# Automation Technology Closes the Loop on Circular Plastics

EMERSON

Plastics recycling is necessary to advance worldwide sustainability efforts, but technical difficulties have limited implementation, with only about 9% of all plastics recycled. Fortunately, various efforts are underway to address this issue by closing the loop to create a circular plastics paradigm, as opposed to current linear efforts.

There are six main types of plastics in widespread use, and each presents a different challenge for integration into circular recycling. Fortuitously, the three most commonly used plastics—polyethylene terephthalate, high-density polyethylene, and polypropylene—are recycled the most easily and most often.

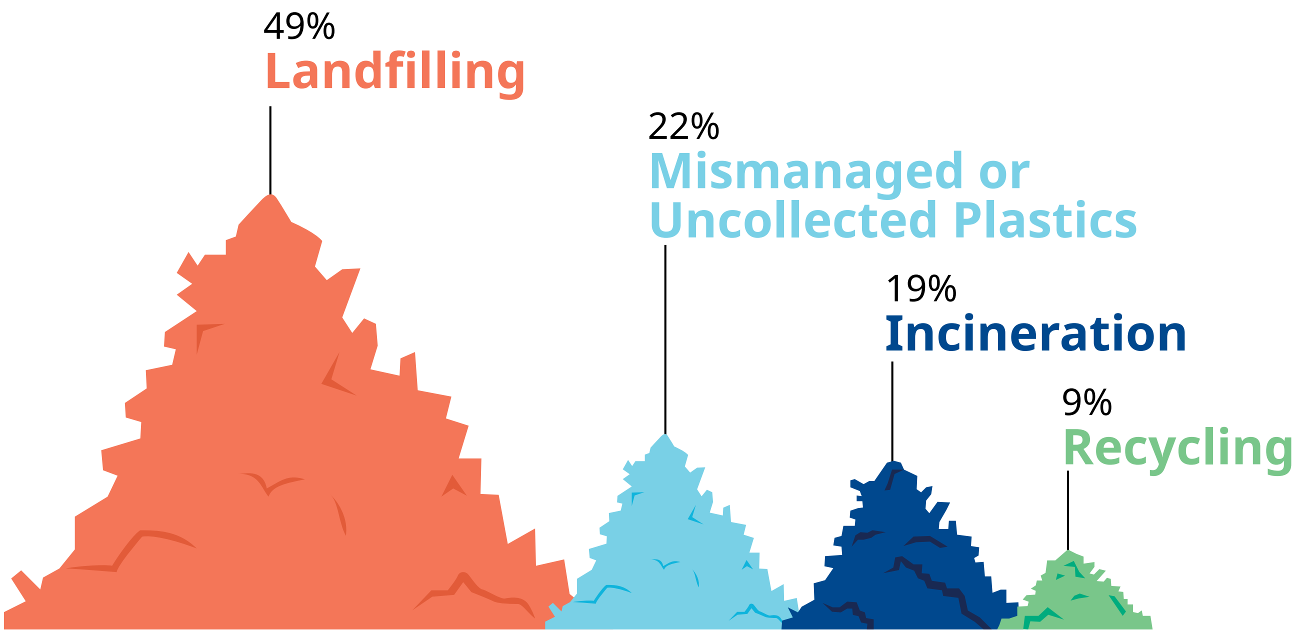

The main methods used for plastics are mechanical recycling via remelting, and three different advanced recycling technologies: dissolution, depolymerization, and conversion via pyrolysis. Each method has its advantages and challenges, but all share a common need for automation to optimize operations, minimize energy use, and ensure safety.

These new processes still depend on traditional automation methods and tools, which Emerson has been providing to its customers for decades. These solutions, plus deep domain expertise, make Emerson the right choice as a partner to help close the loop on plastics recycling.

# Are Recycling Efforts Effective?

Given how many different colored bins are deployed for residences, companies, and even street corner trash cans, most people would likely conclude that most plastic is already being recycled. Unfortunately, this is not the case. Globally, only 9% of plastic waste is being recycled. Some types of plastic are recycled more than others. For example, recycling of polyethylene terephthalate (PET) bottles and jars has reached nearly 30%, as has high-density polyethylene (HDPE).

## Global Plastic Waste Management




*In spite of efforts by many well-meaning consumers, very little plastic is being recycled, although the amount is growing.*

Of course to have an overall average of only 9% means other plastics are far lower, with some virtually zero. Compare this to aluminum can recycling, where it's typically higher than 75%. So, the question quickly emerges, why so little plastic? Is a circular economy practical at all?

*Mixed plastic trash is difficult to separate into different types and colors.*

# Aluminum as the Example

Aluminum trash has a high recycled rate. In Brazil, it reaches 95%. How is it possible to be so high?

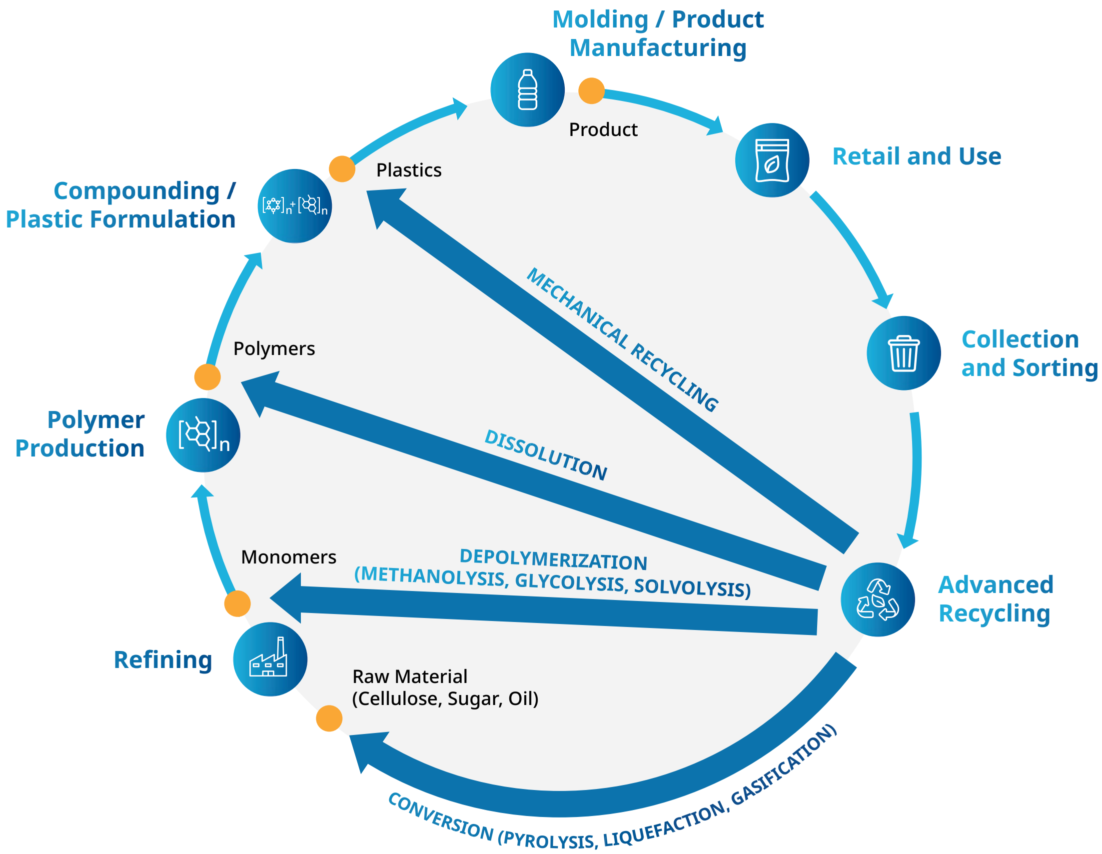
- Most metal scrap is either aluminum or ferrous alloys that can be separated magnetically, so aluminum is fairly easy to isolate from mixed scrap.
- Producing new aluminum from scratch (bauxite) is significantly more expensive than recycling.
- Aluminum does not degrade when it is remelted and reused.

Plastic is almost the direct opposite of aluminum on each point:

- Plastic trash is difficult to separate into individual types.
- Producing most plastics from scratch is cheaper than recycling, although such manufacturing consumes fossil fuels.
- Most plastics suffer quality degradation if remelted, although the extent of this varies by type.

# The Plastic Value Chain

The plastic value chain is largely the same for any type of polymer. They all begin with the same basic feedstocks, including oil, natural gas, cellulose, or others. These are refined and turned into monomers and then polymers. Eventually the items are molded into the ultimate product, are used by consumers, and then eventually end up in the trash. When implementing a circular economy, we start at the collection/sorting end and bring it around to an earlier point on the chain. There is no requirement to go all the way back to the beginning. So, for the chemical recycler, the question becomes, how far down the chain do we want/need to go to achieve our goal?




*The plastic value chain is linear under most situations these days. Making it circular calls for determining where in the process it starts over. Different recycling methods cut back into the chain at different points.*

# Not All Polymers Are Alike

There are at least six polymers commonly used in packaging and other applications. The most common, as indicated by their recycling number designations, are 1-PET (or PETE), 2-HDPE, and 5-PP (polypropylene). These are also the most recycled. Others, such as 3-PVC (polyvinyl chloride), 4-LDPE (low-density polyethylene), and 6-PS (polystyrene) are less common and more difficult to work with for recycling. Often, different types may be used in combination based on their properties.

PLASTIC RESIN IDENTIFICATION CODES

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| PETE | HDPE | PVC | LDPE | PP | PS | OTHER |
| Polyethylene Terephthalate | High Density Polyethylene | Polyvinyl Chloride | Low Density Polyethylene | Polypropylene | Polystyrene | Other |
| Recyclable | Recyclable | Recyclable at specialist points | Recyclable at specialist points | Recyclable | Recyclable at specialist points | Not easly recyclable |

* Check with your local recycling program to confirm which materials are accepted in the recycling bin or at a special drop-off or collection program.

*There are six types of plastics used commonly today, each with specific identification codes. The green selections are the most readily recyclable.*

# Mechanical Recycling—Remelting

The shortest and easiest jump is mechanical recycling, which is closest to the aluminum example. It takes one kind of sorted plastic trash, sorted for color as well as material, shreds it into flakes, removes contaminants, and remelts it to make new containers out of old ones. It is not suitable for every kind of plastic, as some polymers lose quality with remelting, but it is very popular for PET as this material can withstand multiple melting cycles.

Depending on the application, virgin feed may be mixed with recycled material. Mechanical recycling requires very careful sorting as different plastics have different melting points and may not mix in liquid form. This is the most common recycling method and supports the high percentage of recycling for PET.

*PureCycle Technologies holds a global license for the only patented solvent-driven purification recycling technology and designed to transform PP plastic waste into a continuously renewable resource. The purification process removes color, odor, and other impurities from PP waste, resulting in a virgin grade recycled plastic that can be reused multiple times.*

# Advanced Recycling—Dissolution

In some situations, it is necessary to go farther down the chain to achieve the desired recycling goal. Chemical recycling uses two primary methods to take sorted trash and turn it back into virgin-quality plastic of the same type, dissolution and depolymerization.

Dissolution, where sorted plastic waste is turned into a liquid using a solvent. This does not break down the polymer, but still renders it as a liquid. Depending on the type of plastic, the solvent may be a paraffin (hexane, octane, etc.), or an aromatic (toluene, xylene, etc.). In most actual applications, the plastics processed this way are PVC, PS, PE, and PP. Since the solvent is designed to work on one specific plastic, other materials in the mix remain solid and can be strained out.

*Eastman Chemical's process turns polyester polymers back into monomers that can be scrubbed of contaminants and repolymerized into virgin-quality plastic. Eastman Chemical's Polyester Renewal Technology uses glycolysis or methanolysis to break down polyester into its basic monomer. This means it can recycle all types of PET bottles and films, and even polyester fabrics. Once in its liquid monomer form, the purification process is able to extract dyes and pigments, so colored feedstock is not a problem. Once contaminants have been removed, the monomer is repolymerized, creating virgin-quality pellets suitable for any application.*

# Advanced Recycling—Depolymerization

Depolymerization moves back one more step on the value chain. It breaks down the long polymer molecules, turning the plastic back into a monomer, effectively reversing the final stage of the plastic's original manufacture. Again, this only works on one kind of plastic, namely PET, due to the complex reactions involved.

*ReNew ELP uses a combination of heat and steam to break polymers down into hydrocarbons. Its process is very sophisticated and is used to produce specific types of oil products and gases, even with feedstocks such mixed plastics, and non-plastic materials such as paper. It calls for tight control of the actual heating process, using supercritical water and steam, combined with catalysts and separation steps. The company says that "water acts as 'molecular scissors' to break down the polymeric bonds, donating hydrogen to create useful short-chain, stable hydrocarbons, which are separated and stored."*

# Advanced Recycling—Conversion via Pyrolysis

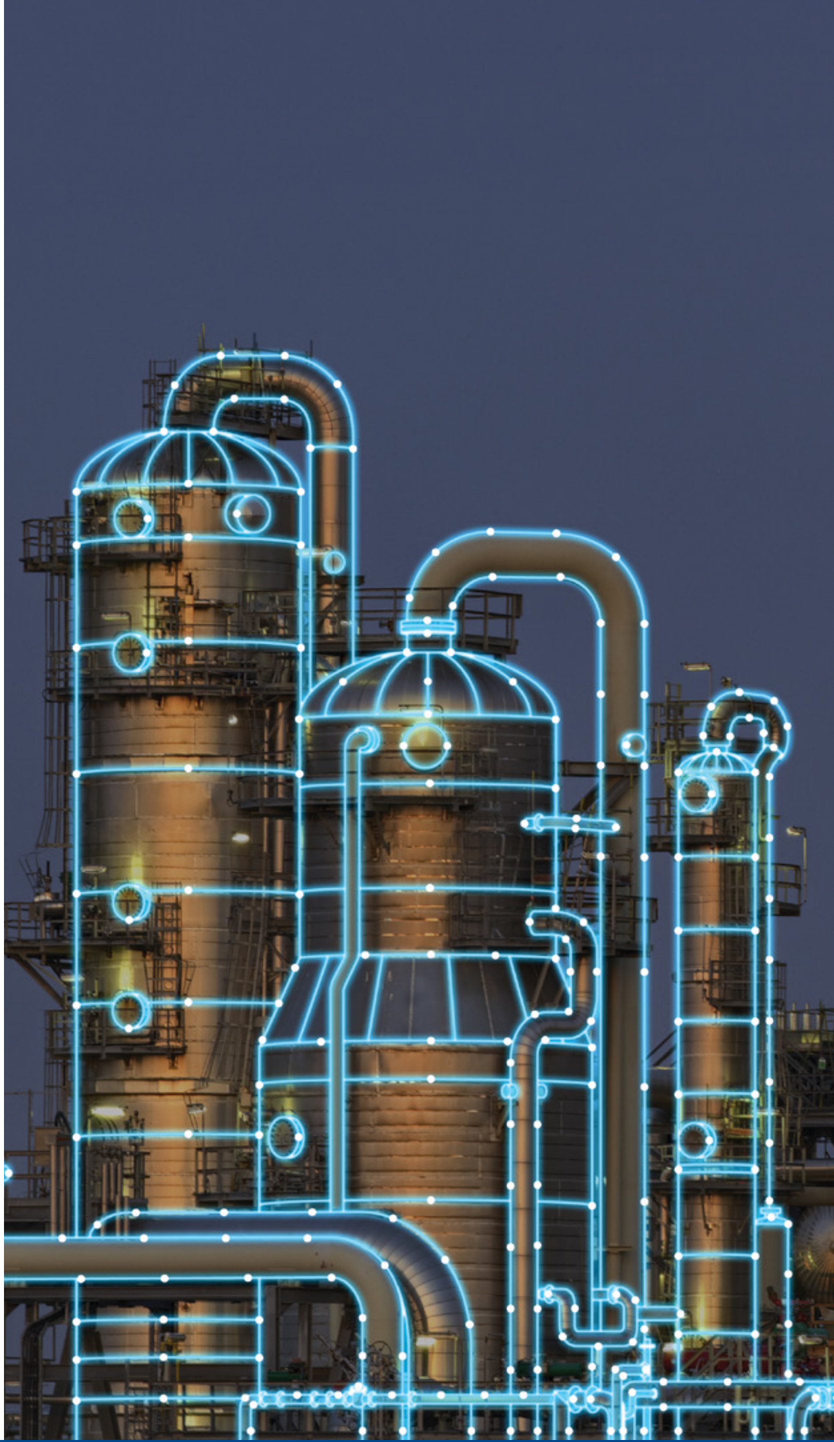
In some cases it is desirable to go even farther back on the chain and break down the chemical structure into more basic molecular components. This has a major advantage in that it works with mixed or minimally sorted trash. The process design determines how far the breakdown progresses. When trash is loaded into a pyrolysis reactor and heated without oxygen, mixed plastics can be gasified and liquified, yielding a variety of useful products, including oil that can be used by a refinery.

# Automation for Building a Circular Economy

The scale of the global plastic waste problem is motivating many companies to develop innovative processes and stake out a position in this growing industry segment. Those chemical companies are using the advantages of automation to improve the speed and accuracy of decision making across the entire supply value chain. This is possible because people at all levels are taking actions based on having the right information in the hands of the right expert at the right time.

The world's essential industries are increasingly demanding robust and boundless automation that transcends boundaries to help empower safe and reliable operations across a facility or enterprise. Innovation is ushering in a digital transformation that enables companies to exploit digital technologies to create vast amounts of manufacturing data. This supports manufacturing expertise better than ever before, but only if the right scalable technology strategy is matched to business goals.

Many companies, both long established chemical producers and startups, are developing new solutions for addressing different segments of the larger recycling and circular economy picture.




# Choosing the Right Technologies and Partner

These may be new processes, but they depend on traditional methods and tools. This is where Emerson comes in. We can help by providing control strategies, instrumentation, and general know-how for all the processes that are needed.

Leveraging decades of digital innovation and leadership across all automation categories, Emerson has expanded its portfolio to incorporate the AspenTech family of asset optimization software. These platforms are powered by industrial artificial intelligence (AI), creating the most comprehensive digital transformation portfolio in the industry.

Our solutions empower companies with unprecedented flexibility to generate, manage, and use the rapidly growing body of data each plant operation generates. As operators use new kinds of data and software in innovative ways to support day-to-day tasks, Emerson helps make data actionable by more personnel in the context of their role, regardless of location.

# Technology Accelerates Change

### Sense and Measure

Instrumentation technologies provide visibility into the process, creating high-integrity data to drive decisions. This portfolio of products helps customers eliminate blind spots in locations and applications previously out of reach.

Includes:

- Corrosion detection
- Tank lead detection
- Safety instrumented systems
- Equipment monitoring

### Automation Systems and Software

Digital automation systems improve decision making agility through intuitive analytics and improved visibility. Advanced software provides on-demand access to expertise, while automated workflows empower personnel to focus on high-value activities, rather than low-value routine tasks.

Includes:

- Distributed control systems
- Programmable logic controllers
- Safety systems
- Alarm management
- Asset monitoring
- Digital twin

### Control and Act

Effective process control capabilities provide operators with the confidence to act in ways that improve and optimize operation.

Includes:

- Digital valve control
- Process isolation
- Discrete functions
- Edge controllers

### Advanced Software

Modular, AI-based software delivers high performance engineering applications to create world-class facilities.

Includes:

- Supply chain management and scheduling
- Capital project estimation and economic analysis
- Process and energy analysis
- Asset performance management

As the interest and demand for recycled product grows, leaders realize how advanced automation is the greatest strategic lever available to boost operating performance and improve safety, while achieving sustainability targets.

Closing the loop on circular plastics calls for the right partner, and Emerson is uniquely positioned to provide products and services to meet all these demands.

**Emerson.com/AdvancedRecycling**

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