FOUNDATION FOR REGENERATION

JOHNSON COUNTY KANSAS

KANSAS CITY MISSOURI

Mid-America Regional Council Solid Waste Management District

Material Flow Analysis of discarded materials in the Kansas City Metropolitan Area

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Executive Summary

The Kansas City Metropolitan Area (KCMA) currently operates predominantly within a linear “take-make-waste” system that results in significant material loss and economic inefficiencies. This Material Flow Analysis (MFA) provides a comprehensive assessment of KCMA’s waste streams, highlighting opportunities to transition towards a circular economy—one that retains resources in productive use, reduces landfill dependency, and creates economic value.

KEY FINDINGS

In 2023, an estimated 2.98 million tons of materials were discarded in KCMA. Of this, 77% was landfilled, while only 7% was recycled and 15% composted. This reliance on landfilling results in the loss of valuable materials that could otherwise be repurposed, recycled, or reused. The commercial and industrial (C&I) sector contributed the largest share of waste at 45%, followed by residential at 28%. Organic materials (21%) and paper (19%) were the most prevalent discarded materials, indicating strong potential for improved composting and recycling programs.

The economic analysis revealed that materials currently sent to landfills hold an estimated market value of $250 million. By diverting these materials through enhanced recycling and reuse strategies, KCMA could create over 5,000 jobs in waste recovery, remanufacturing, and other circular economy sectors. Additionally, reducing landfill dependence would mitigate environmental harm, such as carbon emissions and land degradation, particularly from high-impact waste streams like textiles and e-waste.

To support this transition, several key interventions are recommended. Expanding recycling infrastructure and composting facilities can significantly increase material recovery rates. Strengthening collaboration between public and private waste management stakeholders can improve data transparency and efficiency. Policy measures, such as landfill diversion incentives and mandatory recycling programs, can encourage participation and drive systemic change. Lastly, public education and engagement efforts are essential to shifting behaviors toward more sustainable waste practices.

CONCLUSION

KCMA has an opportunity to transform its waste management system into a circular economy model that prioritizes resource efficiency, economic growth, job creation and environmental stewardship. By addressing key barriers and implementing targeted interventions, the region can become a leader in sustainable urban development.

01 Introduction

The transition to a circular economy is vital to addressing the environmental, economic, and social challenges posed by the traditional linear 'take-make-waste' model. This system generates significant discarded materials, and contributes to climate change, biodiversity loss, and pollution. Crucially, it results in the loss of valuable materials that could otherwise be recovered and reused, missing significant economic opportunities. A circular economy, in contrast, seeks to close material loops, ensuring resources remain in productive use while creating local economic resilience and stimulating innovation.

The Kansas City Metropolitan Area (KCMA) consists of diverse sectors and currently operates within this predominantly linear system. This report uses a Material Flow Analysis (MFA) to examine the region's waste streams, tracking how materials exit the system. As urban areas like KCMA face increasing economic and environmental pressures, transitioning to a circular economy could be an important driver for future developments. This study identifies the volume of the current system and uncovers opportunities to recover value, create economic benefits, and reduce environmental impacts. By emphasizing higher-order recovery processes, such as reuse, refurbishment, and recycling, the study demonstrates how previously wasted materials can become valuable resources that support local economic growth and job creation.

The report also pinpoints critical hotspots where targeted interventions could yield significant economic, environmental, and social benefits. Developed in collaboration with stakeholders from both sides of the Kansas-Missouri state line, these insights provide actionable recommendations for policymakers, waste management operators, and businesses. By embracing circular practices, KCMA can transform waste streams into economic assets, reduce environmental harm, and position itself as a leader in regenerative regional development. In this report, we will use the terms "waste" and "discarded materials" interchangeably, depending on the context.

"Discarded materials" emphasizes their inherent value and potential for recovery, repurposing, and reintegration into the circular economy. However, when referring to the current waste management system and its associated stakeholders, we will use "waste" in its conventional sense to align with existing frameworks and industry practices.

THE CURRENT WASTE SYSTEM IN KCMA

In the U.S., a significant proportion of discarded materials ends up in landfills, making it one of the largest producers of landfilled solid discarded materials globally. Despite advancements in recycling and composting programs in certain regions, landfilling remains the dominant waste management method.

The reliance on landfills stems from a combination of factors, including historical practices, economic convenience, and the availability of vast land areas in parts of the country. However, this approach poses substantial economic, environmental, and social challenges. Landfilled materials represents a loss of valuable materials that could be recycled or reused, contributing to the higher cost of sourcing new materials and the further depletion of natural resources. The full potential of the circular economy is as much as 700 billion USD in global consumer goods materials savings alone (*Ellen MacArthur Foundation, 2013*). Additionally, the decomposition of organic materials in landfills produces methane, a potent greenhouse gas, exacerbating climate change.

Landfilling also requires significant land use, often displacing natural ecosystems and affecting nearby communities. These areas frequently bear the burden of environmental pollution, including leachate contamination of soil and water resources and air quality impacts from landfill gas emissions.

Furthermore, the heavy reliance on landfilling perpetuates a culture of disposability, discouraging innovation in discarded materials reduction and resource recovery technologies.

A multifaceted discarded materials management system operates within the KCMA that handles a variety of discarded materials streams from residential, commercial, industrial, and municipal sources. Residential discarded materials management differs based on housing type. Single-family homes typically receive curbside collection services provided either directly by municipal programs or through contracts with private haulers. In contrast, discarded materials from apartment buildings, especially larger multi-unit complexes, is managed more like commercial discarded materials.

Commercial and industrial discarded material streams are predominantly managed by private haulers contracted directly by businesses or property management companies. Prominent private waste management companies in the region include WM, Republic, and GFL which handle both residential and commercial needs. This dual system of public and private haulers, coupled with the different handling processes for single-family homes and apartment buildings, reflects the diverse discarded materials management infrastructure in KCMA.

The waste management landscape in the Kansas City Metropolitan Area (KCMA) is complex, shaped by a network of landfills, transfer stations, and materials recovery facilities (MRFs) operating on both sides of the Kansas-Missouri state line. Waste haulers often make disposal decisions based on proximity, operational convenience, or the most competitive tipping fees. However, the region's largest landfills are owned and operated by major industry players like WM, Republic Services, and GFL. These companies frequently transport discarded materials across state lines to make operations more efficient and maximize profitability. This results in a system where discarded materials do not always follow jurisdictional boundaries, which complicates solid data tracking.

"Johnson County prides itself not only for its high quality of life but also for consistently creating economic development and job opportunities for our local economy. We recognize that solid waste knows no jurisdictional boundaries and often represents inefficiencies, environmental degradation, and lost opportunities for our entire region. Johnson County is excited to support this Material Flow Analysis which will help lay the groundwork for future climate-smart waste management and circular economy efforts in the Kansas City region."

Mike Kelly, Chair, Board of Commissioners, Johnson County, KS

"The MARC Solid Waste Management District has embraced a vision of system change from efficient disposal in landfills of unwanted materials to a system that recovers materials and assigns value equivalent to the raw materials embedded in them. The Material Flow Analysis performed by Metabolic and the Foundation for Regeneration is the first step in assigning an economic value to these materials prompting a shift in perception toward prioritizing economic development of businesses that will capture, repurpose, process and remanufacture locally. Recovering these valuable materials will meet a regional need for goods as an alternative to dependency on global sources."

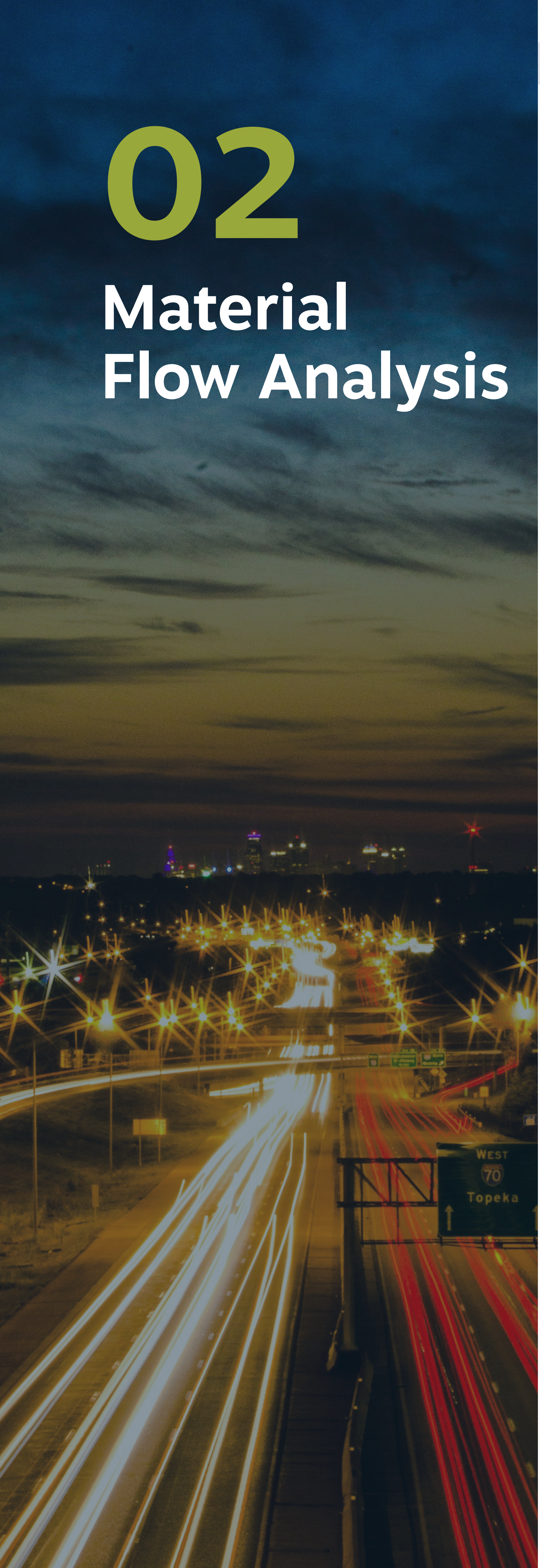
Dr. Dianna Havner Bryant, Program Manager, MARC SWMD

"The City of Kansas City, Missouri, is proud to support this analysis and a shift toward a more circular future in KC. Knowing what's in our waste stream gives us actionable insights into the type of economic growth we can help drive in the region."

Louis Cummings, Deputy Director, Public Works, City of KCMO

02

Material Flow Analysis



A Material Flow Analysis (MFA) is a systematic method used to quantify the flows and stocks of materials within a defined system over a specific time period. In this case the annual generation and management of discarded materials in four distinct regions: the Kansas City Metropolitan Area; the City of Kansas City, Missouri; Johnson County, Kansas; and the MARC Solid Waste Management District (representing the counties of Cass, Clay, Jackson, Platte and Ray in Missouri).

METHODOLOGY

The methodology involved multiple stages of data collection, processing, and visualisation, providing a comprehensive picture of material flows and their associated impacts. The first stage of creating an MFA involved gathering data on discarded material generation, composition, and treatment methods. Data sources included client-provided reports, local government datasets, and supplementary desk research. Where gaps existed, proxy data such as population size, employment statistics, or local and national averages were used to estimate missing values. It is important to note that the specific method employed during the data processing phase varied for each of the regions analysed. These differences were due to the varying availability and granularity of data for each region. For example, some regions required the use of proxy data or estimations based on population size and landfill capacity studies, while others had more complete datasets provided by local authorities. This also influences the way in which the output has been created. Finally, we aggregated the outcomes of Kansas City, Johnson County and the MARC Solid Waste Management District to estimate the discarded material volumes of the Kansas City Metropolitan Area.

VISUALISATION

These MFAs are presented as Sankey diagrams. Sankeys are a powerful visualisation tool used to represent the flow of materials, energy, or other resources within a system. The width of each flow in the diagram is proportional to the quantity of material or resource it represents, making it an intuitive way to highlight hotspots, imbalances, and opportunities within the system.

The discarded material stream sources are grouped into residential, commercial and industrial (C&I), construction and demolition (C&D), and unknown sources. Materials were classified into aggregate types such as organics, plastics, metals, construction debris, hazardous household waste (HHW) and e-waste. See Appendix 2 for detailed categorization and methodolgy.

Using the processed data, Sankey diagrams were created for each region to visually represent the movement of materials through the waste management system. These diagrams illustrated the origins, types, and treatment methods of discarded materials, including landfilling, recycling, and composting. The diagrams provided a clear and intuitive overview of material flows, highlighting inefficiencies such as the high proportion of discarded materials sent to landfills and the underutilization of recycling opportunities. This analysis serves as the basis for identifying possible interventions aimed at enhancing resource recovery and promoting more sustainable discarded materials management systems, highlighting key discarded materials streams, inefficiencies, and opportunities for improvement.

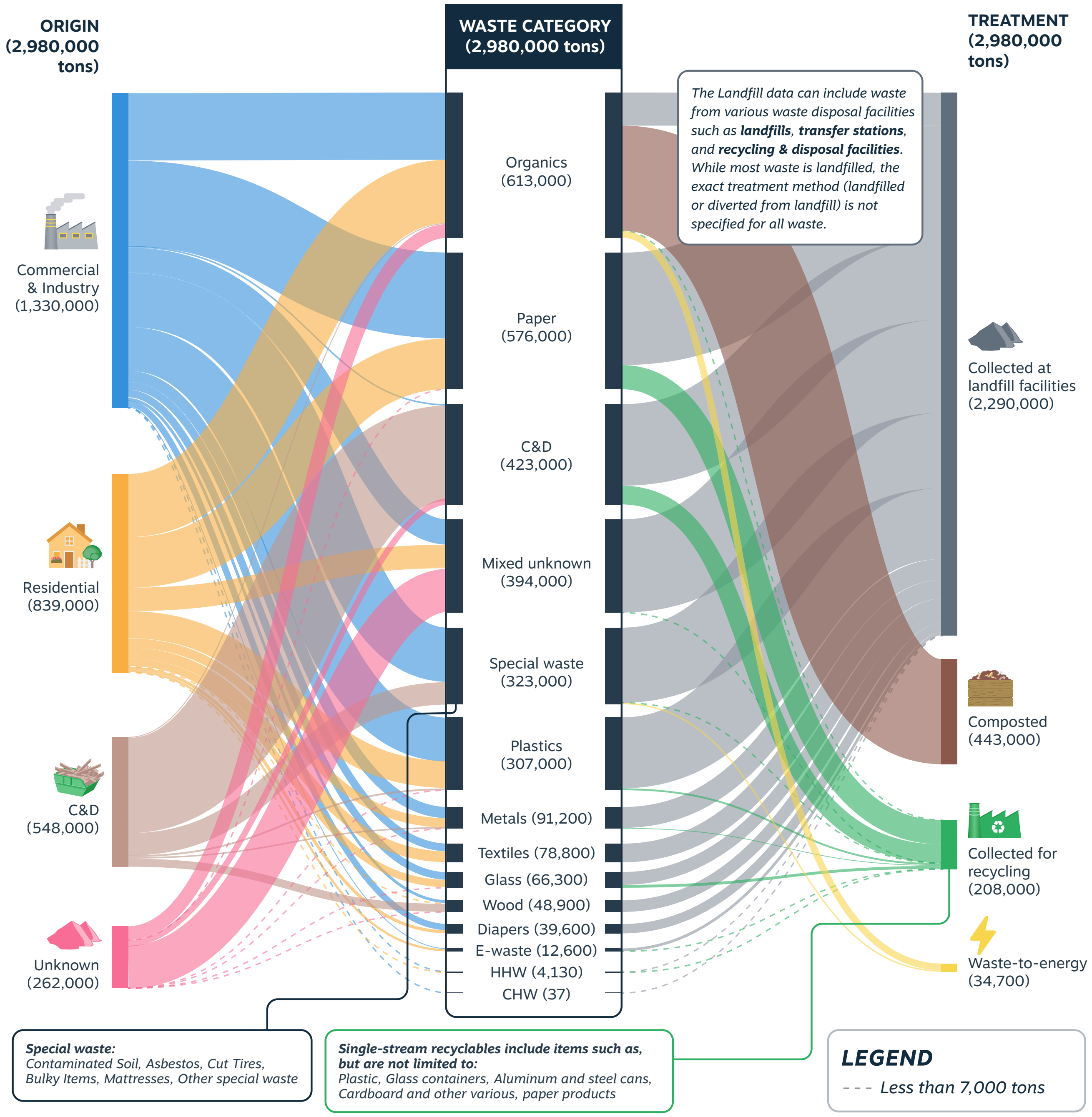


Figure 1 *Material Flow Analysis*

SECTORS

In total, all sectors combined produced approximately 2,980,000 tons of excess materials in 2023. The largest amount of materials came from the C&I sector (45%) followed by residential (28%). The C&I sector includes businesses and multi-family homes with more than six living units, a grouping that often results from the KCMA's prevalent urban structure. The reason for the significant discarded materials is linked to the concentration of businesses and high-density housing, which typically generate more commercial discarded materials due to more residents and commercial activity in these zones. Unfortunately, due to the quality of the data, the origin of a large proportion of excess materials is unknown (9%).

MATERIALS

The majority of the discarded materials were organics (21%) and paper (19%). The prevalence of organics, such as food and yard materials, is largely due to the region's climate which plays a role in supporting year-round agricultural and landscaping activities, which naturally produce large quantities of organic material. The region's suburban and residential areas often have large yards and green spaces, contributing significant amounts of organic materials This also ties into the KCMA's food industry, contributing to organic materials production. Again, this is a densely populated area, and waste studies conducted by the Missouri Department of Natural Resources (Missouri Waste Composition Study, 2016), indicate that paper and organic materials are prominent in both residential and commercial discarded materials streams.

TREATMENT METHODS

Of the data that we collected, 77% of the excess materials were collected at landfill facilities, with only 7% being recovered through recycling and 15% being composted. It shows that, by far, landfilling is the primary disposal method. The data is indicative of the national trend in the U.S. and the broader Kansas and Missouri region, where landfilling remains the dominant discarded materials treatment method despite efforts to increase recycling rates. This over-reliance on landfills is a major concern not only because of all the materials being lost and the missed opportunity for creating new jobs and boosting the local economy, but also the environmental and social impacts associated with their disposal. The KCMA has been making strides in improving discarded materials management strategies, but there are still major gaps in recycling infrastructure and public participation. A study conducted by the Kansas City Design Center in 2015 found that the city's discarded materials diversion rate was 27%, significantly below the national and regional averages.

03 Embedded impacts

Embedded impacts are the environmental and social effects incurred throughout the lifecycle of a material or product, from raw material extraction and manufacturing to assembly, transportation, retail, and ultimately disposal. At each stage, various inputs are required, such as energy, water, land, labor, and additional materials, while outputs like emissions, wastewater, solid waste, and by-products are generated. These inputs and outputs collectively influence the environment, with land use affecting biodiversity, water consumption reducing freshwater availability, and emissions degrading air, water, and soil quality. The type and scale of embedded impacts vary between materials, encompassing all the resources and environmental consequences tied to their production.

Often referred to as indirect impacts, footprints, or Scope 3 emissions, embedded impacts represent the upstream and downstream consequences associated with a product before and after its use. These impacts are for the most part experienced outside the KCMA.

This contrasts with direct impacts (scope 1 or 2), which occur during the usage phase, within the KCMA. By reusing or recycling materials, we not only prevent discarded materials but also conserve the resources, energy, and effort invested across the supply chain. Including the financial cost of transporting virgin materials and newly manufactured goods into the KCMA. Prolonging the lifespan of materials reduces their embedded impact relative to their lifetime, making reuse and recycling essential strategies for sustainability. Addressing embedded impacts is critical to fundamentally improving supply chains and achieving a broader sustainability transition, complementing efforts to mitigate direct issues like discarded materials generation and energy consumption.

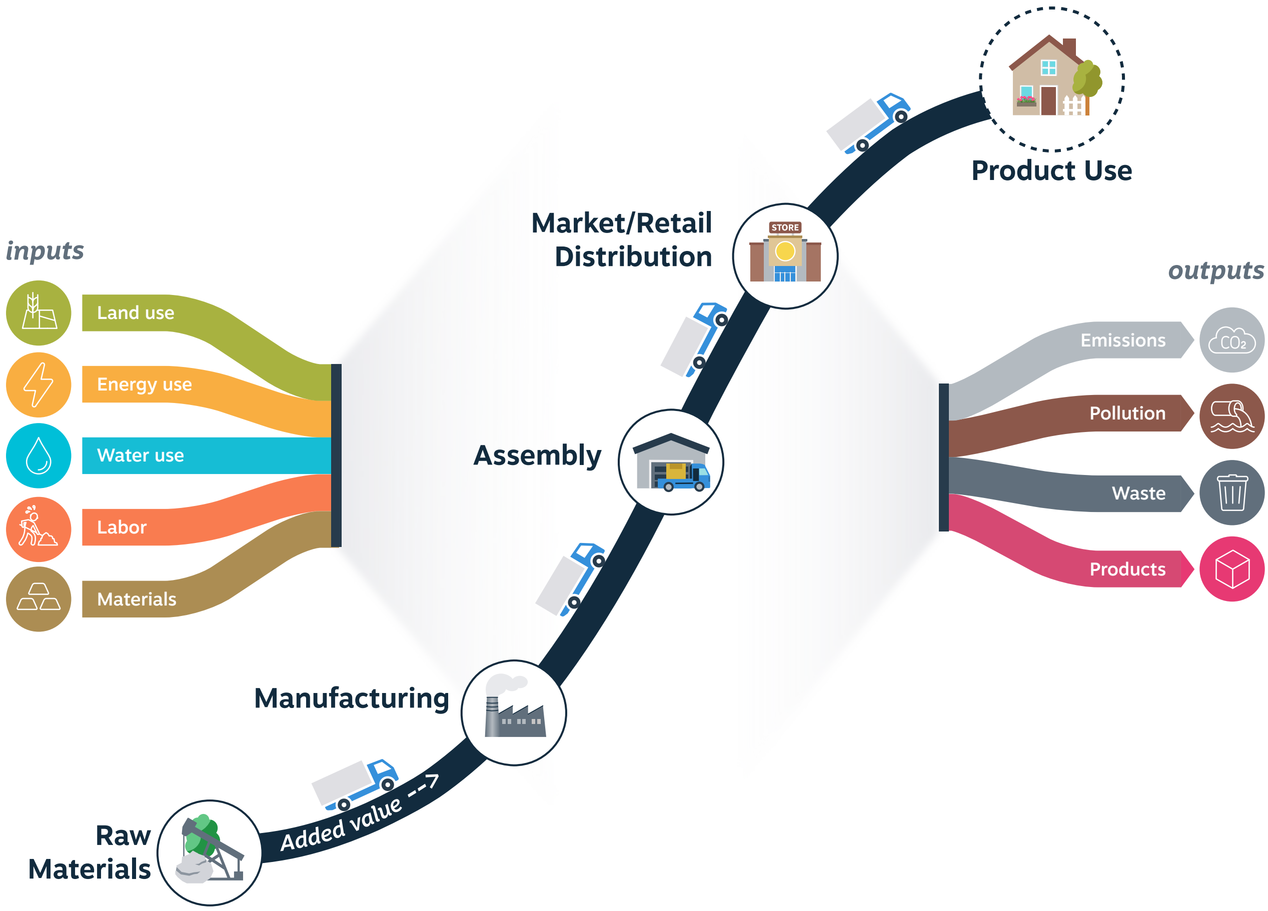


Figure 2 *Inputs and outputs associated with product development*

Embedded impact of excessed materials in the KCMA

Figure 3 shows the embedded impact of the discarded materials that are produced in the KCMA. Only those materials for which we found a good impact factor proxy are considered. The amount of material in terms of its mass, is not the only, nor the best indicator to judge the necessity for reuse or recycling, as explained above. For example, a relatively lightweight material like aluminum may have a disproportionately high embedded carbon footprint due to the energy-intensive processes required for its extraction and manufacturing.

By examining embedded impacts alongside mass, the analysis offers a more nuanced understanding of the environmental significance of different materials. This approach helps prioritize actions like reuse and recycling for materials with high embedded impacts, even if they represent smaller waste volumes. The data in Figure 3 underscores the importance of considering lifecycle impacts when designing strategies to recover resources.

The embedded impacts of these materials on the environment have been indicated based on global averages. Figure 3 shows the relative share of the different materials in terms of mass and three types of embedded impacts; land use, carbon dioxide equivalent (CO2-eq.) emissions, and water usage. It shows that, while textiles make up 3% of the mass, they cause almost 12% of the total agricultural land occupation and almost 60% of the water usage. Textiles, such as polyester, cotton and nylon make up the composition of modern clothing. The significant impact of this composition highlights the importance of using these materials for as long as possible and, once they reach the end of their lifespan, ensuring that they are recycled responsibly. However, to truly reduce our overall environmental footprint, we must also reduce our extraction of raw materials, such as cotton. This way we can ensure that the benefits gained from recycling are not diminished. Another interesting example, that underlines the importance of looking at other metrics than mass, is e-waste. While e-waste makes up only 0.5% of the mass, it accounts for almost 6% of the carbon footprint.

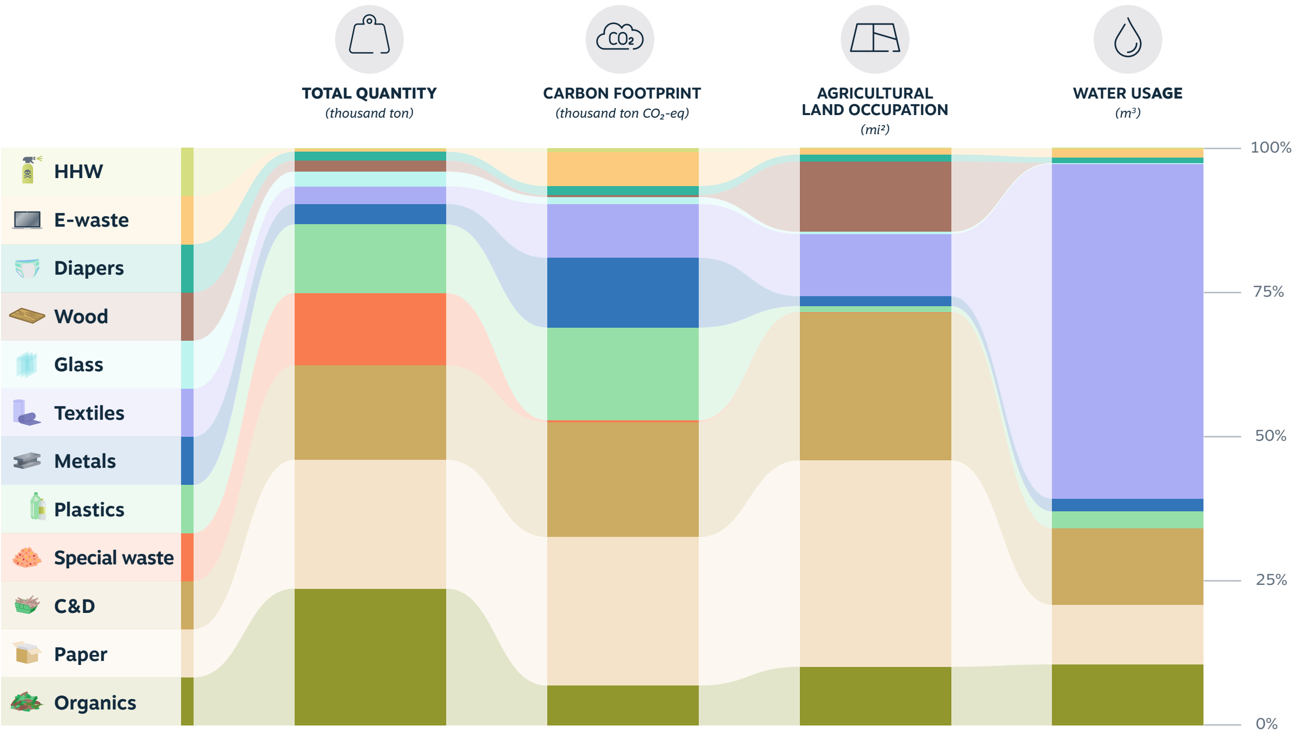


Figure 3 Relative share between embedded impacts of discarded materials in the KCMA

** Only those materials for which an impact factor is known are shown in the chart.*
*** These impacts related to the specific materials are based on global averages.*

04

The potential for a more circular economy

The core aspects of a circular economy present the KCMA with a transformative opportunity to reduce discarded materials, recover valuable resources, and stimulate economic development by creating jobs and attracting innovative activities and businesses.

By leveraging R-strategies such as reuse, repair, and recycling, the region can keep materials in productive use for longer, diverting significant discarded materials from landfills, and reducing both disposal costs and environmental impacts.

Circular waste management in the KCMA extends beyond increasing recycling rates—it requires rethinking the entire lifecycle of materials to maximize their value while minimizing discarded materials.

Using the concept of the Value Hill, interventions should target the peak of the hill, emphasizing actions like reuse and repair to retain the highest value of materials before they degrade. Effective strategies also involve reducing discarded materials generation at its source and redesigning systems to use resources more efficiently. These approaches not only regenerate the environment but also foster economic growth, create jobs, and build a cleaner, more resilient community.

THE VALUE HILL

The Value Hill model illustrates the lifecycle of products and materials, emphasizing the importance of retaining value across three phases: creation, usage, and post-use. In the creation phase, value is built through thoughtful design and production processes that focus on durability, repairability, and modularity. These design choices are crucial for extending a product's life and ensuring that its components can be easily repaired, upgraded, or repurposed. By prioritizing efficient use of resources from the outset, the foundation is laid for circularity.

At the peak of the hill, during the usage phase, products deliver their primary function and fulfill their intended purpose. Extending this phase through regular maintenance, repair, and optimized usage helps conserve resources and reduce the need for premature replacement. This stage maximizes the utility of products, ensuring they perform effectively for as long as possible.

In the post-use phase, materials and products continue to play an essential role in circular systems. Through a series of recovery strategies—commonly known as the R-strategies—products are kept in circulation rather than being discarded. These include reuse, refurbish, remanufacture, repurpose, recycle, and recover.

Each strategy focuses on retaining the value embedded in products and materials, whether through direct reuse, transforming components into new products, or recovering valuable raw materials.

The cascading R-strategies in the post-use phase ensure that materials re-enter the economy instead of ending up in landfills or incinerators. For example, a product might first be reused or refurbished to extend its functionality. If its condition deteriorates, it could be disassembled, with its components remanufactured or repurposed. Finally, materials that cannot be repurposed can be recycled or recovered to extract their remaining value and recirculate the materials into new products, starting a new journey on the Value Hill.

The Value Hill shows the interdependence of all phases in creating a functional circular economy. Together, these interventions not only reduce discarded materials and conserve resources but also support economic growth by fostering innovation and creating new market opportunities. By emphasizing circularity and material recovery, the KCMA can reduce environmental impacts, drive regenerative development, and build a resilient economy that efficiently manages resources across their full lifecycle.

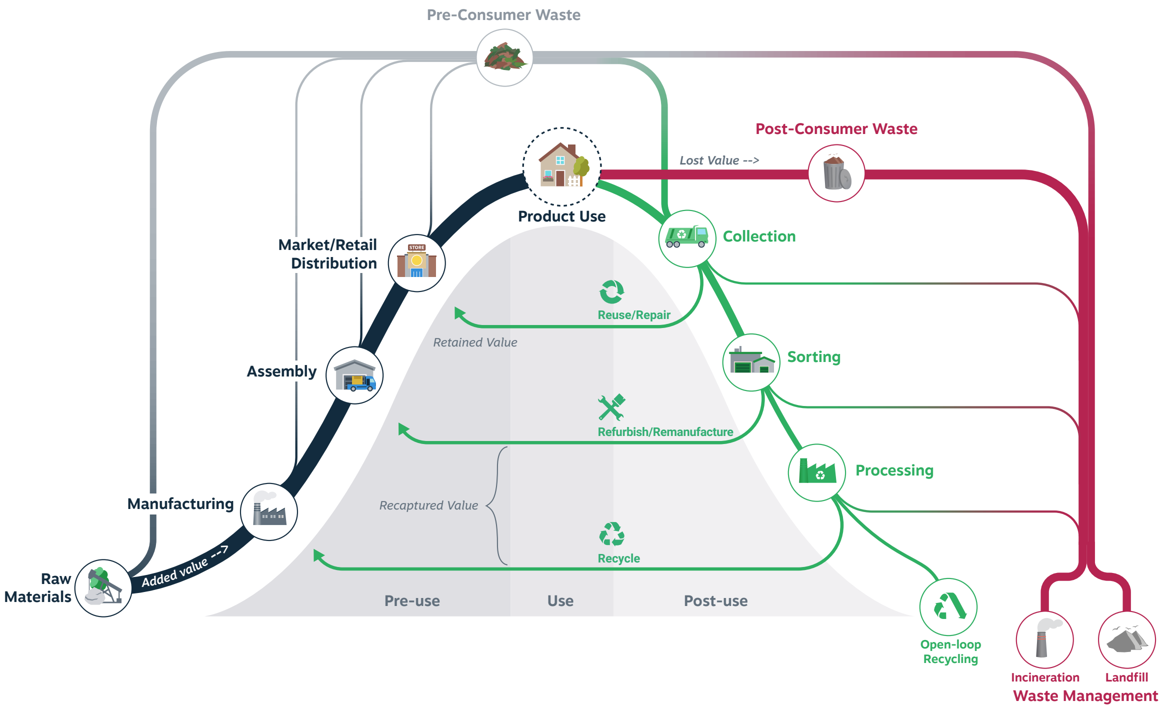


Figure 4 *Value Hill*

DIVERTING WASTE FROM LANDFILL TO CREATE VALUE

Based on the data used for this report, a deep dive was done into the materials that are currently being landfilled in the KCMA. Landfilling is costly, both financially and environmentally, as it requires significant expenses for discarded materials disposal and management while contributing to greenhouse gas emissions and pollution. Additionally, it drives the demand for virgin resources, as discarded materials are not recovered or reused, leading to continued resource extraction, higher material costs, and further environmental degradation.

To get insights into the economic potential of diverting materials from landfill, an analysis was conducted to estimate the economic value of materials currently sent to landfills in the KCMA. This analysis focused on two key aspects: the financial value of potentially diverted materials and the job creation opportunities associated with material recovery.

To estimate the value of these materials ending up in landfill facilities, secondary market prices for recyclable materials were sourced through desk research. These prices were applied to the discarded materials volumes identified in this research, providing estimates of the lost value associated with current disposal practices.

JOB CREATION POTENTIAL

Zero discarded materials strategies, which prioritize discarded materials prevention, reuse, composting, and recycling, have been proven to create far more jobs than traditional disposal methods. Studies highlight that zero discarded materials systems not only generate substantial employment opportunities, but also offer higher wages and better working conditions, particularly in recycling, remanufacturing, and composting.

In this analysis, potential for job creation has been calculated by using material-specific employment factors. For every 1,000 tons of discarded materials recycled, an estimated number of jobs was derived based on industry averages. This includes direct jobs (~55%), which are associated with the actual transformation of recyclable materials into marketable products, such as collection, sorting, processing, logistics, and technicians, as well indirect jobs (~45%) that include upstream supply chain economic activity that supports recycling processes. Jobs related to remanufacturing and reuse are not included in this analysis, but hold great potential to add on top of the job creation potential of recycling.

The results of the economic analysis are visualised in a bubble chart in Figure 6. In this graph, the axes represent the quantity of a material and its corresponding residual economic value, while the size of each bubble indicates the job creation potential. Some material groups were excluded from this analysis, due to the unclarity of their specific content, or lack of recycling methods.

FINISHED PRODUCTS ARE WORTH MORE THAN THE RAW MATERIALS INSIDE THEM

This analysis focuses solely on the secondary market prices for recyclable materials, providing an estimate of their current monetary value. However, the true economic value of a product extends far beyond the sum of its individual material components, as it includes the added value from design, manufacturing, and functionality. Numerous factors influence the ultimate economic outcome of recycling these materials, and many different applications exist to convert these material streams into new products or applications. Therefore, this study limits its scope to the present market value of recycled materials, acknowledging that this represents only a fraction of their broader economic potential.

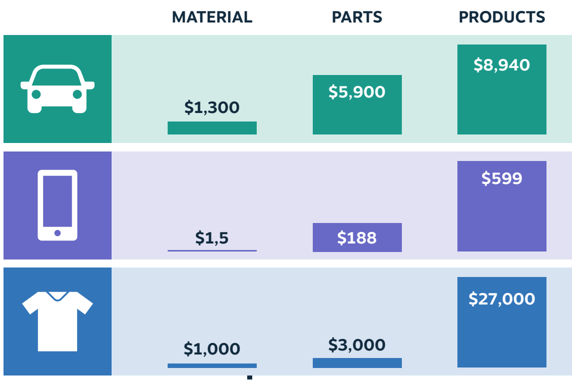


Figure 5 *Difference between value of materials, parts, and products*

This complementary analysis of discarded materials streams in the KCMA highlights the untapped value of many materials currently sent to landfills with potential of being recovered. The visual shows the mass (y-axis), residual value (x-axis), and job creation potential (bubble size) for each category of materials currently ending up in landfills around the KCMA.

We estimate a total residual market value of ~$250 million for materials currently being landfilled annually, alongside the creation of more than 5,000 jobs if these materials were recycled. Again, this represents only the current scrap value of the individual material streams, and the job potential for recycling these materials. On the other hand, the cost of landfilling these materials is estimated to be ~$80 million, using an average price of $57.63 per ton of landfilled material (EPA, 2020).

Additional research from local sources suggest that landfill tipping fees in the KCMA likely range between $34 and $57 per ton, depending on the specific facility and discarded material type.

PLASTICS

Plastics make up a significant portion of these discarded materials with ~300 kilotons annually and represent a major opportunity for circularity. Diverting plastics from landfill could generate $100 million in revenue and recycling could create around 2,800 jobs, while drastically reducing reliance on virgin resources like petroleum. Many innovative solutions exist that are able to properly and effectively sort mixed discarded materials streams into separate categories.

Converting these plastic materials into new products unlocks lots of economic potential that is not yet included in this analysis. Similarly, materials like textiles and metals, though smaller in volume, show substantial residual value (~$26 and ~$70 million, respectively) and can contribute significantly to economic development through recycling and reuse.

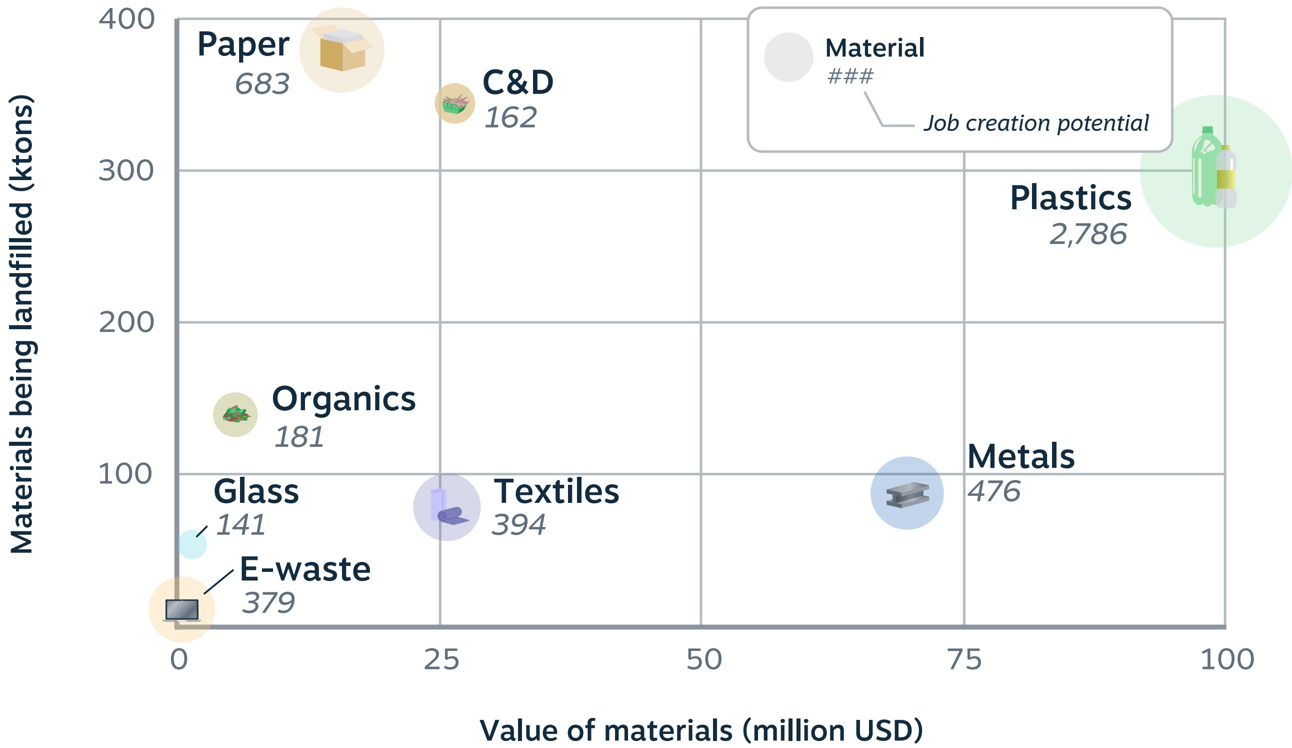


Figure 6 *Residual value of materials currently being landfilled in the KCMA and job creation potential for recycling*

ORGANICS

Food waste is a clear example of the untapped potential within a circular approach. Each year, significant quantities of food (~150 kilotons) are discarded in the KCMA. While composting is a step toward reducing landfill reliance, it recaptures only a fraction of food waste's value. R-strategies like preventing food waste at the source, or repurposing it into higher-value applications such as animal feed, bio-based materials, or renewable energy, would yield far greater economic and environmental benefits. Achieving these outcomes requires infrastructure for separate collection or advanced sorting to maintain material quality and usability, ensuring that the highest-value opportunities are prioritized.

OTHER WASTE TYPES

Even larger volumes of C&D materials (~340kilotons) and paper (~380 kilotons) are ending up in landfills in the KCMA every year. These materials show significant potential for job creation and have a substantial economic value when diverted from landfill, estimated at around $40million annually.

On the other hand, a relatively small volume of glass is being landfilled. A key contributing factor is that Ripple Glass is already collecting and recycling ~20% of that material in the KCMA. Also e-waste shows low amounts being landfilled, and therefore, although having high potential recovery value per ton and significant job creation potential, showing rather small financial opportunities compared to other discarded material streams.

This analysis underscored the broader socio-economic benefits of improving sorting and recycling infrastructure. The visualisation intuitively identified materials with the highest combined economic and employment impact, highlighting opportunities to align discarded materials management practices with regional employment goals and key priorities for resource recovery and circular economy initiatives. KCMA has the chance to implement innovative circular solutions by addressing barriers to reuse and recycling. For discarded materials streams where markets are less developed, medium-term strategies such as waste-to-material conversion or energy recovery through biogas production or incineration can provide a practical alternative. By embracing a comprehensive circular strategy, the region can unlock economic growth, reduce environmental impacts, and position itself as a leader in regenerative business.

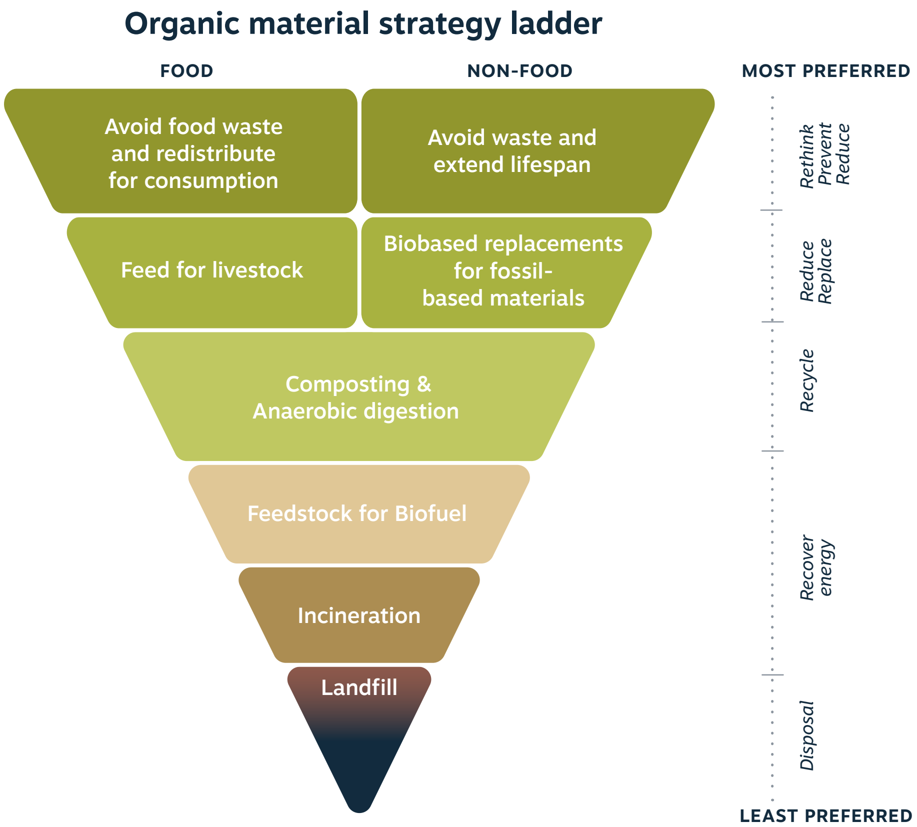


Figure 7 *Organic waste processing hierarchy*

JOB CREATION BEYOND RECYCLING

Recycling offers significant potential for creating local jobs, but other circular strategies like remanufacturing and repair hold an even greater promise. These activities demand a skilled workforce, including technicians, craftspeople, and machine operators, and they provide a strong boost to local businesses by keeping production and services close to the community. For example, repairing electronics, refurbishing furniture, or even restoring old appliances creates jobs that require hands-on expertise, which boosts a diverse workforce. Remanufacturing, which involves rebuilding products to a like-new condition, not only extends the life of items but also reduces the need for raw materials. These higher R-strategies generate more value from each product while also boosting sustainability and long-term employment opportunities.

The **Zero Waste and Economic Recovery: The Job Creation Potential of Zero Waste Solutions** report, published by the Global Alliance for Incinerator Alternatives (GAIA), highlights the significant potential of zero waste strategies to create jobs. It demonstrates that zero waste approaches, such as repair, recycling, remanufacturing, and composting, generate far more jobs than traditional disposal-based systems like landfilling and incineration. Recycling alone generates over 50 times, and remanufacturing nearly 30 times, as many jobs as these disposal methods.

The data show that waste management approaches that have the best environmental outcomes also generate the most jobs. Beyond quantity, zero waste jobs also tend to offer higher wages, better working conditions, and opportunities for skill development. The integration of informal waste workers into formal systems can improve their quality of life by providing access to higher wages, job security, and benefits like health insurance (Ribeiro-Broomhead, J. & Tangri, N. 2021).

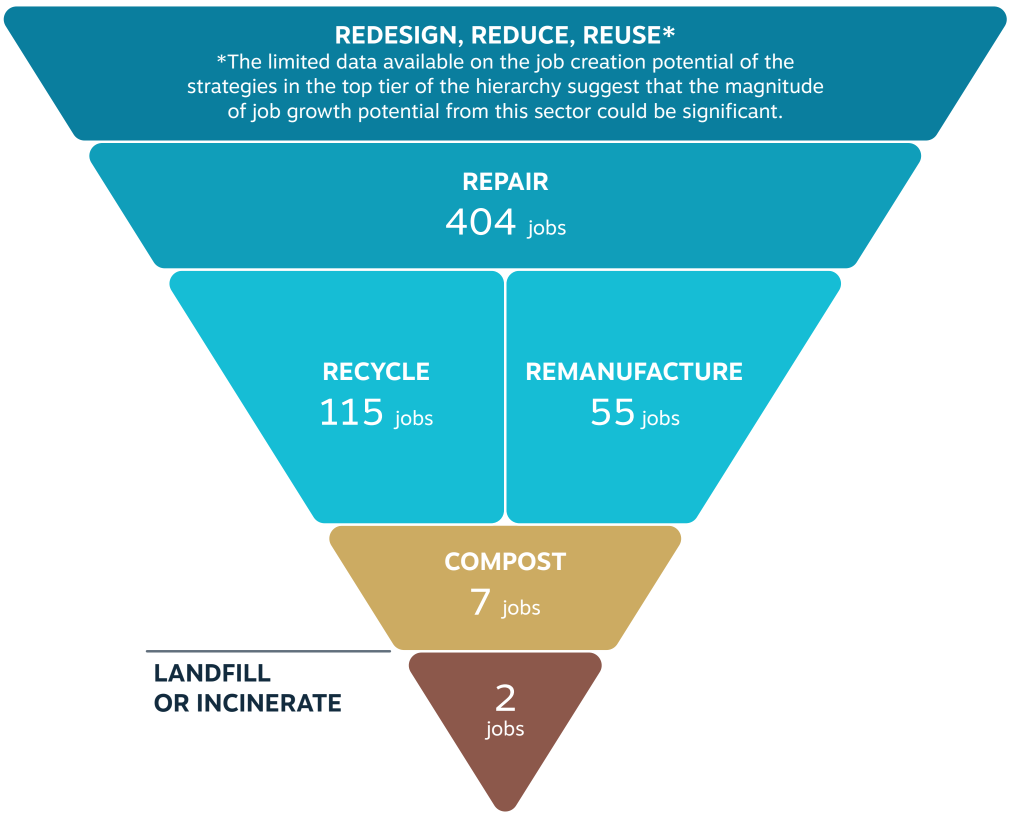


Figure 8 *Waste hierarchy with mean job generation figures per 10.000 metric tonnes of waste processed per year*

WASTE MANAGEMENT IN THE NETHERLANDS

Over the past decades, the Netherlands has transformed its waste management system from a landfill-dependent model to one of the most efficient systems globally. This shift was driven by a combination of economic, environmental, social, and economic factors, alongside progressive legislation and public awareness campaigns.

Up until the 1970s, waste in the Netherlands was largely landfilled, with minimal environmental safeguards. Rapid economic development and population growth led to increasing amounts of municipal and industrial waste, resulting in growing concerns about land scarcity and pollution. The impact of discarded materials on soil and groundwater quality, coupled with the visible degradation of the natural environment, urged the Dutch government to take action.

The 1980s marked a turning point. The government implemented a policy making landfill disposal economically unviable and encouraging alternative waste treatment methods. During the 1990s and 2000s, advancements in recycling infrastructure and public participation further modernized the waste management system. Separate collection systems for paper, plastics, glass, and organics were introduced, supported by public campaigns emphasizing the environmental and economic benefits of recycling. These efforts were complemented by bans on landfilling recyclable and combustible waste, as well as investments in modern waste-to-energy facilities.

Today, the Netherlands recycles nearly 80% of its municipal, C&D and commercial materials. The remaining 20% of discarded materials that are not recycled is primarily managed through waste-to-energy incineration, with only a very small fraction (around 1%) sent to landfills.

Figure 9 *Waste separation station in the Netherlands.*
Source: https://www.recyclingplastics.eu/recycling-process

05 Barriers

Through our analysis and additional research, we have identified several key barriers to effective discarded materials management in the KCMA. While not exhaustive, this represents a selection of the most prominent challenges encountered during the study.

PUBLIC VS. PRIVATE HAULERS

The discarded materials infrastructure in the KCMA is hindered by fragmentation between public and private haulers. Public haulers primarily handle residential discarded materials, while private haulers dominate the commercial and industrial sectors, resulting in inconsistencies in the waste management system. Private haulers often operate with different incentives than public organizations, limiting a shared responsibility. Establishing a common goal could address this disparity and foster collaboration.

A comprehensive understanding of where the discarded materials originated, where it was hauled, its volumes, and treatment methods—including data from private haulers—would enable better decision-making to unlock economic opportunities. To achieve this, mandatory information-sharing requirements should be integrated into all hauler contracts across the region.

MUNICIPAL ORGANIZATIONS

In the United States, waste management responsibilities are typically housed within public works departments or environmental services divisions at the municipal level. These entities focus on providing services like trash collection, recycling, and landfill operations, with an emphasis on public health, safety, and environmental compliance and less on economic opportunities. As highlighted in this report, waste management carries significant economic potential, including job creation, revenue generation from recyclable materials, and reducing disposal costs. Integrating aspects of waste management with economic development offices, or fostering stronger collaboration between these departments, can help unlock these opportunities and maximize the economic benefits of sustainable discarded materials practices.

MINDSET AND EDUCATION

One significant barrier to improving recycling in the KCMA is the prevailing mindset around waste management. Many residents and businesses view discarded materials primarily as a disposable nuisance rather than a resource with potential value—or mistreat discarded materials because of lack of education (*Fox4 Kansas City*). These experiences lead to low participation in recycling programs and high contamination rates in recyclable materials.

Misconceptions, such as the belief that most recyclables end up in landfills, further discourage efforts. Beyond that, it also seems that the ecosystem of the waste management industry is not fully aware of the issue on the one hand and the potential that is out there on the other hand. A Global Waste Index study by SenSeono ranks the United States 25th out of 38 researched countries on the basis of different waste-handling criteria including amount of discarded materials generated, recycling rates, incineration, landfilling, and the consequences of mismanagement like illegal dumping (*SenSeono, 2022*).

06 Recommendations

The KCMA has a significant opportunity to enhance its waste management systems and transition toward a circular economy. This section outlines the key recommendations.

UTILIZE REGIONAL COLLABORATION

With MARC serving as a key resource for collaborative planning in the region, a strong foundation for coordinated governance and implementation already exists. However, this set-up could be leveraged more effectively to achieve a more effective waste management system. Enhancing collaboration to include parties like the Kansas City Area Development Council (KCADC) and others would enable collective decision-making on how best to organize and capitalize on local economic opportunities, ensuring that efforts and benefits are shared equitably across the region.

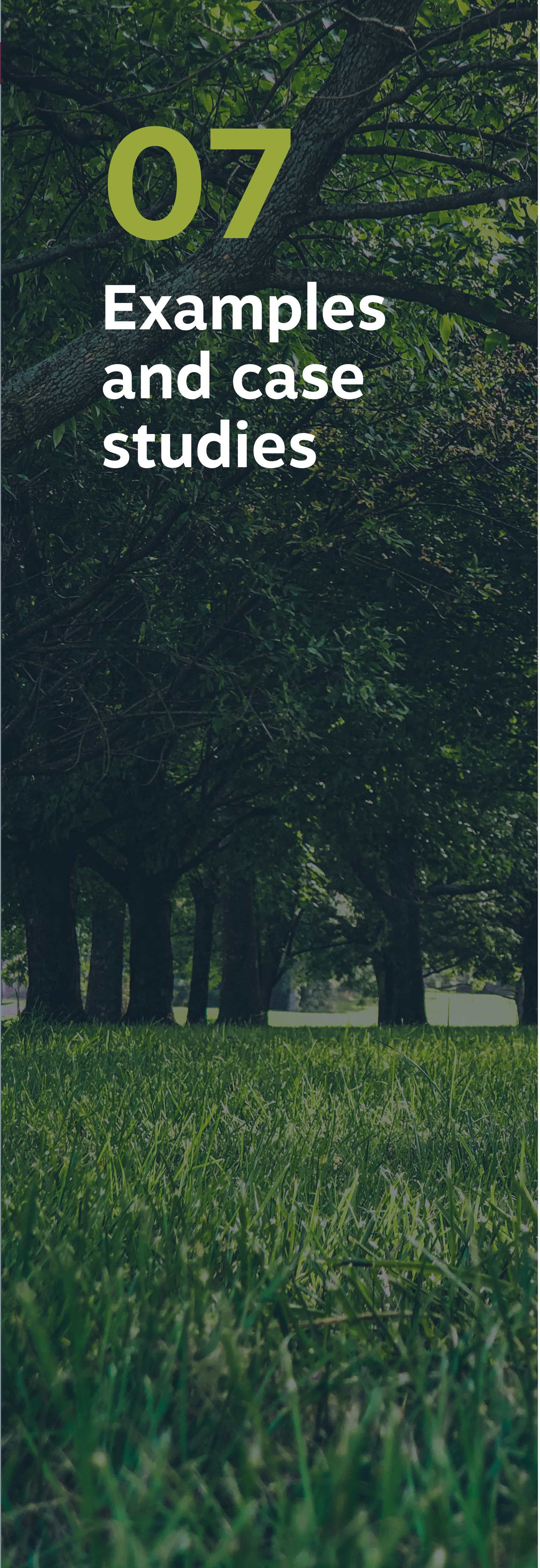
ENHANCE DATA QUALITY

Accurate, reliable data is foundational for effective decision-making. Currently, inconsistencies and lack of transparency in data collection and reporting hinder a comprehensive and comparable understanding of material flows within the KCMA. To address this, we recommend the development and adoption of a collaborative data-gathering system involving key stakeholders, including municipalities, waste haulers, transfer stations, recyclers, composters, landfilling facilities, and industries.

A centralized, standardized platform for data sharing would enable more accurate tracking of waste streams, improving the ability to identify inefficiencies, monitor progress, and design targeted interventions. For example, better data would enable stakeholders to accurately estimate the volume and composition of waste generated and its potential for reuse or recycling. In turn, this leads to more informed investment in infrastructure and policies that align with regional sustainability goals. All parties stand to benefit from this system. Waste managers can optimize logistics and operations, policymakers can make evidence-based decisions, and businesses can identify new opportunities for innovation and resource recovery. Establishing a collaborative data framework would also strengthen regional resilience by fostering trust and cooperation among stakeholders, ensuring all voices are included in the decision-making process.

ADAPT STRATEGIES THAT GO BEYOND RECYCLING

Implementing circular business strategies such as refurbishment, repair, and remanufacturing significantly enhances material retention and extends product lifespans. Climbing higher on the R-ladder, innovative design approaches—such as modularity and disassembly—further maximize recoverable value. However, these advanced strategies require proactive collaboration from upstream stakeholders across the value chain to ensure their feasibility and scalability. While precise estimates for recycled products and higher R-strategies are challenging due to their complexity and variability, their retained value is substantially greater than the material-specific figures presented here.



07 Examples and case studies

Kickstarting a local circular economy is not easy, as it is a complex and comprehensive task, requiring an understanding of the system and bold action. Fortunately, all around the world cities are trying to make the circular economy work, and with success. Every year more and more cities and regions set up extensive plans and circular strategies. However, implementing those has not always shown to be easy. Many projects have failed before others could succeed. To leverage this global experience in the best way, one can only learn from other peers and build on those lessons learned.

In this chapter, we selected several case studies that have shown to have substantial potential and can be implemented successfully. Based on the previous section, material groups that have high potential in the KCMA are plastics, metals, C&D, textiles, organics, and paper. The volumes of glass and e-waste have shown to be relatively small compared to the rest, and therefore are not taken into account in this chapter. Nevertheless, although not the focus here, these should of course also be considered, especially e-waste. That material stream is growing rapidly and comes with high environmental impacts, as well as being dependent on ever more scarce metals. Developing a local circulation of these metals not only generates economic benefits, but also delivers strategic advantages.

Additionally, for glass, as well as metals and paper, the local recycling infrastructure is relatively well developed, as these are the most commonly recycled materials. The main challenge here is to separate these materials from mixed discarded materials streams, so that they can be fully and properly recycled.

Taking all this into account, we end up a list of three selected material streams that have high circular potential in the KCMA, which are the following:

- **Plastics**
- **C&D**
- **Organics**

For every of these three material groups, we selected case studies that have shown to be successfully established, commercially attractive, and relevant to the local context. In appendix 3, we also included a list of additional case studies on these material streams as well as others. These differ from pilot-scale to large-scale commercially implemented projects, and include local as well as global projects.

Plastic

EASTMAN CHEMICALS

OVERVIEW

Eastman in Kingsport, Tennessee, is known for being the headquarters of Eastman Chemical Company, a major global specialty materials company. Eastman is heavily involved in the production of advanced materials, chemicals, and fibers. They have a strong focus on circular economy initiatives, particularly in molecular recycling technologies for plastics.

Figure 10 *Polyester recycling facility at Kingsport, Tennessee*
Source: SourcingJournal

KEY FEATURES

Operating state-of-the-art facilities across Europe and North America, Eastman employs advanced mechanical recycling technologies, including:

- **Molecular Recycling:** Uses methanolysis to break down hard-to-recycle plastics into basic molecules.
- **Polyester Renewal Technology (PRT):** Converts waste PET plastics into high-quality materials for reuse.
- **Carbon Renewal Technology (CRT):** Processes mixed plastic waste into molecular building blocks for new products.
- **Large-Scale Capacity:** Can recycle 110,000 metric tons of plastic waste annually.

KEY METRICS

Annual Processing Capacity: This facility has the capacity to recycle 110,000 metric tons of plastic waste annually, converting it back into high-quality materials.

Product Range: Produces recyclates such as polypropylene (PP), low and high-density polyethylene (LDPE and HDPE), mineral-filled polypropylene, and medium- and high-impact polystyrene, designed for injection molding and extrusion applications.

End Markets: Serves industries including automotive, construction, household goods, and packaging.

PLASTICS MICROFACTORY – CIRCULAR LIVING LAB, METRO PHOENIX, USA

OVERVIEW

The Plastics Microfactory, part of the Circular Living Lab in Metro Phoenix, launched in February 2024 as a collaborative initiative between Arizona State University (ASU), the City of Phoenix, Goodwill of Central and Northern Arizona, and Hustle PHX. The facility transforms plastic waste into high-value products like tabletops, stools, and skateboards. This localized and community-driven approach promotes a circular economy while providing economic benefits and creating skilled jobs in the region.

Figure 11 *The Plastics Microfactory in Phoenix, Arizona*
Source: https://circularlivinglab.org/projects/plastics-microfactory/

KEY FEATURES

Localized Recycling Solution: Processes post-consumer and industrial plastic waste, including hard-to-recycle plastics, into reusable materials for local markets. Reduces transportation emissions by focusing on localized collection and processing.

Practical Recycling Technology: Employs thermal and mechanical processing systems to convert recovered plastics into new, durable products. While the technology itself is established, the innovative application in a small-scale, community-focused setting demonstrates its scalability and accessibility.

Community and Economic Impact: By creating skilled jobs and producing affordable, sustainable materials, the microfactory positively impacts the local economy and fosters community engagement in sustainability initiatives.

KEY METRICS

Processing Capacity: Up to 550 tons of waste per year.
Employment Opportunities: 10 skilled jobs created.
Product Output: High-quality products like tabletops, stools, and skateboard decks.

C&R

BREWSTER BROS C&D WASTE RECYCLING PLANT – LIVINGSTON, SCOTLAND

OVERVIEW

Brewster Bros, located in Livingston, Scotland, operates the UK's largest construction and demolition (C&D) *waste recycling plant*. Established in partnership with CDE Group, the facility processes significant volumes of non-hazardous soil and stones from C&D and excavation waste into high-quality recycled aggregates and soils. It demonstrates the commercial viability of large-scale C&D recycling and contributes to a circular economy.

Figure 12 *C&D recycling plant in Livingston, Scotland*
Source: Brewster Bros

KEY FEATURES

High-Quality Material Recovery: Processes 400,000 tonnes of C&D waste annually into recycled aggregates (e.g., sand, gravel, and topsoil). Diverts over 98% of its incoming waste from landfills, reducing environmental impact and conserving natural resources.

Advanced Recycling Technology: Utilizes CDE's wet processing system for efficient separation and cleaning of materials. Closed-loop water management recycles 90% ofwater, minimizing freshwater use.

Environmental and Economic Impact: Supplies cost-effective, sustainable materials to Scotland's construction industry, reducing reliance on virgin resources. Generates revenue through the sale of recycled materials, supporting local infrastructure and development.

KEY METRICS

Processing Capacity: 400,000 tonnes of C&D waste per year.
Landfill Diversion Rate: Over 98%.
Water Recycling: 90% of water is reused within the plant.

NEW HORIZON URBAN MINING – CIRCULAR CONCRETE IN ACTION

OVERVIEW

New Horizon, a Dutch group of C&D actors, gathered as The Urban Mining Collective, and are transforming the construction industry by applying circular principles to concrete. Leveraging the Smart Liberator technology, they recover up to 95% of concrete from demolished buildings and convert it into high-quality raw materials for new construction. This innovative approach minimizes waste, reduces carbon emissions, and preserves natural resources, setting a benchmark for sustainable urban development.

Figure 13 *'Urban Mine', producing Circular concrete with the Smart Liberation Technology in Amsterdam, NL*
Source: https://www.jajo.com/en/jajo-harvests/

KEY FEATURES

Smart Liberator Technology: Recovered concrete is crushed, and this groundbreaking technology separates cement paste from sand and gravel, enabling the reuse of all components in new concrete production.

Selective Demolition: Precision dismantling ensures up to 95% of concrete from demolished structures is recovered with minimal contamination, preserving its quality for reuse.

Collaborative Approach: Partners with developers, municipalities, and architects to integrate circular materials into both public and private construction projects.

Project Impact: Circular concrete has been successfully utilized in flagship projects like the Circular Pavilion in Amsterdam, demonstrating its scalability and performance.

KEY METRICS

Material Recovery: Recovers up to 95% of concrete from demolished buildings for reuse in new construction.

Carbon Emissions Reduction: Recycling aggregates and cement paste reduces CO_2 emissions by approximately 80% compared to producing virgin materials.

Reduced costs: Deconstruction of buildings 10 - 15% cheaper than traditional demolition.

Landfill Diversion: Diverts thousands of tons of concrete waste annually from landfills, significantly contributing to circular economy goals.

Organic

TRANSFORMING ORGANIC WASTE STREAMS INTO BIO-LNG IN THE NETHERLANDS

OVERVIEW

Shell, Renewi, and Nordsol have partnered to tackle the dual challenges of waste management and renewable energy production. The project focuses on recycling organic waste streams into bio-LNG (liquefied natural gas) to support sustainable transportation while contributing to the circular economy.

Figure 12 *Nordsol bio-LNG production site at Wilp, NL*
Source: Nordsol

PROJECT PARTNERS

Renewi: Responsible for collecting organic waste from various sources, including restaurants, retail outlets, and food processing industries across the Netherlands. The company processes this waste through anaerobic digestion to produce biogas.

Nordsol: Operates a bio-LNG production facility that converts the biogas supplied by Renewi into bio-LNG using cutting-edge technology. The facility is co-located at Renewi's site in Amsterdam Westpoort for efficiency.

Shell: Acts as the long-term offtake partner, distributing the bio-LNG through its LNG filling stations across the Netherlands, catering to heavy-duty road transport needs.

KEY FEATURES

Organic Waste Collection: Renewi collects organic waste from various industries, ensuring that waste that would otherwise be landfilled or incinerated is utilized.

Biogas Production: Through anaerobic digestion, Renewi processes the waste into biogas, a renewable energy source primarily composed of methane and CO_2.

Bio-LNG Conversion: Nordsol uses advanced technology to separate methane from the biogas, liquefying it into bio-LNG. The CO_2 by-product is captured and marketed for industrial applications, ensuring a fully sustainable process.

Distribution: Shell distributes the bio-LNG through its LNG filling stations, enabling transport companies to reduce their carbon footprint by switching to a renewable fuel option.

KEY METRICS

Annual organic waste processed: 75,000 tonnes Annual Bio-LNG Production: Approximately 3,400 tons.

Environmental Impact: Enables over 13 million kilometers of CO_2-neutral driving annually.

Circular Economy Contribution: Redirects organic waste into energy production, reducing landfill and incineration waste.

BLACK SOLDIER FLY (BSF) CONVERTING ORGANICS INTO FERTILIZER, FEED AND OILS

OVERVIEW

Black Soldier Fly (BSF) technology utilizes Hermetia illucens larvae to convert organic waste into valuable products like protein-rich animal feed and organic fertilizers. Companies such as EnviroFlight and Innovafeed exemplify the commercial application and scalability of this sustainable waste management solution.

Figure 12 *Innovafeed production site in Nesle, France*
Source: https://innovafeed.com/en/our-production-sites/

KEY FEATURES

- Organic Waste Conversion: Processes food waste, agricultural by-products, and manure, reducing waste volume by approximately 50-60% within days.
- Offers a rapid and efficient alternative to traditional waste management methods.

High-Value Products:

- **Protein Meal:** Serves as a sustainable ingredient in aquaculture, poultry, and livestock feed.
- **Insect Oil:** Functions as an alternative to traditional oils in animal feed formulations.
- **Frass:** Provides a nutrient-rich fertilizer for agricultural applications.

Commercial Leaders:

- ***EnviroFlight (USA)***: Established the first commercial BSF facility in Maysville, Kentucky, in late 2018. Initial production capacity of 900 tons of dried BSF larvae annually, with plans to expand to 3,200 metric tons per year.
- ***Innovafeed (France)***: Operates the world's largest insect production site in Nesle, France, with a current capacity of 15,000 tons of insect protein annually. Plans to expand production capacity to 60,000 tons of insect protein per year at a new facility in Decatur, Illinois, USA.
- *Entobel (Vietnam)*: Entobel established its first commercial BSF facility in Vietnam in 2013, with an initial production capacity of 1,000 tons annually. The company plans to expand to 10,000 tons per year by 2027, focusing on sustainable insect farming and converting organic waste into high-value protein and fertilizer.

KEY METRICS

Waste Reduction: BSF larvae can decrease organic waste volume by 50-60% within a few days.

Protein Content: BSF larvae comprise approximately 40-45% protein and 30-35% fat, making them a high-quality feed ingredient.

Production Capacities:

- EnviroFlight: Aims to reach an annual production capacity of 3,200 metric tons of dried BSF larvae.
- Innovafeed: Targets an annual production capacity of 60,000 tons of insect protein at its upcoming U.S. facility.

DIVERT'S INTEGRATED DIVERSION & ENERGY FACILITY – TURLOCK, CALIFORNIA

OVERVIEW

The *Divert facility* in Turlock, California, processes unsold food products into renewable natural gas (RNG) and soil amendments. Operational since 2023, it is a state-of-the-art facility designed to tackle food waste sustainably while contributing to California's renewable energy goals.

Figure 12 *RNG production site at Turlock, California*
Source: https://divertinc.com/divert-celebrates-milestone-with-turlock-ca-facility-opening/

KEY FEATURES

Material Processing: Processes up to 100,000 tons of food waste annually from retailers, manufacturers, and food service providers. Uses proprietary depackaging and anaerobic digestion technologies.

Renewable Energy Production: Produces 225,000 MMBtu of RNG annually, injected into the Pacific Gas and Electric (PG&E) natural gas grid. Offsets more than 25,000 tons of CO_2 annually, equivalent to removing 5,000 gas-powered cars from the road.

Soil Amendment: Converts byproducts into nutrient-rich compost for sustainable agriculture.

Environmental Impact: Diverts significant organic waste from landfills, reducing methane emissions.

KEY METRICS

Annual Processing Capacity: 100,000 tons of food waste.

Renewable Energy: 225,000 MMBtu of RNG annually.

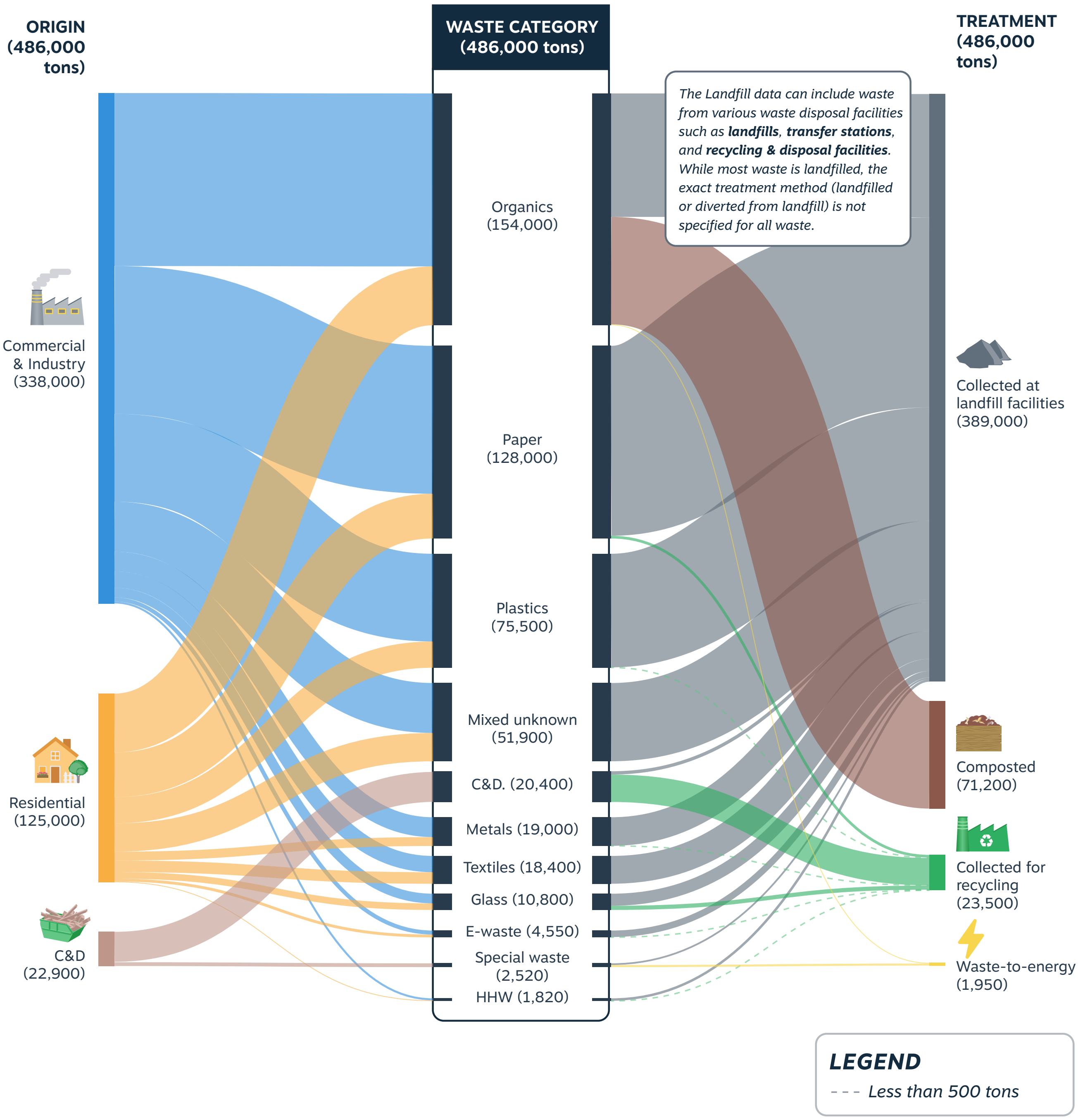
CO_2 Reduction: Offsets more than 25,000 tons annually.

08 Appendix

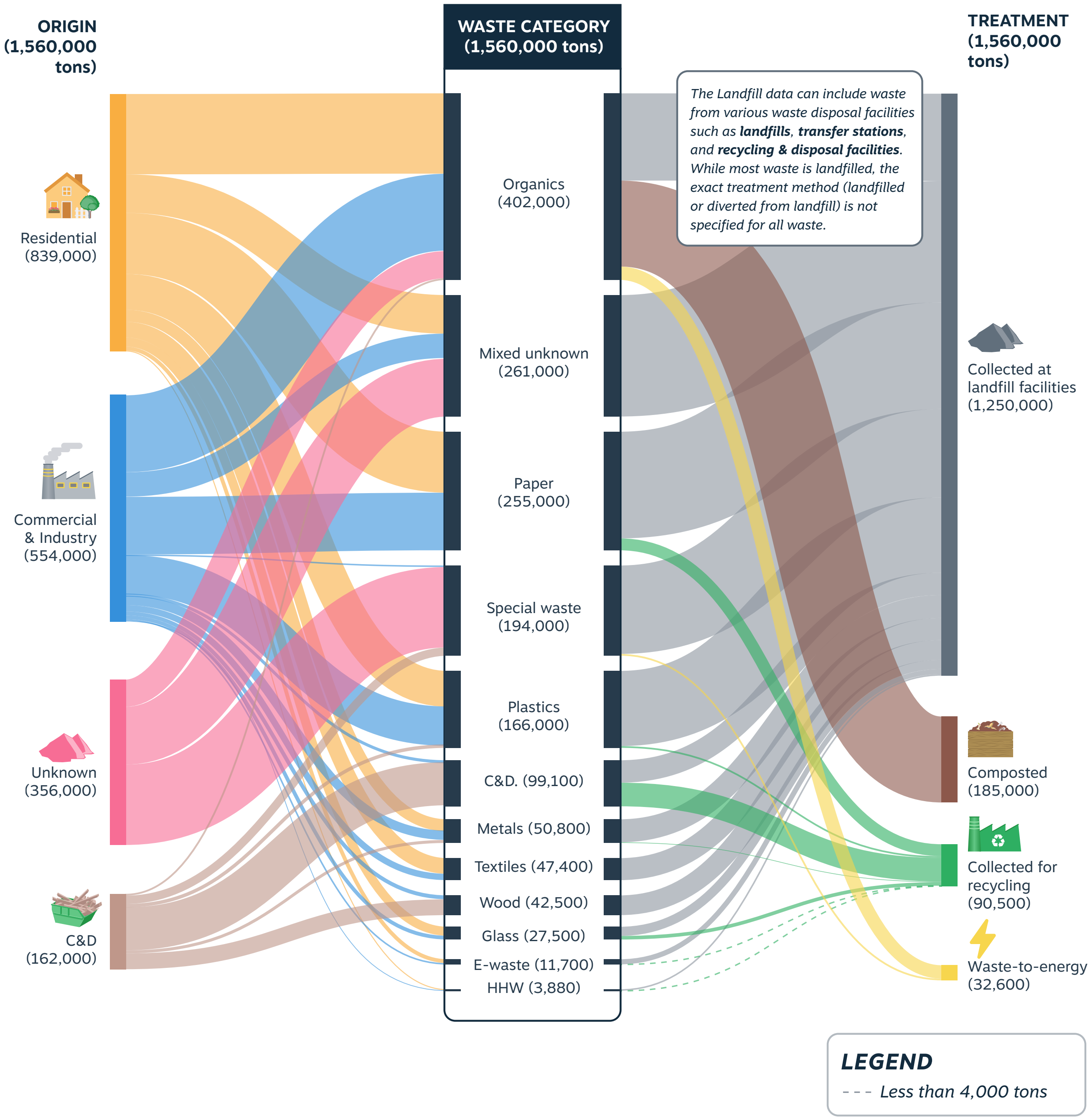
Appendix 1: Material Flow Analysis

As stated earlier, we have identified gaps in the available data, which may result in some variations between our findings and actual conditions. However, we have remained true to the data provided, ensuring transparency and consistency in our approach. These results serve as a foundation for understanding material flows and highlight the importance of improving data collection for more accurate future assessments.

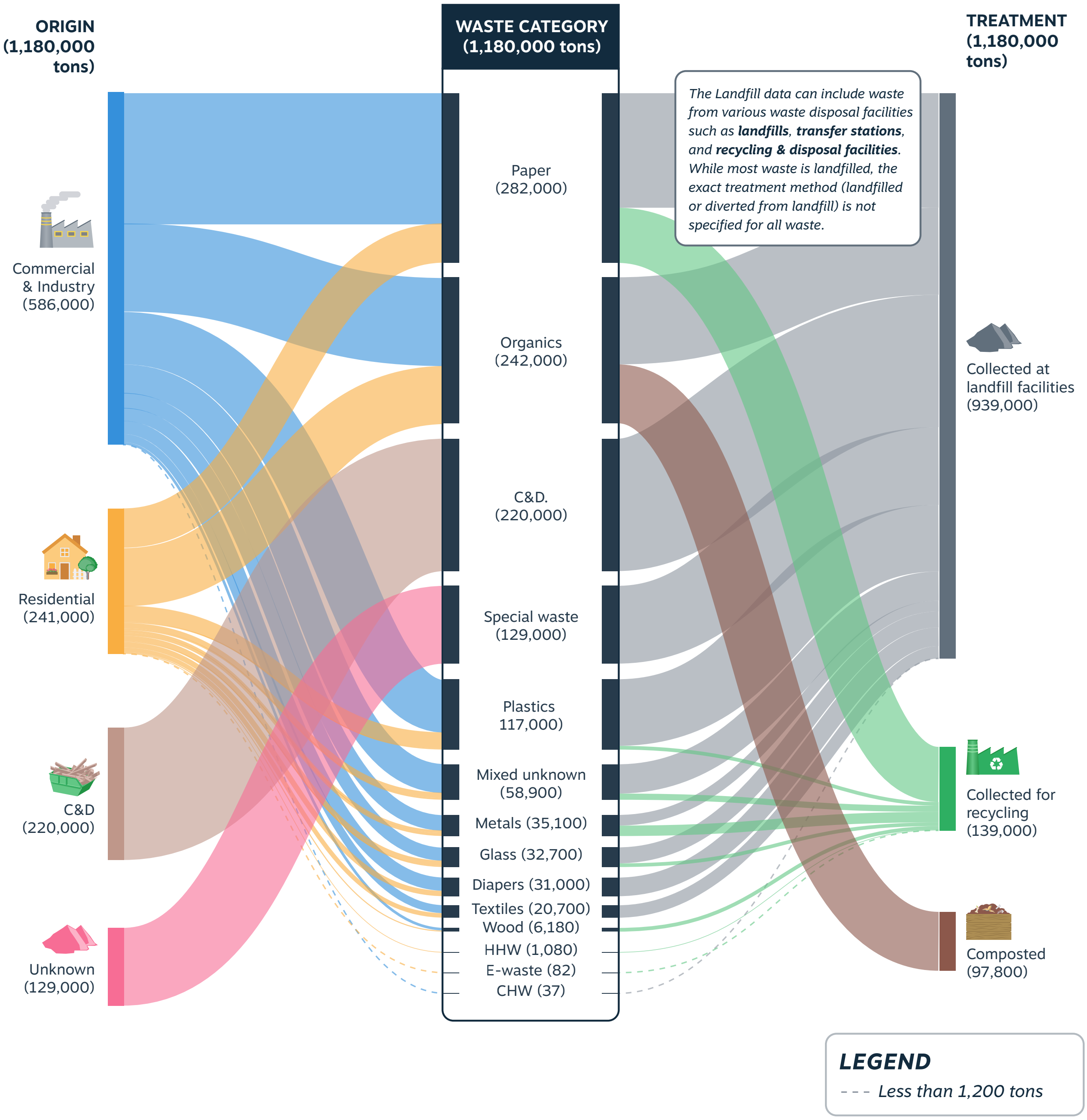
CITY OF KANSAS CITY, MISSOURI



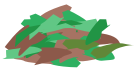
MARC SOLID WASTE MANAGEMENT DISTRICT



JOHNSON COUNTY, KANSAS

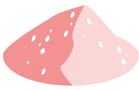


Appendix 2: Waste composition per material group



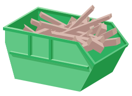
ORGANICS:

- Organics
- Tree trunks
- Sludge
- Food
- Yard Waste



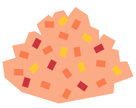
MIXED UNKNOWN:

- Inorganics
- Other waste



CONSTRUCTION & DEMOLITION (C&D):

- Concrete/Brick/Rock
- Roofing materials
- Gypsum Board
- Dirt/Sand/Gravel
- Other C&D



SPECIAL WASTE:

- Contaminated Soil
- Asbestos
- Cut Tires
- Bulky Items
- Mattresses
- Other special waste

HOUSEHOLDS HAZARDOUS WASTE (HHW):

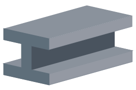
- Latex Paint
- Motor Oil
- Flammable Liquids
- Pesticides
- Antifreeze
- Oil-based Paints
- Aerosols
- Fluorescent Bulbs
- Oxidizers
- Used Oil
- Fuels/Fuel Blends
- Flammable Solids
- Spontaneously Combustible
- Dangerous When Wet
- Organic Peroxides
- Poisons
- Dioxins
- Corrosives, Acids & Bases
- Batteries - Lead Acid
- Sorted Batteries
- Batteries - Lithium
- Mercury
- Pharmaceuticals / Sharps
- Propane
- Free Store Mixed Items
- Other: Cooking Oil
- Other: Isocyanates

COMMERCIAL HAZARDOUS WASTE (CHW):

- Latex Paint
- Used Oil
- Aerosols
- Oil-based Paint
- Fuels/Fuel Blends
- Oxidizers
- Poisons
- Corrosives, Acids & Bases
- Sorted Batteries
- Antifreeze
- Fluorescent Bulbs

PAPER:

- Paper
- OCC
- Mixed Paper
- Cartons

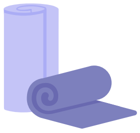


METALS:

- Metal
- Steel Cans
- Aluminum
- Scrap metal

PLASTICS:

- Plastic
- PET Plastic
- Natural HDPE Plastic
- Color HDPE Plastic
- Rigid HDPE Plastic
- Polypropylene Plastic
- #5 Poly Prop/Bypass Plastics



TEXTILES:

- Polyester
- Nylon
- Cotton

RECYCLABLES:

Single-stream recyclables refer to materials that are typically accepted through municipal curbside recycling programs or drop-off locations, processed through a Material Recovery Facility (MRF), and sold as commodities to markets where the material is then repurposed. Single-stream recyclables include items such as, but are not limited to:

- Plastic
- Glass containers
- Aluminum and steel cans
- Cardboard and other various paper products

The full range of materials accepted through a municipality's single-stream recycling program can vary by community or by hauler.

Appendix 3: Additional case studies

Case study overview			
	Material	**Description**	**Source**
Polystyvert recycling process	Plastics	Producing virgin-like recycled resin using a dissolution technology.	*Link*
Plastalyst	Plastics	Developing green, safe, and efficient catalysts that make plastic recycling financially attractive.	*Link*
MBA Polymers	Plastics	Specializes in recovering high-value plastics from complex waste streams, such as electronics, appliances, and vehicles to produce near-virgin quality recycled plastics like ABS, HIPS, and PP, which are used in manufacturing new products.	*Link*
Greenfib®	Plastics	A sustainable, recyclable, 100% bio-based, high-performance, and responsibly sourced plastic derived from non-food.	*Link*
North Carolina ban on PET and HDPE to landfill	Plastics	Much of the waste that is sent to landfill/incineration has recycling potential. Placing a ban on such recyclables could steer an incentive for producers and waste treatment facilities to look into potential alternative routes.	*Link*
LOCAL3	Plastics	Creating and developing a recycling channel for multi-component plastic packaging.	*Link*
Carbios PET biorecycling	Plastics	World-first enzyme-based process enabling infinite recycling of PET plastics and fibers.	*Link*
Upsyde	Plastics	A joint venture between Braskem and Terra Circular, that specializes in upcycling mixed and hard-to-recycle plastic waste into durable goods such as pallets, road plates, and heavy-duty mats.	*Link*
Ekopolimer	Plastics	Conversion of single-use plastics into value-added, recyclable material.	*Link*
Eastman	Plastics	Uses molecular recycling to convert hard-to-recycle plastics back into virgin-like recycled resin.	*Link*
CRDC Global	Plastics	Accepts all types of plastic waste and converts it into RESIN8, a concrete additive suitable for structural and non-structural uses.	*Link*
SmartCrusher	C&D	A process that recycles concrete by selectively separating its components, preserving their integrity to enable nearly climate-neutral concrete production from waste.	*Link*
Rilegno	C&D	Association between different wood recycling entities, produces a wide range of different products from the retrieved wood residuals, e.g. particleboard and MDF panels, together with pulp for paper mills, wood- concrete composites for construction and pallet elements.	*Link*
Unilin	C&D	Specializes in recycling wood waste, transforming it into high-quality chipboard and MDF products through advanced sorting and cleaning technologies.	*Link*

	Material	Description	Source
Lee's Summit Resource Recovery Park	C&D	Employs state-of-the-art recycling technologies and processes that efficiently sort and process C&D materials, ensuring that a significant portion are reclaimed and reused in productive ways.	Link
ValueWaste	Organics	Converts urban biowastes into high-value products.	Link
METHAVOS	Organics	A dry process piston flow digester with vertical multizone agitation.	Link
Unicollecte	Organics	Intelligent robotics system able to sort different waste streams into colored bags.	Link
Flexibuster	Organics	Small-scale anaerobic digestion plant to convert organic waste on-site into electricity, heat, fertilizer and water.	Link
FluidSolids Biocomposites	Organics	A solution to upcycle organic waste streams into performance materials.	Link
Aikan	Organics	Green energy and compost production from solid waste.	Link
SHOC Technology & Recycling	Organics	A strategy to develop treatment sites for organic matter from household waste.	Link
JF Pyrolysis Products-from-Waste System	Organics	Waste conversion technology as a carbon-neutral alternative to fossil fuels.	Link
Biogreen	Organics	A biogreen pyrolysis process converting waste into useful products.	Link
Missouri Organic Recycling	Organics	Kansas City region's premier collector and processor of food and yard waste. Produces mulch, compost, topsoil, biochar, and more.	Link
TPS Process	Textiles	A supercritical CO_2 technology to delaminate the materials from wastes.	Link
Reju	Textiles	Developing the infrastructure to take certain textile waste and regenerate it at scale, starting with polyester.	Link
Blue Phoenix	Incineration bottom ash	Ash concentrator to produce non-ferrous concentrate and mineral aggregate, which can be used in concrete production.	Link
Aventum Plasma Gasification	Hazardous waste	Plasma converter system for the treatment of hazardous waste.	Link
The Patented Plagazi Process	Non-recyclable waste	Circular solution converting non-recyclable waste via plasma gasification to green hydrogen.	Link
UBQ™ thermoplastic material	MSW	A biobased thermoplastic made from 100% unsorted landfill-destined waste that can replace oil-based resins.	Link
PreTred	Tires	Rubber roadway barriers from recycled waste tires.	Link
TyreFlow Recycling Process	Tires	A full end-to-end solution for upcycling of waste tires	Link
RetourMatras	Used mattresses	Recycling mattresses into new raw materials. Video overview.	Link

	Material	Description	Source
Collaborative Recycling	Bulky items and furniture	A digital solution reducing waste by recycling furniture, equipment and materials	*Link*
Flourish	Furniture	A furniture bank in Grandview, MO, that collects gently used household goods and furniture to furnish homes for families overcoming housing insecurity.	*Link*
Carbotura	All materials	Accepts all waste (except nuclear and ammunition). Using microwave and plasma technology, the waste is converted into valuable materials like Anode-grade graphite, graphene, metals, silica, industrial gases and oils, and more.	*Link*
Developing the materials marketplace: Austin	All materials	The Austin Materials Marketplace is an online platform where businesses can exchange waste and by-products with organisations that can reuse them.	*Link*
Artificial intelligence for recycling: AMP Robotics	All materials	AMP's artificial intelligence (AI) platform AMP NeuronTM uses cameras to scan mixed waste streams and identify the different materials. Neuron's deep learning capability allows for continuous improvement of the identification and categorisation of paper, plastics and metals, by colour, size, shape, brand and other traits.	*Link*

Appendix 4: Data

MATERIAL FLOW ANALYSIS

Region	Source and assumptions
Johnson County	• Johnson county, Kansas Draft 2024 solid waste management plan • Waste treatment data received from Tomahawk WWTP, Middle Basin WWTP, Mill Creek WWTP and Secure eCycle (Olathe) • Numbers used for Johnson County are based on 2022 data • Waste treatment data is added to the 2022 numbers. This is allocated proportionally to the total waste originating between Commercial & Mulity family and residential
MARC SWMD	• Statewide Waste Composition Study (2018) • Regional Landfill Capacity Study (2024) • MARC Landfill Capacity Working Model • Waste treatment data received from GFL Environmental, Lee's Summit Resource Recovery Park, Ripple Glass, MARC SWMD Collections, Midwest Recycling Center, Missouri Organic, City of KCMO Wastewater, Little Blue Valley Sewer District, Systech • Population data from the United States Census Bureau • Capacity volumes were converted from Cubic Yards to Imperial tons • We assume 100% of waste collected at GFL Environmental, City of KCMO Wastewater and the Little Blue Valley Sewer District originates from the MARC SWMD • Waste streams collected at Lee's Summit Resource Recovery Park, Midwest Recycling Center and Systecht are allocated proportionally (~65%) to the total population between MARC SWMD and KCMA • We assume 80% of waste streams collected at Missouri Organic originates from the MARC SWMD, since most of the waste comes from Missouri
KCMO	• Employment numbers from the U.S. Bureau of Labor Statistics • Population data from the United States Census Bureau • Waste treatment data received from GFL Environmental, Lee's Summit Resource Recovery Park, Ripple Glass, MARC SWMD Collections, Midwest Recycling Center, Missouri Organic, City of KCMO Wastewater, Little Blue Valley Sewer District, Systech • We allocated the total waste generated in the MARC SWMD proportionally to the number of employees per sector and number of residents between MARC SWMD and KCMO • We assume 100% of the waste collected at City of KCMO Wastewater originates from KCMO • At least 7% of waste collected at pick up curb sides at GFL Environmental originates from KCMO • Waste streams collected at Lee's Summit Resource Recovery Park, Midwest Recycling Center and Systecht are allocated proportionally (~23%) to the total population between KCMO and KCMA • Waste streams collected at MARC SWMD are allocated proportionally (~35%) to the total population between KCMO and MARC SWMD • We assume 2% of waste collected at Little Blue Valley Sewer District originates from KCMO, since most of the services of Little Blue Valley lies outside of KCMO

Region	Source and assumptions
KCMA	• Solid Waste Management Plan 2020 Update , Wyandotte County/Kansas (2022) • Data received from Leavenworth, KS county transfer station and the cities of Leavenworth and Tonganoxie • Data received from Lake Region Solid Waste Authority for Miami, KS county • Waste treatment data received from GFL Environmental, WM, HAMM (Leavenworth County), Lee's Summit Resource Recovery Park, Ripple Glass, MARC SWMD Collection, Johnson County, Midwest Recycling Center, Secure eCycle (Olathe), Missouri Organic, CS Carey, City of KCMO Wastewater, Little Blue Valley Sewer District, Tomahawk WWTP, Middle Basin WWTP, Mill Creek WWTP, Systech, Little Blue Valley Sewer District • Total waste generated is an aggregation of the total waste generated in Johnson

SCOPE 3 IMPACT FACTORS SOURCES

- Ecoinvent 3.10 (2020)
- Agrifootprint 6.2.1
- Data from the Nationale Milieudatabase (NMD)

ECONOMIC VALUE ANALYSIS

Metric	Sources and assumptions
Value	• Circular Charlotte Towards a zero waste and inclusive city (Metabolic, 2018) • Recycle.net (n.d.). Global recycling marketplace & information center. Retrieved on december 2024, from https://www.recycle.net/ • Historical Recycled Commodity Values U.S. Environmental Protection Agency Office of Resource Conservation and Recovery (2020) • Milbrandt, A., Zuboy, J., Coney, K., & Badgett, A. (2024). Paper and cardboard waste in the United States: Geographic, market, and energy assessment. Waste Management Bulletin, 2(1). • Values are adjusted with inflation correction.
Job potential	• Recycling Economic Information (REI) Report (2020

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