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SYSTEMIQ

EXECUTIVE SUMMARY

Transforming PET Packaging and Textiles in the United States

Systems Change Scenarios and Recommendations to Cut Waste, Create Jobs, and Mitigate Climate Change

Advisory Partners: Closed Loop Partners, Eunomia, The Recycling Partnership – Solving for Circularity

ABOUT REPORT

This report assesses the current state of circularity of PET packaging and polyester textiles in the U.S., uses detailed system modeling to quantify the impact of applying proven circular approaches (reduce, reuse, recycling) under different scenarios, and outlines recommendations for government and the private sector to achieve the benefits of an ambitious scenario.

The study was commissioned and financed by Eastman.

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Systemiq, the systems change company, was founded in 2016 to drive the achievement of the Sustainable Development Goals and the Paris Agreement by transforming markets and business models in five key systems: nature and food; materials and circularity; energy; urban areas; and sustainable finance. A certified B Corp, Systemiq combines strategic advisory services with high-impact, on-the-ground work, and partners with business, finance, policymakers and civil society to deliver systems change.

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ADVISORY PARTNERS

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Closed Loop Partners is a firm at the forefront of building the circular economy, and is comprised of three key business segments: an investment arm, Closed Loop Capital Management; an innovation center, the Center for the Circular Economy; and an operating group, Closed Loop Builders. The Center for the Circular Economy executes research and analytics, unites organizations to tackle complex material challenges and implements systemic change that advances the circular economy. The Center's expertise spans circularity across the full lifecycle of materials, connecting upstream innovation to downstream recovery infrastructure and end markets.

Learn more at:
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The Recycling Partnership

The Recycling Partnership is a purpose-driven organization committed to building a better recycling system, one that delivers the economic and environmental benefits that our communities and the hundreds of thousands of people who work throughout the recycling industry deserve. The Recycling Partnership's team of experts, practitioners, and thought leaders with real-world experience works with its partners to insist on meaningful change across the recycling system and assist communities, companies, and policymakers in enacting such change.

Learn more at:
recyclingpartnership.org

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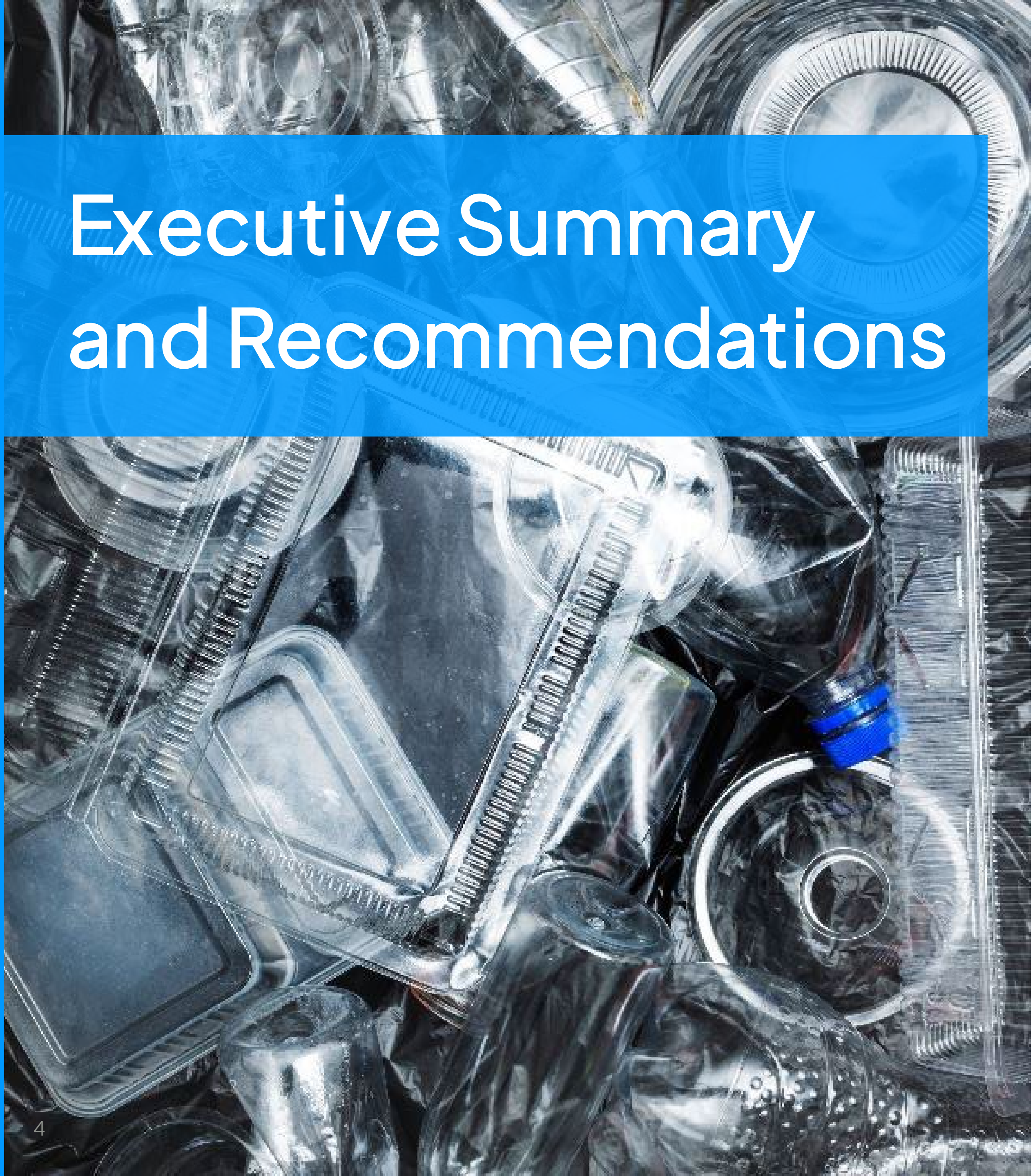


Executive Summary and Recommendations

Packaging and textile materials account for one-third of the annual material waste footprint of a typical U.S. citizen.[a,1] PET/polyester makes up 30% of all plastic packaging and textiles[b,2,3], with demand growing faster than for other packaging and textile materials.

PET (polyethylene terephthalate) plastic – known as polyester when spun into fibers – is a versatile material and the building block for products that we use every day in our economy, particularly in packaging and textiles. PET packaging applications include plastic bottles for beverages and cleaning products, as well as food trays and clamshells. Polyester textiles applications include apparel, curtains, carpets, vehicles, upholstery and many industrial applications.

Thirty percent of all plastic packaging and textiles sold every year in the United States are made from PET/polyester, with consumption growing 2.3% year-over-year[c]. PET consumption totals 62 pounds per U.S. citizen every year, one of the highest in the world[d]. Each year over 100 billion PET bottles and 10 billion polyester garments are sold in the U.S.[e].

Notes **a.** Systemiq analysis based on EPA waste generation data. Note the EPA data is based on municipal solid waste (MSW); **b.** Systemiq analysis based on EPA waste generation data and U.S. Plastic Pact; **c.** Systemiq analysis based on Dow Jones; **d.** The U.S. produces the most plastic waste per person worldwide with an average of 287 pounds per person per year for all plastics (Statista 2023); **e.** Systemiq analysis

The PET/polyester system in the U.S. is mostly linear today.

PET/polyester products are predominantly made from fossil fuel-derived feedstocks and the system in the U.S. is mostly linear with ~90% sent to disposal after one use, and 10% mechanically recycled.

Production and disposal of PET/polyester uses 320,000 barrels per day of oil-equivalent fossil fuels (2% of U.S. demand)[a] and generates 120 million metric tons of GHG emissions per year (CO_2 equivalent) – similar to all annual emissions from the State of North Carolina[4].

The 7.9 million metric tons of PET/polyester packaging and textiles sent to landfill or incinerated each year would have an estimated financial value of around $7 billion[b] if they were recycled.

Circular Economy Potential for PET/Polyester

PET/polyester is a material with high potential for circular economy approaches, including reduction, reuse, and material-to-material recycling via mechanical recycling or depolymerization recycling.

PET/polyester has properties that offer high potential for circularity. For example, the amount of PET/polyester used can be reduced with lighter-weight packaging, given the material's strength and durability even at low thickness. Conversely, PET containers can also be made into thick-walled formats designed to be reused multiple times. Resale and rental of apparel, including items made of polyester, is a prevalent and growing example of a reuse economy[c]. Mechanical recycling approaches[d] are well established for clear bottles and emerging for other applications. In addition, PET/polyester has a lower life cycle climate impact when compared to some packaging materials, such as glass (see *Annex A1*).

For harder-to-recycle formats, the molecular structure of PET/polyester is also well-suited to depolymerization recycling, sometimes called "molecular recycling". Depolymerization recycling, a material-to-material technology, converts PET/polyester back into monomers (the building blocks of new plastics) and then combines them again to make virgin-quality recycled PET/polyester. In contrast, other commonly-used plastics (e.g. polypropylene and polyethylene) are made from strongly-linked molecules that are not suitable for depolymerization recycling.[e] Depolymerization recycling is now entering the U.S. market at commercial scale with support from apparel and packaged goods companies and the federal government.[f]

Circular economy approaches are already generating environmental and economic benefits in the U.S. The apparel resale industry for all materials generates annual revenues of $45 billion and is growing quickly at 12% year-over-year.[g,5,6,7,8] PET packaging recycling is an industry estimated to generate in the order of $1billion annually in recycling revenue,[h] despite PET packaging

Notes **a.** Barrels of oil equivalent; **b.** Based on U.S. rPET price end of Q1 2024 ($1130/metric ton) and assuming high recycling yields; **c.** Note that all upstream reduction assumptions are laid out in detail in the technical appendix to this report. The lightweighting potential is based on reduction progress that has already been achieved; **d.** Cleaning and re-melting at low temperature without changing the plastic chemical composition; **e.** These other plastics require energy-intensive thermal process (e.g. pyrolysis) to break down the plastics into oils and gases, which then need further steps to be converted into new plastics (see Box 2); **f.** The first large-scale plant (capacity of 110kt per year) became operational in 2024 (Eastman plant in Kingsport) and 4 industrial-scale PET/polyester depolymerization recycling plants have been announced in the U.S. (Eastman, Syre, Revalyu, Ambercycle). Many innovators continue to advance the technology (e.g., Reterra, Circularix); g. Systemiq analysis based on fmi (2023), PYMNTS (2023), Statista, ThredUp (2024); **h.** Systemiq analysis recycling rates lagging behind comparable countries (23% in the U.S. vs. 42% in Canada)[9].

Textile circularity is a key challenge that requires systems-level change and new technology deployment in order to move away from reliance on recycling plastic bottles into textiles and towards textile-to-textile recycling at scale.

Polyester textile recycling has not yet achieved meaningful scale. As a result, recycled PET, used in both packaging and textiles, is only generated by recycling PET packaging ,and the vast majority of recycled polyester textiles today are derived from plastic bottles.

However, scaling up depolymerization recycling could offer a recycling solution for textiles with high polyester content. The virgin- quality recycled PET output from depolymerization could then be used to produce either packaging or textiles, resulting in a flexible system.

Scenario analysis carried out for this study examines the environmental and economic benefits that could be realized by scaling up proven circular economy approaches for both packaging and textiles. This analysis shows that accelerating the transition towards a circular economy could cut waste, reduce GHG emissions and create a significant number of U.S. jobs by 2040, with further improvements expected beyond that date.

The scenario analysis in the report shows that scaling up proven circular economy approaches for PET packaging and polyester textiles by 2040 could increase recycling rates for packaging to ~70% and for textiles to ~19% - a result that can only be achieved though the combination of mechanical and depolymerization recycling. This demonstrates strong progress towards a circular economy for PET/polyester and would provide the foundation for further systems change after 2040, particularly for textiles.

Virgin PET/polyester consumption could be reduced by almost half by 2040, relative to the continuation of current trends (from 13 to 7 million metric tons). Waste disposal could also be halved, from 12 to 6 million metric tons. GHG emissions from PET packaging could decrease by ~60%. If recycling solutions are localized in the U.S. and not outsourced to other locations, by 2040 the industry could generate about 46,000 more direct jobs in reuse and recycling than today (100,000–200,000 more when including indirect jobs) and $4.9 billion in additional revenue for recycling industries.

Accelerating the Transition to a Circular Economy for PET/Polyester

Acceleration of ambitious legislation, industry action, new technology scale-up and research is needed to address system challenges and scale PET/polyester circularity.

This report's analysis identifies a clear opportunity to reduce the environmental impact of PET/polyester consumption and unlock the economic, social and environmental benefits of a circular economy for these versatile and prevalent materials. There are some promising inroads towards PET/polyester circularity already in play, but there is a need for ambitious government and private sector action—as well as cross-sector collaboration and additional research—in order to address economic and structural barriers to circularity, and to achieve the benefits projected in this report.

RECOMMENDATIONS FOR GOVERNMENT

Government policy makers at the state and federal levels have a critical role in setting ambitious legislation and program goals to create the enabling conditions for the transition from a linear economy to a safe and sustainable circular economy for PET/polyester.

A range of policy instruments, as well as implementation approaches, are required to work in parallel, with harmonization between states where possible. Well-designed Extended Producer Responsibility (EPR) legislation is highlighted as a particularly important policy instrument for both packaging and textiles. EPR is already in use in five states and has the potential to scale up circular economy approaches by creating financial incentives for sorting and recycling investments and improved product design[a].

Six recommendations are identified for government:

1 Adopt best practice policies and implementation approaches to reduce unnecessary consumption of textiles and single-use packaging. Examples include:

- **Restrictions and disclosure requirements** on the destruction of unsold apparel, alongside **policies to disincentivize "fast and ultra-fast fashion"** and **reduce the use of unnecessary packaging.**
- **Reuse/refill mandates or incentives** to support the transition from single-use to reusable packaging.
- **Collaborating with industry** to develop new circular systems for practical applications: for example, closed loop reuse systems for beverage containers at venues (e.g. malls, universities), events (e.g. sport stadiums), or city-level reuse/refill initiatives, including public water fountains.

Note a. In the past three years, Extended Producer Responsibility (EPR) legislation for packaging has been enacted in five states with ten other states considering EPR laws, in addition to Deposit Return Systems for beverage containers in ten states (Bottle Bills – a type of EPR legislation). The core of EPR is a financial mechanism that holds producer companies responsible for products at end-of-life and mobilizes industry financing to improve recycling economics compared to primary material production. Although lagging behind packaging, legislation to improve textiles circularity are now also gaining momentum and have been adopted in two states.

2 Introduce well-designed EPR legislation for both packaging and textiles,

seeking harmonization and convergence where possible within the U.S., building on lessons learned domestically and globally, and ensuring that EPR legislation is designed to support the key pillars of the PET/polyester circularity approach outlined in this study. For example, EPR legislation should:

- **Encourage and reward product design for circularity through eco-modulation**[o] (including durability, reuse, recycling, and low microplastic release);
- **Incentivize U.S. domestic infrastructure,** leveraging existing sorting and recycling systems and scaling up new ones, rather than large-scale imports of recycled materials. This will help increase U.S. recycling rates and reduce landfill volumes over time;
- **Consider high-yield material-to-material recycling technologies** as a responsible end-market to widen the scope of products that can be recycled into high-value outputs. Ensure that EPR system design allows for innovation of high-yield material-to-material recycling technologies and has the flexibility to adapt as technology, infrastructure and product design evolve;
- **Adopt differentiated strategy for textiles EPR** compared to packaging, taking into account different global supply chain configurations; supporting circular and durable design, apparel resale/recommerce and not only recycling; and considering the impact of EPR fees on export markets for apparel resale. Clarity on how markets for collected recyclables are defined and considered is particularly important for establishing textiles EPR, while accounting for full coverage of "net costs"[a] is required to incentivize investments in sorting and recycling infrastructure;
- **Be clear on which packaging and textiles products will be covered,** the recycling targets or KPIs that will be applied, and who is obligated to meet them, and ensure that EPR systems are interoperable across states;
- **Provide support for a broad range of interventions to enable circularity** including end-market development and research and development (R&D) funding via the Producer Responsibility Organization (PRO);
- **Encourage flows of recycled materials into high-value end products** with potential for multiple recycling loops rather than low-value non-recyclable products; this supports the economics of recycling and thus encourages investment in infrastructure;
- **Evaluate the benefits of integrating well-designed Deposit Return Systems** (DRS) for beverage containers (commonly referred to as Bottle Bills) on top of a curbside collection model for all other packaging and textiles; this analysis should take into account the proven potential for significantly higher recycling rates within DRS systems and the opportunity to prevent contamination versus the potential downside impacts of lower value of curbside packaging recycling streams when beverage containers are removed;

Note a. Net of recycling revenues

3

Enact policies to increase demand for post-consumer recycled content (rPET) to reduce market volatility. Examples include:

- Recycled content mandates in legislation;
- Variable EPR fees (known as eco-modulation);
- Incentives and public procurement rules promoting use of recycled materials from U.S. recyclers;
- Supporting the development of end-markets for recycled materials; and
- Implementation of credible mechanisms to account, trace, and ensure safe recycled content from plastic waste inputs to recycled plastic.

4

Set recycling targets by product type for both packaging and textiles, expand coverage of curbside recycling collection for all packaging types, and establish highly-localized drop-off points for textiles, combined with extensive public education campaigns.

5

Increase the price of sending waste to disposal through higher landfill and incineration fees to further boost reuse and recycling and disincentivize linear models.

6

"De-risk" private sector investments by increasing public investment into circularity infrastructure, technology, and research.

Public investment can be made as grants or loans from the federal through municipal level or incorporated into blended financing opportunities. Public sector investment can support a systems-change "tipping point" by catalyzing investment from the private sector into reuse and recycling infrastructure, including collection, sortation and high-yield material-to-material recycling. In addition, many of these infrastructure investments are capital-intensive, with longer payback periods, and so could benefit from "de-risking" from the public sector.

RECOMMENDATIONS
FOR INDUSTRY

PET/polyester producers and recyclers are investing in new technology innovation and scaling.

Consumer goods companies are making ambitious commitments to eliminate unnecessary packaging and reduce virgin plastic use, design products and packaging for reuse or recycling, and use post-consumer recycled content in packaging[a].

Commitments to use recycled polyester in apparel have also emerged across the fashion industry, currently almost fully reliant on mechanically-recycled PET from plastic bottles but with some companies aiming to prioritize textile-to-textile recycling[b].

These are all promising trends, but wider adoption and accelerated action is still required to support the transition to circularity. Five recommendations are identified for companies in the packaging and textiles value chain:

7 Reduce unnecessary consumption (and waste) of textiles and single-use packaging,

through reduction of material use, collaborating on deploying reuse/resale systems, reselling or donating unsold textiles, and moving away from "fast and ultra-fast fashion" business models.

8 Implement best practice design for circularity

through industry collaboration and alignment to enable durability and multiple reuse cycles, maximize recycling and the production of high-value rPET, and minimize microplastic release. Accelerating design for circularity while maintaining fitness for use is particularly necessary for polyester textiles, including shifting from blends to high-purity textiles, and will require value chain collaboration to align on best practices.

Notes a. PepsiCo commits to 100% rPET use for all bottles in the U.S. by 2030. Coca-Cola aims to have at least 25% of beverages by volume sold in refillable or returnable containers, 100% packaging recyclable and use at least 50% recycled content by 2030; b. Most brands' commitment on polyester is focused on rPET incorporation, but a few are also aiming to support textile-to-textile recycling (e.g. Patagonia, VF, Lululemon).

9 Maximize textile collection for reuse and recycling

by offering and incentivizing take-back programs and accessible collection points in apparel, homeware, and carpet stores and collaborating with existing collection programs. Collaboration on collection will lay the groundwork and gather brand/retailer momentum behind EPR policy for textiles.

10 Increase procurement of domestically-generated post-consumer recycled content from both packaging and textiles through long-term contracts

to reduce market volatility and boost domestic infrastructure investment. Reducing the textile industry's reliance on rPET from bottles is necessary in order to strengthen the circularity of both value chains.

11 Implement best industrial practices

to control microplastics generation, capture microplastics during use phase (e.g. washing machine filters) and during the recycling and handling process (e.g. dust and water controls).

RECOMMENDATIONS FOR

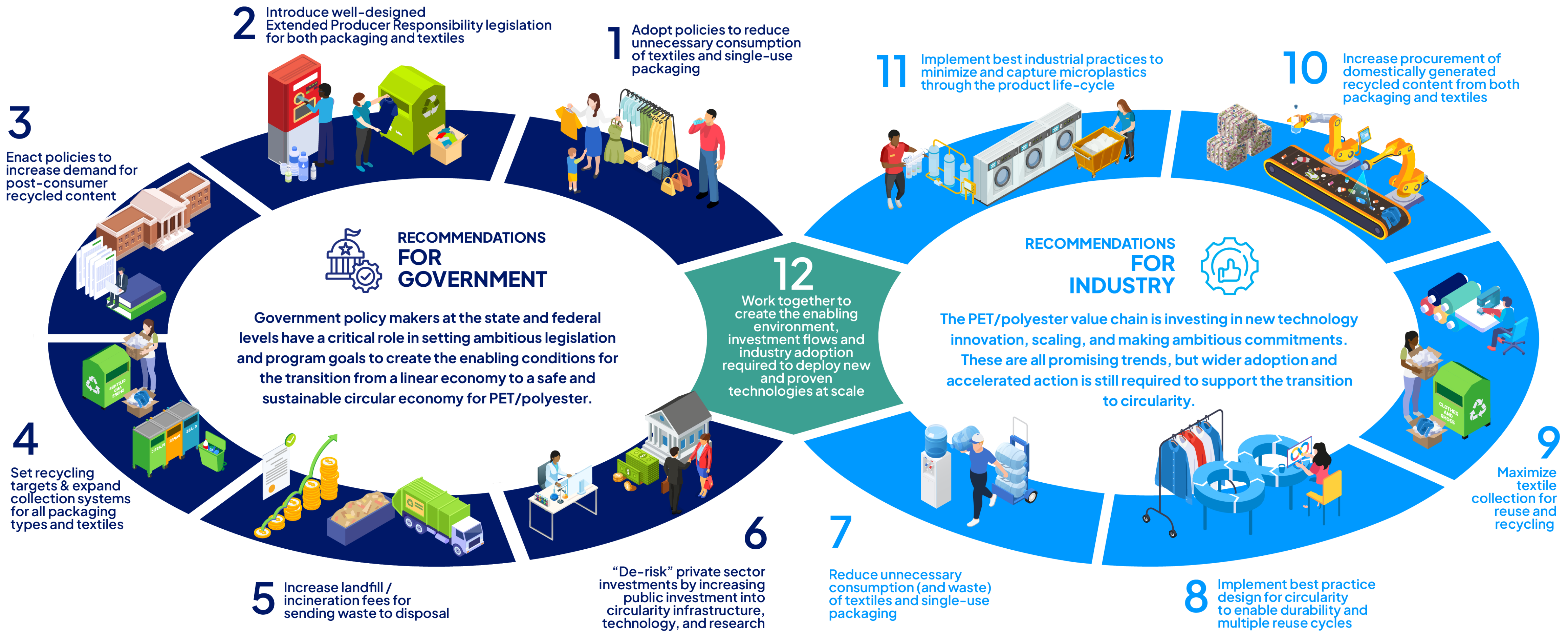
CROSS-SECTOR COLLABORATION

The study highlights the range of new and proven technologies that are now available to accelerate action across the full spectrum of circular economy approaches. Scaling up these technologies will require coordinated action from government, industry, investors and research institutions, as identified in the following recommendation:

12 Work together to create the enabling environment, investment flows and industry adoption required to deploy new and proven technologies at scale.

Examples include digital technologies to forecast demand and reduce unsold stocks in textiles, advanced sensor-based and AI-enabled sorting of packaging and textiles for resale, reuse or recycling, and deployment of advancements in both mechanical recycling and depolymerization recycling.

Twelve recommendations to address system challenges and scale PET/polyester circularity.



RECOMMENDATIONS FOR FUTURE RESEARCH

Key outstanding system questions and knowledge gaps have been identified in this study and are recommended for further research, including:

- **Strategies to unlock higher recycling rates for end-of-life textiles,** above and beyond the ambitious application of proven approaches in this study, where polyester textiles only reach 19% recycling rate by 2040. This includes research into consumer behaviors.
- **Further definition of principles for complementary mechanical and depolymerization recycling** based on environmentally- and economically-optimal feedstock allocation principles and practical approaches to implementing these principles.
- **Potential impacts of recycled PET imports on recycling industry growth and recycling rates in the U.S.** Imports currently account for around 20% of recycled PET use in the U.S. while domestic recyclers run below capacity[10].
- **Environmental justice and consumer health concerns, including the extent and impact of packaging and textile supply chains** contribution to microplastics pollution and exposure to chemicals of concern[11], and the most effective mitigation measures.
- **Optimal distribution of recycled PET from mechanical and depolymerization recycling to product applications,** including environmental, cost and logistics considerations. This can be impacted by rPET quality requirements (e.g. depolymerization generates virgin quality rPET), manufacturing locations (e.g. polyester textiles could be recycled in the U.S. , whereas the majority of production of new textile products occurs outside U.S.).
- **Environmental impact trade-offs between different material and system alternatives**, including comparing circularity and climate impacts of PET/polyester compared to other materials such as polypropylene and polyethylene with credible life cycle assessments at a granular product level and also between reuse and single use systems.

Conclusion

The quantitative modeling carried out for this study demonstrates **the potential for system innovations** in the packaging and textile sectors to achieve waste reduction, resource conservation and climate mitigation goals, and create green jobs. **The size of the prize is substantial.** Momentum is building through shifts in the EPR policy landscape, ambitious circularity commitments and action in the packaged goods and fashion sectors, and new technologies emerging at scale.

Coordinated and ambitious action is now required across industry value chains and multiple levels of government to unlock these benefits and create examples of circular and low-emissions PET/polyester value chains at scale that can be emulated by other material systems.

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This report assesses the current state of PET packaging and polyester textiles circularity in the U.S., uses detailed system modeling to quantify the impact of applying proven circular approaches (reduce, reuse, recycling) under different scenarios, and outlines recommendations for government and the private sector to achieve the benefits of an ambitious scenario.

For further information please see systemiq.earth/pet-polyester-us
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