PYXERA Global

Optimizing Circular Logistics: A Revisited Approach

Sponsored by FedEx®

July 2024

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Note: The views and opinions expressed in this report are those of the authors at Pyxera Global and do not necessarily reflect the opinions of any funders or entities mentioned herein.

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Acknowledgments

We would like to extend our deepest gratitude to several individuals whose contributions have been invaluable to the development of this report.

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Glossary

3PL - Third-party Logistics

AI - Artificial Intelligence

Blockchain - A system in which a record of transactions, particularly crypto-currency transactions, is maintained through a peer-to-peer network of computers

Bottle Bills - Any law that requires a refundable monetary deposit upon the sale of a beverage container that is refunded to the customer upon their return of the container.

CalRecycle - California's Department of Resources Recycling and Recovery

EPR - Extended Producer Responsibility

HMR - Hazardous Materials Regulations

Materials passports - A material passport lists all the materials included in a product throughout its lifecycle

MRFs - Materials Recovery Facility

OEM - Original Equipment Manufacturers

PaaS - Product as a Service

Planetary boundaries - The limits to the impact of human activities on the Earth system, beyond which point the system could no longer self-regulate and the stable Holocene period would end

PRO - A Producer Responsibility Organization is responsible for managing the collection and recycling of products subject to EPR laws.

RFID - Radio Frequency Identification

Re-X stream or Re-X - Re-X refers to elongating the lifetime of products or parts via reuse, repair, remanufacturing, refurbishment, or repurposing.

RCRA - The Resource Conservation and Recovery Act (RCRA) was enacted in 1976 and governs the disposal of solid and hazardous waste in the United States.

Introduction

In a world where our traditional economic systems strain under the weight of inefficiency and waste, a transformative shift is not just a choice but an urgent necessity. With its unsustainable practices, our linear economy can no longer suffice. It has become necessary to fundamentally alter our thinking about how global supply chains should function and implement a model that reduces waste and maximizes existing resources.

The alternative to a linear supply chain is a circular, or 'closed-loop' supply chain that exists within a circular economy – a new economic model that aims to keep materials in use for as long as possible.

In 2023, FedEx sponsored a circular supply chain pilot implemented by Pyxera Global, which resulted in the publication of a report, Powering Sustainability Through Circular Logistics, focused on the role of logistics companies in facilitating the circulation, not just the reverse flow, of goods and materials in a circular economy.

In that report, we aimed to expand the role of logistics, not just to move goods from manufacturing to consumer, but to help enable a transition to a circular economy.

We called this reimagined role for logistics in a circular economy circular logistics, a term that encapsulates the transformative potential of the industry.

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In circular logistics, logistics providers facilitate the movement of products beyond transporting from point A to point B. It involves logistics providers exploring new business processes (e.g., the rise of **consolidated returns**) that could include needed processes for a circular economy, including the collection, sorting, and redistribution of materials to keep those materials in circulation for as long as possible.

It also involves logistics providers actively supporting the enabling environment necessary for those new models to succeed. By leveraging their expertise in managing highly specialized transportation networks, logistics providers are a natural fit to find and promote new solutions to embed these needed elements of a circular economy.

Through our research, the rationale behind circular logistics, encompassing its environmental and social benefits– the "why" – became clear:

- **Less pollution and waste, both globally and more pressing at the local level where often underserved communities bear the brunt of pollution and waste**
- **Decreased greenhouse gas emissions and decarbonized economy by promoting product reuse, thereby lessening the demand or need for new material extraction to make new products**
- **The recovery and reuse of critical resources in circulation to address political and financial risk and volatility that could lead to materials shortage**
- **Increased employment opportunities alongside skilled workforce development**

After the publication of the first report, it was clear that the "how" of circular logistics required further research and exploration to develop a core series of value propositions for the logistics industry. This new report, which includes an evaluated pilot project, stakeholder interviews, and desk research, explains the value propositions for the logistics industry in circular logistics.

Summary of Research to Date

Circular logistics involves collecting products and materials after use, transporting them to a sorting location, sorting them based on the highest value for their next use, and then distributing them to a service provider for reuse, repair, refurbishment, remanufacturing, or repurposing (also known as a Re-X stream or Re-X).

By closing the loop, the product or its constituent materials remain in the economy and are not discarded in landfills. Additionally, the reuse of core materials reduces the demand for virgin resources.

Source: Metabolic

Collection

Collection refers to the process of gathering a product or material when it reaches the end of its first useful life cycle, aggregating it with similar materials, and keeping it in the supply chain.

Today, the term "collection" in the logistics industry tends to be synonymous with product returns. The **return economy is a multi-billion-dollar industry**. Across the logistics industry, small-scale operations are cropping up that more closely resemble collection processes for circular logistics, but they are disconnected from each other and highly localized in nature, often dependent on local infrastructure and opportunities left vacant by municipal waste haulers.

In an ideal state for a circular logistics system, used or unwanted products and materials would be collected using a variety of methods from various locations. The most accessible and convenient location for the consumer would be regular curbside pickups directly from consumers' homes, like today's waste and recycling efforts with pre-scheduled pickups and clear instructions on what can be collected. While this is the most convenient option for consumers, it is challenging to scale solutions and implement them cost-effectively.

There are opportunities for logistics companies to retool existing infrastructure in innovative ways

Challenges associated with transitioning from the current to the ideal state of circular logistics primarily revolve around both financial barriers and consumer behavior. Financially, using the “milkman model” of regular pick-ups at customers’ homes has not proven to be cost effective. For consumers, detailed instructions, education, and training are also necessary to maintain the integrity of the core materials.

Still, we believe there are opportunities for logistics companies to retool existing infrastructure in innovative ways to engage in the collection portion of a circular logistics network.

Sorting

After products are collected, they are most often transported to a central location for sorting. Sorting involves categorizing products and materials to distribute them to the Re-X stream with the most retained value. For example, electronic waste recyclers will first attempt to repair, use hardware for spare parts, and then finally break down the product into its core components.

In an ideal circular logistics network, products are sorted at strategic locations or "nodes," such as distribution centers or sorting facilities. These nodes serve as crucial points in the supply chain, where products are sorted based on criteria like destination, product type, size, weight, or priority.

In this ideal state, logistics companies would fully embrace their role as sorters in a circular supply chain, capitalizing on their central position and existing interactions with products and consumers. By integrating efficient sorting processes for used products and materials, logistics companies can significantly contribute to a more sustainable and circular economy.

The key is to determine who will be responsible for the cost of collection and sorting. Some materials have resale value equivalent to these costs or higher, but many raw materials do not have the same pricing, eliminating the financial lever businesses use to implement new practices.

Sorting for product quality also presents a significant challenge. In the example of e-waste, skilled labor is currently required to assess and diagnose the condition of a donated item. Sorting for product quality offers a valuable opportunity for job creation, but this requires skills development or upskilling not available in many locations. While specialized equipment can streamline the task, the manual approach requires a high level of skill and attention to detail.

This makes it possible for skilled workers to play a vital role in accurately assessing materials suitable for reuse, repair, refurbishing, remanufacturing, repurposing, and recycling. Consequently, this labor-intensive process not only fosters employment but also encourages the development of specialized expertise in specific regions of the country.

Sorting is the biggest challenge facing the further evolution of circular logistics offerings. However, by optimizing networks and developing new relationships with warehousing facilities and distribution centers, the sorting can occur at or near these local logistics nodes that already have significant transportation infrastructure in place.

This optimization also enables local economic development for sorting and bundling of products that companies can then send for reuse over long distances with the most effective use of space. In the end, circular logistics can provide economic development opportunities for cities, particularly for low-wage, low-skill workers who can quickly gain specialized skills and improve their standard of living.

Circular logistics can provide economic development opportunities for cities

Redistribution

Logistics companies have mastered global product distribution through complex, interconnected transportation networks and sophisticated tracking systems. However, current logistics networks primarily focus on the one-way movement of goods and products from manufacturers to consumers, with varying degrees of transparency depending on industry certification requirements.

Current logistics networks rely on contracts between manufacturers or suppliers and end-users that determine how and where goods should be delivered. This impartial approach allows logistics companies to focus purely on efficient transportation and delivery services without concerning themselves with specific product applications or requirements.

The logistics industry can play a significant role in material and product redistribution. This becomes more critical as we address waste and work diligently to decarbonize key sectors of the economy, such as vehicle electrification. Given the increasing demand for high-value materials and their limited quantities, local and regional recirculation markets will need to be prioritized to secure these building blocks for a new economy.

The logistics industry can play a significant role in material and product redistribution

Redistributing materials in a circular economy is critical for creating a more sustainable world, but significant challenges exist. These include ineffective utilization of certifications, packaging challenges, and ensuring a reliable supply of products for end-users. These barriers must be addressed to implement a circular economic model successfully.

Further, opportunities lie in developing agreements between closely aligned customers (who are committed to circular logistics and sustainability goals) and logistics companies to deliver products and provide preferential access to transportation services to return the product at the end of its useful life without additional cost.

Opportunities for Change

At the conclusion of our last report, our team identified five opportunities for the logistics industry to accelerate a circular economy:

1. Make use of existing services and facilities for circular logistics (e.g., Prologis using a warehouse to both distribute new tires and then collect used tires for recycling).
2. Improve the value chain by selecting vendors that adhere to robust sustainability targets.
3. Accelerate the collection and redistribution of used materials and goods by influencing economic incentives or new regulations to drive change.
4. Collaborate pre-competitively with peers, pilot with customers, and collaborate within the business units to rethink former models of distribution and waste management.
5. Build logistics knowledge within local and regional logistics providers who are often best equipped to manage the Re-X processes.

Evaluating the E-Waste Reverse Supply Chain

Pyxera Global conducted a pilot project from September 2023 to January 2024 to test several of the opportunities presented in the initial report.

The primary focus of the pilot was to determine the most effective ways to integrate circular supply chain practices that prioritizes social and environmental impact. Electronic waste (e-waste) was identified as the industry vertical of focus for this pilot, as many materials in electronic devices hold intrinsic value, such as critical metals.

At the conclusion of the pilot, our key learnings included:

- Certifications meant to advance circularity—such as those governing the handling of hazardous materials—can, in practice, hinder it if organizations intending to adhere to the rules and procedures are (a) under-resourced or (b) under-trained.
- Collection packaging needs to be low-cost to be financially viable at scale, which may require changing standard operating procedures for packaging, particularly “return” items at the end of their useful life (versus traditional returns).
- Smaller, community-based organizations are nimble and open to change, which can mean adapting faster to emergent circular logistics models. For large sectors of the economy with the most potential for value capture, close partnerships from the smallest organizations to larger entities are critical for circular supply chains to take hold.
- Often, retooling existing infrastructure or adapting existing processes is not the most expedient method to introduce sustainable change. Leveraging design thinking and starting “anew” was often the most effective approach.
- To make circular logistics financially viable in the short and long-term, there must be a significant volume of materials collected. This requires more investment in marketing and communications regarding product reuse.

Methodology: Linking Past Research to Present Inquiry

The goal of this report is to consolidate all findings and research gathered to date and explore open or unresolved issues in greater depth. The report also aims to refine and strengthen specific areas where the logistics industry can accelerate the transition to a circular economy.

The Pyxera Global team pursued four research questions at the onset of phase two of research, each exploring different facets of the circular economy: the circular logistics policy in the United States, a landscape assessment of circular logistics providers, the incentives and drivers to participate in a circular economy, and various case studies of circular value chains.

These considerations formed the backbone of our research, which primarily focused on the United States. However, we also considered policies and logistics providers outside of the U.S., considering their relevance to shaping the future direction of the circular economy within the United States.

Our policy research aimed to understand the current policy landscape and its impact on the circular economy. The landscape assessment mapped the current reverse logistics providers and the position of circular logistics in regards to the growth needed to transition the economy.

The research on incentives and drivers for participating in a circular economy focused on requisite partners, including municipalities, local enterprises, large corporations, and logistics companies. Finally, examining case studies provided insights into the opportunities and challenges in guiding the development of new circular value chains.

We employed various methods to collect information in each research area, including desk research, stakeholder interviews, and analysis of findings detailed in **our first circular logistics report**. For policy desk research, we prioritized government sources such as the Environmental Protection Agency's website, federal court documents, state government websites, and city records of bills. Our policy research followed a hierarchical approach, beginning with international policies and progressing to national, state, and municipal policies.

The landscape assessment desk research involved reviewing articles, environmental blogs, studies on e-waste recycling needs and hazards, and determining the top companies in reverse logistics. Through case study research, we analyzed papers and were guided by semi-structured interviews with key players.

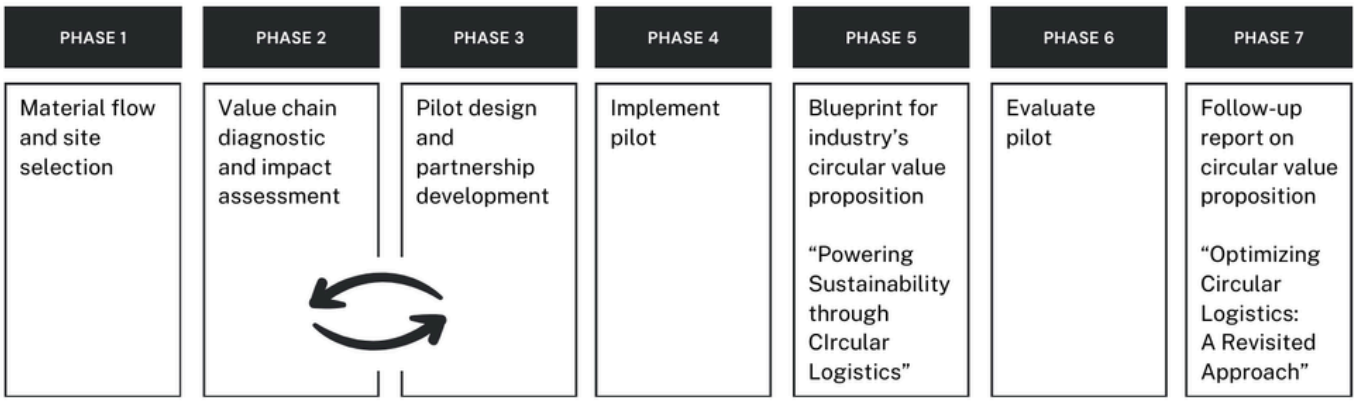
The research on incentives and drivers included interviews with staff from geographically diverse U.S. cities, employees at large and startup material-specific recycling companies, and circular economy practitioners.

This report also draws on findings from our previous report, completed in 2023, and earnings from the pilot program, which concluded in early 2024. In this report, we outline the value proposition for logistics companies and manufacturers, urging them to more quickly explore circular logistics practices and participate in the circular value chain.

While the report addresses the inhibitors to a circular economy that logistics companies can potentially resolve, it does not provide a detailed overview of challenges, like planned obsolescence, that fall beyond the scope of logistics companies' influence.

The research completed for this report will guide the design and implementation of future circular logistics pilots. After building on the achievements and learnings from the initial pilot, the next phase will aim to scale up operations, linking small businesses in a specific geographic area with major clean energy technology manufacturers through forward procurement agreements.

Research Phases



Unlocking Value: How Logistics Companies Can Transform Supply Chains into Supply Networks

In the rapidly evolving landscape of sustainability and resource management, the transition to a circular economy is no longer a distant vision but an imminent necessity.

As global concerns over finite resources and environmental degradation intensify, shifting towards circular production and consumption models becomes increasingly urgent. Within this paradigm shift, the role of the logistics industry has emerged as a pivotal component, not only as part of the transition but with an opportunity to actively shape the development of a circular supply network.

Our team contends that logistics companies are well positioned to adapt to the demands of a circular economy and proactively shape its course.

In a report published by Pyxera Global in September 2023, **Powering Sustainability Through Circular Logistics**, our team proposed several opportunities for logistics providers to reimagine their ability to accelerate the development of circular supply chains. The logistics industry is sector-agnostic, providing an opportunity for industry leaders to connect diverse supply chains while addressing materials gaps across industries.

The goal is to transform supply chains into supply networks optimized to move material to the next Re-X vendor that would provide the highest value.

The next section explains three proposed roles for logistics companies in circular supply networks.

Logistics companies are well positioned to adapt to the demands of a circular economy and proactively shape its course

1 Logistics companies can help facilitate both consumer and local business participation in the circular economy by providing more convenient collection solutions.

Consumers are the starting point for reintroducing products and materials into a circular supply chain. A behavior change at the consumer level will be required to recover used products and materials. This can be accomplished through financial incentives, behavioral marketing campaigns, and convenient collection methods.

A successful circular economy requires widespread infrastructure for local and regional collection points connected to larger logistics networks. Logistics companies might consider operating collection points where consumers can conveniently drop off a wider assortment of items at strategic locations optimal for shipping. These locations may include logistics company storefronts, post offices, partner companies, or large stores with a high shipping volume. Although many collection bins exist, they often cater to specific products (such as only laptops or solely Apple laptops) and lack multiple bins for various products in one convenient location.

Collection efforts are often also tailored to specific brands (see page 23). However, product- and brand-neutral logistics companies can overcome this by establishing multiple generalized collection bins in one location. The goal is to maximize convenience for consumers in recirculating products.

One opportunity to finance these collection programs is through **EPR (Extended Producer Responsibility)** schemes, with logistics companies serving as the PROs (Producer Responsibility Organizations). To support the creation of Re-X markets, logistics companies can use existing logistics infrastructure, like collection and sorting schemes, to support small businesses and municipalities with infrastructure gaps or economic restraints. For example, they might explore discounted shipping fees to lower the initial entry barriers for smaller local businesses.

Some companies and governments provide financial incentives for returning products (see page 27), or consumers only 'own' products temporarily through **product-as-a-service models (PaaS)**. Logistics companies can integrate the software with other organizations and municipalities. This integration enables them to notify customers when they can or need to return products while providing information about collection options. These options may range from curbside pickups or storefront drop-offs, which can be arranged and paid for by the consumer as part of the PaaS model.

Innovative business models in logistics, such as **Prologis** real estate investments, can encourage business-to-business linkage and collaboration by offering access to logistics facilities as a service without the high upfront cost. Finding new models to enable access to technology and operational expertise can modernize supply chains worldwide.

As shown in our pilot program, collecting products, especially those with high-value components (i.e., electronics), through individual consumer shipping is likely too expensive unless the Re-X value is known to be high (e.g., reuse or repair) before collection. Therefore, shipping by individual consumers should likely be reserved for returning PaaS products, where returns are built into the business model.

Ryder provides transportation solutions and an optimized transportation network, including vehicles, enhanced visibility, routing, and scheduling. In conjunction with Ryder, Goodwill has outsourced all the logistics operations, from collecting donated items to transportation to distribution centers across the US to delivering the items to the agencies that would supply the goods to people in need.

Logistics companies can support the movement to circularity by applying differentiated shipping fees to organizations moving products and materials intended for a high-value Re-X stream.

This offset in transportation costs could help balance the competitive landscape until small companies reach the right scale to become cost-effective.

2 Logistics companies can create networks with geographic clusters for optimal sorting.

The efficiency of circular services depends on service providers forming geographic clusters within specific value chains. Developing these clusters, or hubs, minimizes the time, cost, and environmental impact of material transportation.

A network of sorting clusters, moving from general to more specific value chains, will decrease the distance traveled by products and materials, thus lowering greenhouse gas (GHG) emissions. At the municipality level, the sorting node of a circular supply network would categorize undifferentiated materials and products as close to the collection source as possible. This process facilitates high-value circular logistics streams, such as reuse or repair, at smaller local nodes, sending them to local enterprises for repair and reuse. It also minimizes the need to transport large volumes of potentially low-value products across long distances and minimizes or eliminates the need for specialized or per-product packaging.

The efficiency of circular services depends on service providers forming geographic clusters within specific value chains

In our pilot project, the local node co-located sorting and repair at the same location: the social enterprise sorted products suitable for repair and then did the repair onsite. Co-locating these services eliminates the need for transporting material.

Another efficient local co-location strategy for sorting vendors could involve partnering with material recovery facilities (MRFs), which municipalities use to recover waste, including trash and recycling. Local sorting locations can also manage and transport reusable products, such as coffee cups, foodware, or packaging for locally-refilled products.

At the next level, likely regional in scope, products can be sorted for refurbishing, remanufacturing, repurposing, and recycling. These regional sorting locations can serve as volume aggregators for specific materials across industries. This includes transporting materials to the correct reprocessing facilities, which requires the materials to be properly differentiated and separated. This step is key because material extraction can be difficult when products are not designed for disassembly, especially if the products contain high-value materials. Classifying key components then allows the definition of a new value chain, breaking down materials into their commodity parts, isolating high-value materials, and forwarding them to the next link in the **chain.**

Developing the circular logistics value chain requires co-investment partnerships among companies, recirculated material manufacturers, and governments

Hyper-local initiatives of sorting, manufacturing, and shipping clusters have shown good business-to-business material flows. A few examples can be found in the circular textile industry in the Netherlands, the industrial symbiosis in **Kalundborg**, Denmark, and the **Western Cape industrial symbiosis**.

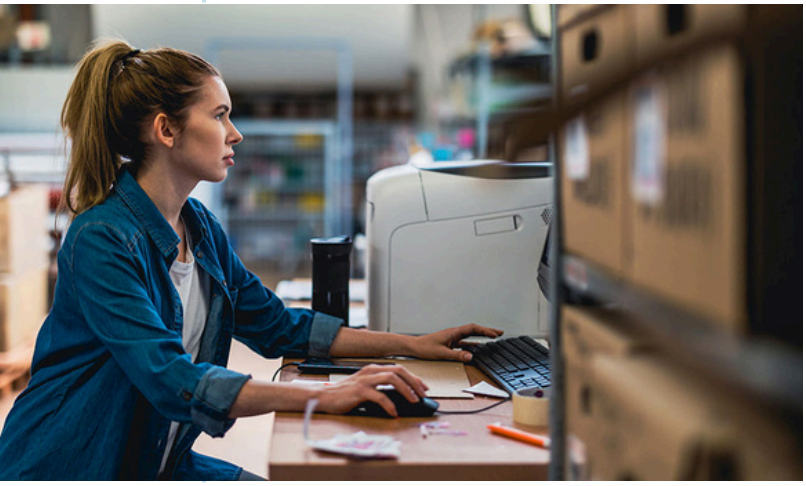
Significant funding is required to develop a multi-layered sorting and redistribution infrastructure. Investments in technology, facilities, and labor upskilling can be costly and often have a low return on investment. Developing the circular logistics value chain requires co-investment partnerships among companies, recirculated material manufacturers, and governments. Governments play a pivotal role by providing resources for solution implementation through grants, infrastructure, and services. They **endorse material collection programs** and facilitate collaboration between organizations by offering tax benefits or incentives for joint efforts, fostering a conducive environment for developing sustainable and circular initiatives.

To create the collection and sorting interoperable infrastructure needed for any product and material value stream, **our team is testing** if it is possible to create the infrastructure by starting with a high-value material stream like electronics.

3 Logistics companies can use data for route optimization and predictability models.

Logistics partners use business intelligence tools to create more predictable models in forward logistics. There is an opportunity to use similar tools to improve accuracy in forecasting material received and improve coordination between aggregators, processing facilities, and companies.

There is limited public data available on material and product circulation due to resourcing limitations, challenges in accessing weighing mechanisms, and the difficulty of including materials passports into products. Developing reliable systems for reporting product and material data, which includes data tracking, management, and reporting mechanisms, **can be pivotal to creating a solid basis for decision-making**. Manufacturers would be responsible for providing product information, necessitating **collaborative efforts** across the supply chain. Implementing such systems across the various links of a value chain can enhance resilience by facilitating the recirculation of materials before reaching the waste stage, thereby supporting the measurement of circularity.



Logistics providers can contribute beyond moving materials by providing valuable data to enable collaboration between manufacturers, collectively reducing the carbon footprint of critical products. This information may include material quality, historical collection rates for prediction modeling, the volume of materials required by manufacturers, supply risks, and seasonal changes in supply or demand. Numerous data tracking mechanisms can enable this data sharing (see page 50).

Logistics providers can contribute beyond moving materials by providing valuable data between manufacturers, collectively reducing the carbon footprint of critical products

Government-led initiatives like the **EPA Recycling Infrastructure Map** provide visibility into recycling hubs nationwide. However, another layer of data is needed to develop commodity markets further. This involves establishing quality standards for strategic materials and assessing the processing capacity of existing facilities. Access to such data enhances the potential for integrating repurposed materials into new supply chains and highlights potential gaps that small businesses could address.

Finally, another valuable data source is a company's environmental impact analysis, which reveals concentrations of emissions and challenges in key value chains. This information enables targeted innovation and pinpoints the most important circular strategies to minimize the environmental impacts in key supply chains.

Larger logistics providers have the credibility and power to collaborate to lobby for policy changes that decrease taxes on labor and increase on new materials, which would be one of the most influential ways to incentivize circular logistics and Re-X material use (see page 47).

Optoro is an example of integrated data in circular logistics. The company handles **client returns** and partners with Returnly to manage refunds and other aspects of the reverse logistics process. In addition to using data gathered from these returns, Optoro combines historical pricing and individual product data into an algorithm that advises companies on the optimal routing for each return item and suggests the most profitable disposition path (e.g., resale, liquidation, repair, recycling, or something else), thereby improving **the profitability of returned inventory** for clients.

Accuris Supply Chain Intelligence provides end-to-end supply visibility using accurate data connecting components to manufacturing locations and facilities across the supply chain. Data provides further details about suppliers and parts in the chain to mitigate supply risks.

An Evidence-Based Approach

Collection: Reintroducing Materials into a Supply Chain

In contrast to forward logistics, which focuses on distributing products from a centralized location, the collection stage of circular logistics entails multiple collection points, various conditions, and often unknown quantities of useful materials. Efficient collection operations play a significant role in processing product returns in different conditions and identifying key materials that can recover their value in a new supply chain.

Many companies engage in circular logistics by collecting products and materials, with many extending their services beyond collection. Additionally, companies not traditionally involved in logistics enter circular logistics and the circular economy by providing space for product collection.

Challenges

- **There are barriers to efficiently collecting materials due to challenges encountered by end-users in delivering the right material or product to the correct location to ensure seamless re-entry into the supply chain.** Additional challenges for collectors include understanding the material's chemical makeup (e.g., identifying the type of plastic used), its intended purpose (e.g., whether it was intended for single-use or if its nature limits maintaining quality), its age (items can range from decades-old refrigerators being retired to fast fashion items discarded with tags still attached), and the presence of hazardous materials (such as heavy metals and chemicals commonly found in electronics and batteries) that inhibit recycling.

- **Processing and collecting materials for circular production pose challenges regarding quality, quantity, design, and pricing uncertainty.** Unlike traditional production methods, estimating the location of materials and aligning them with demand presents a significant challenge, leading to difficulties in optimizing logistics. Charging end-users for collection services beyond utility bills could be unpopular, while separation at the source can be viewed as labor that warrants compensation (e.g., individuals collecting cans, paper, and cardboard who receive payment per collected unit).

- **Implementing source separation in cities without a collection system would result in heavy up-front costs (e.g., rerouting, purchasing new bins, educational outreach, training programs, etc.).** Pick-up frequency laws and city layouts (e.g., space design to hold curbside bins or ease of access of trucks to collect bins) can also impede establishing source separation strategies.

- **The recycling industry grapples with labor challenges, including risky conditions for collectors in vulnerable communities and a labor shortage across the chain.** To address these issues, an initiative called First Mile assists waste collectors in Haiti, Honduras, and Taiwan in earning a dignified income through plastic recycling. This initiative collaborates with informal aggregators, collection centers, and companies to ensure the process yields the necessary volume and quality of materials for accessing sustainable supply chains competing in the commodities market. **Investing in developing individuals' skills and knowledge** is a key aspect for companies to transition into circular models successfully. Logistics companies can partner with local collection and sorting businesses that prioritize skill-building and social inclusion.

- **Companies are also looking to reshore activities and develop local supply chains.** This can benefit small-scale and informal aggregators that struggle with the costs of longer-distance transportation of materials.

- **Inefficient collection results from undifferentiated or mixed-component materials, requiring extra time and advanced technology for sorting** (e.g., multi-layered plastic or a combination of materials).

- **Theft in collection bins (particularly in curbside collection) makes it more difficult to estimate an accurate volume of material to process.** This can lead to expensive collections, given the high cost of transporting empty trucks and the difficulty of selecting the most appropriate collection method based on volume.

Collection → Sorting → Redistribution

Non-Logistics Companies Participating in Circular Logistics	Full-Service Logistics Companies with Multiple Offerings
Happy Returns is a startup that collects and aggregates loose return items at kiosks in malls or stores. It provides online-only retailers with a physical channel for collecting returns. Retailers save on shipping, customers get their refunds immediately and avoid the hassle of packing their items, and malls get additional foot traffic.	XPO Logistics is the second largest provider in North America, with over 100 million sq. ft. of facility space in the Americas and Asia. XPO Logistics offers forward and reverse logistics solutions to business-to-business (B2B) and business-to-consumer (B2C) companies in several countries. It processes returns, refurbishes, disposes, and/or recycles products.
UPS Access Point offers services through a network of 4,000 locations, such as dry cleaners and convenience stores.	Recycle Track Systems (RTS) collects and sorts materials using an AI-powered sensor, Pello. The company manages a variety of waste, including e-waste and metal scraps, delivering sorted waste to the right processing facility using the RTS app.
Walmart offers a Community Recycling Unit that accepts eight different material streams, including aluminum packaging and other consumer goods.	ShipWizard provides "end-to-end 3PL services" to e-commerce stores and other businesses. A key offering is logistics management, with a focus on customer experience. ShipWizard integrates with e-commerce marketplaces, including Amazon and eBay.
Walgreens is using over 7,500 stores for partner FedEx to pick up aggregated packages.	Bowman Logistics offers several logistics and storage services (pick and pack for e-commerce businesses, temperature-controlled food-grade storage, consulting, and space for lease), the company also offers warehousing and returns management for B2B and B2C companies.
	ShipBob is a 3PL company that focuses on forward and reverse logistics services for direct-to-consumer e-commerce stores. It integrates with e-commerce platforms, including Amazon, Shopify, and BigCommerce (among others). ShipBob stores products in its warehouse, packages them, and ships them to consumers. It offers its own return process and also partners with Happy Returns and Returnly.

Collection → Sorting → Redistribution

Companies Managing Hazardous Materials (U.S.)

Cirba Solutions, headquartered in North Carolina and with six locations across the US and Canada, offers globally certified reverse logistics for electronic materials from lithium batteries, including lead acid, nickel, lithium, and alkaline and zinc carbon.

WeRecycleBatteries.com partners with suppliers and organizations to appropriately manage used batteries, offering door-to-door collection in less-than-truckload (LTL) amounts to simplify battery recycling and reduce the risk of hazardous material storage. The organization provides payments for positive value from collected batteries and an invoice if the value is negative. Upon request, they provide Certificates of Recycling for end-of-life processing or Certificates of Reuse for reusable batteries.

Ridwell is a company that collects and stores items that are hard to recycle from households. They collect items such as multi-layer plastic bags, plastic film, clothes, shoes, textiles, household batteries, lightbulbs, and plastic clamshell containers and then provide customers with an additional category of goods to pick up, electronics being one of several. They have operations in Atlanta, Austin, the Bay Area, Denver, Los Angeles, Minneapolis-St. Paul, Portland, and Seattle.

Incentives and Regulations

Specific regulations govern circular logistics collection services. Federal policies like the Resource Conservation and Recovery Act (RCRA) and Hazardous Materials Regulations (HMR) regulate hazardous material in circular logistics. The RCRA empowers the Environmental Protection Agency (EPA) to oversee hazardous material, including e-waste like lithium batteries and CRTs (the glass video display component of an electronic device). The Department of Transportation also mandates proper handling of hazardous materials during transportation. These examples show how restrictions influence the movement of specific materials and determine who can reintroduce them into a supply chain, including transportation, warehousing, and reprocessing.

Bottle Bills: An Incentive Program Case Study

Bottle bills are laws designed to encourage consumers to participate in the circular logistics system. When a retailer buys a bottle from a distributor, the distributor receives a deposit for each container, which is then transferred to the **consumer upon purchase**. Upon returning the bottle to a grocery store or redemption center, consumers receive a refund for the deposit. Then, the distributor reimburses the retailer or distribution center for the deposit. Deposit amounts vary by state, but a typical range is within 5 to 15 cents. Originating in Oregon in 1971, bottle bills are currently in effect in ten U.S. states.

Incentive programs have been proven effective at increasing the volume of materials collected. In fact, states with bottle bills have an average beverage container recycling rate of 60 percent, whereas states without bottle bills have a recycling rate below **30 percent**. Michigan and Oregon lead the U.S. with the highest return rates, with 85 percent of eligible bottles returned. This achievement is credited to their higher deposit amount, which gives citizens a greater financial incentive to return their bottles (i.e.,10 cents compared to the 5-cent deposit common in most states).

While the efficacy of these policies is evident, there are questions about the expectations of producer responsibility. Bottle bill laws place all responsibilities and financial burdens on end-users without holding producers accountable.

Therefore, implementing Extended Producer Responsibility (EPR) and bottle bill laws together distributes responsibility between **consumers and producers**, consequently improving the quality and quantity of materials received. For these laws to work together, producers involved in a bottle bill program do not have to join a Producer Responsibility Organization (PRO) under the EPR law. Legislators hope that simultaneously enacting both laws will boost recycling rates and improve the quality of recyclables, as the materials received through bottle bill programs are much higher quality than curbside recyclables.

Bottle bill programs and EPR laws can serve as the funding mechanism for collection programs, reducing the financial burden for logistics companies to participate in these collection schemes.

Collection → Sorting → Redistribution

Differentiated Fee Structures

Diversifying fee structures is pivotal for cost-effective materials management, driving efficient collection strategies, and developing a centralized processing infrastructure. Business models are increasingly designed to optimize material flows, ensuring they retain value for stakeholders. Building a supply system aligned with material volume, value, and location is foundational, facilitating profitable ventures for all involved.

Municipalities and organizations contribute to this ecosystem by employing diverse incentives, elevating recycling processes, and extracting enhanced value during the crucial collection stage. This integrated approach fosters a more sustainable and economically viable circular economy.

Successfully implementing curbside collection programs would require an active collaboration among haulers, municipalities, and end-users. Incentives and a differential fee structure can shape the responses of these stakeholders. For instance, **material collection fees** based on collected volume (versus fixed fees) or the establishment of specialized technology facilities can help reduce transportation costs and enhance the effectiveness of source separation initiatives.

Tipping fees, which are fees paid by those who dispose of waste in a landfill, serve as an economic deterrent, encouraging the diversion of waste to other Re-X streams.

The California Department of Resources Recycling and Recovery (CalRecycle) employs a differential fee structure for waste disposal facilities. This approach combines grant incentives and maximum tipping fees, ensuring that waste is directed away from landfills. The goal is to make other Re-X streams the most cost-efficient option for businesses statewide.

Achieving systemic change in materials management requires government involvement and legislative support for materials use. For example, **Senate Bill 5022** in Washington State bans single-use plastic in food delivery packaging. Other dynamics spurring change include rising landfill costs, incentivizing municipalities to divert materials from landfills, and implementing **pay-as-you-throw** systems, where trash collection rates vary based on the amount collected per household.

UK retailer **Currys** provides financial incentives for customers to return e-waste regardless of the product's condition. Combined with public awareness campaigns, this initiative is changing waste management behaviors and has significantly increased the amount of material recovered for re-manufacturing.

Collection Strategies

The collection stage is important because it determines the volume of materials collected and, consequently, the potential value of materials that will move forward in the supply chain. The collection model should account for factors such as the value of materials, the challenges in recovery, contamination levels, and the difficulty in aggregating required volumes to ensure a cost-effective process. It is important to note a few differences in how materials are collected if they are collected at the source (before they become waste) or recovered from waste sources.

Defining Embedded Value, Optimal Volume, and Location

Products with low to medium embedded value (lower market value), such as textiles, food waste, packaging plastics, and certain electronics from individual end-users, are typically collected in smaller quantities and dispersed spatially.

To facilitate cost-efficient transportation, self-service drop-offs at collection centers are often used until enough material accumulates. Products with higher embedded value and oversized products can be managed through a business-to-business (B2B) approach, involving pickups at designated locations and processing at specialized facilities or on-site disassembly for more efficient transportation.

Logistics partners can arrange materials strategically in a "super sandwich bale" presentation, compacting various recyclable materials. This approach maximizes truck capacity and improves cost efficiency. The strategic alignment of products and materials in this manner enhances overall efficiency in the collection process.

Most companies can't process their own waste and extend their lifecycle in-house, needing to involve new stakeholders to create value from waste. Cisco, for instance, has partnered with 3PL provider Ryder Systems to centralize collection for used and returned products from customers, partners, and distributors in the Takeback and Reuse program. The program has been an opportunity to turn $8M in losses to over $147M in revenues by collecting, reusing, or recycling end-of-use Cisco devices in 100+ territories/countries globally.

Collection → Sorting → Redistribution

B Optimizing Logistics and Efficiency

Implementing mobile materials management solutions, such as cardboard compactors, can reduce collection and transportation costs by optimizing routes, materials handling, truck capacity, pickup frequencies, and distances between processing facilities.

Compact products play a crucial role in this optimization strategy, making pickups more efficient. Logistics companies can utilize split-body trucks for dual-stream materials management as this offers a way to optimize truck capacity and reduce transportation costs for low-value embedded products.

The key is identifying compatible products for simultaneous collection, achieved by understanding the compatibility between different components and value chains of major commodities and higher-value components from products.

C Aligning EPR Strategies

Companies can participate in circular logistics of their product as an Extended Producer Responsibility (EPR) strategy.

Through centralized collection stations, they can disassemble, remove contaminants, or process used products to recirculate materials in their own supply chain or simplify the material recovery process for the next link in the supply chain, enhancing overall recycling efficiency and effectiveness.

To ensure adequate quantities, TerraCycle Zero Waste Box has made pick-up service for specified materials easier. The organization stores, ships, and recycles waste from end-consumers. This system, paid for by end-users, delivers an empty box and a pre-paid label for users to drop the box (once full) directly at a local carrier's office.

Walmart employs a collection bin system where multi-material packaging is aggregated until it reaches optimal volumes to reprocess. Another model is bottle bill packaging collection, allowing individuals to return packaging for deposit redemption at centralized locations.

Rocky Mountains Recycling Services offers collection services at client facilities, including roll-off dumpsters, palletizers (containers about the size of pallets), and trailers for mixed materials, which are picked up when full and at the client's request.

Sorting: Finding an Optimal Circular Logistics Strategy

Sorting is the foundational step to initiate a new cycle in a circular model, facilitating the efficient Re-X of resources. By categorizing and organizing materials based on their embedded value and potential in a new cycle, we unlock a multitude of opportunities to minimize waste, conserve resources, and mitigate environmental impact.

Challenges

Sorting high-value materials, such as e-waste, can be particularly challenging, notably due to the inadequate infrastructure to manage the rise in e-waste in recent years, the absence of standardized e-waste recycling policies, and the hazardous nature of e-waste.

- **Given the presence of numerous chemicals and toxic heavy metals in electronic devices, e-waste must be broken down into individual components for safe recirculation.** This requires special equipment and is costly and time-consuming. Material Recovery Facilities (MRFs) are evolving to process various materials and often serve as regional hubs for efficient material management.

- **To process and sort hazardous material, MRFs require third-party certifications to meet quality and safety standards.** Leveraging the capabilities of certified facilities is essential for efficiently larger material volumes and collecting and processing material from various municipalities.

Newby Island Resource Recovery Park is in the city of San Jose and serves as a one-stop shop with a recycling facility capable of sorting thousands of tons of mixed recyclables and a zero-waste energy development facility producing electricity and compost from waste.

Marquette County Michigan Solid Waste Management Authority (MCSWMA), a high-capacity and high-technology MRF, caters to the entire region's population and collaborates with academic institutions to develop innovative uses for the collected materials.

Despite the emergence of specialized sorting facilities, a challenge remains in aligning material location with facility proximity to avoid excessive shipping costs that may lead manufacturers to opt for landfills instead. To aid with this challenge, the U.S. Environmental Protection Agency (EPA) has developed **a tool** to locate material processing hubs across the country. The tool provides a general overview of the facility locations and could assist in analyzing those capable of processing environmentally hazardous components.

As previously noted, sorting materials at the source before pick-up reduces cross-contamination between materials, preserves product quality, prolongs functional lifespan, provides valuable data on material generation, and diverts material from **landfills**.

Incentives and Regulations

While no federal laws regulate material sorting, aside from RCRA's oversight of hazardous materials management, many states have enacted laws to regulate material sorting for composting, recycling, or reuse.

These laws include organics bans, which prevent companies or organizations producing substantial food waste from disposing of it in landfills. Instead, they are mandated to donate or compost the waste.

Further, many states provide tax incentives for recycling. For example, Georgia's Investment Tax Credit for Recycling or Pollution Control offers an investment tax credit to existing manufacturing and telecommunication companies in the state. The value of the credit can be raised for investments in recycling or pollution control machinery or equipment.

Additionally, New York provides **grants for waste reduction and recycling**, which are awarded to municipalities, local officials, or school districts. **Virginia** also provides tax credits for purchasing machinery used for recycling or producing materials from recycled materials. These credits are intended to incentivize companies to adjust their operations to include recycling and could also be used to invest in higher-value Re-X streams. This expansion creates more opportunities for logistics providers to collaborate in the circular logistics space.

Policy also plays a key role in determining which materials must be recirculated. For example, 49 states have **landfill bans**, which prevent certain materials from being sent to the landfill including car batteries, motor oil, tires, untreated medical waste, products with mercury, computers, and nickel batteries.

Similarly, 22 states have **recycling mandates** requiring specific materials to be recycled. For example, California has many mandatory recycled materials through the **California Integrated Waste Management Act of 1989**, including aluminum cans, cell phones, glass containers, newspapers, batteries, plastic containers, steel cans, and paint. Twenty-five states have e-waste recycling laws, including California's Electronic Waste Recycling Act of 2003. While most policies today focus on bans and recycling incentives, these existing policy mechanisms can be expanded to include higher-value Re-X streams. These expanded policies would provide a key opportunity for logistics partners to get involved in retrieving materials suitable for recirculation.

CoreCentric Solutions manages an extensive list of appliances, appliance parts, and consumer goods, often handling a company's complete return process. It also manages repairs and re-manufacturing to offer high-quality components through its e-commerce platform.

Sesotec provides technology and systems that sort electrical waste with efficiency and precision. With both individual sorting systems and custom customer-specific sorting solutions, they sort and recycle a variety of materials, including small electrical appliances, refrigerators, electronic devices, and printers, among others.

Sorting Strategies

The sorting stage determines the best Re-X strategy for materials and goods recovered. Having technical expertise to know what has value and being able to extract valuable materials is critical. Understanding the real value of goods as a consumer can be pivotal in increasing the quantity of useful materials going through sorting and reducing what ends up in landfills.

A Building Public Awareness

Educating consumers, manufacturers, logistics providers, and sorting facility staff is critical to improving material sorting and increasing the amount of salvaged reusable materials. Strategies such as door-to-door outreach, immersive experiential education, augmented reality, public relations efforts, and digital marketing (including social media) have proven effective in material recovery. Additionally, storytelling through certifications or eco-labels like the Forest Stewardship Council (FSC), Programme for the Endorsement of Forest Certification (PEFC), Blue Angel, EPEAT, Japan Eco Mark, Nordic Swan, Taiwan Green Mark, and TCO enhances public **awareness**.

B Providing Specialized Services

Technology is a valuable tool for extracting value from challenging products like solar panels, which can be difficult to process due to their size and complexity. These products can require specialized equipment and processes, which can be filled through niche companies such as **SolarCycle**. Products with low embedded value, such as mixed plastics from electronics, require specialized machines to break them down into their essential or commodity components. To process these challenging materials efficiently, higher volumes are **essential**. This creates an opportunity for logistics companies to provide this service.

C Developing Company Partnerships

Logistics providers, manufacturers, and sellers can enhance material sorting by localizing their operations and partnering with material-efficient processing and packaging companies. Companies can operationalize three key processes: screening returned products and pre-sorting to determine optimal material usage, shipping aggregated volumes to appropriate processing partners, and fostering collaborative efforts for innovative solutions across industries. Examples of such cross-industry solutions include the development and use of material-efficient packaging, partnerships to reduce Scope 3 emissions, and the establishment of interconnected **supply chains**.

Redistribution: Connecting Touchpoints

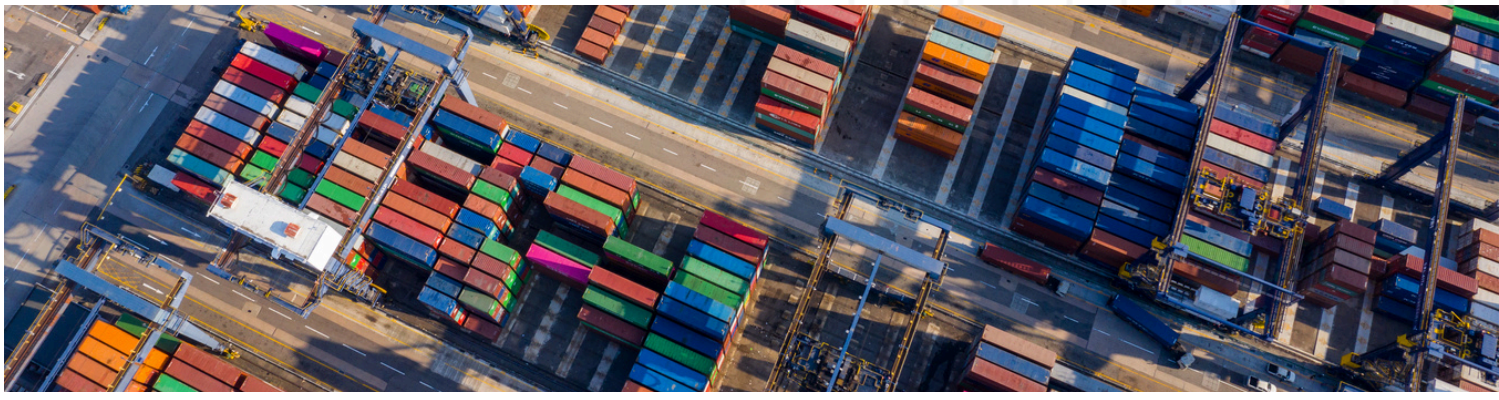
In the circular economy, redistribution heavily relies upon developing new markets that value the differential factors of Re-X products and materials. Like forward logistics, successful redistribution hinges on matching supply with demand to ensure economic viability for all the stakeholders.

Additionally, it is important to identify the multiple touchpoints in the supply chain, aiming for improved value among participating organizations and stakeholders. Additionally, accounting for industry-specific compliance factors of the goods in circulation is essential for effective redistribution. The role of logistics providers in redistribution involves strategically reintroducing materials into markets and linking various touchpoints within specific supply chains. Logistics providers can connect industries that either have or need recirculated materials, building an industry-agnostic supply network. This idea adheres to the first **Circular Economy Principle**, which is to design supply chains that eliminate waste and pollution.

Companies with well-established logistics infrastructure, such as fleets, distribution centers, warehousing, and factories, have leverage to negotiate commercial terms and reduce the transportation costs of materials.

Data can enable companies to take ownership of the most appropriate Re-X strategy for their business model and facilitate effective redistribution.

Apple's device recycling program is a great example of in-house ownership of the recirculation process, encouraging customers to return old phones (providing collection stations and services) to later send to manufacturing sites. Apple uses its in-house technology to disassemble and recover components to build new devices going back into markets.



Challenges

The redistribution of Re-X products resembles traditional forward logistics in that the movement of products is driven by market supply and demand. However, bridging the gaps to mirror traditional forward logistics is a challenge. These gaps include the absence of predictable models, unclear product definitions, and inadequate indicators for measuring success in distribution.

- **There is a lack of standardization in redistributing products and materials**, making it more difficult for logistics companies to determine the most effective way to transport products. In forward logistics, the quantity of goods and packaging is clear, helping build predictable models prioritizing efficiency. And, over time, forward logistics has established industry definitions for products, allowing for better alignment with clients' needs and the provision of specialized services for moving products (such as fragile goods or hazardous materials). The redistribution of goods lacks these standardized definitions, failing to address the requirements for moving specialized products and enabling the circular flow of goods.

- **Circular logistics cannot be evaluated using the same criteria as forward logistics.** A successful delivery must consider additional elements, such as emission reduction and diversion rates, as well as qualitative measures, such as whether it was delivered to the highest-value Re-X stream, to gauge the effectiveness of the circular flow accurately. Circularity indicators and standards also need widespread acceptance and value among customers, including companies and end-users.

- **A new circular model should not prioritize growth for growth's sake.** Traditional growth indicators like cost, efficiency, price, and market growth can lead to overconsumption. The success of the model shouldn't rely solely on these indicators. Instead, it must strike a balance by prioritizing additional benefits such as ecosystem health, recovery rates, and employment. This requires redefining competitiveness factors beyond profits and disclosing the true cost of production in a circular economy.

Growing the redistribution of Re-X products and materials needs unique incentives compared to forward logistics. The co-benefits, including social and environmental, must be considered for success. By adding value to the circular flows of Re-X products, operations can contribute positively to society.

Collection → Sorting → Redistribution

Incentives and Regulations

Improving risk management in the private sector is steering behavior and strategies. Companies such as **Apple**, **Patagonia**, **Xerox**, and **Cisco** are implementing waste reduction strategies for their products as part of their environmental/sustainability initiatives.

They do so to mitigate long-term reputational and supply chain risks and cut production costs and business risks. In addition, decarbonization is a key driver for many businesses, leading to innovations aimed at reducing emissions.

Getting products and materials to the right markets can generate more value for the players involved, adhering to the second **Circular Economy Principle**, which is circulating products and materials at their highest value.

End-markets, particularly those in remanufacturing, have clear quality and quantity standards for reintegrating materials into their supply chains. Logistics partners with access to these requirements can move from being shipping partners driven by their clients' needs to becoming circularity coordinators across industries. In this role, they serve multiple clients by providing key data and shipping services.

Public Investment

Government initiatives to incentivize the circular economy include city and state-level policies that guide purchasing and procurement decisions. For example, Phoenix's Sustainable Purchasing Policy encourages city departments to prioritize sustainable products in project purchases.

This policy involves evaluating various attributes such as resource efficiency, eco-labels, toxicity, and social impact. This policy also requires the city to conduct a lifecycle cost analysis for commodity, nonprofessional, and capital improvement project purchases made by any **city department**.

Outlast is a logistics partner using its platform to connect supply and demand in secondary markets (reclaimed materials and reused products). They aggregate verified materials globally and ship directly to customers, streamlining the purchasing experience and making repurposed materials more competitive for large-scale purchases.

Getting products and materials to the right markets can generate more value for the players involved

Other examples of state-level procurement programs and policies include California's Green Procurement Program, Oregon, Massachusetts, Washington, and Minnesota's Sustainable Procurement Programs, Colorado, Vermont, and South Carolina's Environmentally Preferable Purchasing Policy, Maryland's Green Procurement and Environmentally Preferrable **Products** policy, and New York State Executive Order 4 (EO4).

Municipal funds play a significant role in leveling the playing field for businesses entering the circular economy space. They provide economic incentives in the form of grants, company reimbursement for specialized skills-based training, workforce development tooling, physical infrastructure, taxation classification (i.e., a tax break), small business loans, entrepreneurship training programs, and more.

Under these circular procurement policies, circular logistics companies may explore receiving grants and tax credits from local governments, lowering costs and ensuring a market for the goods they distribute.

National and international examples of Private Sector-Government collaborations include **Nth Cycle US $2.15M grant** for their e-waste mineral extraction technology. **BioPak in Australia**, receiving government funding to develop the first national composting network to manage organic and compostable waste. **Italy's aluminum recycling National Consortium** serves 5,000 municipalities through public- private collaboration.

The **city of Austin has a Circular Economy Program** aimed at businesses, nonprofits, and individuals. The program has resources such as an upcycled products directory and access to fix-it clinics for individuals. The Circular Austin Showcase is a space for entrepreneurs and social businesses to pitch and receive funding for sustainable business ideas.

The **ProCirc project** is funded by the European Regional Development Fund and led by public and private organizations across Belgium, Denmark, The Netherlands, Norway, The UK, and Sweden. The initiative aims to accelerate the circular economy through circular procurement, considering the whole life cycle of goods and services. ProCirc developed a Circular Procurement Framework including Minimum Circular Requirements, a Circular Procurement Toolbox, Transnational Implementation Roadmaps and Policy Recommendations to implement circular procurement initiatives.

Standardization for Market Development

Voluntary standards and guidelines drive the development of a market for circular products. Companies have different incentives to adhere to voluntary standards, including managing reputational risks, responding to consumer trends, optimizing operations, achieving cost savings, and preparing or future regulations promoting circularity.

Lifecycle assessment, for instance, is a useful guideline for assessing product design inefficiencies and communicating environmental impacts and concerns with certain materials to downstream stakeholders. Compliance with these standards and guidelines will likely become mandatory for companies in the future, making it important for logistics companies to adhere to them. This ensures their ability to operate and responsively meet the needs and opportunities of their customers.

Standards are designed to respond to the most pressing environmental or social challenges. Some sustainability certifications, like Fair Trade, Forest Stewardship Council (FSC) Certification, and ISO 14001 certifications, apply to repurposed products and those in their first use cycle across different industries.

Meanwhile, standards like **Cradle to Cradle** (C2C) and industry-specific ones like **R2-V3** are specifically crafted to lead the circularity movement. For instance, **R2-V3** responds to the challenges within the electronics reuse/recycling space, improving the competitiveness at the facility level.

Call2Recycle is a logistics partner with the largest battery recycling program in the U.S. They partner with public agencies, retailers, businesses, and municipalities to process recovered materials from e-waste and reintroduce them to markets.

Outsourced rental models such as **CHEP** pallets and container pooling systems optimize empty truck mileage, ensuring quality and reducing up-front purchasing costs. The rental model allows smaller companies to track material flows across the supply chain and conveniently connect different stakeholders.

Standards are designed to respond to the most pressing environmental or social challenges

Collection → Sorting → Redistribution

Redistribution Strategies

A Accessing Commodity Markets

Reclaimed materials competing in commodity markets need consistency in volume, quality, and supply to have a competitive price point and incentivize more investments to recover them.

B Connecting Service Providers and Local Governments

Municipalities control waste by implementing bans or restrictions on certain materials from entering landfills. They can also stimulate the circular economy by contracting material recovery or redistribution services to divert material from landfills. Municipalities can offer incentives to encourage individuals or businesses to continue diverting material from landfills, even if it requires paying a premium.

Municipalities can support the circular economy by partnering with small- and medium-sized enterprises (SMEs) through public-private facility ownership and operation. Different models of public and private partnerships are possible, which involve combining infrastructure ownership and capital expenditure (CAPEX) investments from public entities with the operational capacity and business management skills of private entities.

To achieve successful collaborations, both parties must align their bottom-line interests, considering communities' well-being while generating profits to sustain operations over time. This framework creates opportunities for social businesses to participate, as exemplified by Biopak and Italy's aluminum recycling National Consortium.

C Implementing Full-Range Logistics

3PL partners offer a full range of client services, including inventory tracking, repair management, and shipping operations to fulfill orders. These services could work in forward and reverse logistics. For instance, **Image Microsystems** is a 3PL partner working with companies to manage the product recovery processes to redistribute through wholesale or retail channels.

More companies use 3PL services to better respond to customer demands and the sector's needs. **Electronic Recyclers International (ERI)**, for example, offers e-waste recovery services, including full truckload (FTL) and less-than-truckload (LTL) pickups, "white glove" services, ERI patented secure locked bins, and trailer staging for electronics collection. The company also offers a **Redeployment and Lease Returns program** with repaired units as part of its circular solutions portfolio.

This role of 3PL logistics is important in business logistics, and municipalities also benefit from outsourcing material recovery services. Logistics companies can optimize their operations by participating in these material flows, effectively assuming this responsibility from municipalities. Moreover, logistics companies can generate new revenue by using empty transportation capacity to move reclaimed materials.

The role of 3PL logistics is important in business logistics, and municipalities also benefit from outsourcing material recovery services

Advancing the Climate Agenda: How Logistics Drives the Circular Economy

The transition to a circular economy must be closely intertwined with discussions on the global climate agenda, as the two are inextricably linked. Decarbonizing our economy has a significant role in national and global climate agendas.

While not legally binding, goals such as Net Zero emissions and fulfilling National Determined Contributions (NDC) are compelling governments and businesses to seek pathways toward achieving these targets. This represents a considerable challenge and an opportunity to reduce emissions within a circular economy framework. It involves reimagining how products and services are manufactured and distributed across the supply chain.

Transportation, one of the largest contributors to emissions, underscores the need to reduce greenhouse gas (GHG) emissions in logistics operations. Simultaneously, there's a need to rethink the role of logistics within an industry-agnostic circular economy, recognizing logistics companies are also the critical link connecting all nodes of the supply chain.

Scope 3 emissions, classified as indirect emissions according to **GHG protocol standards**, include all emissions throughout a company's supply chain, both upstream and downstream.

This concept drives governments and businesses to seek strategies to meet emission reduction targets, presenting an opportunity for companies to address emissions linked to extraction, processing, transportation, and eventual disposal by redistributing them. Particularly, emissions from solid waste and wastewater disposal in a company's production and operations **can be relatively small**. However, diverting materials from landfills and implementing circular logistics strategies can affect emissions reduction in other sectors.

In the U.S., existing tools such as the EPA's **Waste Reduction Model (WARM)** support the decision process for companies regarding materials management practices. They use high-level comparative estimates of the potential GHG emissions, energy savings, and economic impacts of materials managed in baseline and alternative materials management practices, including source reduction, recycling, composting, anaerobic digestion, combustion, and landfilling.

By recycling, reusing, or repurposing material from one sector, companies can obtain materials with a lower carbon footprint compared to virgin materials. This enables them to operate within the planetary boundaries while contributing to emissions reduction efforts. Facilitating the flow of materials is key, underscoring the pivotal role of logistics and transportation in collectively curbing GHG emissions.

Three key strategies contribute to this goal:

1. **Aggregation and optimized material flows - to tackle the volume challenge for various critical materials and reduce supply risks.**
2. **Enabling data-centered decision-making - to foster collaboration in manufacturing and within the supply chain.**
3. **Cleaner transportation - to transition to green energy fleets and design more efficient supply networks.**

Optimizing Value Chains Through Coordination and Efficiency

Our research, interviews, and experience demonstrate that piecemeal redesigns are inadequate for value chains. Because value chains are highly interconnected, a comprehensive overhaul involving all stakeholders is required to sustain lasting change.

While this report focuses on the logistics industry, it is necessary to contextualize its role within the larger value chain it serves. A **value chain analysis** describes a social system wherein enterprises, markets, individuals, governments, and supporting actors collectively contribute to value generation. This approach helps in understanding the different links involved, transcending market-based decisions to address interactions between economic development and social inclusion, as well as between economic growth and the environment.

From a coordinated value chain perspective, the aim is to identify gaps for value creation through effective market mechanisms, public-private partnerships for development, inclusive business practices, and standards facilitating the integration of new materials and products into emerging markets.

An example of a value chain approach is the Netherlands' response to the textile waste challenge. The country established a Mission-oriented Innovation System (MIS) approach, encompassing supply, demand, research, patent dissemination, infrastructure, policy, and institutions. These components work together to promote circularity throughout the value chain.

Stakeholder Engagement and Integration

Collaboration is needed to navigate the complexities of transitioning from linear economic models to circular ones. To achieve a fully coordinated value chain, it is critical to understand the interests of every link within it and secure stakeholders' commitment through a strategy that aligns with their long-term goals. Furthermore, investing in dedicated research and development and strengthening governance structures are equally vital to implementing circular economy programs effectively.

Small, Medium, and Large Manufacturing Companies

The private sector excels in innovating, incubating, testing, and scaling solutions to identify the most efficient approach toward circularity. Working with companies and manufacturers from **the design stage** can help build the after-use value chain of a product through:

1. Designing products with their whole lifecycle in mind and analyzing the best use of components for reclaimed materials.
2. Optimizing product circulation across the supply chain by designing products and packages with standardization and optimal logistics in mind. This includes leveraging retailer infrastructure for circular strategies and employing **circular packaging to facilitate collection** through retailers (e.g., optimizing shelf space and facilitating easier disassembly for material storage).
3. Leveraging **EPR policies** to hold producers accountable throughout the entire lifecycle of their products.

Lastly, investing in workforce skills and knowledge development helps companies transition to a circular economy. This includes enhancing frontline workers' capacity to obtain well-paying jobs that demand hard skills in any stage of a circular logistics strategy or circular flows. Training leadership positions and ensuring alignment with circular models are crucial for companies to seize new business opportunities and successfully shift towards circularity.

Walmart and Pure Strategies collaborated on a playbook for suppliers. The playbook emphasizes challenges in recycling and using reclaimed materials and includes clear examples to support other companies considering a transition to reclaimed materials.

Training leadership positions and ensuring alignment with circular models are crucial for companies to seize new business opportunities and successfully shift towards circularity

Municipalities and Government-Led Institutions

The government's role is to support the implementation of solutions by intervening when the private sector may face limitations. Involving small businesses or social enterprises in the circular economy requires support from local governments.

For example, local governments can prioritize hiring local businesses as municipal vendors while offering incentives for collective arrangements. This approach allows small enterprises to fulfill vendor requirements for specific services.

Success hinges on creating aligned incentives and more collaboration among the central government, municipalities, relevant governmental bodies, private sector actors, civil society stakeholders, and the informal waste sector to better coordinate the movement of materials before they are treated as waste in landfills.

End-Consumers and Intermediaries

The decision to discontinue using a product or an object marks its entry into the circular economy. Therefore, consumers need clear, action-oriented guidance on handling these items when they are no longer needed.

Transforming the approach from waste generation to material recovery and recirculation within a supply chain requires educating consumers and the leaders of companies and sorting facilities.

Matching convenience is crucial when implementing systems that foster a circular economy. One major barrier to adopting these practices is the lack of time due to increasing work hours with decreasing returns. People need more time for these desired societal behaviors to become the norm. Therefore, circular systems should be considered alongside other social interventions.

An example of governmental contributions to building fully coordinated value chains is the New Circular Economy Action Plan under the European Green Deal. This program addresses multiple challenges for circularity across various industries and is a regional approach to create enabling conditions for the development of circular value chains.

Academia and Research Centers

Academia and research centers play an important role in developing and testing methodologies and technologies to improve inefficiencies within a value chain. Research and innovation can improve process efficiency, leading to more eco-friendly materials, enhanced methods for reclaiming materials, and better integration between sectors. The outcomes of research can guide the third **Circular Economy Principle**, which is to regenerate nature by designing and understanding better ways to integrate materials with natural regeneration processes.

Academia must reshape its programs to cultivate a workforce equipped with the hard skills necessary to confront future sustainability challenges. Additionally, institutions must disseminate knowledge regarding the implications of climate targets across various sectors, as well as the social and economic benefits of climate change mitigation and adaptation measures.

Incentives for Value Chain Stakeholders

Stakeholder interviews reveal that municipalities, local enterprises, large corporations, and logistics companies increasingly recognize the advantages of transitioning to a circular economy.

These benefits include reducing costs, resource optimization, value retention, and new business revenues. Strategic partnerships are pivotal in activating and streamlining circular business models or initiatives, creating shared value for all parties, including customers, suppliers, and investors, as well as shared targets to use resources strategically.

Multiple sources need to provide clear and consistent messaging about transitioning to a circular economy. This communication should emphasize enforcement mechanisms, such as fines and penalties for non-participation (referred to as “sticks”), and incentives, including the benefits of adopting circular practices and the clear financial advantages (referred to as “carrots”).

Logistics companies must track and understand the current status of these benefits and penalties, as complying with these regulations will require significant operational changes.

The “Sticks”

Fiscal Instruments for Businesses

“Sticks” includes regulatory requirements, fines, and penalties. Without sufficient regulatory sticks, developing appealing “carrots” is crucial to incentivize individuals to participate in a circular economy. This strategy can gradually reshape market dynamics and consumption patterns by establishing strong fiscal measures such as material collection fees, landfill taxes, bans, and awareness programs targeting consumers and businesses.

For instance, EPR laws present a potential funding mechanism for reverse logistics. However, only ten states in the United States have passed **EPR laws**, and each addresses a different material/product value chain. These laws vary in terms of their targets and fee structures, making it difficult to influence market conditions.

Additionally, few EPR laws meet the current conditions for the recovery and reuse of materials, and they are not effectively driving market change to develop the infrastructure for recovery and reuse. An exception to this is California’s **unique EPR law** which includes a requirement for reuse and refill. Despite this, EPR laws are growing in popularity and represent a potential funding mechanism for circular logistics companies, as they would become members of the Producer Responsibility Organizations (PROs) established under EPR laws.

Radical policy changes include differentiated tax structures benefiting recirculated products, shifting the tax structure to benefit more labor-intensive reclaimed materials or goods, removing subsidies from fossil fuels, and changing the cost balance between reclaimed and virgin materials. Unfortunately, this still faces significant challenges with preemption laws such as “ban on bans” which prevent municipalities from controlling what type of waste is generated in their communities.

A common example in the United States is **preemption laws** that prevent the ban on plastic bags. This includes categories of laws that cities cannot legally implement, such as incentives for recycled content, reclaimed materials businesses, or regulations for the sale of auxiliary containers for products.

In Germany and Switzerland, the solid waste sector has effectively reduced more than half of their linked emissions, using EPR policy amendments, managing waste collection, improving recycling and energy recovery infrastructure, as well as avoiding organic waste in landfills. In fact, a Recycling Partnership Study shows the efficiency of EPR Laws, increasing recycling rates in European countries and an estimated increase in the U.S. recycling rate by 48 percent when implemented correctly.

The “Carrots”

Financial Instruments for Material Recovery

Stakeholders may have different motivations for engaging in a circular economy: reducing or better managing waste, cost savings in materials management, or managing reputational risks for their companies.

Unfortunately, the current economic systems do not reward circularity by default, so governments need to create a more equitable playing field for organizations willing to adapt to the new system.

A new rewards system can benefit markets, including consumers and companies, by providing clear financial benefits and savings to encourage the change. Existing examples include deposit-return schemes, tax write-offs, and special fee structures such as **pay-as-you-throw programs**.

Local governments need further financial benefits to participate in a circular economy. Financial and technical support to municipalities can mobilize the private sector to implement and operate circular economy strategies. Municipalities can encourage consumers to take specific actions, like collecting specific items for a reward, which can significantly impact recovery quantity and quality.

Funding from private and public sources is required to develop an infrastructure for the circular economy. Investments from the public and private sectors in technology, labor upskilling, or processing facilities can be cost-intensive and usually have a slow return on investments.

The Circular Innovation Collective (CIC) is a coalition between the City of Amsterdam, Bankers without Boarders, Metabolic, and the Impact Hub Network. This initiative addresses a circular economy challenge across products and materials, accessing the right financial mechanisms to support the development of value chains in the circular economy. Through a business acceleration program, the initiative is helping reach Amsterdam’s ambitious circular economy goals while addressing the entrepreneurial gaps, particularly in the circular textile sector. The collective is encouraging circular venture financing using outcome-based instruments and generating new jobs in the circular economy.

A new rewards system can benefit markets, including consumers and companies, by providing clear financial benefits and savings

Creating the Logistics Framework to Enable a Circular Economy

Data-enabled tracking mechanisms enhance the visibility of products throughout the supply chain, preserving their value.

Technologies like Radio Frequency Identification (RFID) and materials passports provide key data points to track and redirect high-value goods within a supply chain. These tools are valuable for disclosing material content and quality, facilitating a transition across multiple lifecycles, and using appropriate tags to avoid misplacement and losses. Logistics companies can use RFID and invest in materials passport development to better track materials.

Emerging technologies like artificial intelligence (AI) and blockchain hold potential for enhancing quality assurance and transparency. By expediting the identification of defective or faulty items, these technologies can disclose information to all stakeholders involved, enhancing the efficiency of quality control processes and expediting recycling operations. This becomes significant when dealing with hard-to-obtain materials and conflict minerals in electronics, solar panels, batteries, and jewelry.

Lenovo uses blockchain to improve the visibility and traceability of material in a complex global supply chain. The company has optimized operations by tracking goods, reducing human error in time-consuming activities, and connecting government and freight forwarders to improve transparency in their product flow. The company plans to use blockchain technologies with supplier activities, especially tracing the origin of minerals and metals used.

Limeloop is pioneering the sustainable shipping space, offering reusable and traceable packaging solutions for products and support to optimize workflows across the supply chain to drive informed decision-making.

Furthermore, blockchain technology offers secure and transparent data storage solutions, enabling trust and integrity in various industries, such as the diamond trade. Through its decentralized architecture, blockchain ensures that **critical information** is accessible to all stakeholders while safeguarding its authenticity.

B Localization is a key to circularity, reducing emissions and streamlining collaboration.

A localized economy has the potential to reduce transportation-related carbon emissions, minimize secondary/tertiary packaging, and create local economic value through more resilient supply chains. A local economy also simplifies the coordination of relationships among service providers, manufacturers, logistics companies, and other stakeholders in a circular economy.

Industries such as automotive, technology, and pharmaceuticals have benefited from **onshoring** and place-based supply chains. Any increase in the localization of service provisions and goods manufacturing, including optimized storage and distribution facilities, would be a dramatic increase from the current state.

The green innovation IT center **Sintronics** in Brazil is a circular electronics manufacturing wing of the cross-industry partner Flex. The company offers an 'integrated ecosystem' in circular electronics manufacturing, from reverse logistics to R&D and access to recycling facilities to put remanufactured materials back into supply chains. The success of its **partnership with technology company HP** lies in the proximity of the recycling and innovation center and HP's manufacturing site. This partnership has allowed both companies to create closed-loop processes, resulting in a 50 percent collection time reduction, a 30 percent cost reduction, and a 97 percent component recovery rate (going back to HP's products and other supply chains). Now, this partnership aims to increase the percentage of recyclable materials in HP's products to 45 percent, increasing collection rates from end-users and identifying post-consumer materials from other sectors.

Ultimately, a circular economy will require individual localized economies that are eventually integrated into the global market. However, initiatives promoting localization are often viewed solely in technical terms and judged on the upfront funding required. Therefore, it is important to assess the social, environmental, and economic co-benefits of the circular economy and incentivize it with alternative financial mechanisms.

Current success stories are usually company-specific, but that's not a scalable solution. Any systems developed should not be designed for a single application but should aim for versatility and capacity to serve various needs.

The existing infrastructure that supports the reuse of containers and packaging for local community needs could be expanded to accommodate the requirements of larger consumer packaged goods (CPG) companies.

This change would require significant modification of manufacturing systems, which is a substantial undertaking for those companies.

A circular economy will require individual localized economies that are eventually integrated into the global market

Any local recovery and processing system should be designed for working across material types and company brands. Policies concerning taxes on landfill tipping fees present another avenue for change. Substantially increasing these fees, particularly in states with low taxation, like Arizona, could stimulate private-sector innovation in materials management, alleviating the strain on municipal resources.

C Regulation and policy can be important levers to drive change.

In the United States, discussions have centered on a number of potential policy incentives to drive change. One example is shifting taxes from payroll to companies using virgin materials, thereby recognizing and valuing externalities. This change would prioritize repair and reuse by altering the incentive structure, which requires more labor for collection and sorting, as well as circular logistics streams such as repair.

Another idea involves removing subsidies to rebalance the cost dynamics between recycled and virgin materials made from fossil fuels. Currently, subsidies favor virgin materials like plastics, making them cheaper despite their higher societal cost. A third approach leverages sales taxes to incentivize purchases of second-hand items by offering them tax-free.

D Measuring circularity goes beyond traditional economic indicators alone.

Shifting economic development metrics to include grant programs for circular economy companies could incentivize businesses to adopt sustainable practices. Furthermore, establishing mechanisms for tracking, managing, and reporting data and facilitating data transfer channels among corporations, consumers, and original equipment manufacturers (OEMs) will be critical for measuring circularity. Logistics providers, serving as the connection point between these stakeholders, will play a critical role in managing and disseminating this data. National and local governments should define key performance indicators (KPIs) for the private sector, setting common goals with stakeholders and defining strategies accordingly.

Examples of circularity KPIs include those prioritized in the **WBCSD Circular Transition Indicators** (CTI) method, **ISO 59020** standards, and the **Corporate Sustainability Reporting Directive (EU) (CSDR)**. This approach is key to defining a **taxonomy for the Circular Economy** across regions to guide relevant interventions needed in the most critical industries.

We urge logistics companies and manufacturers to more quickly explore circular logistics practices and participate in the circular value chain

What Comes Next

circular supply chain coalition

The Circular Supply Chain Coalition (CSCC) is poised to kickstart the implementation of the recommendations from Pyxera Global's two reports.

The CSCC theory of change targets a pivotal issue: the disconnection of local enterprises from global circular supply chains. Through a tailored mix of strategies and initiatives, we're primed to elevate communities so they can reap the rewards of circular economies, promoting resilience for all.

1. **Identify and Engage with a Community**
2. **Connect with Global Supply Chains**
3. **Strengthen & Coordinate Local Value Chains**

The Circular Supply Chain Coalition catalyzes change by bridging the gap between economic development and sustainability by enabling local enterprises and communities to engage in global circular supply chains. Many of these social enterprises operate on a hyperlocal level and lack the reach and resources to scale their efforts. Meanwhile, large corporations are increasingly interested in using recycled materials in their products (i.e., lithium from used batteries in electric vehicle batteries).

In a fully implemented CSCC project, small businesses in one city that process e-waste will be networked together in a cooperative model. They will sell recovered materials to a large clean energy technology manufacturer through a forward procurement financial mechanism called a Circular Services Agreement. The CSCC will coordinate and implement that new supply chain.

To get involved, follow the CSCC on **LinkedIn** or contact **info@circularsupplychain.org**.

Appendix: Working Landscape Assessment of Reverse Logistics Company Actors

Collection

Recycle Track Systems
Ryder
ShipWizard
XPO Logistics
Sesotec
Happy Returns
Physical stores offering trade-ins (unnamed)
ShipBob
Ridwell
IT E-cycling
GEFCO CEVA logistics
Mercury Logistics
Bowman Logistics
We recycle solar
ERI
RTS
A3 Global
Cirba Solutions
Interstate

Storage

ShipWizard
XPO Logistics
Ridwell
A3 Global
FedEx
UPS
ShipBob
TMCC
Bowman Logistics
ERI
GEFCO CEVA logistics
We Recycle Solar
Interstate
RTS
CoreCentric Solutions
Image Microsystems

Sorting, Dismantling or Shredding

ShipWizard
Sesotec
XPO Logistics
Cirba Solutions
GEFCO CEVA logistics
Interstate
RTS
CoreCentric Solutions
Cat2Recycle
ERI
Rocky Mountain Recycling
IT E-cycling
AMP Robotics
Image Microsystems
A3 Global

Distribution

Optoro
XPO Logistics
Cat2Recycle
Ryder
GEFCO CEVA logistics
ShipBob
CoreCentric Solutions
ShipWizard
IT E-cycling
Interstate
Image Microsystems

Additional Services

UL Solutions
Prologis
AMP Robotics
werecyclebatteries.com

PYXERA Global

Pyxera Global is a nonprofit organization that drives positive social change through partnerships and community-driven programs. With over thirty years of experience in over a hundred countries, our mission is to address our world's most pressing challenges, one community at a time.

By bringing together stakeholders from various sectors with diverse perspectives, skills, and resources, we create space for honest dialogue and innovative solutions. Through this collaboration with our partners, we work towards a world where equitable and regenerative systems enable all communities to thrive.

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