



# The materials ecosystem

## Unlocking the value of waste

How connected systems and people are helping plastic waste reach its full potential



## Index

### [An introduction to the materials ecosystem](#)

Dow's approach for a better way to make,  
use and reuse plastics ..... 3

### [Chapter 1](#)

Eco-conscious consumers: How purchasing  
power drives systems change ..... 6

### [Chapter 2](#)

It starts with design: How circularity  
'by design' is accelerating ..... 10

### [Chapter 3](#)

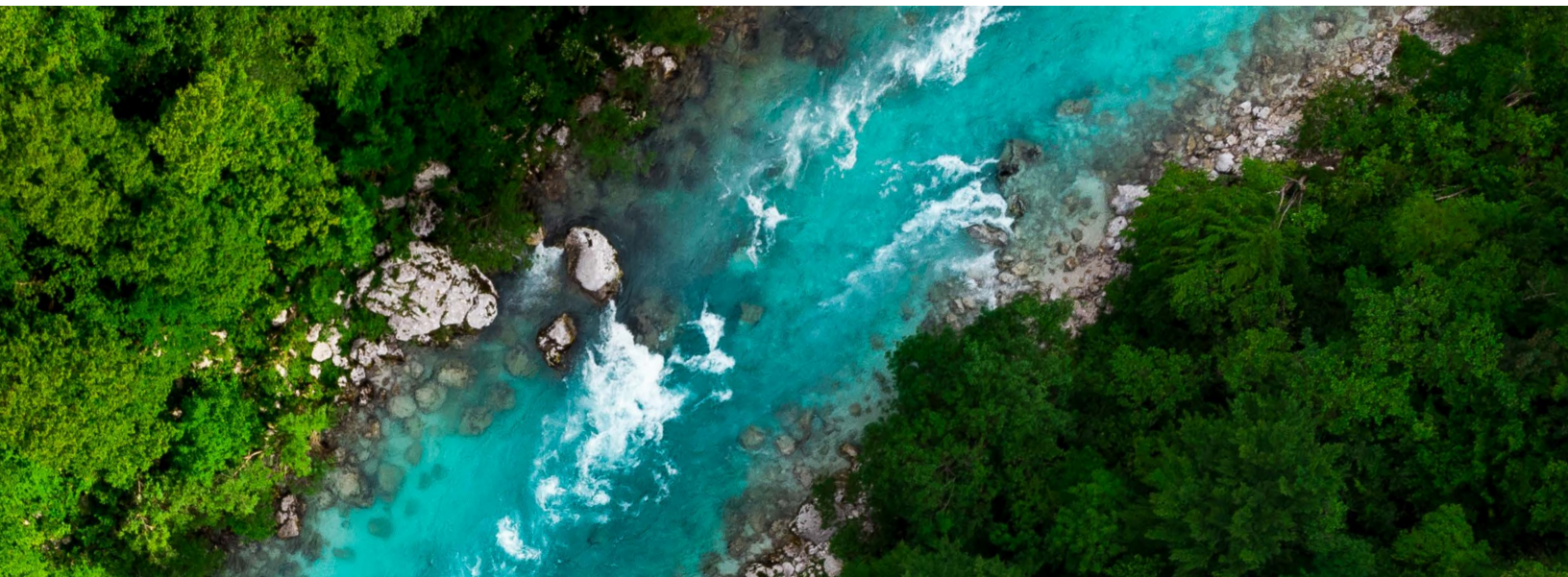
Finding value in waste: Signs of progress  
in waste collection and recycling ..... 14

### [Chapter 4](#)

Material origins: How inventive recovery technologies  
are transforming more used plastic into high-value waste ..... 18

[Conclusion](#) ..... 21

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# An introduction to the materials ecosystem

## Dow's approach for a better way to make, use and reuse plastics.

By definition, waste is unwanted, requires disposal and is not always valued. However, when science and economics find a way to take this unwanted material, break it down into its basic building blocks and turn those building blocks into something useful again, plastic waste is transformed and takes on value.

A *materials ecosystem* is developing around plastic and renewable waste to deliver its total value. The materials ecosystem adds value to plastic waste through recycling technologies and circular solutions.

By repeatedly converting plastic waste into new products, less waste ends up in landfills, incinerators or as environmental leaks.

*“Plastic circularity requires many stakeholders – and understanding how they interact, what influences them. Systems thinking helps us find solutions to keep used plastics out of the environment and in the circular economy.”*

*– Rob Kaplan, CEO and Founder, Circulate Capital*

## What is the materials ecosystem?

The materials ecosystem is a web of interrelated technologies, processes and people that transform plastic waste and renewable waste — such as used cooking oil and plant waste — into useful materials. The ecosystem includes consumers and stakeholders

in waste management, recycling, design, manufacturing, retail, brand ownership and public policy.

The materials ecosystem addresses our society's challenges today: consumers' evolving concern for their environmental footprint and the subsequent surge in demand for products and packaging with key sustainability benefits.

This concern is reflected in global policy frameworks that are changing how plastics are made, used and reused.

It takes a *systems* approach to identify the gaps, connect the best partners and give it our best to disrupt how the world values, sources, transforms and monetizes plastic waste.

There is genuine economic value in waste. The materials ecosystem enables markets for plastic waste to generate positive environmental and financial returns.

This interconnected system not only helps reduce plastic waste but also creates a new value chain for innovations in science and new jobs, new value for existing jobs, and new collaborations.

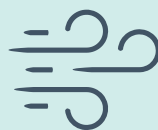
Creating an ecosystem is a transformation of the way plastic waste is handled. All countries do not move at the same pace in any transformation. Each country develops at its own speed, depending on its unique circumstances. However, there is an opportunity to leap-frog what we have collectively learned, creating infrastructure and policies that move us forward in the same direction.

## How does the materials ecosystem function and support transformation?



### Connections

Waste transformation counts on the materials ecosystem elements working together, from infrastructure to partners and technologies.



### Influences

Influences such as consumer behavior and the regulatory landscape are complex and affect the materials ecosystem at local, regional and global levels.

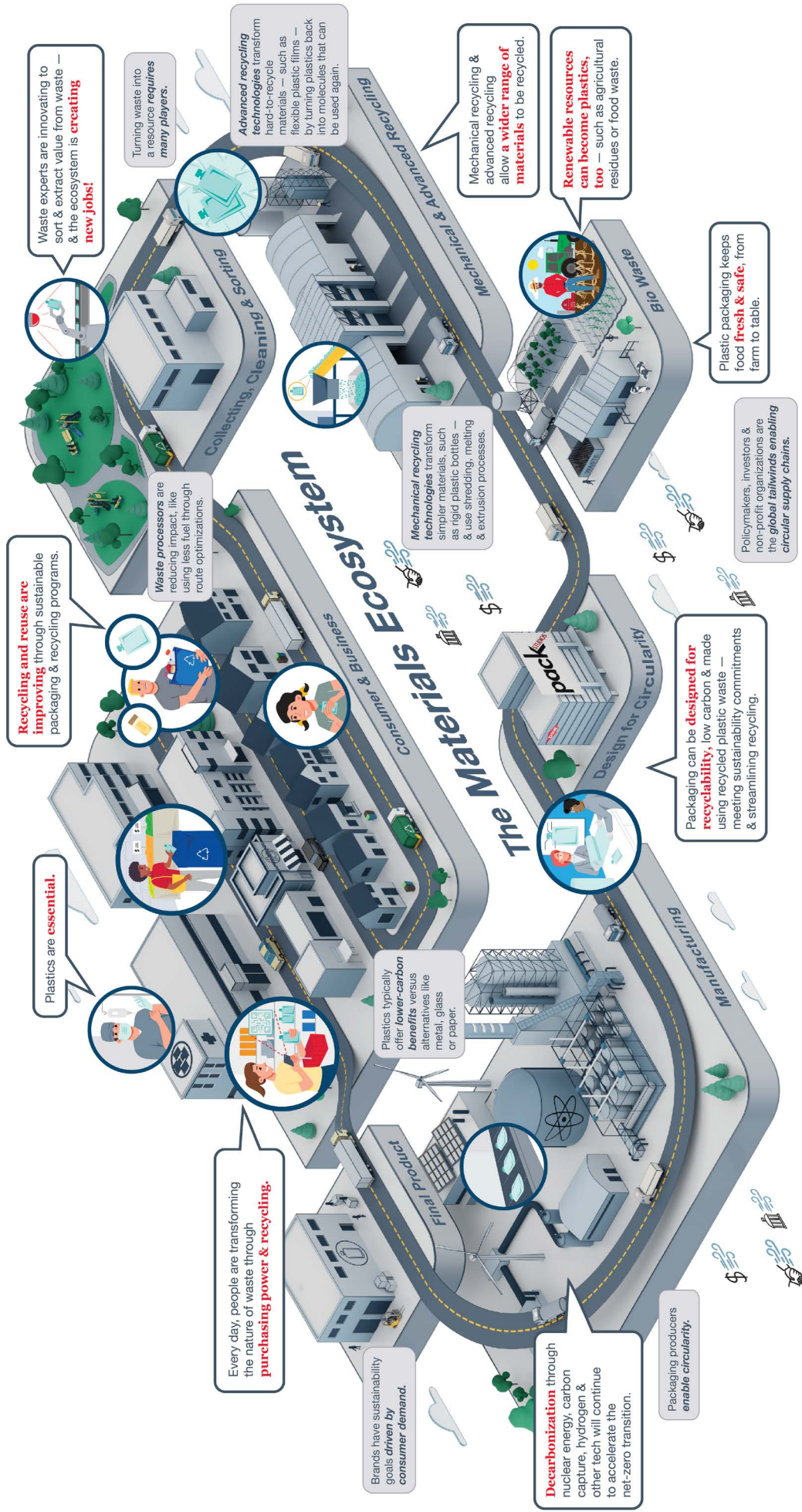


### Gaps

Disconnects in the materials ecosystem present opportunities to innovate and collaborate.

# Unlocking the Value of Waste

An innovative systems approach to help waste reach its full potential



# Accelerating our roadmap to Transform the Waste

Dow's Transform the Waste target aims to transform plastic waste and other forms of alternative feedstock to commercialize 3 million metric tons of circular and renewable solutions annually by 2030. To reach our target, we are collaborating with other stakeholders across value chains to support the materials ecosystems to collect, reuse or recycle plastic waste.

To support Dow's Transform the Waste target and increase accountability and robust decision-making around evolving our plastics franchise, we formed a

new business platform in 2022, Circular & Renewable Solutions (C&RS) — aligned with our [Packaging & Specialty Plastics](#) operating segment.

There is substantial demand for recycled plastics, and through C&RS we will continue to collaborate to return more plastic waste and other waste into the materials ecosystem.

For more information, visit the [Dow Progress Report](#).

## 2030: Path to profitable growth



## Collaborating and investing across the plastics recycling value chain to enable the materials ecosystem

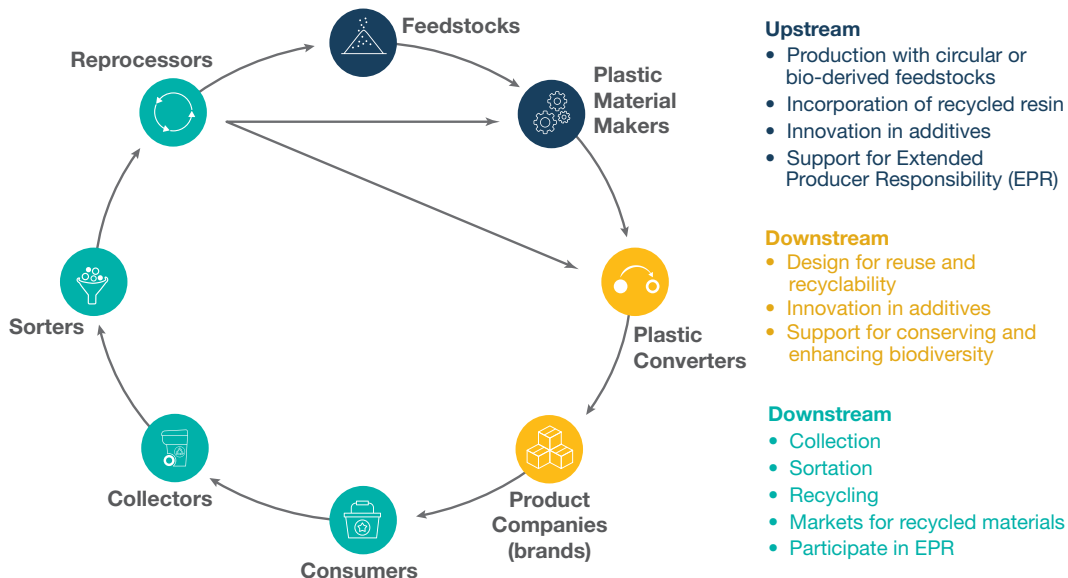


Chart representing how Dow is collaborating and investing across the plastics recycling value chain to enable the materials ecosystem.

## CHAPTER 1

### Eco-conscious consumers:

How purchasing power drives systems change

Today's consumers are increasingly purchasing products based on the product's impact on the planet.

In [an extensive 2023 study](#), McKinsey and NielsenIQ examined spending behavior and consumer sentiment related to products with environmental, social and governance claims.<sup>1</sup> The takeaway for consumer packaged goods (CPG) companies is a fact-based business case for making environmentally and socially responsible products and packaging.

An increasing number of companies have set sustainable packaging commitments. Brands are redesigning products to enable recyclability and use of recycled content and incorporating more recycled content to meet consumer brand preference and differentiate from competitors.

Here, we look at a few examples of how consumer support for sustainability impacts the materials ecosystem.

### Connections:

Consumers seek sustainable choices — labeling leads the way

The shift in consumer demand for sustainable choices is revolutionizing the plastics industry — and research shows sustainable packaging and labeling is resonating with today's shoppers.

An essential component of achieving sustainability-based brand loyalty is labeling. Veronica Riojas, chief marketing officer, PepsiCo in Latin America, foresees consumers examining sustainability information on packaging similar to how they read nutritional labels now. Consumers will increasingly want to know where a product was manufactured, what kind of "footprint" it left and what natural resources were used in its production.

[McKinsey & Company reports](#) that consumers are willing to pay more for sustainable packaging and buy more products that offer sustainable packaging if these products are available and clearly labeled.<sup>2</sup> According to a [recent study by Deloitte](#), consumers look at factors such



Consumers can drive entire industries to change. A growing consciousness about climate change, paired with fast access to information and influence, is rapidly shaping how consumers buy and recycle.

*"They're going to look at the packaging and judge whether it meets their expectations on recyclability," Riojas said at the recent [Sustainability Next Summit hosted by Dow and Fast Company](#).<sup>3</sup> "This is going to be a different consumer."*

as whether a product is made from recycled materials, how it's sourced, whether it minimizes packaging, its carbon footprint and whether it enables biodiversity.<sup>4</sup>

While consumers are looking to brands to make products more sustainable, a majority would also be willing to take more responsibility for recycling if they had the correct information and access to recycling infrastructure.

## Influences:

### Policy for label standardization is gaining momentum

Studies show that recyclability claims are the most important to consumers because they're actionable; these claims tell people whether an item can be recycled.

However, recycling infrastructure is a highly localized system. Depending on where an item is sold, state-level or country-level marketing regulations and guidelines may require a label to specify recyclability based on the availability of recycling facilities in each state or country — and sometimes, in a particular community.

Research by [McKinsey & Company](#) shows that of 30 countries surveyed, representing all regions, most are stepping up efforts to tackle waste management — with more than 40% already having Extended Producer Responsibility (EPR) efforts in place.<sup>5</sup> Regulatory

measures include reduction and limitation; packaging design and safety; labeling and traceability; collecting, sorting and EPR; and recycling and reuse. Policies to standardize and increase transparency will further empower customers but also highlight challenges, such as confusion about recycling.

A major challenge is that not all plastics marked as recyclable are collected and recycled in all communities. There is no harmonized approach. An example of how an organization is addressing the gap between labels and recycling is [Recycle Check](#), a package-specific labeling platform launched by [The Recycling Partnership](#). This dynamic platform provides localized, real-time package-specific recycling information in seconds.

*“Eight in 10 people believe in recycling’s positive impact, yet two-thirds of U.S. household recyclables are wasted each year. Confusion about what and how to recycle is a key driver of this loss. Dynamic labeling solutions such as Recycle Check can help to reduce this loss.”*

— *Keefe Harrison, CEO,  
The Recycling Partnership*



# Gaps:

## Infrastructure challenges create opportunities for collaboration and new economic models



While the increased development and use of transparent labeling can empower consumers in their decision-making — both while purchasing products and while disposing of products — there are new models, like refill and reuse packaging. With refill options, brands offer refillable packaging for items such as detergent, soap and more. This allows the consumer to refill and reuse the original packaging. Plastics continue to play an important role in these new models, as they have the lowest carbon footprint over other materials and can help maintain the properties needed to protect the product.

At the forefront in consumer interest is the U.K., where [more than 70% of citizens](#) are willing to use refill packaging in an effort to make more sustainable choices.<sup>6</sup> While some brands have begun refill and reuse pilot programs, the [Ellen MacArthur Foundation](#) noted in their 2022 progress report, “Reuse ambitions remain limited, as very few brands and retailers have a reuse strategy in place. Despite an increasing number of reuse pilots, many are fragmented and not embedded in a business strategy that could lead to reuse at scale.”<sup>7</sup> This remains a complex opportunity with solutions needed to address the logistics, cleaning and economic hurdles to scale these new models further.

### Key takeaways

- Brands that use recycled materials in their products and packaging and retailers that curate more sustainable products are wisely pacing their investments to build brand loyalty among consumers, as more brands transition to sustainable materials use and recyclability.
- Consumers will increasingly rely on labeling and clear sustainability information to guide product purchasing decisions. However, consumer interest in sustainable products is outpacing standards in labeling.
- Variabilities in methodologies and local recycling affect how policymakers and brands work together, to provide consumers with more and better sustainability-related information.

### Packaging is changing with reuse innovations

In collaboration with our value chain partners, Dow enables reusable packaging. For example, Boox, in partnership with Dow and Pregis, have incorporated [REVOLOOP™](#) recycled plastics resins with 50% post-consumer recycled (PCR) content into the Boox bag, a reusable poly-mailer that can be used 10-plus times before being repurposed into more bags.

Another example is Kimberly Clark’s refillable liquid soap flexible pouches via their Kleenex brand, developed by Printpack, Codiqindsa and Dow to enable recyclability.





# UNLOCKING the value of waste

## Brands meet consumer demand for sustainability in new ways

Although ideal for food protection and production efficiency, traditional flexible plastic packaging is much harder to recycle. To tackle this challenge, Yooji brought together three pioneers in sustainable packaging: [ePac](#) brought expertise in printing and manufacturing; [Leygatech](#) brought its pioneering film extrusion and machine-direction orientation technology; and Dow provided high-performance polyethylene resins, for the necessary combination of stiffness, orientability and sealability — as well as unique design for recyclability and testing capabilities at [Dow's Pack Studios](#) in Tarragona, Spain.

The result is revolutionary; a film pouch offering outstanding food protection with a transparent section to view the food inside. Crucially, the pouch achieves all this using just one material — polyethylene — to enable recyclability.



*“Our customers are parents who particularly care about the way we produce and package our food – and its impact on our environment. Creating a fully recyclable packaging, with zero compromise on food safety, was the natural next step.”*

*– Isaure Laguens,  
Product Innovation Manager, Yooji*

## CHAPTER 2

### It starts with design:

#### How circularity “by design” is accelerating

To realize a circular economy — one where waste is designed out and materials are planned for one valuable application after another — the things we use must be designed to be recyclable and made from recycled content.

Design is indispensable to supporting whole markets in transforming materials use for less environmental impact, like automotive lightweighting, resulting in lower carbon output and higher energy efficiency.

The Ellen MacArthur Foundation has described the circular economy as a “design challenge,” and this definitely applies to plastics circularity. It’s why more than 500 organizations have signed on to the [Ellen MacArthur Foundation’s New Plastics Economy](#), committing to making 100% of their plastic packaging reusable, recyclable or compostable by 2025.<sup>7</sup>

Developing packaging has always been a balancing act. Consumer packaged goods (CPG) brand owners and other manufacturers must consider tradeoffs between cost and performance while ensuring that product

### Connections:

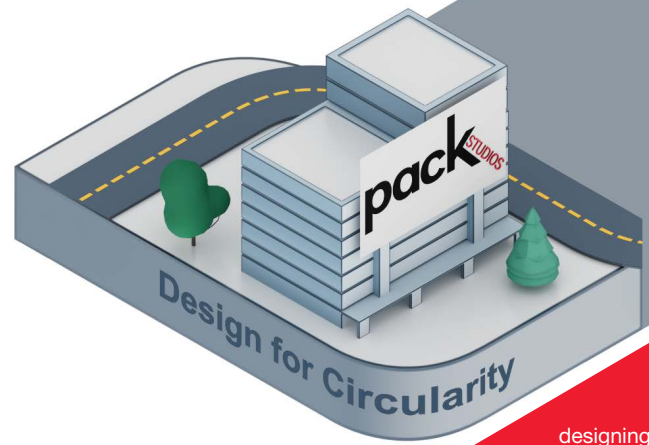
#### The design toolbox expands alongside commitments to circularity

What makes design “groundbreaking” is now intrinsically tied to how well the design enables the product to be considered sustainable by consumers. That’s true for organizations as diverse as footwear companies and food manufacturers.

What’s driving this? To start: consumer demand and sustainability commitments by brands and regulations.

An increasing number of companies are innovating to overcome design challenges that meet the sustainable packaging mandates and public commitments made by these organizations. Design for packaging can step up to meet this new normal, and it requires everyone along the value chain to transform. Examples include:

- Materials science companies are innovating more circular materials options for plastics. Examples include high- and low-density polyethylene resins for



Who we’re designing for has shifted from individuals to a system of connected people and processes. Recyclers, brand owners and others share a common goal: Design products and processes to minimize waste from the beginning and keep materials in use for as long as possible.

integrity remains intact. Other factors include safety, distribution and material availability.

How do we balance all these variables and still meet targets to enable recyclability and use of recycled content for packaging?

It’s a tall order, but today’s innovators are boldly pushing design to meet new standards. Here, we examine how design for circularity is evolving as a critical lever of the materials ecosystem.



mono-material films and materials created from renewable waste such as used cooking oil and plant waste.

- Packaging converters are exploring how they evolve to generate growth and new partnership opportunities that support customers (brands and retailers) as they revise their packaging portfolios by designing recyclable structures and embedding recycled content into those structures.
- New design models are enabling a shift away from disposable to reusable. Unilever, a Dow value chain partner, [highlights that refill and reuse](#) innovations are promising but also are “in their early days,” tied to how the international legally binding instrument to end plastic pollution advances the acceptance and acceleration of reusable and refillable packaging.<sup>8</sup>

# Influences:

## Extended producer responsibility legislation brings new value to design



Many companies are already redesigning packaging and other products to make them more sustainable, and Extended Producer Responsibility (EPR) policies change how this benefits each organization's bottom line. The status of EPR policies and how they work vary by country.

In Europe, for example, companies that create easily recycled packaging will pay lower EPR fees on those products.

*"It rewards redesign and stops the notion that the sustainable option is always more expensive,"* said David Carroll, director of external affairs for the trade association Plastics Europe, at the [recent Sustainability Next Summit](#), hosted by Dow and *Fast Company*.<sup>9</sup>

The Circular Economy for Flexible Packaging ([CEFLEX](#)) sees EPR systems based on circularity principles and empowered by clear legislation as essential to realizing the circular economy for plastic packaging. The CEFLEX initiative is a collaboration of European companies, associations and organizations representing the entire value chain of flexible packaging.

*"At CEFLEX we would like to see EPR systems evolve to be a key coordinating factor in allocating plastic waste with preferred recyclers, based on optimizing cost, environmental impact and end market demand for these materials. Appropriate and transparent EPR fees based on actual costs will encourage best practice,"* said Graham Houlder, managing director at CEFLEX.

Tackling plastic pollution is a key element of the European Green Deal, a roadmap which outlines the European Union's (E.U.) ambition to net zero by 2050. As part of the Green Deal, the plastic value chains face regulations aiming at circularity in several markets like packaging and automotive, specifically on sustainable packaging through the Packaging and Packaging Waste Regulation (PPWR). Under the latest [European Commission proposal](#), E.U. member states must reduce packaging waste per capita by 15% by 2040, in comparison with 2018 levels.<sup>10</sup> Additionally, the proposed conditions by 2030 include:

- targets for the amount of reusable packaging used in certain sectors
- use of mandatory recycled content across plastic packaging
- mandatory recyclability for all packaging based on design for recycling criteria
- mandatory eco-modulated packaging EPR fees based on recyclability for all packages

At Dow, we see these proposed changes as positive, reflecting a sensible way forward for the industry. However, in order to reach the recycled content targets outlined in the [PPWR](#), the industry and value chain needs policymakers to introduce the right framework to truly enable the transition to a circular economy. Establishing EPR or alike policies at the local or national level are necessary to ensure that waste management systems function appropriately and are economically self-sustaining. This is a necessary piece to enable the circularity of plastics. The plastic pollution instrument should require countries to establish such policies and provide flexibility for implementation at the local and/or national level as determined by each country. Because there are varying degrees of success of EPR policies where they exist around the world, it is important for the agreement to define common principles for the design of effective policies. We see the following as critical to the policy design:

- *Addresses the Problem:* Funds are dedicated to waste infrastructure and management and are sufficient to cover the full costs. The overall program is administered in an efficient way, and consumers know how they can manage their waste.
- *Flexible:* Industry can do what they do best – innovate to find the most effective and efficient way to meet our legal responsibilities while adhering to harmonized reporting requirements and standardized definitions.
- *Fair:* Accountability and enforcement are key aspects of the system. It also discourages free-riders (imports) and is applied equally to all products in the category (for example, paper, glass, plastic, and aluminum packaging).

## Gaps:

The value of strong design is dependent on how we recycle

Today, we are designing in a time of rapid change in which the circular economy and the linear economy coexist. This means tensions exist between the old model and the emerging one.

Consider how some customers benefit from newer flexible pouch designs with a film structure that's recyclable. This packaging approach can mean less weight, less materials use and a reduction in carbon emissions. But to consider only the material efficiency without considering what happens to the flexible packaging at its end-of-life overlooks the complete picture.

One example from the U.S.: While many have the ability to return monolayer polyethylene (PE) film to retail stores, commonly called “store drop-off,” this option is less convenient than curbside recycling — and access to curbside plastic film recycling is currently limited in communities. The technical recyclability of a package does not equate to it being recycled.

While solid progress is being made through sustainable packaging goals, 2025 targets are expected to be missed by some companies. The prospect of not meeting all 2025 targets reinforces the urgency for businesses to accelerate action, particularly around reuse, recyclable and circular flexible packaging, and decoupling business growth from packaging use.



*“Today, there is not enough recycled plastic for companies to meet mandates or their public commitments. It’s out there — but the materials ecosystem is not efficiently accessing it, yet. We need products and packaging to be made from recyclables and designed for the circular economy.”*

— Brent Bell,  
Vice President of Recycling, WM

### Key takeaways

- Investment in recyclability can directionally align with policies, including EPR, as they evolve.
- Design innovations — including for recyclable flexible and film-based packaging — are necessary to nudge stronger recycling options and transition more plastic packaging into recyclable structures.
- Refill and reuse models also need to be part of the solution to enable more sustainable consumption.

### Maximizing the value of waste materials

The full value we can reap from waste — to reuse it in new products — is dependent on design. A [study](#) conducted at the China Packaging Design and Innovation Center found that the front-end design for recycling determines 80–90% of the recovery value of plastic packaging; that is, the recovery rate of plastic packaging wastes and the quality of recycled products depend not only on the recycling technologies but also on the front-end design for enabling recyclability.<sup>11</sup>



# UNLOCKING the value of waste

## Closing the loop with Liby

Liby, a leading home and personal care brand in China, is a strong example of a brand accelerating the transition to sustainable packaging, including through [China's first recyclable packaging for laundry pods in 2020](#).

Liby's packaging for various products – including for laundry pods, liquid detergent, powder detergent, and dish wash tablets – is enabled by Dow's INNATE™ TF Polyethylene Resins for Tenter Frame Biaxial Orientation and earned the first “Double E” (easy-to-collect and easy-to-regenerate) label in China. This label helps consumers distinguish recyclable packaging from other packaging. This Dow-enabled packaging is [officially certified in China](#) for its ability to reduce carbon emissions by 35% compared to traditional unrecyclable packaging materials, supporting brand owners in achieving their carbon reduction goals.



## CHAPTER 3

# Finding value in waste:

## Signs of progress in waste collection and recycling



Modern sorting plants apply several technologies adapted to specific waste streams—ranging from enhanced optical sorting technologies to advanced solutions, such as the use of digital watermarks and artificial intelligence.

Global tailwinds are enabling circular plastic supply chains. Momentum stems from corporate commitments to sustainable packaging, global policies that support a circular economy, the negotiation of an international legally binding instrument for tackling the plastic pollution crisis and investments in disruptive innovations.

[Circulate Capital](#), a Dow partner, reports that the amount of capital infused into private equity firms that invest in circular economy solutions, such as [Closed Loop Partners](#) and [Lombard Odier](#), has increased fivefold since 2020.<sup>12</sup>

We're witnessing first-hand how barriers to transforming waste are being broken down through technology, and the value of recycled materials is increasing.

Alongside this positive momentum, we also recognize a major challenge: Plastic waste is in large supply — but it is not being accessed. The gap between downstream demand for circular plastics and available supply is significant.

While the materials ecosystem is a global construct, the actual “systems” that tap into that supply, before transforming it for new products and packaging, are highly localized.

The local players in waste management, recycling, design and manufacturing are essential to waste reaching its full value potential through local recycling options, infrastructure, education and incentives.

The most recent technological advancements to transform waste focus increasingly on local collection and recycling of a larger variety of materials. As technology and recycling infrastructure improve worldwide, “wish cycling” lessens over time and consumers can more freely place items like [flexible and film packaging](#) into their bins.

Here, we examine examples of how the public's good intentions and recycling capacity connect and how global organizations are improving recycling as a key part of materials-management efforts.

## Connections:

### Recycling success hinges on improving local access and behavior



Recycling is often cited as the most common action taken to help the environment. Data shows people want to recycle. The Recycling Partnership (The Partnership) notes in [recent research](#) that 80% of U.S. residents see recycling as having a positive impact.<sup>13</sup> According to the [United Nations Environment Programme](#), over the last several decades, recycling rates in high-income countries have continued to increase.<sup>14</sup>

Even so, about two-thirds of household recyclables — [32 million](#) tons of recyclable paper, glass bottles, plastic containers and more — end up incinerated or in landfills every year in the U.S. alone.<sup>13</sup> According to The Partnership, many are confused about what and how to recycle, and that lack of confidence in themselves, labels, or the ultimate impacts, has grown into a lack of confidence in the recycling system. As shared in [The Partnership's 2023 Knowledge Report](#), even if every American had curbside recycling, we know that over half of all residential materials would still be lost to landfills and one of the main reasons for that is behavior — not access.<sup>15</sup>

Improving household recycling requires understanding what drives behavior and creating conditions that support the recycling behavior we seek. Dow's environmental

nonprofit partners — including [The Partnership](#), the [Alliance to End Plastic Waste](#) (the Alliance) and [Delterra](#) — are demonstrating that behavior change is possible.

“The moment of truth for changing recycling behavior is in the kitchen,” says Cecilia Sluga of Delterra, about the residents Delterra works with in Argentina. Delterra is an independent environmental nonprofit tackling broken recycling systems in the global South.

Delterra has learned that what works in one community may not work in another. They've built their knowledge base at a grassroots level by going door to door, kitchen to kitchen. In Olavarria, Argentina, [Delterra](#) seeks to appeal to the city's identity and collective pragmatism.<sup>16</sup> To generate support, they invite the community to learn about the new industrial processes and how the recycling system works.

Delterra's approach incorporates the supply side through community-owned, self-sustaining waste management systems that produce a reliable stream of high-value recyclables — and the demand side by working with corporate players to build aggregation, traceability and logistics solutions.

## UNLOCKING the value of waste

### Mr. Green Africa drives positive change

A strong example of communities creating unique programs and localized infrastructures can be found in Mr. Green Africa, the first recycling company to be a Certified B Corporation on the African continent. Leveraging incentives to stimulate awareness and participation, [Mr. Green Africa's](#) trading points are scattered across Nairobi, where deposited plastic waste is exchanged for cash or Green Points that may be used to purchase daily goods and supplies. Here, part of the economic fabric depends upon residents earning income for their recycling efforts. Collected materials are turned into recyclates and sold to meet the rising demand for recycled plastic feedstock: high-quality PCR (post-consumer recyclates).



# Influences:

## Technology driving change and efficiencies



Globally, less than 10% of the plastic used around the world is recycled, according to a [2022 report by Organization for Economic Co-Operation and Development](#) — with most of the remaining 90% being incinerated or ending up in landfills.<sup>17</sup> There are many reasons for this low recycling rate, which have been discussed earlier, including infrastructure — but the technology available to recycle plastics is no longer one of those reasons. The industry has invested [\\$17 billion so far](#) in new recycling technologies and investments to deliver circularity.<sup>18</sup> One accelerator we see is digital tools to track, trace and provide more transparency in the circular supply chain.

To fully realize the value and impact of technology on recycling, the industry needs to lean into non-traditional partners in the materials ecosystem, such as [BanQu](#), a supply chain compliance software developer. Through the adoption of BanQu offerings, companies can trace the lifecycle of their products, from raw materials to disposal, making it easier to mark areas for improvement and recycling optimization. Other non-traditional partners, such as [Empower](#) and [Recykal](#), are using technology and

innovative solutions to help transform material waste into circular solutions.

What's more, the BanQu solution creates a traceable, transparent and equitable supply chain that helps waste pickers be paid for the value of waste they collect. BanQu CEO Ashish Gadnis recently shared his view on the value of waste pickers, recyclers, and smallholder farmers at the [2023 Fast Company Innovation Festival](#), sponsored by Dow.

Partners such as the Alliance understand the critical importance of harnessing technology such as artificial intelligence to process and analyze large volumes of data rapidly and with great accuracy, significantly improving the efficiency of waste sorting and collection. Recognizing the sheer scale of this global challenge, the Alliance has been championing significant investments in developing and deploying cutting-edge solutions to make a tangible difference in waste collection and recycling. Furthermore, the Alliance promotes collaboration among industry leaders, innovators and governments to accelerate technology implementation.

# Gaps:

## Infrastructure challenges create opportunities for collaboration and new economic models



Government intervention plays a crucial role in propelling large-scale implementation of successful waste management models. This critical support can enable countries to improve waste management at a scale that increases the volume of waste entering the recycling channels rather than being consigned to landfills, incineration or even worse scenarios, such as open burning, leakage or dumping.

In some communities, the entrepreneurial spirit of citizen waste pickers has filled a gap left by the absence of government-funded programs. Non-governmental organizations (NGOs) are supporting these efforts with seed investments. One example is in São Paulo, Brazil, where [Boomera](#), a Dow partner, invests in waste-picking cooperatives. Boomera provides cooperatives and their employees with training, equipment, administrative support and more. Their efforts have prevented plastics from going to landfills and have helped develop a strong, efficient circular economy.<sup>19</sup>

In many developing countries, private investments and funding from companies like [Circulate Capital](#) allow an increased focus on improving waste and recycling infrastructure. In India, this support enabled Dow and its collaborators to develop a [new polyethylene film solution](#) using post-consumer recycled plastics, introducing a closed-loop solution for packaging in the region.

### Key takeaways

- New and emerging technologies are becoming increasingly important in addressing the inefficiencies and limitations in the plastic recycling industry.
- Collaborative efforts led by organizations like the Alliance are crucial for promoting the adoption of innovative technologies in tackling global plastic waste challenges.
- By prioritizing investments in technological recycling innovations, stakeholders can better align economic viability with environmental sustainability, helping realize the vision of a waste-free world.



# UNLOCKING the value of waste

## WM & Dow improve residential recycling through pilot learnings

Dow and WM announced the launch of a [bold new collaboration](#) in 2022 to improve residential recycling for plastic films by allowing consumers in select markets to recycle these materials directly in their curbside recycling. According to [The Recycling Partnership](#), currently, only 1.9% of U.S. households have access to curbside plastic film recycling, the plastic material with the lowest overall recycling rate.

The initiative will enable consumers in pilot cities to recycle film plastics like bread bags, cling wrap and dry-cleaning bags directly in curbside recycling. Once operating at full capacity, the program is expected to divert more than 120,000 metric tons (MT) of plastic film from landfills annually. Through our pilot, we are adapting to what we learn. This pilot tested how consumers can be supported to recycle film, whether they do recycle film, the quality of that material, and how it reacts to processing. The good news: we learned that consumers did recycle films when guided on what they could put into their bins. We also learned this material did process into film bales, but we see that the quality needs to improve significantly for the end-market specifications. Together, we are working on more adjustments and innovation to improve in this area.



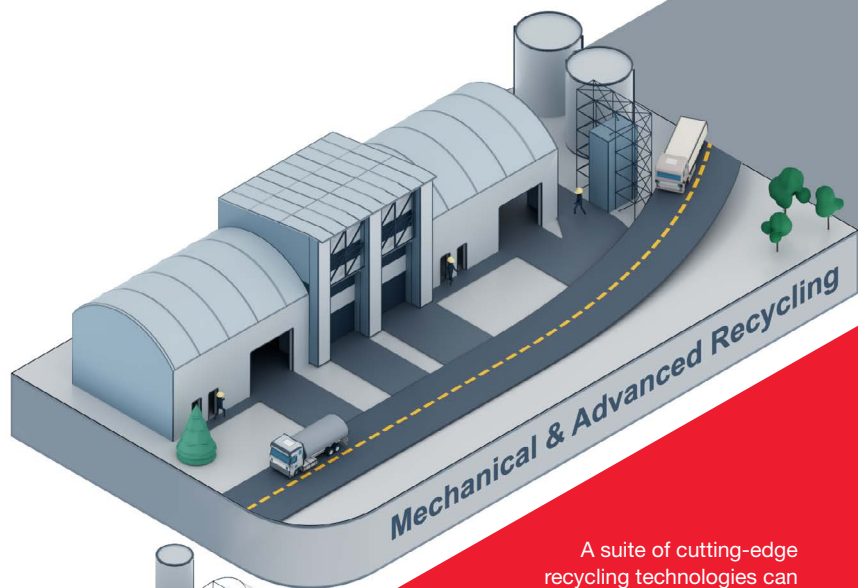
## CHAPTER 4

### Material origins:

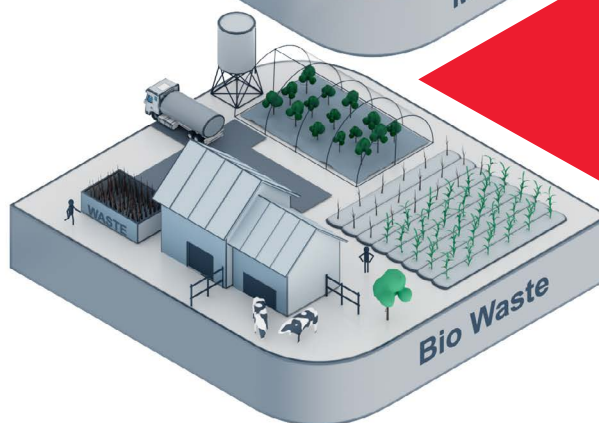
How inventive recovery technologies are transforming more used plastic into high-value waste

The present-day goal is to unlock more and more types of waste that can be reintroduced into production as a raw material.

Here, we explore conventional, advanced and emerging technologies at different stages of development and how this diversity in tech must be deployed to make more waste transformation possible.



A suite of cutting-edge recycling technologies can transform more types of waste into new materials for new products and packaging.



### Connections:

Converging plastic recycling technologies drives increasing value from waste

Recycling technologies are critical components of the continuously improving process of transforming discarded plastic into new products. Advanced and mechanical recycling each have an important role in more efficient processes and increased recycling.

Mechanical recycling is the most commonly used process by which plastic waste is turned into new products without the structure of the material being significantly altered. It uses less energy than other forms of recycling, but it does have limitations. For example, highly regulated plastics such as those used in food packaging currently cannot be produced by mechanical recycling at scale due to quality, performance and safety restrictions.

To enable broader use of recycled plastic, Dow is investing in an innovative technology called chemical recycling, also known as advanced recycling, a complementary technology to mechanical recycling. Advanced recycling offers massive, untapped market potential and the ability to bring sustainability and

circularity to previously incompatible areas such as food-grade and medical-grade packaging. Advanced recycling allows the same material to be reused repeatedly while offering the same high-quality plastic.

About [nine million tons](#) of polyethylene and polypropylene are currently used in food packaging in the European Union.<sup>20</sup> These materials currently cannot be recycled back into food contact application by mechanical recycling. But by investing in chemical recycling alongside mechanical recycling, we can help improve overall recycling rates and achieve recycled content targets in this sector. Additionally, recent life cycle assessment data produced by the [WMG research group](#) at the University of Warwick found that every ton of plastic that is chemically recycled prevents nearly three tons of CO<sub>2</sub> being released through incineration.<sup>21</sup>

Alongside our partner [Mura Technology](#), we are planning and building multiple chemical recycling facilities in the U.S. and Europe, adding as much as 600 kilotons



of recycling capacity by 2030. In October 2023, Mura opened the world's first commercial-scale [HydroPRS™](#) (Hydrothermal Plastic Recycling Solution) advanced plastic recycling plant in Teesside, U.K. The purpose-built facility at the Wilton International industrial site will process flexible and rigid mixed plastics, including films, that are currently considered 'unrecyclable'.

Mura's innovative HydroPRS™ process uses supercritical steam (water at high temperature and pressure) to convert plastics to their original materials and oils. The HydroPRS™ process complements mechanical recycling and enables a circular plastics economy through the production of recycled plastic feedstock for the manufacturing of new plastic. In the coming years, Mura plans to have 1 million tons of HydroPRS plastic recycling capacity in operation or development.<sup>22</sup> This process will be fundamental in closing the loop on plastic waste and keeping it within the circular economy. Crucially, it allows hard-to-recycle plastics to be recycled.

Valoregen, a Dow partner, is building [France's most significant single hybrid recycling site](#), combining mechanical and advanced recycling technologies under one roof. Valoregen will be able to reduce the overall carbon emissions produced from these processes as it strives to limit the transportation of waste products to different sites. The ultimate goal: a systems approach capable of recycling all plastic waste in one place.

To achieve progress we must create a viable marketplace for varied recycling technologies and waste materials. There is no single solution, but a combination of new partnerships and innovative technologies is driving a systems evolution.

## Influences:

### How mass balance creates more certainty for circular plastics

Mass balance rules for measuring recycled content are vital to the growth and sustainability of industry. This is particularly true in the plastics sector, where mandatory recycled content targets are increasingly seen as a viable method for replacing fossil-based materials with sustainable alternatives.

While recycled content policies provide the regulatory certainty necessary for business investments, there's a critical need for effective methods to measure and validate the recycled content of plastics. Here, mass balance becomes pivotal, allowing tracking and communicating the use of materials derived from advanced recycling methods in their finished products.

A mass balance approach has many benefits. In the plastics industry, it addresses concerns from brand owners about recycled content at product level and credible on-product claims to be communicated to consumers for food contact applications. The audited process also enables traceability throughout the supply chain and can measure the credibility of sustainability claims. This empowers consumers to drive a change in the packaging value chain in a credible manner, prevent greenwashing and allow the scale-up of circular solutions.

If we want to tackle the plastics problem effectively, mass balance accounting is an essential piece of the puzzle. The risks of not recognizing this process can create confusion for consumers. Brands and retailers will struggle to meet legal requirements on recycled content and consumers' expectations of meaningful recycled content targets.

Dow shares more on its chemical recycling (also known as advanced recycling) and mass balance accounting perspective in a recent [BusinessGreen](#) article.<sup>23</sup>

Businesses and consumers alike want change. To meet that, we've dramatically increased the amount of circular and renewable feedstocks going into our production lines. By mass balancing this way (rather than creating dedicated lines for producing bio-based or circular polymers), we're reducing the environmental impact of our process and ensuring the world gets bio-based products in the most cost-efficient way.



## Gaps:

### Diversifying sources of more sustainable content for new plastics

To produce new plastic materials that are more sustainable — and reduce the use of traditional fossil feedstocks and the carbon footprint associated with them — it will take a combination of feedstocks produced from recycled plastic waste and bio-based materials.

Bio-based describes materials derived from organic materials available continuously (i.e., renewable) from agricultural, plant and fungal sources living in a natural environment. Dow focuses on non-edible renewable resources. Advances in bio-based sources remain a catalyst for scaling alternative feedstock adoption.

Used cooking grease from animal fats has been effective in renewable plastic production for years, in addition to tall oil from the paper industry. Recently, Dow and [New Energy Blue](#) announced a long-term supply agreement in North America in which New Energy Blue will create bio-based ethylene from agricultural residues for plastics production.

Dow's agreement with New Energy Blue, staffed by experts with deep experience in bio-conversion ventures, is the first agreement in North America to generate plastic source materials from corn stover (stalks and leaves). This is also Dow's first agreement in North America to utilize agriculture residues for plastic production. This agreement would play a pivotal role in Dow's approach to building material ecosystems that value, source and transform waste into circular products.

On top of expanding the use of recycled waste feedstocks, the use of renewable bio-based feedstocks and carbon capture technologies will need to increase to enable manufacturing processes that are more energy-efficient and less carbon-intensive.

### Key takeaways

- Making every plastic recyclable will entail complementary technologies in varied stages of maturity and adoption — including mechanical, advanced, hybrid and emerging innovation — to unlock more raw materials and waste for circular feedstocks.
- While recycled content policies provide the regulatory certainty needed for business investments, we need ways to measure and validate the sustainable content of plastics. The globally accepted practice of mass balance accounting, which recognizes materials entering and leaving systems, is used to determine the amount of recycled content in the production process and to track the progress of circularity.
- To produce new plastic materials that are more sustainable, it will take a combination of feedstocks produced from recycled plastic waste and bio-based materials.



## UNLOCKING the value of waste

### Redefining what high-quality washing means for plastics circularity

To transform recyclable plastics that are difficult to recycle, like film plastics from discarded food packaging, mechanical recyclers need detergents and antifoam agents to improve the quality and consistency of post-consumer recycling (PCR) streams. These agents remove surface contaminants such as adhesives and control foaming to enable greater water circularity. Innovative products like [EVOWASH™](#) detergents and antifoams improve the quality of recycled plastic while maximizing the reuse of processed water.



# Conclusion

Dow places high value on the success of materials ecosystems as we continue to evolve our Packaging and Specialty Plastics business in a world more considerate of materials and their impact. Along with our partners, we are redefining the future of plastics in society by investing in new technologies and infrastructure to develop next-generation, low-carbon solutions that contribute to a more circular economy.

We're approaching challenges with new vigor and continued confidence because plastic is an essential material and a vital part of our journey toward a low-carbon future. That pursuit is challenged by a paradigm that pits old, linear approaches with new, circular ones. Now is a time of exciting and challenging transition. The materials ecosystem allows us to address current gaps, connect the best partners and disrupt how the world values, sources, transforms and monetizes waste. It will help scale successful models into templates for communities worldwide to reference and follow.

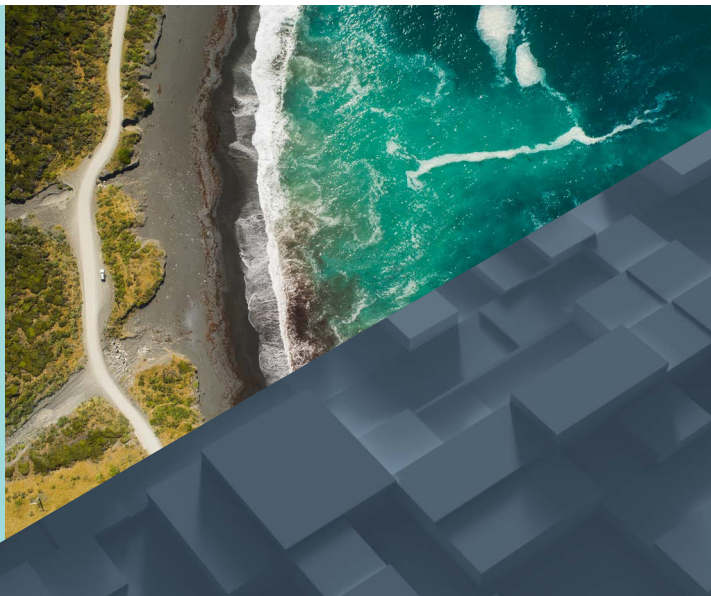
Innovation evolves and expands the materials ecosystem. Dow has a more than 125-year legacy of approaching innovation through collaboration. We work alongside

our customers to address their product challenges to enhance sustainability, performance and productivity. Our capabilities allow us to improve R&D processes and outcomes that accelerate product development and allow us to help solve modern-day challenges for our customers and society. It's why Dow is exploring multiple technology pathways to enable the delivery of circular and low-carbon emissions solutions at scale.

Dow's vision and commitment to recognizing and supporting material ecosystems that revolutionize waste perception is crystal clear: Waste should no longer be seen as a burden but as a valuable resource waiting to be harnessed. The journey to practical and productive circularity is underway. Dow is proud to be at the forefront of this transition, ready to inspire, collaborate with partners and share its vision to positively impact the world through the materials ecosystem.

Everyone benefits from a circular economy for plastics. At Dow, we're developing products and emerging technologies across the globe to do just that, advancing a sustainable circular economy, and lowering carbon footprint through design, recycling, and sustainable feedstocks.

Visit [Polymers with purpose](#)



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