BRIEFING NOTE

Advanced material-to-material molecular recycling of plastics

MAY 2026

Synthesis of research on the social, economic, and environmental impacts of advanced material-to-material molecular recycling alongside mechanical recycling, reduction, and reuse strategies

Purpose of this fact sheet

This fact sheet explains:

ABOUT

What advanced material-to-material molecular recycling is and how it expands the recyclability of everyday goods when combined with mechanical recycling.

OPPORTUNITY

How recognizing both mechanical and advanced material-to-material molecular recycling in legislation may influence affordability, accessibility, and convenience for consumers as well as whether recycling targets are achievable in practice.

BENEFITS

The broader economic, social, and environmental benefits of including *both* mechanical and advanced material-to-material molecular recycling, in addition to reduction and reuse strategies, in a sustainable plastics system.

This document was prepared by Systemiq, with the input of Professor Cameron Miller, and commissioned and financed by Eastman. It is based primarily on "Transforming PET Packaging and Textiles in the United States" published by Systemiq with support from an independently chaired Steering Group with diverse representation from industry, civil society, and academia.

Foreword

In New York and across the country, state policymakers are developing Extended Producer Responsibility (EPR) regulations to increase recycling rates and reduce waste. This drives producers and brand owners to make choices about the design of products and packaging - choices with cost implications that are often passed on to the consumer.

Many consumer goods are packaged in plastics that are considered harder to recycle, meaning they not suitable for traditional mechanical recycling. As currently written, New York's proposal only allows for the use of mechanical recycling technologies and restricts the use of packaging types that are not recyclable by these technologies.

Advanced material-to-material molecular recycling technologies convert harder-to-recycle plastics into new material with no loss of quality or performance. Progress on advanced recycling approaches means more packaging types should be classified as recyclable. The information in this paper – drawing on research published by Systemiq with support from an independently chaired Steering Group – shows that this could lessen the impact on affordability while still delivering the desired environmental and economic goals.

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Key takeaways for policymakers

Analysis conducted in 2024 with support from leading researchers and universities highlights the economic, social, and environmental **benefits of developing advanced material-to-material molecular recycling** alongside mechanical recycling technologies and plastic reuse and reduction strategies.

Across the United States, the analysis shows that for PET alone, which accounts for around 30% of household plastic use, the benefits of this combined approach include:

Reduced costs to consumers

due to lower compliance and material costs in EPR systems that prioritize recyclability

Continued access to affordable products

due to expanded packaging recyclability

46,000 direct jobs created

and 100,000–200,000 total jobs when indirect jobs are included

$4.9b per year

in new revenues for recycling industries

1/2 landfill or incineration

of PET and polyester, including textiles, by 2040

In New York State, recognizing advanced material-to-material molecular recycling as a complement to mechanical recycling, reduction, and reuse would:

- **Enable in-state job creation** across plastic waste collection, sorting, and recycling
- Support **plastic waste reduction goals**
- **Enable ambitious recyclability goals in EPR systems** without restricting access or raising prices for everyday products

For PET packaging and polyester textiles[1] (with similar benefits expected for other widely used plastics such as Polypropylene (PP) and Polyethylene (PE)[2]), the analysis finds that scaling advanced material-to-material molecular recycling would:

Increase recycling rates and divert plastic waste from landfills

Advanced material-to- material molecular recycling could account for ~40% of domestic PET recycling and ~50% of projected recycling growth by 2040, when textile recycling is included.

Create additional economic value

Advanced material-to-material molecular recycling could generate an additional $1.9 billion per year in national recycling revenues.

Increase volume and quality of post-consumer recycled (PCR) content to meet sustainability targets

Advanced material-to-material molecular recycling converts harder-to-recycle PET packaging and polyester textiles suitable for the most stringent food- and textile-grade applications.

Help avoid unnecessary product restrictions or costs for producers and consumers

Advanced material-to-material molecular recycling broadens the set of products that are "recyclable in practice" as it can process materials that pose challenges for mechanical recycling systems, yet deliver critical performance benefits.[3]

1. Used in beverage bottles, food trays, and polyester textiles, among many other applications.
2. Polypropylene (PP) and Polyethylene (PE) are two widely used polymers. PP is commonly used in food containers, toys, medical devices & textiles, and PE is commonly used in plastic bags, shrink wrap and squeeze bottles.
3. Some formats that are harder to mechanically recycle are used because they deliver performance benefits in specific applications, such as product protection, barrier properties (to oxygen, moisture, light, etc.), durability, and weight, helping maintain quality, safety, and affordability.

1 Definition and role of advanced material-to-material molecular recycling

While some advanced recycling technologies can also be used for waste-to-fuel or energy-recovery applications, the focus of this fact sheet is on **advanced material-to-material molecular recycling**, where the priority outcome is **producing virgin quality recycled material**.

Expanding advanced material-to-material molecular recycling processes means more plastic can safely be used again in food, beverage, medical, and high performance products, keeping materials in the loop. For instance, well-known brands such as **Yeti**, **Warby Parker**, and **Eileen Fisher** already use sustainably sourced plastic created using advanced recycling processes.

EXHIBIT 1 Comparison of processing methods based on output

	MATERIAL -TO-MATERIAL		MATERIAL-TO-FUEL
	MECHANICAL RECYCLING	ADVANCED MATERIAL-TO-MATERIAL MOLECULAR RECYCLING	PLASTIC WASTE PROCESSING
DESCRIPTION	Physically sorts, washes, and remelts plastics without changing their chemical structure. Most effective for clean, single-material streams.	Breaks plastics down to their molecular building blocks and rebuilds them into new plastic materials, removing dyes, additives, and contamination.	Converts plastic waste into fuels rather than new materials (not considered as recycling according to ISO definitions).
FEEDSTOCK	Clean, sorted plastics. Today mostly composed of unpigmented, rigid bottles, e.g., PET or HDPE beverage bottles.	Plastics that are harder-to-mechanically recycle, e.g., food trays, opaque bottles, flexibles, polyester textiles.	Mixed or residual plastic waste (PE/PP) that is harder to mechanically recycle.
OUTPUT AND QUALITY	Recycled plastic (variable grade depending on inputs and technology)	Virgin-quality recycled plastic	Fuels, oils or energy
SUITABLE APPLICATIONS FOR OUTPUTS	Varies depending on inputs and technology, and can result in some loss of quality over time if recycling rates reach high levels.	Suitable for food, beverage, medical, and textile applications.	Does not produce new plastic.
ILLUSTRATIVE TECHNOLOGIES	Grinding, washing, melt filtration, extrusion, pelletizing	Depolymerization, methanolysis, glycolysis, hydrolysis, enzymatic recycling, pyrolysis, gasification	Pyrolysis, gasification

2 Affordability, accessibility, and convenience for consumers

Advanced material-to-material molecular recycling supports environmental goals while preserving affordability, product availability, and convenience for New York consumers.

Plastics remain an essential part of daily life for New Yorkers, especially for small businesses and households on tight budgets. In many uses, plastics provide a valuable mix of benefits: they protect products, keep out oxygen and moisture, block light, and hold up to everyday wear and tear, all while being lightweight and relatively affordable.

These performance advantages make plastics a common choice for hygienic packaging, healthcare products, apparel, and other everyday goods. In the food system, plastic packaging can also help reduce spoilage and waste, which averages nearly **350 pounds per person per year**, roughly three grocery bags per week.

For certain applications, such as colored and opaque bottles, pill bottles, food trays, takeout containers, and textiles (see Exhibit 2), **plastics are among the highest-performing options available and are not easily substituted without tradeoffs**. By reducing unnecessary plastics and scaling reuse and recycling, New York can retain these benefits while lowering the overall environmental footprint.

EXHIBIT 2 **Advanced material-to-material molecular recycling enables the recycling of everyday products that are currently difficult to recycle and often bound for landfill,** such as

Food packaging
PET trays, clamshells, takeout containers

Dairy and household goods
Opaque and coloured bottles e.g., for beverages, oils

Healthcare products
High-purity opaque or colored PET for OTC and medical uses

Textiles, fabrics and durable goods
Polyester clothing, sportswear, carpets, upholstery

Recognizing advanced material-to-material molecular recycling in policy means that these products have a higher chance of being recycled in practice and at scale. This gives producers greater flexibility to meet recyclability requirements and continue to offer **familiar, convenient** products at **affordable** prices for consumers.

What this means for consumers

Recycling policy can affect both product prices and what stays on shelves. If packaging must switch from plastic to other materials because it cannot meet recyclability or recycled-content requirements in practice, it can lead to substitutions that may increase degradation and spoilage, and costs can rise.

Costs may also increase if companies need to redesign packaging, products, or delivery systems. In some cases, this can lead to products being reformulated or withdrawn, reducing convenience, choice, and availability for consumers. For instance, popular squeeze pouches used for baby food are difficult to mechanically recycle.

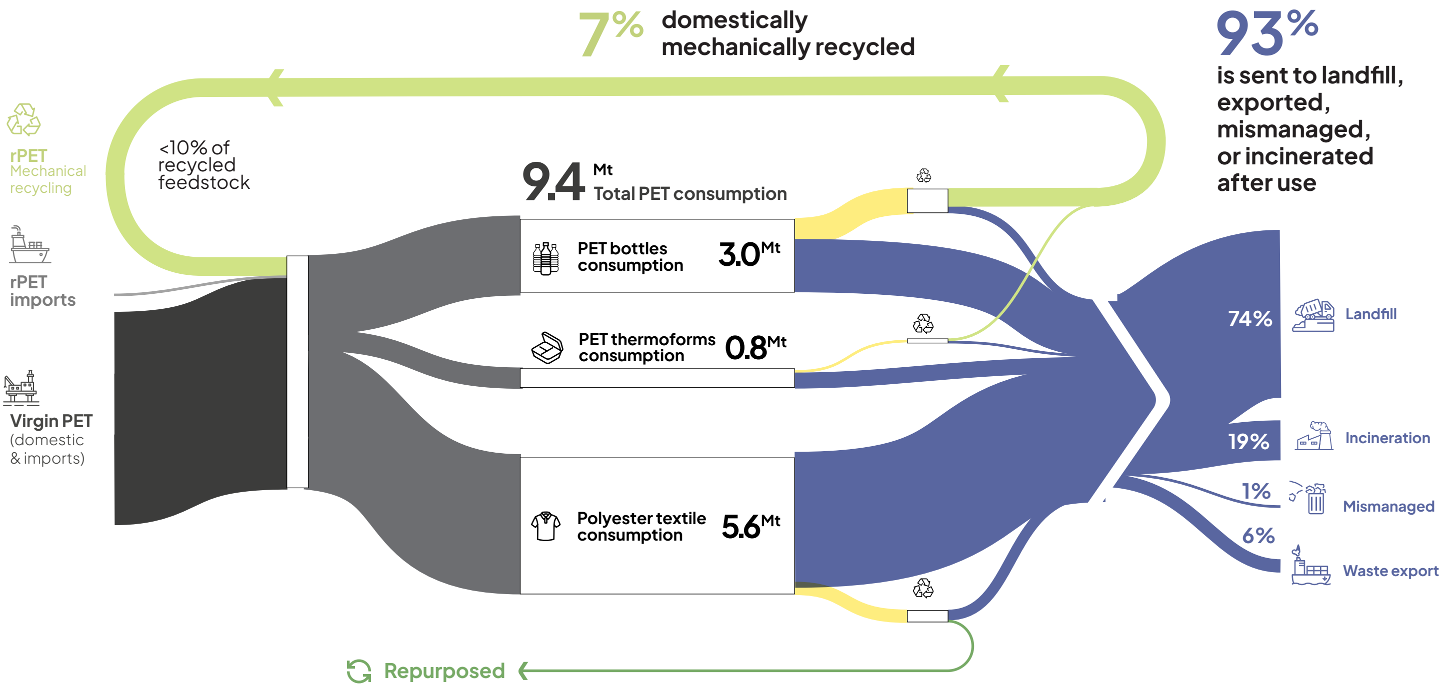
In addition, **EPR fee structures can directly affect costs**. Under Oregon's EPR program, which is in its early implementation phase, producer fees are generally higher for packaging that is harder to recycle.[4] Creating pathways to recycle such materials can help reduce EPR fees.

4. For example, EPR fees are ~170% or more higher for colored versus transparent PET bottles at present. Circular Action Alliance (2025), Oregon Fee Schedule.

3 Limitations in the current recycling system

Currently, only 7% of PET is recycled domestically– mechanical recycling alone cannot deliver sufficient volumes to support a sustainable packaging and textiles system.

EXHIBIT 3 **PET packaging and polyester flows**, 2022, United States



Source. Systemiq (2024), Transforming PET Packaging and Textiles in the United States. See report for full breakdown and assumptions.

Over 100 billion PET bottles and 10 billion polyester garments are sold in the U.S. each year. Together, this represents 30% of all plastic packaging and textiles sold every year, growing 2.3% year-over-year. Today, only 7% of the volume is recycled domestically, while the remaining **93% is sent to landfill, exported, mismanaged, or incinerated after use.**[5]

Many PET packaging formats (such as food trays, take-out containers, opaque beverage bottles, and pill bottles) and polyester textiles are not recycled at scale due to the technical and economic limitations of mechanical recycling.

Independent, system level analyses and market studies consistently find that:

- **Mechanical recycling alone cannot supply enough high quality PCR** to meet rising recycled content targets across packaging and textiles;[6]
- **Polyester textiles are unlikely to be recycled at scale** without advanced advanced material-to-material molecular recycling;
- **Excluding advanced material-to-material molecular recycling is likely to increase reliance on virgin plastic**, imports of recycled material (weakening domestic supply chains), and landfill and incineration.

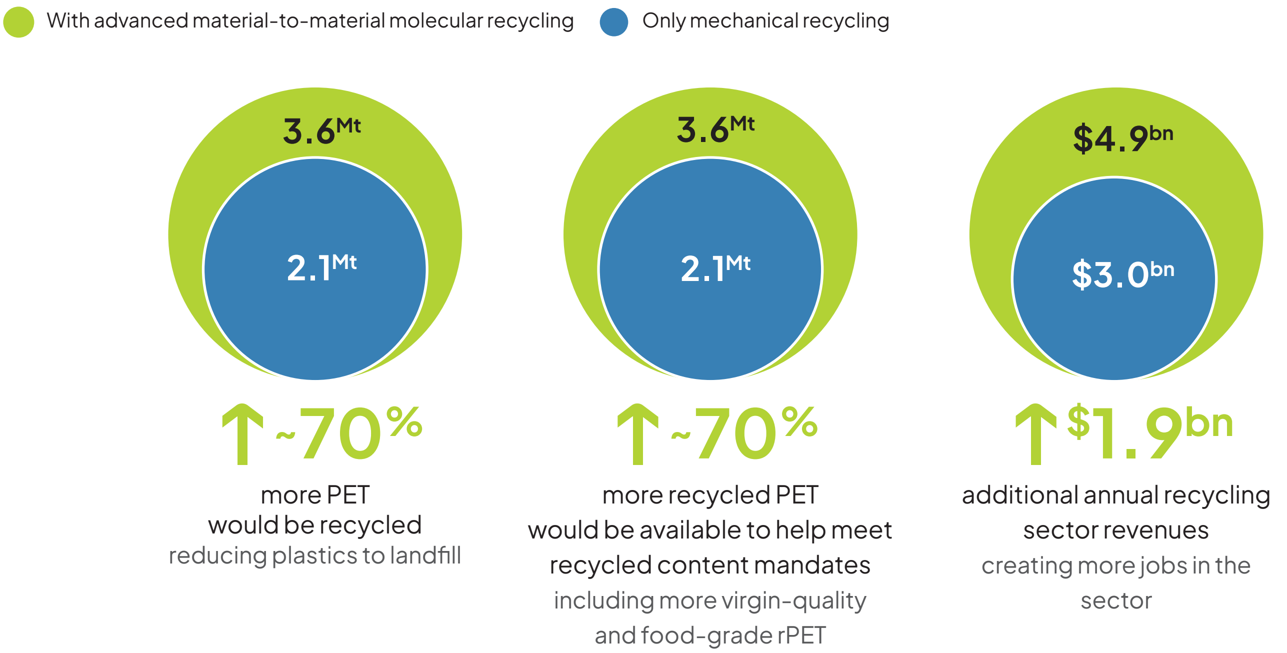
5. Systemiq (2024), Transforming PET Packaging and Textiles in the United States - https://www.systemiq.earth/transforming-pet-packaging-and-textiles-in-the-us
6. Clark, R.A. and Shaver, M.P. (2024). Depolymerization within a circular plastics system. Chemical Reviews, 124(5) https://pubs.acs.org/doi/10.1021/acs.chemrev.3c00739

4 Benefits of scaling advanced recycling with mechanical recycling

Advanced material-to-material molecular recycling will help increase recycling rates, bolster the domestic supply of recycled material, and reduce pressures on constrained New York landfills.

EXHIBIT 4

Impact of advanced material-to-material molecular recycling scaled in combination with mechanical recycling for the U.S. PET packaging and textiles system under an ambitious circularity scenario, 2040, illustrative



Source. Systemiq (2024), Transforming PET Packaging and Textiles in the United States

Nationwide modeling of the U.S. PET system shows that achieving ambitious recycling and recycled-content goals by 2040 will require **both** mechanical and advanced material-to-material molecular recycling. In this analysis, advanced material-to-material molecular recycling is needed to generate about **40%** of projected rPET supply in 2040, around 1.5 million tons out of ~3.6 million tons total, by processing hard-to-recycle packaging and polyester textiles.[7]

7. The Ambitious Circularity Scenario quantifies the impact of applying proven circular economy solutions at scale across the PET/polyester supply chain, in line with best practices in the U.S. today. Sensitivity modeling has also been used to understand the impact of deviations from the Ambitious Circularity Scenario and the factors that have the highest impact on the overall system outcomes by 2040.

5 Economic, social, and environmental benefits

When mechanical and advanced material-to-material molecular recycling are deployed together, alongside reuse and reduction efforts, as part of a sustainable plastics system, the benefits are substantial. For states like New York, these system-wide benefits translate into concrete, local impacts across jobs, waste management, and community outcomes.

Economic and employment benefits nationally by 2040 under an ambitious circularity scenario

46,000
net new direct jobs created

nationally by 2040 in recycling, reuse, and collection, with **100,000–200,000 total jobs** when indirect employment is included. For New York State, this means expanded opportunities for in-state jobs in materials collection, sorting, processing, and recycling infrastructure.

$4.9 billion
per year

in additional revenue for the U.S. recycling industry by 2040, with New York positioned to capture a share of this value through growth in the recycling sector.

Environmental benefits nationally by 2040 under an ambitious circularity scenario

↓ 50%

PET waste to landfill or incineration, compared to current trends, reducing pressure on New York State landfills and dependence on out-of-state disposal.

↓ 50%

virgin PET consumption compared to current trends.

↓ 60%

greenhouse gas emissions for PET packaging, relative to current trends.

70%

recycling rate for PET packaging, up from 23%, and **20-fold increase** for polyester textiles (to ~19%).

Community benefits

Avoided cost pass-through to consumers from higher packaging and compliance costs, supporting affordability for New York households.

Reduced reliance on landfills and incinerators, which in New York are often concentrated near vulnerable and overburdened communities.

Lower risks of plastic leakage into local waterways, neighborhoods, and public spaces, improving environmental quality and community health.