

Chemicals Practice

Plastics recycling: Using an economic-feasibility lens to select the next moves

The Plastics Recovery and Reuse model helps identify the most effective moves to boost plastics recycling, using analysis of fully integrated economics across the value chain.

by Wenting Gao, Thomas Hundertmark, Theo Jan Simons, Jeremy Wallach, and Christof Witte



The worldwide crisis of plastics-waste pollution is leading to calls for action from a wide range of stakeholders, from consumers to regulators to brand owners to plastics producers. The desire to see action is easy to understand, but identifying the most effective approaches to current waste problems—and those of the future—represents a complex challenge spanning the entire plastics value chain.

The elements that could provide the foundations of a successful recycling system—a circular economy for plastics—are well recognized. The first is to design or redesign plastic products to be recyclable. Next is putting in place effective systems to recover end-of-life plastics. The third element is to reuse the recovered plastics by recycling them, turning them into new products that will create value. Our recent research has shown substantial value-creation potential in capturing plastic waste and using existing technologies to process it to make new plastics and other chemicals.¹ To date, however, investments to translate this potential into reality have been relatively small. Globally, only around 15 percent of plastics produced each year get recycled.

What explains that paradox? The contributing factors to the plastics-waste problem are complex and include issues ranging from consumer choice to food-supply safety to entrenched manufacturing systems. Not least is plastics' seemingly inexhaustible potential to meet consumer demands more cost effectively than other materials, especially in packaging.² This has fueled plastics' strong growth trajectory, averaging 6 percent per year since 1965. But it has also allowed the use of plastics to get well ahead of society's ability to handle waste-plastic volumes, despite the clear potential for economically viable ways to reuse the material.

The need for a way to sort through the options

This is not the kind of challenge that will be solved with a single stroke. A wide range of approaches

tailored to the recycling needs of different plastics, applications, and regional waste-management systems will be necessary. And while plastics waste has become a particularly acute environmental problem in geographies where waste is largely unmanaged, our research shows that implementing these approaches in developed markets has the potential to improve recycling rates there too.³

But the large number of possible approaches—and the difficulty in evaluating the options—is likely contributing to the slow progress. It's been challenging to identify what would make a circular economy for plastics economically feasible, not least because of the different economics of recycled plastics and virgin resins. Nor has there been a fully integrated value-creation assessment of these elements across each of the thousands of different resins, applications, and geographical combinations.

Our research shows that the current fragmentation of the value chain and the regional nature of waste-management systems represent a further barrier to progress. This is holding back dialogue among potential value-chain partners about what needs to be fixed to speed the development of a circular economy for plastics and about trying out different approaches to achieve higher-value-creating outcomes. Uncertainty continues about future regulations—for example, CO₂ taxation—while overly simplistic proposals for solving the plastics-waste problem continue to circulate, confusing the issue even further.

Building a granular and integrated understanding of the challenge

In response to these challenges, we have developed the first fact-based economic-feasibility perspective on the potential for recovery and reuse across the full plastics value chain.⁴

As part of our research, we investigated more than 1,000 combinations of used resins, applications,

¹ Thomas Hundertmark, Mirjam Mayer, Chris McNally, Theo Jan Simons, and Christof Witte, "How plastics waste recycling could transform the chemical industry," December 2018, McKinsey.com; Thomas Hundertmark, Chris McNally, Theo Jan Simons, and Helga Vanthournout, "No time to waste: What plastics recycling could offer," September 2018, McKinsey.com.

² Peter Berg, David Feber, Anna Granskog, Daniel Nordigården, and Suku Ponskhe, "The drive toward sustainability in packaging—beyond the quick wins," January 2020, McKinsey.com

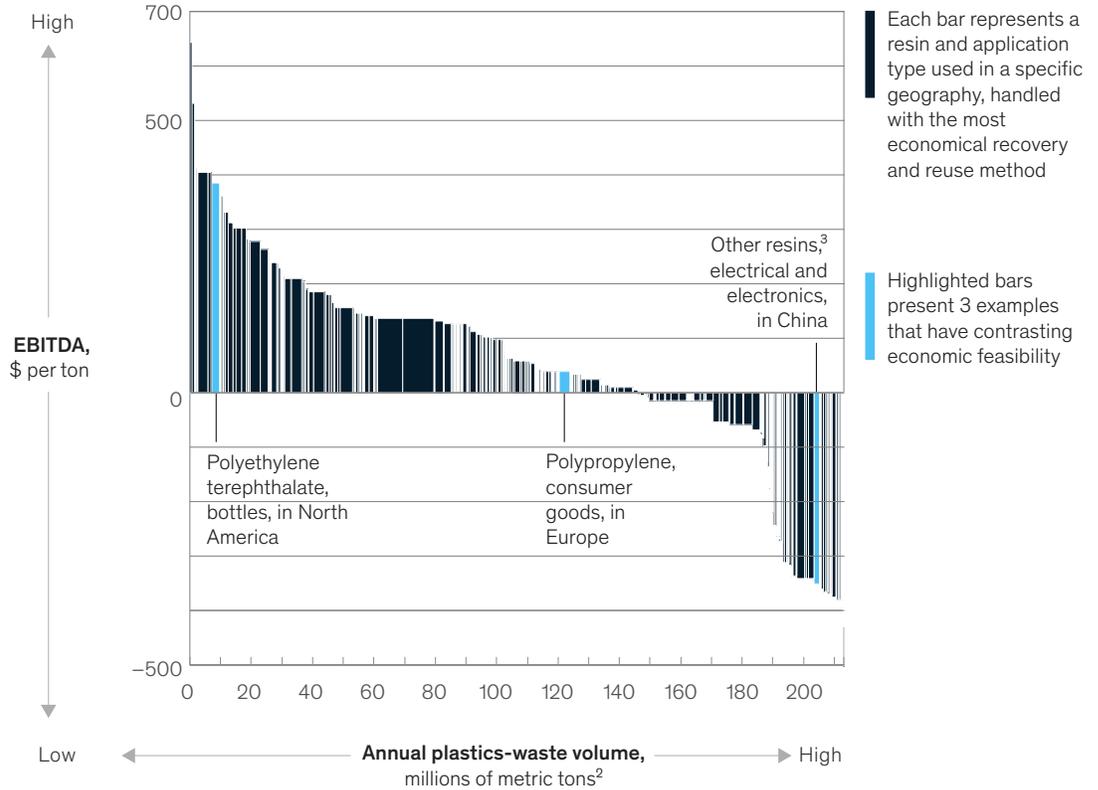
³ Thomas Hundertmark, Manuel Prieto, Andrew Ryba, Theo Jan Simons, and Jeremy Wallach, "Accelerating plastic recovery in the United States," December 2019, McKinsey.com.

⁴ The model is built to show the economics of a system under a single owner, with an integrated end-to-end cost structure. This approach makes it possible to identify the total margin pool available that could be distributed among the different participants.

Exhibit 1

The Plastics Recovery and Reuse model’s cost curve ranks the economic feasibility of recycling initiatives at a highly granular level, across geographies.

EBITDA of waste volumes to recovery and reuse¹



¹ EBITDA: earnings before interest, taxes, depreciation, and amortization. EBITDA of waste volumes to recover and reuse, including full system-operating-expenditure costs (eg, collection, sorting, reprocessing) and revenue from sales of core projects and byproducts (eg, fuel, energy, monomer, polymer). The calculations are based on an oil price of \$60/barrel, and all other costs are taken as of Nov 25, 2019. The chart only includes volumes that currently go to landfill/incineration after collecting and sorting.

² Metric tons: 1 metric ton = 2,205 pounds.

³ Plastics categorized as “other” under the Resin Identification Code and indicated as “7” (ie, the category that covers ABS, polyamide, polycarbonate, rubbers, and all other resins not covered by the six major resin families).

and geographies to estimate the costs of recovery and reuse for each. These have been incorporated into our Plastics Recovery and Reuse model. The analysis is based on current “as is” economics to provide a sound basis for capital-investment decisions (see sidebar, “Understanding the Plastics Recovery and Reuse model”).

The model reflects nearly all the complexity of the plastics-waste universe and identifies the

approaches that will create the most value. How the recycling economics compare for resins in different applications and in different geographies can be shown in a cost curve (Exhibit 1).⁵

An important capability of the model is that it can provide guidance on future steps. For example, by making transparent the value-creating potential of the many different combinations of resin, application, recovery systems, and geography, this analysis can

⁵ The curve covers the plastics-waste volumes that can realistically be collected today and assumes that a certain volume will be “lost,” particularly in economies at an early stage of development in their waste-management systems and those in which informal collection systems represent a large share. We have considered in our modeling a volume of approximately 210 million metric tons per year out of a total of 270 million metric tons per year of plastics waste (one metric ton equals 2,205 pounds). This volume represents waste volumes that currently go to landfill/incineration after collection and sorting.

Understanding the Plastics Recovery and Reuse model

Plastics waste is a global problem, but the waste is generated locally, and dealing with the problem will require granular, local-level solutions. The research behind our Plastics Recovery and Reuse model is based on detailed analysis and modeling of plastic usage and waste flows, and of their economics across four dimensions: resin, application, geography, and recovery and reuse route. Each of the dimensions is built up from its detailed components (exhibit).

The seven components for the resin dimension cover the major-volume resins—polyethylene terephthalate (PET), polypropylene (PP), high-density polyethylene

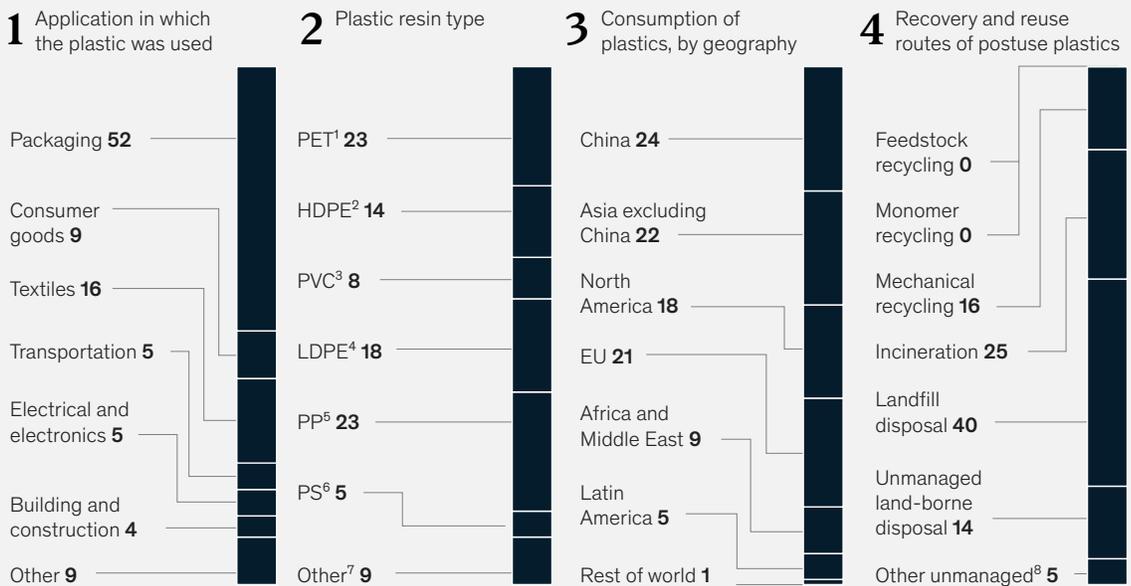
(HDPE), low-density polyethylene (LDPE), polystyrene (PS), and polyvinyl chloride (PVC)—with a final category covering acrylonitrile-butadiene-styrene (ABS), polycarbonate (PC), polyamides (PA), and the large-volume synthetic rubbers. For the applications dimension, we included 86 applications based on the following categories: building and construction, consumer goods, textiles, transportation, electrical and electronic systems, and multiple types of packaging (including bottles, caps and closures, packaging for food, flexible packaging, industrial packaging, and miscellaneous other packaging).

The seven geographies covered are Africa and the Middle East, Asia excluding China, China, the European Union, Latin America, North America, and the rest of the world. For the recovery and reuse dimension, we modeled seven routes to provide a comprehensive picture of the options now in play. Five of these represent managed approaches—mechanical recycling, monomer recycling, feedstock recycling (with the pyrolysis process frequently referenced), incineration, and landfill disposal—and two represent unmanaged waste flows—unmanaged land-borne disposal and other unmanaged volumes, including leakage to marine biosystems.

Exhibit

The model incorporates analysis of global plastics flows across four dimensions—applications, resins, geography, and recovery and reuse route.

4 dimensions of global postuse plastics flows, state of play in 2018, %



¹Polyethylene terephthalate. ²High-density polyethylene. ³Polyvinyl chloride. ⁴Low-density polyethylene. ⁵Polypropylene. ⁶Polystyrene. ⁷Plastics categorized as "other" under the Resin Identification Code and indicated as "7" (ie, the category that covers ABS, epoxy resins, polyamide/nylon, polycarbonate, PMMA, EVA, SAN, and other resins not covered by the six major resin families). ⁸Other unmanaged volumes, including leakage to marine biosystems.

Combining the efforts of the recycling and petrochemical industries is still at an early stage on the learning curve, and simply gaining scale could significantly improve the overall economics.

help guide policy makers as they develop regulation to encourage plastics reuse.

At the same time, players across the value chain will likely benefit from moving up the learning curve as the plastics-recycling industry gains momentum—and as plastics-recycling systems and their costs evolve. The model has therefore been designed to have a high degree of flexibility so it can incorporate a range of target costs, as well as assumptions about how debottlenecking and efficiencies derived from continuous operational improvements could reduce costs. It can also be used to help reimagine process flows and work with a range of unit costs to inform decisions on future investments best.

These kinds of capabilities should help facilitate the new discussions that value-chain partners need to have about how they could adjust requirements and specifications to improve the economic feasibility of different segments of plastics recovery and reuse activity—and help get past the fragmentation and lack of dialogue that holds back the industry now.

Showing how the recovery and reuse options compare

If we add in capital costs as well as operating costs, our analysis shows that, at an oil price of \$60 per barrel, only a limited number of plastics-recycling opportunities are currently value creating in themselves. We define “value-creating opportunities” as those that provide a positive return on the capital invested in all three elements (collection, handling, and processing) at a level sufficient to satisfy what private investors typically seek. These kinds of value-creating initiatives account for only around 20 percent of volumes

(Exhibit 2). The analysis also suggests that, for many combinations, the initial capital investment required creates a major disincentive to potential investors.

The majority of plastics-recycling activities are in the middle, where recovery and reuse generate positive earnings before interest, taxes, depreciation, and amortization but do not create value. This category accounts for around 50 percent of cases. Investors are in effect showing good sense by not investing yet in these plastics-recycling initiatives.

The final category—around 30 percent of volumes—consists of a range of resins and applications that do not offer attractive economics for recycling or reuse under most market conditions. This is because of factors such as that the capture of the used materials and their reprocessing are prohibitively expensive.

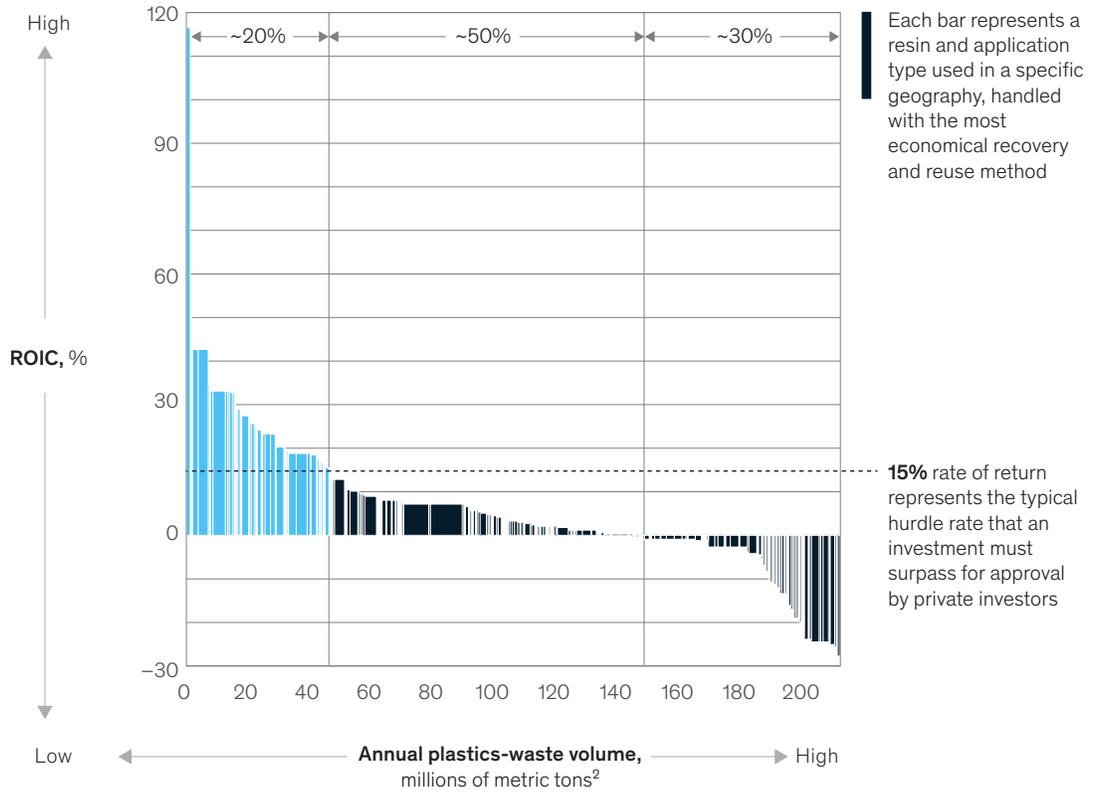
What can be done to improve these applications' recycling economics? Combining the efforts of the recycling and petrochemical industries is still at an early stage on the learning curve, and simply gaining scale could significantly improve the overall economics.

More cost-effective collection systems could help, and there could be scope to redesign products in this category to improve their recyclability—for example, through making them out of different resins when possible. But there are also applications for which the cost incurred in recycling, with no possibility of earning a profitable return, could be deemed acceptable because the plastic used there simply does the most economical, as well as the most carbon-efficient, job. The model can make these additional factors transparent and include them in the integrated economics.

Exhibit 2

Recovery and reuse opportunities with high enough return on invested capital to cover investment hurdles represent about one-fifth of plastics-waste volume.

Simplified ROIC of waste volumes to recovery and reuse¹



¹ROIC: return on invested capital. Simplified ROIC (based on calculation of earnings before interest, taxes, depreciation, and amortization divided by capital expenditures) of waste volumes to recovery and reuse, including full system cost and revenues (ie, operating and capital costs of collection, sorting, and reprocessing and revenue from sales of core products and byproducts, including fuel, energy, monomer, and polymer). The chart only includes volumes that currently go to landfill/incineration after collection and sorting.

²Metric tons: 1 metric ton = 2,205 pounds.

Identifying the major hurdles to progress and ways to overcome them

The Plastics Recovery and Reuse model can be used in a number of ways, including assessments of economic viability on regional, resin, and application bases. It can also identify the main bottlenecks to economically feasible recovery and reuse, such as a lack of economically attractive recycling capacity. The model is flexible; it can accommodate a wide variety of real-world situations—for example, an analysis of municipal-waste streams with a broad mix of resins and

applications. In this way, it can provide a detailed and powerful approach to understanding the status quo and to simulating future scenarios, such as the removal of specific resins or applications.

For investors within the value chain or infrastructure investors, the model can show how different oil-price scenarios and petrochemical-cycle phases are likely to affect the economics of plastics reuse and recycling so that ventures can be made resilient to shifts in economic conditions. For regulators, the cost curve can help guide policy

decisions that improve the economic feasibility of plastics-recovery and-reuse systems across municipalities, regions, and countries.



Resolving the plastics-waste problem is a complex challenge that will require choosing from the large number of possible approaches and tailoring them to the recycling needs of different plastics,

applications, and regional waste management systems. But despite evidence that recovering and reusing plastics waste could generate substantial value, investments have been held back by a lack of clarity about the economic feasibility of the various approaches. Bringing an economic-feasibility lens to bear on the possible approaches can guide choices about which moves to prioritize, opening the way to investments that can help resolve the challenge worldwide.

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