REPORT

Waste Management Transformation

Navigating the global journey towards sustainable waste management, economic revitalization and addressing the climate emergency

Roland Berger

Contents

Fast Facts

- The majority of waste, globally, is not managed effectively
- A global, collective and coordinated effort is required to solve the climate emergency
- A staged approach is required and not 'a one size fits all' solution

Around USD 90-120 billion, is wasted every year in lost material value

Management summary

The world is facing a series of complex challenges because of ongoing environmental degradation. To build a viable future – one in which both economies and the environment thrive – we need to make sustainability our number-one priority. Improving waste and resource management in individual countries has a vital role to play in this endeavor. But it is only by working collaboratively, as one world, that we will overcome the global emergency.

This report provides a high-level overview of the lost economic opportunity associated with poor waste management. We begin by discussing the circular economy concept and different approaches to quantifying economic value loss. Here, we focus mainly on "material value" – the actual dollar value of materials such as paper and board, plastics, and glass that are sent to landfills or dumpsites rather than being exploited in some way.

We then focus on current efforts to deal with this problem worldwide. As a framework for understanding different countries maturity levels in terms of waste management, we suggest a series of "archetypes". We show that only a collective effort across nations can effectively overcome the global climate emergency. Finally, we examine what can be done to overcome the challenges, suggesting six key steps to addressing the lost economic opportunity.

A global emergency

As we confront the complex challenges posed by environmental degradation and address the global climate emergency, it is increasingly evident that our current mode of operation is unsustainable. To build a future where economic growth and ecological integrity can coexist harmoniously, we must prioritize sustainability and place it at the core of our decision-making processes.

Traditional linear economic models through an era of industrialization, built around efficiency and product sales where products are designed to be obsolete, are not sustainable. We are overshooting planetary boundaries[1], but also from a financial perspective, current levels of global resource consumption cost over USD 7 Trillion annually in environmental damage[2].

Understanding the Circular Economy

The concept of a circular economy advocates for a sustainable economic model that prioritizes the long-term well-being of both humans and nature by reducing waste and minimizing negative environmental impact. Currently, the global circularity rate[3] is around 7%[4] , with about 65% of G20 nations pushing circular economy strategies at both a national and sectoral level. It has significant potential to improve GDP and minimize pollution, environmental degradation, and associated costs.

At its core, the circular economy is centered on three essential points:

 **Production**	A circular economy aims to prevent the need to generate and use new materials that could lead to waste by rethinking how we operate, changing consumption patterns, or meeting consumer needs through alternative business models that move away from product-based revenue.
 **Management**	Once products and materials have entered the supply chain, they are kept in circulation as long as possible through technical or biological cycles. Biogenic material is recirculated or regenerated to nature, and technical materials are repurposed, reused, reconditioned, repaired, remanufactured, and recycled into new products.
 **Leakage**	When a product is lost from the management stage, the circular economy strives to maximize the value from this leakage.

1 https://www.stockholmresilience.org/research/planetary-boundaries.html
2 WEF, Lancet Planet Health, World Bank
3 The circularity rate represents the amount of material that is kept within the circular economy compared to the total amount of material used, expressed as a percentage. A higher circularity rate represents a more efficient use of resources and reduced reliance on virgin materials.
4 CIRCLE ECONOMY The Circularity Gap Report 2023

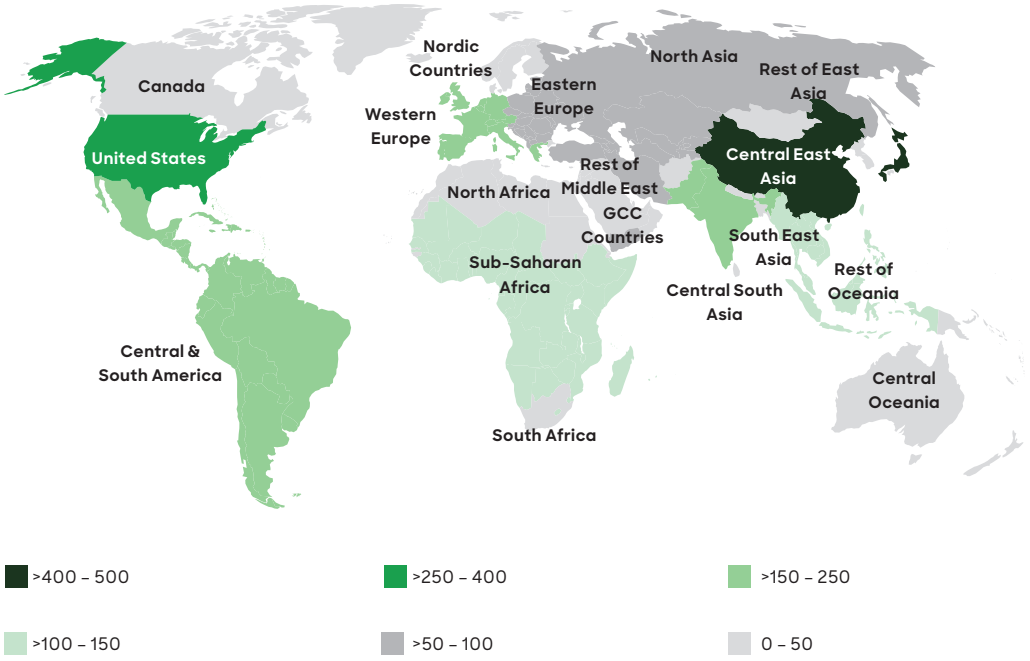
Wasted Value

To illustrate what we mean by economic value loss, we may look at the example of Municipal Solid Waste (MSW). The amount and composition of MSW generated vary worldwide due to economic, environmental, infrastructural, and cultural factors. Our methodology relied on the Roland Berger's global database in waste management[5] as a point of reference for the amount of MSW generated across the globe. For simplicity, countries were grouped into four types: high-income, upper-middle-income, lower-middle-income, and low-income. For each type, the estimated composition[6] of waste was assigned to the amount of waste generated. An estimate on the fate of materials[7] in terms of recycling/composting, landfill, open dumping, or thermal treatment was assumed.

Several material price indices[8] were used to apply the average material value to the weight of material sent to different end destinations to determine an estimated loss in value to help illustrate the level of opportunity for further value recovery.

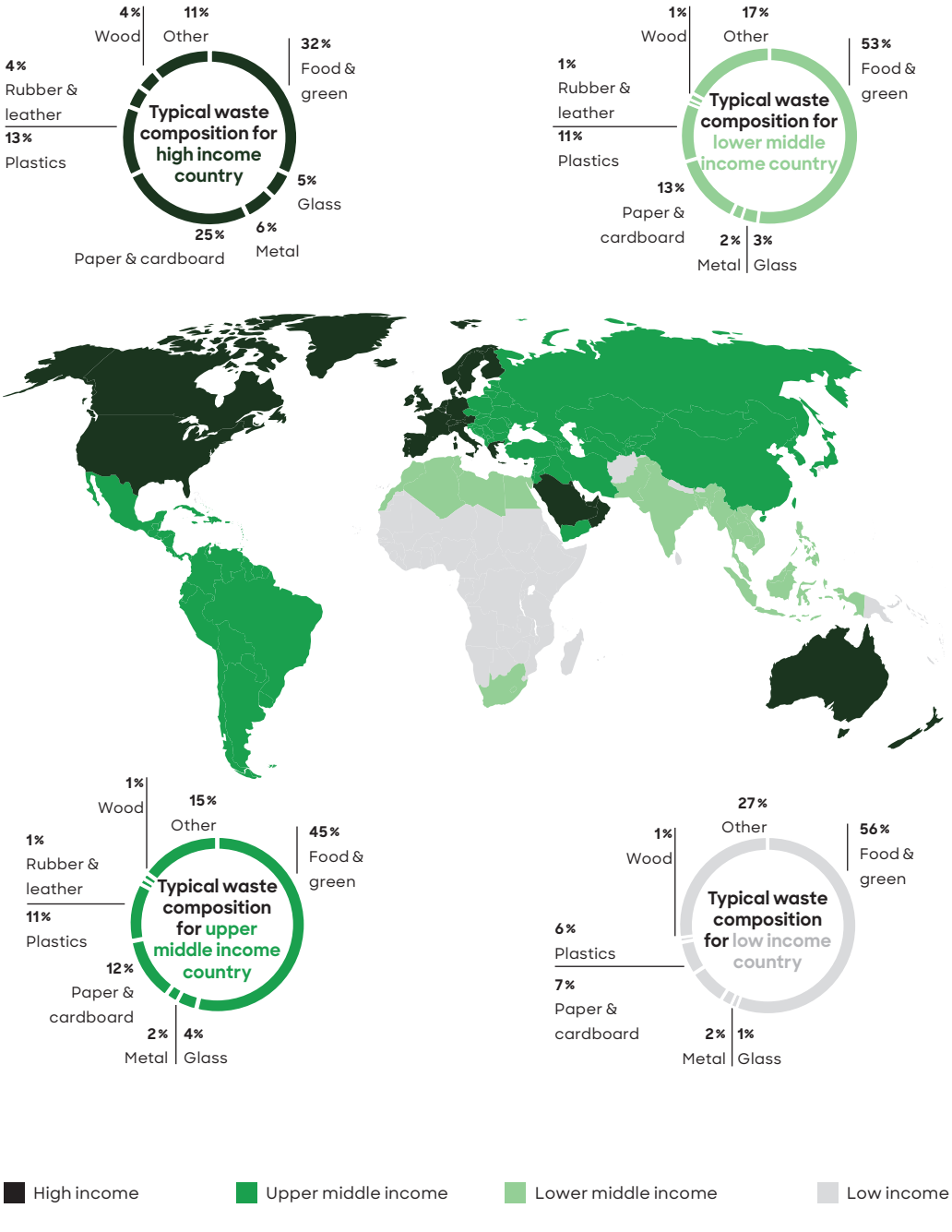
5 Database with high country-level granularity, derived from global sources such as OECD, World Bank and Eurostat
6 Multiple sources informed by Roland Berger research, World Bank, UNEP, ISWA
7 ESSD ,Verified Market Research, Roland Berger
8 Multiple sources, mainly based on EU and US prices (e.g. World Bank, Eurostat, International Monetary Fund, Let's Recycle Web)

A Volume of Municipal Solid Waste generated by geography in million tons/year



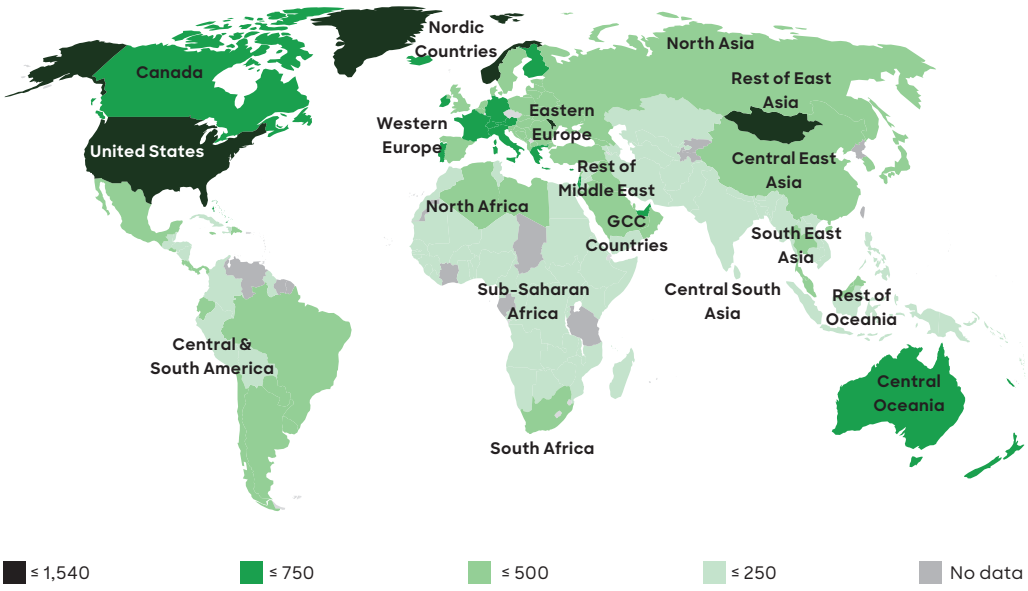
Multiple sources: Roland Berger, UNEP, ISWA., World Bank

B Composition of municipal solid waste by income level



Multiple sources: Roland Berger, UNEP, ISWA., World Bank

C Amount of Municipal Solid Waste
[kg per capita per year]



Multiple sources: Roland Berger, UNEP, ISWA., World Bank

We can quantify the lost economic value of MSW (and other types of waste) in several separate ways:

- **Material value:** Paper, plastics, glass, metal, and other materials have a dollar value. They are tradeable market commodities whose prices vary. The opportunity to realize this value is lost when this material is sent to a landfill for open burning or used to create energy in WtE systems.
- **Lost potential energy revenue:** Biogenic and non-inert materials have an energy value that can be realized using various technologies. If we send materials to landfills or dumpsites that do not have gas capture systems, this value is lost—in addition to the negative environmental consequences. There are many ways to avoid this, such as using organic waste in anaerobic digestion and biogas production, WtE systems, refuse-derived fuel solutions, or gas capture systems.
- **Valorization value from a circular economy:** Central to a circular economy is the increased economic potential of alternative business models, job and industry creation, and material valorization i.e. extracting the maximum value possible from the value of the material and not just the material product. There is often increased value beyond the waste product or material type when considering different applications, e.g., biochemicals in organic waste substituting primary natural chemicals as opposed to composting and the value of compost.
- **Direct and indirect externalities:** Manufacturing products requires energy, water, human capital, and natural resources. These are considered "direct externalities"

with an economic cost. That value is lost when the material is wasted. "Indirect externalities" include unnecessary weight on airplanes due to poor waste management, resulting in more fuel being used, or where waste materials become litter, such as broken glass, resulting in a vehicle puncture or injury, creating an additional cost to society. Resolving the material consumption and waste management problem thus has multiple first and second-order benefits across society. These are rarely calculated but are substantial in economic cost.

In our discussion below, we focus only on material value; in future papers, we will address other economic losses in more detail.

Material value

The total value of Municipal Solid Waste (MSW) generated annually is estimated at USD 160-180 billion, out of which 56-67%, estimated at USD 90-120 billion, is wasted every year in lost material value. Of this, around USD 16-21 billion of material value is lost to WtE, and while this is offset by around USD 13 billion in energy revenue[9], the result is a loss of USD 3-8 billion compared to the value that could be gained from recovering the material.

In line with the principles of a circular economy, WtE maximizes the value from leakage in the form of energy revenue. However, it remains a linear residual disposal system and has lost economic opportunity, as once this value is recovered, there is no option to recover it again. This does not mean that WtE is bad, of course: It is a necessary and beneficial sanitary solution for dealing with residual waste that would otherwise be disposed of in controlled or uncontrolled practices, causing considerable damage to the environment and human health.

The above estimates are based on basic waste management infrastructure solutions, including material and energy recovery facilities and compositing sites. The figures would be significantly higher if we considered the lost economic opportunity from other solutions, such as biochemical recycling or high-end upcycling.

In developing nations, valuable technical materials are not always lost to dumpsites, and the informal sector may have already extracted them. However, the value that remains here is the residual waste as a biogenic-rich fuel feedstock for energy solutions after removing any inert or precious metals. There will, of course, be value to some metals previously lost to dumpsites and landfills through legacy dumped electronic waste, given the current prices of precious metals such as Cobalt, Tin, and Nickel, valued at more than 20,000 USD/ton, highlighting possibilities for landfill mining efforts. The main value is the mixed residual landfilled waste, with increasing examples of dumpsites being mined/material being recovered and used as refuse-derived fuel.

9 MULTIPLE SOURCES, (E.G. EUROMONITOR, WORLD BANK)

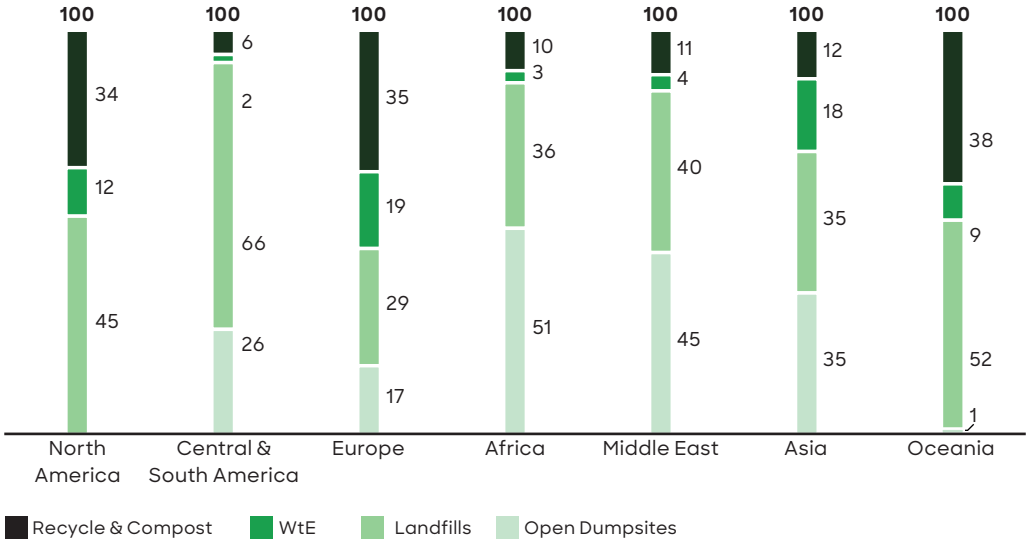
10 ESSD ,Verified Market Research, Roland Berger
11 World Bank Group
12 International Monetary Fund

Collective and Tailored Solutions

Waste management solutions differ across regions. However, it is critical that we work collaboratively—as one world—to prevent the significant loss of economic value and the associated environmental impact. To do this, the basic principles of the circular economy and decarbonization must remain at the forefront of all solutions.

Countries find themselves at different points of waste ecosystem maturity - regarding the amount of MSW they generate, the amount of material they recover, and the infrastructure they use. The solutions we propose for waste management need to fit the local context. For example, switching from open dumpsites to controlled landfills with gas capture and dirty Materials Recovery Facilities (MRFs) may not be appropriate in advanced economies, but it could have a significant environmental and economic impact in developing nations.

D **Management of Municipal Solid Waste by Region**[10]
Based on reported/collected volumes



Source: Roland Berger

Some practical, effective steps can be taken. For example, within a single year, if there was a global shift away from a system of open dumpsites to one of dirty MRFs and gas capture. Based on previous assumptions, this could generate a recovery of USD 78-106 billion[11] in material value and reduce the amount of CO2 released into the atmosphere by ~1 billion tons. Based on the current average global carbon price of $6 per ton[12], this would equate to an annual saving of around **USD 6 billion**, excluding the cost of additional natural capital benefits. Clearly noting the huge variation in carbon pricing, taxes and so on, alongside predictions on the need for a carbon price of $75 by 2030, this could be as high as **USD 75 billion** - the point not being the absolute precise saving in dollars, but that it is significant, and it will rise.

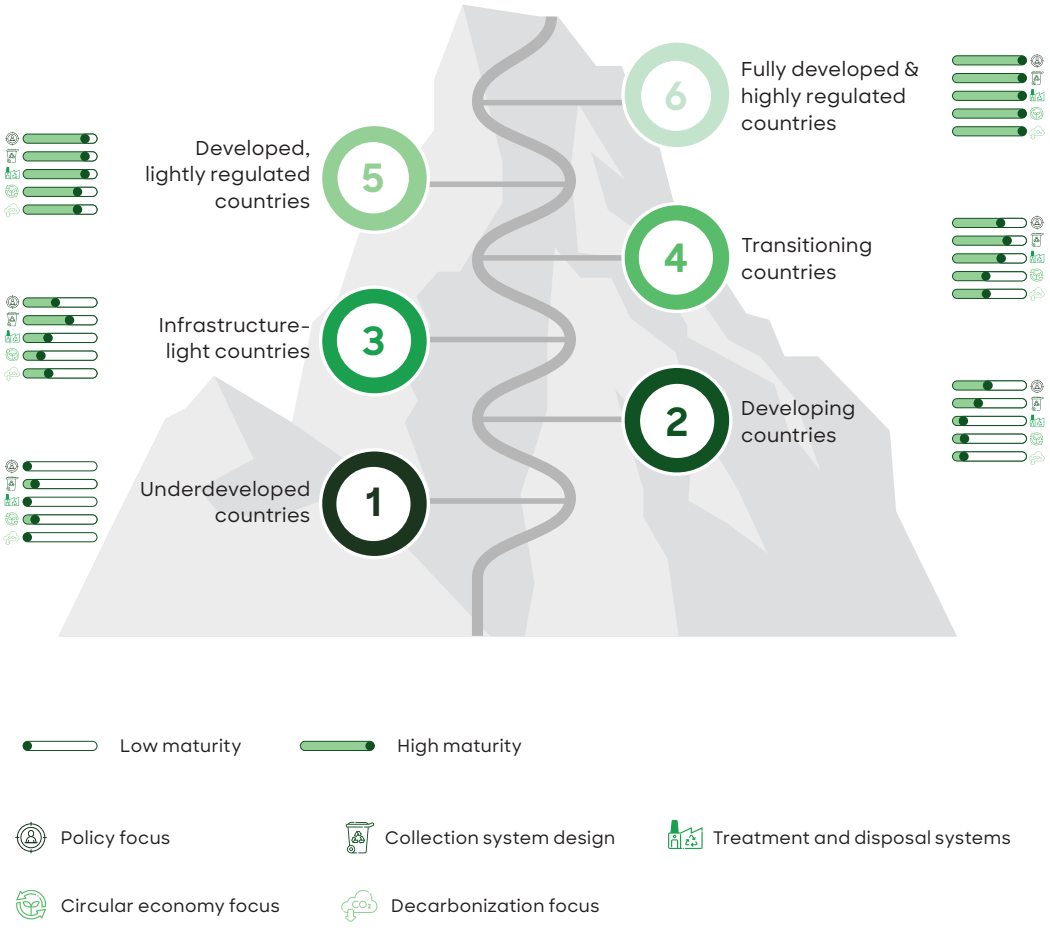
When considering the global financing position, it is essential to recognize the value of appropriately distributing funds to where they will be most impactful for our collective benefit as we seek to address the global climate emergency.

Tailored Solutions

We stated above that all countries must contribute to progress towards sustainable global outcomes: We must work collaboratively as one world. However, waste management solutions today differ from region to region, as do countries' ambition levels. To help understand the rather complex picture, Roland Berger has created a framework consisting of six distinct "archetypes" or types of countries regarding their maturity in waste management and action required. Although archetypes usually evolve along a particular path over time, their progression is not always a linear journey through each archetype: When countries change from one archetype to another, it will depend on their level of ambition, the enablers in place, and numerous other factors. Some countries may also sit between two archetypes. However, the framework provides guidance about proportional responses and accountability, enabling us to begin collectively addressing the climate emergency.

E Overview of the Six Archetypes

The journey



Source: Roland Berger

F Archetype One: Underdeveloped Countries

Without any formal waste ecosystem, policy, or regulation, and with some presence of the informal sector, overall waste is uncontrolled and out of sight, causing significant environmental and human health impact.

Policy focus	• Understanding & controlling waste flows • Building expertise
Collection system design	• Implement common collection points • Informal recycling
Treatment and disposal systems	• Transition away from open dumpsites to engineered landfills
Circular economy focus	• **Focus on Leakage** - Recycling efficiency
Decarbonization focus	• Minimize open burning practices

Source: Roland Berger

G Archetype Two: Developing Countries

Shifts towards converting the informal sector to formalized and controlled systems to manage the impact of poor waste management on the surrounding environment.

Policy focus	• Formalize waste collection systems • Addressing social & environmental concerns • Part Gov't subsidized
Collection system design	• Implement 2 bin systems (wet & dry waste)
Treatment and disposal systems	• Transition away from open dumpsites to engineered landfills
Circular economy focus	• **Focus on Leakage** - Recycling efficiency
Decarbonization focus	• Prioritize capturing landfill gas to limit leakage • Ban open burning practices

Source: Roland Berger

H Archetype Three: Infrastructure Light Countries

Increased funding and policy focus on diverting material from landfills, recovering value by concentrating on recycling and composting systems, and landfill gas capture.

Policy focus	• Maximize landfill diversion • Maximizing material recovery • Market driven & Gov't subsidized
Collection system design	• Advance into 3 bin systems (recyclables, organics, residual) • Central bring systems
Treatment and disposal systems	• Transition to MRFs & Composting facilities for better value recovery • Mechanical recycling
Circular economy focus	• **Focus on Management** - Recycling efficiency, Resource efficiency
Decarbonization focus	• Advance landfill gas capture efficiencies

Source: Roland Berger

I Archetype Four: Transitioning Countries

Focus on significant landfill diversion from landfill and addressing residual waste management through Energy from Waste systems and attracting the private sector.

Policy focus	• Restricting landfills • Maximize value of residual waste • Fiscal incentives / market driven
Collection system design	• Established mixture of different source segregation systems
Treatment and disposal systems	• Clean MRFs, & Advanced organic systems • Introduce WtE facilities to maximize residual waste recovery
Circular economy focus	• **Focus on Management and Leakage** - Recycling efficiency, Resource efficiency, Consumer waste reduction
Decarbonization focus	• Waste to RDF to offset other carbon intensive sectors • Maximize landfill gas capture

Source: Roland Berger

J Archetype Five: Developed, Lightly Regulated Countries

Established a waste ecosystem for collection, treatment, and disposal with partial producer responsibility accountability and a focus on embedding circularity and decarbonization across the waste sector.

Policy focus	• Waste minimization • Focus on maximizing recycling economy • Partially regulated and system cost recovery
Collection system design	• Further segregate waste through 4 bin systems (fibers, recyclables, organics, residual) • Limited EPR segregated waste collections
Treatment and disposal systems	• Large dependency on a range of mechanical and thermal decomposition technologies • Chemical recycling
Circular economy focus	• **Focus on production & Management** - Recycling efficiency, consumer waste reduction, new business models, lifetime optimization, product & system design
Decarbonization focus	• Reduce reliance on WtE & decarbonize its feedstock • CCUS • Alternative collection fleet fuels

Source: Roland Berger

K Archetype Six Fully Developed and Highly Regulated Countries

Complete producer responsibility systems that are highly regulated and exploratory in treatment systems, circular economy, and decarbonization.

Policy focus	• Focus on circular economy policies & decarbonization • Fully regulated, target driven and imposed
Collection system design	• Maximize waste segregation through >4 bin-systems • Full EPR & DRS • Re-use, repair, and re-manufacture
Treatment and disposal systems	• Introduce waste to Hydrogen, SAF • Chemical Recycling • Bio economy related technologies
Circular economy focus	• **Focus on production, management & leakage** - Recycling efficiency, consumer waste reduction, new business models, lifetime optimization, product & system design
Decarbonization focus	• Carbon targets / focus on collection and treatment • Removal of WtE except for biogenic waste • Integrate alternative and renewable fuels across waste ecosystems • Regenerative negative carbon solutions

Source: Roland Berger

In a true eutopia circular economy, regulation may not need to exist in the future as the waste ecosystem has been replaced by material cycles that are in total alignment with and mirror the natural ecosystem.

A collective effort

While embracing the principles of the circular economy and decarbonization is imperative for a sustainable future, the level and pace of adoption will vary around the globe. To have an immediate impact on the global emergency, we need a collective global effort to raise the baseline of effective waste management across all countries to at least archetype 3. Actions by developed societies in archetypes 5 and 6 are noteworthy, but on their own, they are not enough to offset failures to address the basics of waste and resource management in less developed countries.

While landfill with gas capture is not a circular solution, in countries with no formal collection and open burning existing exits, landfill with gas capture is undoubtedly an improvement in formalizing waste collection and mitigating environmental impact. Similarly, mass burn WtE is not a circular solution, but where there is minimal infrastructure and a heavy reliance on landfills, it is a sensible, proportionate residual treatment option for diverting material (especially biogenic waste) from landfills.

Global success combines applying advanced circular solutions in some countries while also focusing on getting the basics of waste and resource management in others to pave the way for a more sustainable and prosperous future.

Recommendation

To make progress on addressing the lost economic opportunity associated with the poor management of waste, we recommend the following:

1. Establish the appropriate enablers, such as innovation, appropriate funding mechanisms, recycling infrastructure, and effective policies, education, inspection to provide a strong foundation for improved waste management systems.
2. Develop a global system that can accurately monitor the flow of recyclable materials, enable equitable distribution of funds from producers placing material on the market, and ensure the formal collection of all waste material across the globe.
3. Adopt a global standard terminology for monitoring contributions, preventing dilution of the term "circularity," accurately reporting "recycling rates," and enabling comparisons between various parts of the world.
4. Encourage global cooperation that looks beyond geographical and political boundaries and recognizes the collective effort required to provide the appropriate financing that ensures a global minimum formalized waste management provision to at least archetype 3.

In addition to addressing the loss of material value, it would be essential to consider how we measure material value and the need to go beyond the end material market value. There needs to be more focus on the accounting of natural capital. Including natural capital values in companies' P&L accounting and annual financial accounts would help achieve true transparency about the degree of equilibrium between business and nature and drive the right behaviors.

How we can help?

Roland Berger's proven experience working with multiple governments, their agencies, and the private sector to develop bespoke strategies has helped capture lost value from poor or underdeveloped waste management practices. Roland Berger has helped secure the business case and financing solutions for many clients appropriate to their regional circumstances, aiming to capture maximum value.

Investment in new global tools such as the Virtual Recycling Credit scheme, working with ISWA and the private sector, will help to enable consistency in the recycling measurement and help secure appropriate transfer of funds to regions that lack capital but most need foreign investment. Progressively, this will help to raise the bar on improving waste management practices across the globe.

The deep technical knowledge of waste and resource management across the value chain across Roland Berger, combined with commercial experience and appreciation of the regional differences, helps us to provide informed advisor support to meet our client's ambitions. This improves the quality of waste management practice globally, to our benefit.

FURTHER READING

World Bank Group 2018. What a Waste 2.0: A Global Snapshot of Solid Waste

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Roland Berger is one of the world's leading strategy consultancies with a wide-ranging service portfolio for all relevant industries and business functions. Founded in 1967, Roland Berger is headquartered in Munich. Renowned for its expertise in transformation, innovation across all industries and performance improvement, the consultancy has set itself the goal of embedding sustainability in all its projects. Roland Berger revenues stood at more than EUR one billion in 2023.

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