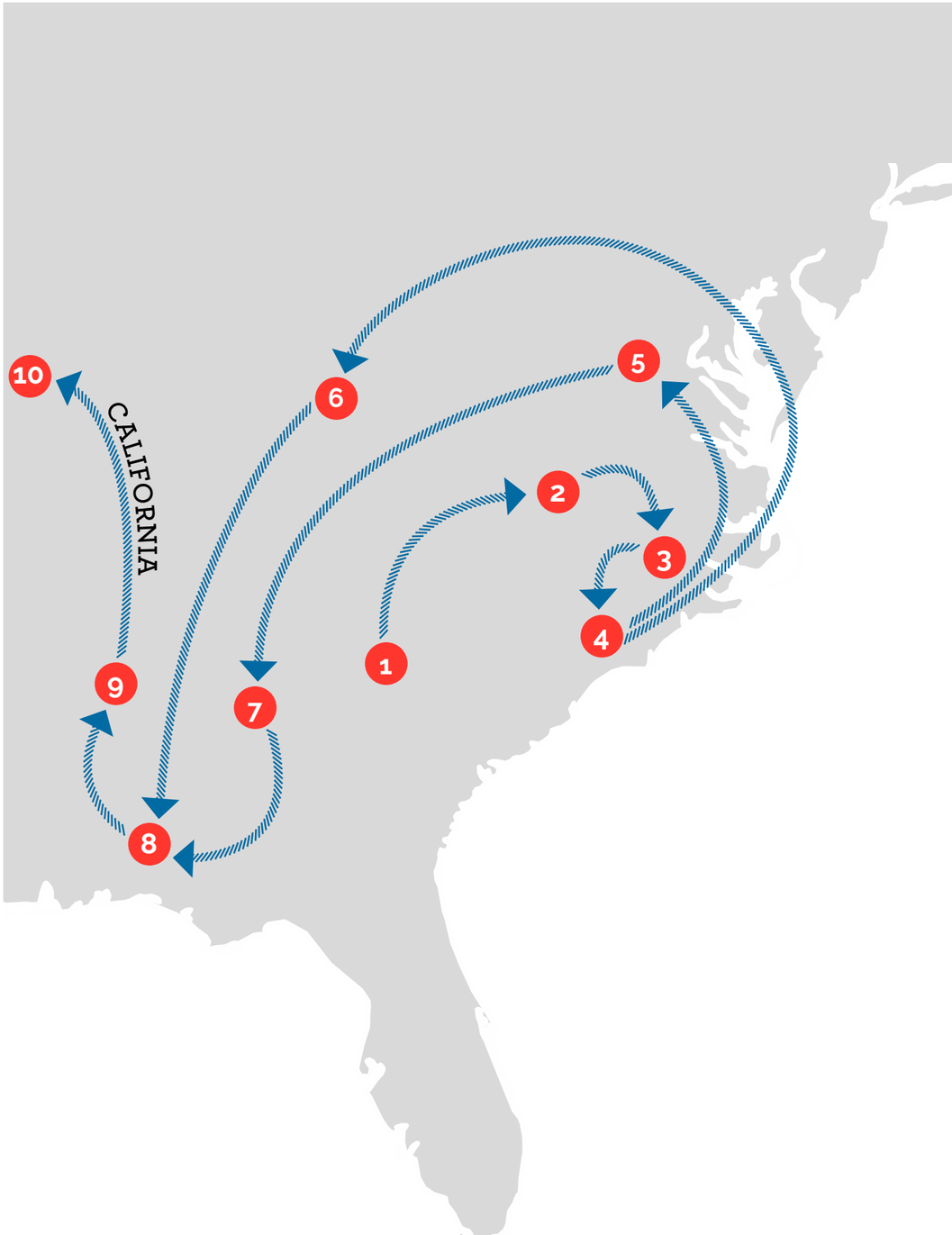
50% rCotton/50% rPET

T-shirts, a wardrobe staple, are made with a wide variety of materials. A textile-to-textile t-shirt made on the East Coast of the U.S. could be:

1. A commercial blend of (1) post-consumer **mechanically** recycled cotton, (2) post-consumer **mechanically** recycled polyester textiles, and (3) post-consumer **mechanically** recycled polyester bottles
2. A blend of (1) post-consumer **mechanically** recycled cotton and (2) post-consumer **chemically** recycled polyester textiles (technology commercial in about two years).

Circular T-shirt Flow

1. Collector: Cotton - Northeast
2. Collector: (Option 1) Polyester, PET bottles / (Option 2) No PET Bottles - Southeast
3. Sorters: Cotton - Northeast
4. Sorters: PET - Southeast
5. Aggregators - Southeast
6. Pre-processors - Southeast
7. Recycler/Fiber Mng.: Mechanical rCotton - Southeast
8. Recycler: (Option 1) Mechanical rPET / (Option 2) Chemical Recycler - Southeast
9. Fiber Mfg. - rPET Southeast
10. Yarn Spinner - Southeast
11. Fabric Mill - Southeast
12. Finished Goods Maker - Southeast
13. Brands - USA



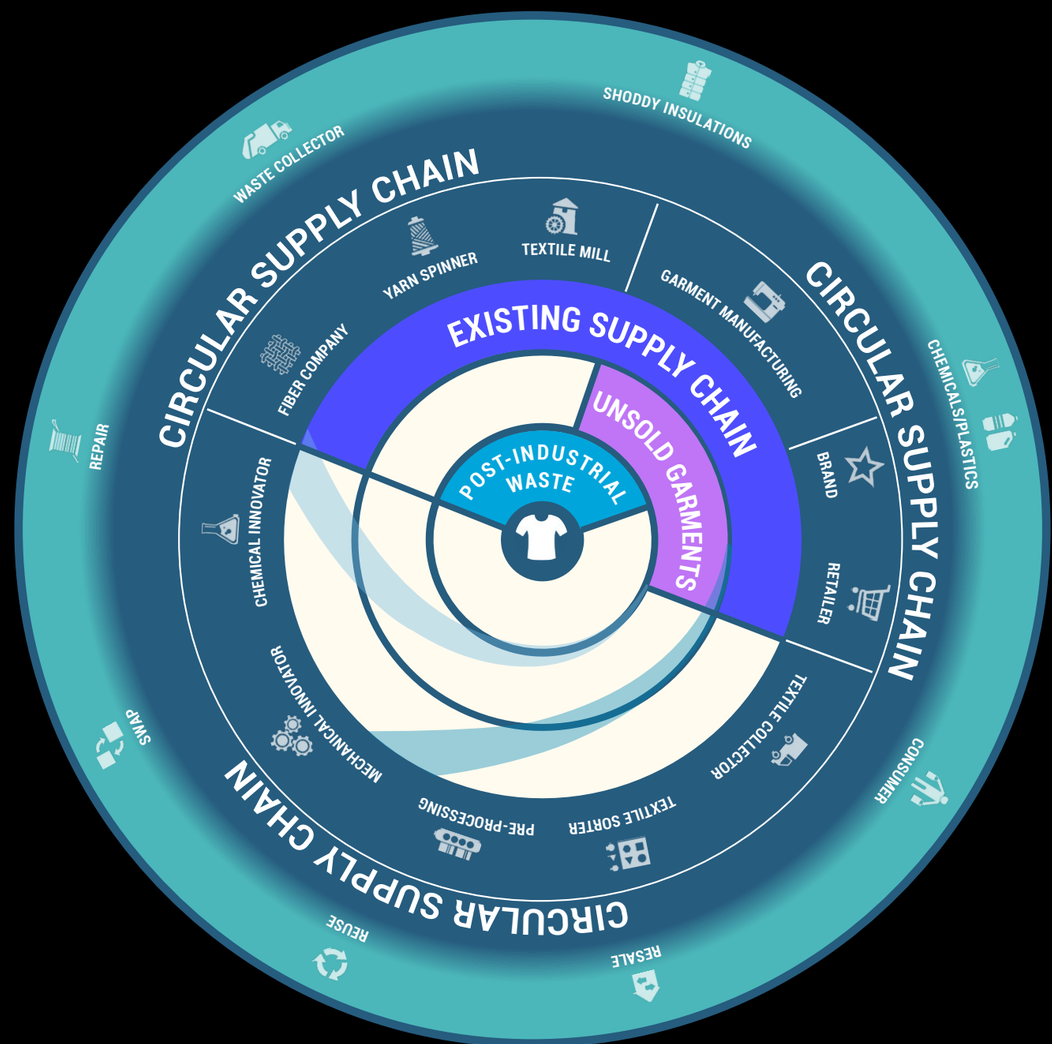
Textile-to-Textile Jean Story

30% Refibra™ Lyocell/40% rCotton/30% Organic Cotton

Jeans are often developed vertically from yarn to finished garment. This model outlines the use of Refibra™, which is a combination of 30% textile-derived pulp and 70% wood pulp sourced from sustainably managed forests. Textile for the pulp is collected in the Southeast. The fiber plant is located in Alabama. rCotton is collected and processed in the Southeast. Organic cotton in grown in Texas. All fiber is shipped to Mississippi, where it is spun into yarn. Fabric and garments are made in California and shipped to US brands and retailers.

Circular Denim Flow

1. Collectors - Southeast
2. Sorters - NC
3. Aggregators - NC
4. Pre-processors - NC
5. Recycler: Cellulose pulp - VA
6. Recycler/Fiber Mng.: rCotton - SC
7. Fiber Mfg.: Refibra - AL
8. Yarn Spinner - MS
9. Fabric Mill - MS
10. Finished Goods Maker - CA
11. Brands - USA



NEXT STEPS

Systems Trial Project Scope

Phase I Research

Building on initial research confirming material paths & products.

Phase II Planning

Outline technical and economic models and plan trial traceability.

Phase III Engagement

Engage trial participants and supply systems.

Phase IV Execution

Trial system from collection through product.

Phase V Evaluation

Product testing and business case development.

Stakeholder Registry

Detailed information is required to transform models into real, functioning systems. To facilitate live connections, we will publish a directory of relevant stakeholders that builds on our previous mapping work.

Register now: www.acceleratingcircularity.org/stakeholder-registry

Trial Goals & KPIs

Testing Models and Links in Trials: Goals	Indicator (Type: Output Outcome Impact)
Demonstrate logistical and technical feasibility of circular textile systems	Volume of spent textiles entering recycling processes
	Total volume of material through system
	On-time delivery of process in- and outputs
	Number of circular products
	Products meet brand quality acceptance standards
Establish best practices for brand/retailer take-back implementation	Number of brands collecting material for feedstock
	Fraction of total rFeedstock in trial attributable to brand take-back
Demonstrate business case for textile-to-textile circularity	New business generated by number of contracts
	Industry buy-in by number of organizations particpating in trials
	Number of businesses sorting to rFeedstock fraction
	Ratio of rFeedstock to total spent textiles collected
Demonstrate improved environmental and social performance	GHG intensity
	Water intensity
	Material diverted from landfill
	Uptake of recycled material in finished products
	Rate of virgin material production growth
	New jobs

Indicator types:

OUTPUTS: **What did we do, and how much of it?**
Time-bound to the trials

OUTCOMES: **What did our interventions directly achieve?**
Baseline metrics & before/after comparisons
for measuring uptake and scale short- to mid-term

IMPACTS: **What was the environmental, social, and economic impact of our work?**
Establish baselines and data collection methodologies for
longer-term impact studies

ACKNOWLEDGMENTS

"Circularity is a team sport."

—Karla Magruder, **Founder and President, Accelerating Circularity, Inc.**

This report would not exist without the many people who contributed their time and effort to the work of modeling circular textile supply systems. We are especially grateful to the members of our Sorting Specifications Working Group, whose knowledge and insights developed the textile use hierarchy and chemical and mechanical sorting matrices. We also wish to thank the growing membership of our Brand and Retail Collaboration Working Group, whose efforts ground us in the realities of bringing circular products to market as well as the complexities of responsibly managing those products at end-of-life. Special thanks to Shelly Gottschamer for volunteering to lead that group as well as for her overall willingness to contribute to the cause. We wish to acknowledge the members of our Steering Committee and Board of Directors, who continue to shepherd the project with strong oversight and strategic leadership. We are grateful for our funders, especially the Walmart Foundation, whose support ensures we can carry this work forward. Thank you all very much.

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