WHITE PAPER

ExxonMobil

Supporting value chain collaboration for an advanced recycling infrastructure

Exxtend™ technology for advanced recycling helps to support plastics circularity

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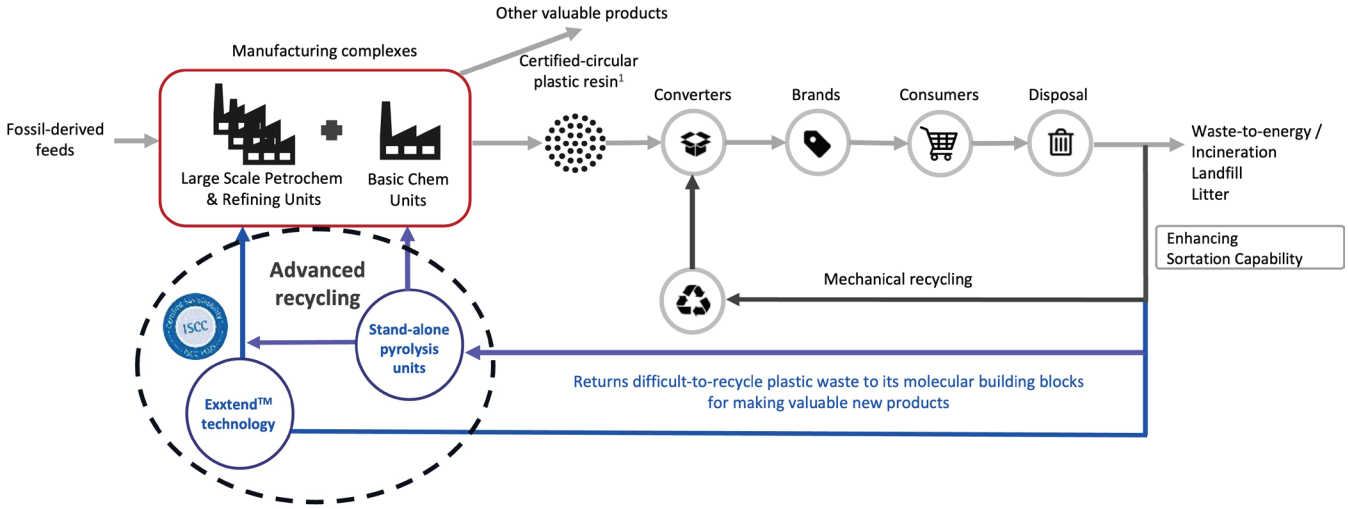
Developing a robust feedstock supply infrastructure is critical to the growth of advanced recycling technologies, which are complementary to current mechanical recycling methods. It is important that the plastic industry help establish an infrastructure that supports these quickly emerging technologies. This white paper highlights the challenges, opportunities, and collaboration involved in creating an advanced recycling infrastructure, and the steps ExxonMobil is taking to help maintain resiliency.

What is advanced recycling?

ExxonMobil's Exxtend™ technology for advanced recycling transforms plastic waste at a molecular level into usable raw materials that are attributed via the ISCC PLUS mass balance approach using the "determined by mass" option with "certified free attribution" applied to the amount of certified-circular polymers we sell.

Advanced recycling diverts difficult-to-recycle plastic that might have otherwise gone to landfill or incineration. With the ability to break down complex, multi-polymer material and remove contaminants, this technology can be a complement to mechanical recycling. Our technology, built on decades of innovation and operational excellence, is helping to enable a circular economy for plastics. We are collaborating with the value chain to help develop an infrastructure to more effectively collect, sort, and process used plastics at scale.

Figure 1 illustrates how advanced recycling technology augments the plastic resin production process.



1ISCC PLUS mass balance approach using the "determined by mass" option with "certified free attribution" applied.
Does not represent GHG emissions or recycled content.

For illustrative purposes only.

Figure 1. How Exxtend technology aims to accelerate progress toward a more circular economy

How advanced recycling technology extends the life of plastics

Many people are familiar with how plastics are mechanically recycled: products are sorted by resin type and then broken down through mechanical force, such as shredding, and heat to process plastic waste into recycled resin.

Mechanical recycling works well, but it has limitations. For example, only certain kinds of plastics can be mechanically recycled together. Additionally, each time you put a plastic through another mechanical or thermal cycle, the performance tends to degrade. Although recycled resins are good for some applications, it can be difficult to incorporate them into more complex structures, such as multilayer films, or food- or medical-grade applications, with stringent safety standards.

This is where advanced recycling has emerged as another potential solution in the recycling toolkit. It starts with end-of-life plastics that are difficult to recycle mechanically. For example, plastics consisting of more complex structures, like multilayer films, or products that have a polyethylene and a PET layer, or even a metalized layer that are difficult to separate for mechanical recycling. All of these materials are good candidates for advanced recycling methods.

Our Exxtend technology for advanced recycling transforms plastic waste at a molecular level into usable raw materials that are attributed via the ISCC PLUS mass balance approach using the "determined by mass" option with "certified free attribution" applied to the amount of certified-circular polymers we sell. Because certified-circular polymers are identical to virgin plastics, they have the same quality and performance, so customers can have confidence incorporating certified-circular polymers into sensitive applications, including hygiene and personal care products.

Examples of material that ExxonMobil has processed using Exxtend technology for advanced recycling include:

- Artificial turf
- High-density polyethylene caps from pipes in oil fields
- Lubricant and grease bottles
- Multilaminate films

Transforming plastic waste into feedstock

Advanced recycling of plastic waste requires a series of steps: collection, sorting and aggregation, shredding and densification, and transportation to a manufacturing facility.

Plastics are sourced from many different places. Collection involves determining where a plastic becomes a "waste" – for example, inside a household, in a retail environment, or at a commercial or industrial space. That answer will help determine how the collection process begins – and will represent the beginning of the value chain. Educating consumers and others early in the value chain about the inherent value of plastics can help increase plastic collection. Developing effective means of collecting a wider range of plastic waste is critical to helping support the growth of technologies like advanced recycling, while also improving the total amount of plastic that can be recycled.

Once the plastic material has been collected, it goes through sorting and aggregation. If the plastics can be sorted at the source (households, retail stores, etc.), sorting and aggregation can be relatively simple. As the value chain matures, more advanced sortation systems need to be developed to accommodate a wider range of plastics.

After sorting and aggregation comes shredding and densifying. Physical specifications for waste must be met and can vary by the recycler. Particle size, feedstock, and bulk density of a feedstock are particularly important. A higher bulk density makes transportation more efficient. The specifications also help ensure that the plastic waste can be conveyed to our manufacturing facility more easily.

As part of the advanced recycling process, ExxonMobil does quality checks on the material, testing the chemical composition of materials. This differentiates Exxtend technology for advanced recycling from mechanical recycling, where the focus is typically on the physical properties of material. With advanced recycling, it is important to understand the chemical properties of a plastic feedstock, such as the chloride, oxygen, or nitrogen levels.

Understanding the chemical composition is also critical to predict things like the yield achieved from that material through our advanced recycling process, or to further understand how those contaminants can be removed through our technology.

In the discussion of developing the infrastructure to help support advanced recycling, it's important to keep in mind that mechanical recycling and advanced recycling are complementary to each other. Figure 2 shows which types of plastics are best suited for a mechanical or an advanced recycling process.

Widening the range of plastic materials society can recycle[1]

Material type	Single-stream plastics recovered for mechanical recycling[2,3]	Mixed-plastics desirable for Exxtend™ technology[4]
2 HDPE	• Monomaterial, single source more common • Polymer properties amenable to M/R	
3 PVC	• Limited single source collection • Lack of monomaterial (additives)	Capable of taking small amounts
4 LDPE	• Film collection & sortation more challenged • Polymer properties not amenable to M/R	
5 PP	• Sortation improving • Polymer properties less amenable to M/R	
6 PS	• Expanded PS foam collection, cleaning, densification is challenged	Acceptable in quantities up to contaminant limits
7	• Not a monomaterial	Acceptable in quantities up to contaminant limits (e.g., high nitrogen content from nylon and polyamides)

[1]In communities with programs and facilities in place that collect and recycle the resulting product.
[2]Plastics Recyclers Europe: PET Market in Europe: State of Play – Production, Collection and Recycling Data 2018
[3]Prepared for ACC by More Recycling, US PCR 2020
[4]ExxonMobil data

Target · Tolerated in feed mix · Challenge

Figure 2. Mechanical and advanced recycling technologies are complementary.

Creating an advanced recycling value chain

Many communities have some infrastructure in place to support mechanical recycling; however, standards for what can and cannot be collected are inconsistent. ExxonMobil partners with several companies and organizations that are investing in new infrastructure that would collect more plastic waste, diverting it from landfill or incineration, while supporting the deployment of advanced recycling technology in municipalities in the US and around the world.

Cyclyx, a joint venture among ExxonMobil, Agilyx, and LyondellBasell, plays a key role in the advanced recycling value chain. Cyclyx has been instrumental in helping to fill in the gap between plastic collection and its use as a feedstock for advanced recycling. They evaluate and chemically characterize plastic waste used by ExxonMobil and others in the advanced recycling industry – meeting their specific feedstock and technology needs.

In 2023, the final investment decisions were made on the Cyclyx Circularity Center (CCC), an advanced sortation facility expected to open in mid-2025 in Houston, TX. This facility represents a $135 million investment by ExxonMobil and LyondellBasell and will have the capacity to produce 300 million pounds of plastic feedstock per year for both advanced and mechanical recycling. This will include material sourced from a combination of post-consumer, commercial, and industrial plastic waste of all kinds. Material coming into the CCC will be chemically characterized, sorted, shredded, and densified before being blended together to create a feedstock that matches each offtaker's unique feedstock specification.

Conclusion

New technologies are emerging to help communities and companies meet their plastic circularity goals. Value chain collaboration and investment is critical to the success of these solutions. This includes developing enhanced feedstock infrastructure to support innovative advanced recycling methods, like ExxonMobil's Exxtend technology.

Mechanical and advanced recycling are complementary processes that provide viable methods for reducing plastic waste. Through key partnerships, together, we can identify existing strengths and capabilities in these processes and work to close gaps in critical infrastructure that would support both solutions.

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