Balancing Cost and Sustainability: Evaluating the Viability of Plastic Alternatives

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Executive Summary

The global plastics industry is facing mounting regulatory, environmental, and health pressures that are reshaping market dynamics. With approximately 418 million metric tons produced in 2023, and contributions of 3.4% of global greenhouse gas emissions, the plastics industry's scale and impact demand attention.

Environmental and human health have been affected as microplastics have been detected in human organs, thus driving litigation, policy action, and growing consumer demand for safer alternatives. Consumer willingness to pay premiums for sustainable packaging ranges from 10-30%, even though corporate adoption remains slow due to cost differentials and supply-chain challenges. Regulatory frameworks are tightening globally, with the EU's Paper Packaging and Waste Directive (PPWD) and California's SB 54 establishing precedent for the strictest Environmental Producer Responsibility (EPR) legislation in the United States.

For investors, this transforming landscape presents opportunities through deploying strategic capital into fiber-based coating innovations, recycled plastic alternatives, and niche applications to achieve cost and performance standards equivalent to virgin plastics.

Through this report, CREO evaluates the economic and environmental viability of plastic alternatives, finding that while fiber-based alternatives and recycled plastics have established market pathways, emerging innovations in niche applications present early-stage investment opportunities.

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1 Introduction to plastics

1.1 Common virgin plastic types

Plastics, and particularly the growing awareness of microplastic toxicity, have become central to global sustainability debates. Over the past decade, the plastics industry has faced mounting headwinds: ongoing litigation, tightening regulatory frameworks, and a steady stream of scientific studies highlighting the environmental and health consequences of plastic use. Simultaneously, consumer packaged goods companies (CPG) are slowly moving away from plastics as many consumers are deeply concerned about the impact of single-use plastic on the environment. These forces are reshaping market dynamics.

To frame the conversation, CREO has focused on the seven primary virgin plastic polymers that dominate consumer products: Polypropylene (PP), Polyethylene (PE), including both high and low-density (HDPE, LDPE), Polyvinyl Chloride (PVC), Polyethylene Terephthalate (PET), Polyurethane (PU/PUR), and Polystyrene (PS). For investors, understanding the economic and regulatory trajectory of each of these polymers is critical to assessing risk exposure and identifying opportunities in recycling, alternative materials, and circular economy innovations.

1.1.1 How do these virgin plastic polymers differ?

Virgin plastics are a type of synthetic polymer made from hydrocarbons derived from crude oil. Hydrocarbons are organic compounds that can either have a cyclic benzene ring made up of carbons and hydrogens or no ring.

The process to produce virgin plastics starts when crude oil is identified. Oil is then extracted from underground to the surface, where tankers are used to transport the oil to the shore. The pumped oil is then transported to an oil refiner and further goes through a process called fractional distillation.

This process ensures the production of plastics by first heating the crude oil in a furnace, then feeding it as a vapor to the factional distillation tower. The tower separates the mixture into different compartments, called fractions. The mixture of liquid and vapor fractions gets separated in the tower, depending on their weight and boiling point, and when the vapor evaporates and meets a liquid fraction, it partly condenses.

Vapors of the lightest fractions, such as gasoline and petroleum gas, flow to the top of the tower. Intermediate weight liquid fractions, kerosene and diesel oil distillates, lingers in the middle, and heavier liquids and gas oils separate lower down. Through this distillation, petroleum is decomposed into petroleum gas, gasoline, kerosene, naphtha, light oil, heavy oil, etc.[1]

Post distillation, the long-chain hydrocarbons are then cracked to break down the mixture of complex hydrocarbons into simpler molecules. Cracking can be performed in two ways, steam or catalytic. Steam cracking uses high temperature and pressure to break the hydrocarbons down without a catalyst. Catalytic cracking adds a catalyst that allows the process to occur at lower temperatures and pressures.

To produce plastics, naphtha and natural gas from oil refining operations are typically the raw materials used as feedstock. Thus, the raw-material molecules are converted into such monomers as ethylene, propylene, butene, etc., and are then linked together. Chemically, these polymers are made up of repeating monomers, or small molecule units. The most common plastics fall under two family of polymers, thermoplastics, and thermosets.

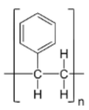
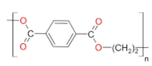
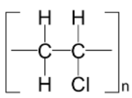
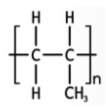
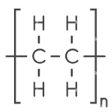
Thermoplastic polymers:

These polymers are a type of plastic that soften and become moldable when heated and then processed through extrusion, injection molding, thermoforming, and blow molding. These polymers harden once cooled and can undergo this process multiple times with no changes in chemical properties.[2]

Thermoplastics are produced by joining monomers together to form longer chains through polymerization. Depending on the type of monomer, the chains could have side branches. If only a few short side branches occur, then the chains form ordered, crystalline regions. However, if these chains have many large side branches, it makes the regions less ordered leading to the polymer being amorphous. Examples of these amorphous polymers are PS and PVC.

Even with polymers with crystalline regions, there are always some amorphous regions between the crystallites, leading to them being called semi-crystalline. Examples of these semi-crystalline polymers are PE, PET, and PP. For these polymers, as the temperature increases it is much easier to break the bonds between polymer chains and allow the plastic material to be shaped.

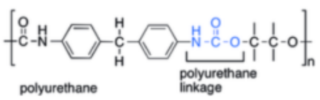
Figure 1: Leading thermoplastic polymers

Chemical Structure	End-use Industries	Performance characteristics	Chemical Structure	End-use Industries	Performance characteristics
Polystyrene (PS) 	• Packaging • Building & construction • Consumer goods • Medical	• Lightweight • Transparent • Rigid	Polyethylene Terephthalate (PET) 	• Packaging • Textiles • Automotive • Electronics • Medical	• High tensile strength • Rigid • Durable • Heat resistance • Excellent barrier qualities
Polyvinyl chloride (PVC) 	• Construction • Electrical • Medical • Consumer goods	• Durability • Corrosion resistance • Flame retardant • Excellent dielectric properties	Polypropylene (PP) 	• Packaging • Automotive • Textiles • Medical • Consumer goods	• Versatile • Durable • Chemical resistance • Lightweight • Heat resistance
Polyethylene (PE) 	• Packaging • Building & construction • Consumer goods • Medical • Agriculture	• Chemical & moisture resistance • Electrical insulation • Durability • Low melting point	HDPE/LDPE	• Building & construction • Packaging • Consumer goods • Coatings	• HDPE: Chemical resistance • HDPE: Rigid • LDPE: flexible • LDPE: transparent

Thermoset polymers:

Thermosets are plastic formed by permanently hardening a resin through a process called curing. And unlike thermoplastics, once cured, thermosets cannot be melted and reshaped as these polymers undergo irreversible chemical reactions during curing, creating strong cross-linkages between polymer chains. This strong cross-linkage increases strength and resistance; however, it can make the material more brittle. Aside from acrylic, PUR is a type of thermoset plastic. PUR is formed by combining isocyanate resins with polyols. Thermoset polymers are often used in the automotive, construction, and electronics industries. In consumer applications, they are more common in soft-drink containers and special packaging as lining. Thermoset polymers are often used as a protective coating on a variety of applications.

Figure 2: Leading thermoset polymers

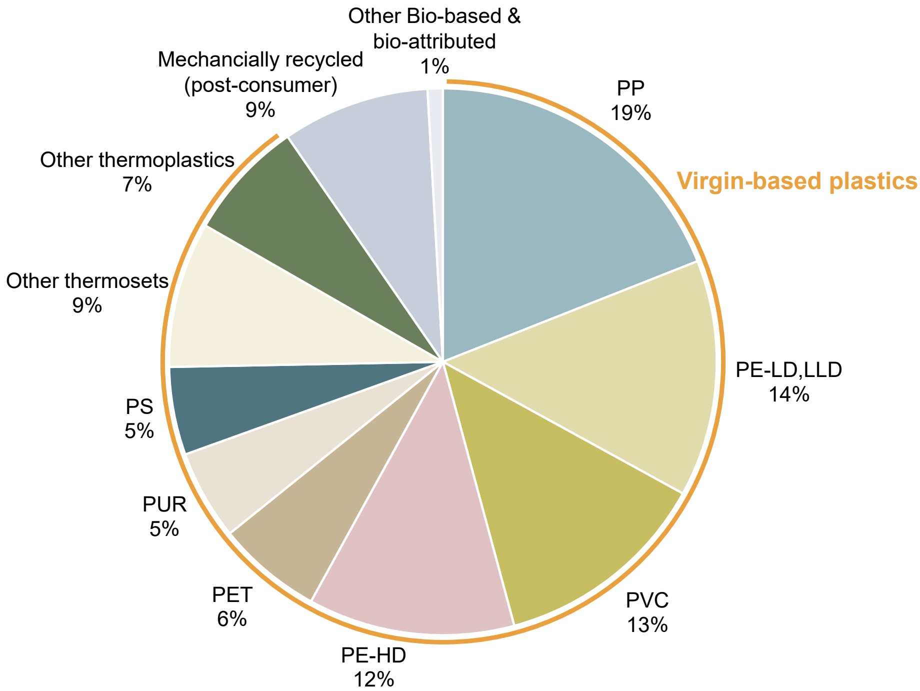
Chemical Structure	End-use Industries	Performance characteristics
Polyurethane (PUR)  	• Automotive • Building & construction • Furniture • Consumer goods • Coatings	• High elasticity & flexibility • Durable • Chemical resistance • Versatility • Excellent thermal insulation

1.2 Market overview

As of 2023, global plastics production reached approximately 418 million metric tons. The industry remains overwhelmingly dependent on fossil-based feedstocks, which account for nearly 90% of total output. The remaining 10% is comprised of circular alternatives, including mechanically recycled (post-consumer) plastics, bio-based polymers, chemically recycled materials, and other emerging categories.

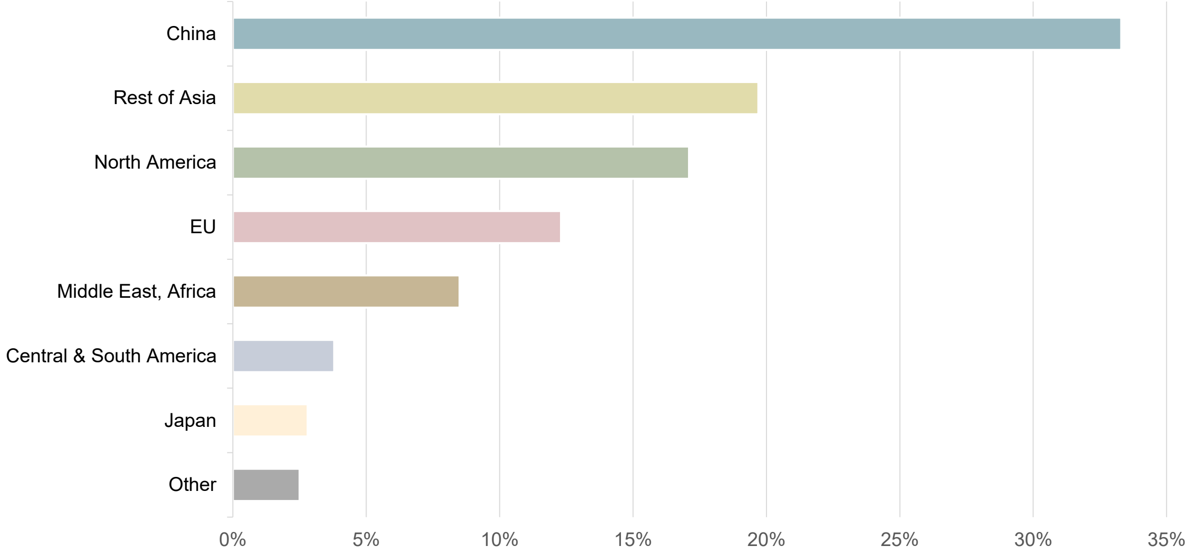
From a resin perspective, PE dominates the global market, representing more than 25% of total production. PP follows at 19%, with polyvinyl chloride PVC and PET rounding out the next largest segments. These resins form the backbone of consumer and industrial applications worldwide.[3]

Figure 3: Global plastic production by resin



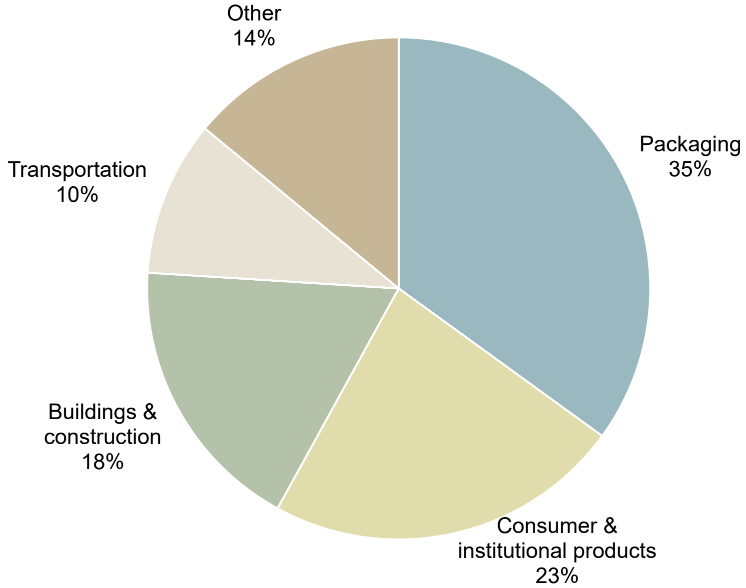
Geographically, production is concentrated in China and the broader Asia-Pacific region, which together account for slightly over 50% of global virgin plastics output. North America contributes approximately 17%, while Europe represents about 12%.

Figure 4: Global plastic production by region



In terms of end-use, plastics remain heavily skewed toward packaging, which represents more than 35% of demand. Other significant applications include consumer goods and building and construction materials, highlighting the sector's deep integration into everyday economic activity.

Figure 5: Global plastic production by end-use application



1.3 Environmental effects

Plastics present a unique sustainability challenge as they do not naturally degrade in the environment, leading to persistent accumulation across ecosystems. With almost 80% of microplastics found on land, and roughly 20% found in the water, microplastics are a global issue and have entered the environment in diverse ways: irrigation, sewage sludge, littering, atmospheric deposition, etc. Microplastics are also prevalent in the marine environment due to hydrodynamic processes and wind and ocean current transportation. Due to their tiny sizes, microplastics can be ingested accidentally by marine organisms such as fish, mussels, zoo plankton, sea birds, etc.[4]

Beyond ecological damage, plastics carry significant climate implications. In 2019, the Organization for Economic Cooperation and Development (OECD) estimated that plastic products were responsible for 3.4% of global greenhouse gas (GHG) emissions across the entire life cycle. The World Economic Forum (WEF) further warns that, absent intervention, the global plastics industry could account for up to 15% of global carbon emissions by 2050.[5]

1.4 Human effects

Microplastics and nanoplastics, types of much smaller microplastics, have emerged as a central focus of global litigation, regulatory scrutiny, and public health concerns. Current estimates suggest that 10 to 40 million metric tons of these particles enter the environment annually, with volumes projected to double by 2040 if current trends persist.[6]

Research indicates linking exposure to serious health outcomes, including cancer, cardiovascular disease, reproductive complications, and other systemic disorders. Microplastics have been detected across multiple human organs and tissues: including the brain, heart, stomach, lymph nodes, placenta, and reproductive systems.

Animal and cellular studies reinforce these concerns, associating microplastic exposure with inflammation, immune system impairment, tissue deterioration, altered metabolic function, abnormal organ development, and cellular damage.[7] In 2024, pediatric otolaryngologist Dr. Kara Meister documented significant microplastic presence in pediatric tonsil tissue, not only on the surface but embedded deep within.[7] Her team further identified teflon particles under microscopic analysis, underscoring the pervasive infiltration of plastics into the human body. Despite extensive research, critical unknowns remain, such as the duration of microplastic retention in the body and how individual genetics, environmental factors, or lifestyle may influence health outcomes.[7]

With microplastics posing escalating risks to both human health and environmental stability, the investment community has a critical role to play in driving the transition away from traditional plastics.

2 Alternatives to plastics

In this paper, CREO evaluates the comparative economics, sustainability benefits, and performance of emerging alternatives to conventional plastics. The analysis is structured across three major segments: bio-based alternatives (paper and molded fiber), circular plastics (bioplastics or recycled plastics), and niche applications such as mycelium-based or seaweed-based alternatives.

2.1 Bio-based alternatives (Paper and molded fiber)

Bio-based alternatives, particularly paper products, have steadily gained traction as substitutes for plastics. Derived from renewable and abundant lignocellulosic biomass, paper products offer clear sustainability advantages: they are often recyclable, biodegradable, and widely accepted and perceived as sustainable by consumers.

The primary applications for paper are in packaging, consumer goods, and single-use items. Global demand for paper-based alternatives continues to rise, driven by both consumer preference for sustainable products and policy mandates that penalize virgin plastics. For investors, this segment represents a scalable and proven pathway toward capturing growth in sustainable packaging markets.

2.2 Circular plastics

Circular plastics currently account for approximately 10% of global plastic production, with the majority derived from post-consumer mechanically recycled materials. Bio-based plastics remain a small fraction, representing less than 1% of circular output.

Mechanical recycling involves a series of processes: sorting, grinding, re-granulating, compounding, and washing. These processes are required to convert waste plastics into reusable materials. This method is most effective with thermoplastics such as PE, PP, and PET, which are commonly repurposed into packaging films, bags, food containers, beverage bottles, and textile fibers.

According to a McKinsey study, there is an opportunity for up to $50 billion investment across the value chain to add up to 20-25 MT of advanced and high-quality mechanical recycling, along with supporting feedstock supply by 2030.[8] Uniting players across the value chain will be key to derisking the investment.

For investors, while cost-competitiveness remains challenged by virgin resin, regulatory incentives and consumer demand for increased recycled content are expected to strengthen margins over time.

2.2.1 Polyhydroxyalkanoates (PHA) and Polylactic Acid (PLA)

Within the bioplastics segment, PHA and PLA are leading the transition away from virgin plastics. Bioplastics, such as PHA and PLA, are often derived from biodegradable and renewable sources.

PHA is a group of biopolymers produced by bacterial fermentation. The fermentation process typically requires natural feedstock like plant oils or wood residue. Once the microorganisms receive the feedstock, it is then subjected to specific conditions to encourage PHA production, which these microorganisms store as an energy reserve. The PHAs are then extracted or harvested from the bacteria and put through a purification process, before it is processed into usable plastic products.[9]

PHA's are fully biodegradable, making them compostable plastics and can decompose in marine environments and landfills. PHA plastics also are highly flexible, strong, and are durable, akin to many conventional plastics, and deal with heat well. With many plastics typically utilized as food contact material, barrier properties are a key requirement to meet performance standards. PHAs, in this case, also have excellent barrier properties, keeping out water vapor and gases. PHAs typically are utilized as packaging solutions for consumers, food service, and also in such medical applications as sutures and drug-delivery systems.

PLA is a natural bioplastic that comes from plants like corn and sugarcane. The fermentation of these plant sugars leads to the production of lactic acid, forming the building blocks of PLA. Further through polymerization, it links these acids together to create biodegradable PLA. Blending PLA with other polymers leads to differing properties for varying applications.[10] The strength, durability, and flexibility of these new plastics all vary depending on how they are made and the application of different additives, like plasticizers, antioxidants, and anti-hydrolysis agents.

Unlike PHAs, PLAs do not have a high melting point and have difficulty coping with warm or hot conditions as the heat makes them break down and lose their shape. PLAs also have limited durability, as they wear out fast, especially if used outside or exposed to light, moisture, and changing temperatures. Typical PLAs might also be renewable and recyclable, but not entirely sustainable. They can only decompose under industrial composting conditions and therefore are not naturally biodegradable. PLA plastics typically are utilized in food packaging applications as well as medical applications.

2.3 Niche applications

Beyond mainstream alternatives, niche innovations are emerging as high-potential disruptors in specific applications.

Mycelium, grown using agricultural waste, forms biodegradable materials that can replace PS in applications such as food containers and shipping insulation. Unlike Styrofoam, mycelium decomposes naturally within weeks, leaving no harmful residue. Mycelium is also utilized in construction and insulation, fashion, and apparel, along with furniture and automotive industries.

Seaweed-based applications, produced from a plant that is abundant along tropical coastlines, require minimal cultivation resources. Seaweed can be processed into biodegradable films, coatings, and wraps. These materials provide a renewable, fully biodegradable alternative to plastic food packaging, avoiding the long-term persistence of traditional plastics in landfills and oceans. Aside from packaging, seaweed-based applications are utilized in agriculture and automotive industries.

Three main types of seaweed exist, red, brown, and green. Red seaweed, the most abundant, contains sulphated galactans that are largely applied to biopolymers for food industrial applications, also containing thinning properties that make them useful in food and medical applications. Polysaccharides derived from brown seaweed are thought to influence properties of film packaging. When applied to packaging, this seaweed type could increase solubility in water, enhance tensile strength, and elongation at break.[11]

For investors, niche applications represent early-stage opportunities. While scalability and cost still remain a challenge, these innovations that are also sustainable alternatives align strongly with consumer demand for novel sustainable solutions and could capture premium market segments in key industries. Currently, seaweed costs more than plastic due to the need for manual processing.

3 Are consumers willing to pay the premium?

3.1 Packaging end-uses

Consumer purchasing decisions are emerging as a primary driver of the transition toward plastic alternatives. According to a survey of over 2,000 American consumers, more than 54% of respondents actively choose products with eco-friendly packaging, while 90% indicated they are more likely to buy from brands that adopt sustainable packaging practices.[12] These findings highlight the growing importance of consumer sentiment in shaping market dynamics and brand competitiveness.

Generational trends are particularly influential. Millennials and Generation Z consumers are at the forefront of this shift, with more than half reporting that they had consciously purchased products with sustainable packaging within the six months preceding the survey. Their preferences are reshaping demand patterns globally, positioning younger consumers at the forefront of low-waste and plastic-free adoption.

Despite this momentum, barriers remain. Consumers are hesitant to fully transition to alternatives due to higher costs, limited availability, and concerns about greenwashing. More than 40% of consumers expressed willingness to pay a premium for sustainable packaging. However, the critical question for both consumer packaging companies and investors is the extent of this “willingness to pay a premium”, particularly under economic stress.

3.1.1 Food service packaging case study

Plastic food service packaging represents one of the largest contributors to plastic waste and environmental debris. Yet, many food service businesses remain reluctant to adopt environmentally friendly alternatives, citing cost concerns and the challenge of passing those costs on to consumers.

Recent studies assessing consumer willingness to pay in both dine-in and takeout scenarios found that 66% of respondents were willing to pay an additional $0.40–$0.50 per person per meal for plastic-free alternatives. This willingness did not vary between dine-in and takeout contexts, suggesting broad consumer acceptance of modest price increases. The incremental cost was sufficient to offset the expense of substituting items such as paper plates, bowls, cups, and takeout containers.[13]

Education and heightened environmental awareness were identified as key drivers of this willingness to pay. However, risks remain during periods of economic downturn or high inflation. Consumer tolerance for price premiums may weaken, creating volatility in demand for sustainable alternatives.

Food service companies have already made the transition to plastic alternatives. Yum! Brands are actively replacing plastic packaging like expanded polystyrene across KFC, Pizza Hut, Taco Bell, etc. and transitioning to fiber-based, recyclable, or compostable materials. McDonalds is working to accelerate solutions to help reduce waste, while also transitioning to more sustainable packaging.

3.1.1.1 Alternatives to virgin plastic case study: Take-out containers

For this case study, CREO limited the scope to focus specifically on wholesale prices for take-out containers, excluding cups, cutlery, straws, etc.

In terms of wholesale prices for take-out clamshells, plastic clamshells remain the cheapest option. Fiber-based products, inclusive of both paper and molded fiber, were priced 10-15% higher than plastics. Seaweed-based compostable clamshells followed with costs ranging from 60-70% higher. Recycled plastics were the most expensive, ranging 100-125% higher than virgin plastic equivalents.

Similar dynamics applied to soup and deli containers, where plastics dominate on cost, while fiber and recycled alternatives remain significantly more expensive.

Table 1: Food service takeout case study results

	Clamshell container wholesale prices (compared to plastics)	Deli container wholesale prices (compared to plastics)
Fiber-based alternatives	10-15%	35-100% (wide range depending on paper or molded fiber application)
Niche alternatives	50-70%	n/a
Recycled plastics	100-125%	100-200%

3.2 Textiles

Sustainable fashion in the United States spans a diverse set of textile categories, including organic cotton, recycled polyester, hemp, linen, and other lower-impact materials.

Recycled polyester, for example, is produced by converting PET bottles into usable fibers, a process that requires substantially less energy than manufacturing virgin polyester. Hemp offers another attractive input due to its rapid growth cycle, high yield, and minimal water and pesticide requirements. Linen, derived from flax, is both durable and biodegradable and typically requires fewer agricultural inputs than conventional fiber crops.

Purchasing decisions are increasingly influenced by environmental considerations and supply-chain transparency, with a growing segment of consumers willing to pay a premium for products perceived as sustainable, durable, and ethically sourced. This shift has supported broader adoption of sustainable materials across apparel categories.[14]

Despite this momentum, price sensitivity remains a significant constraint on market expansion. A 2021 survey reported that more than 80% of consumers still view price as a primary purchasing factor, compared with just over 60% who cite environmental friendliness as important. A separate 2024 study similarly concluded that despite growing interest, higher costs remain a primary obstacle as sustainable products often come at a premium price, limiting accessibility.

This creates a strategic challenge for fashion retailers. Although consumers frequently express interest in sustainable products, actual conversion rates lag when retailers introduce higher prices. According to Deloitte's Gen Z and Millennial Survey, roughly six in 10 respondents in these cohorts report a willingness to pay more for sustainable goods, yet more than half acknowledge that economic uncertainty would make such trade-offs increasingly difficult.[15] As a result, retailers must balance sustainability commitments with pricing strategies that remain competitive in a cost-conscious market.

3.3 Automotives

The automotive sector, similar to packaging, is increasingly integrating bio-based plastics, natural fiber composites, and recycled ocean plastics into vehicle manufacturing. These materials enable automakers to reduce their reliance on conventional plastics and lower their overall environmental footprint, while still meeting the stringent safety, durability, and performance requirements of the industry.

Bio-based plastics are gaining traction as substitutes for traditional petroleum-based polymers. Offering comparable strength, durability, and weight characteristics, these materials are being adopted primarily for interior applications, including seat fabrics, trim components, and other non-structural parts.

Natural fiber composites are emerging as another eco-friendly material as they are strong, lightweight, and biodegradable, making them an attractive option for various vehicle applications. Some automakers are also experimenting with recycled ocean plastics.[16]

Consumer preferences are reinforcing this shift. Sustainability considerations are becoming increasingly influential in vehicle purchase decisions, prompting leading manufacturers such as Tesla and Volvo to integrate recycled materials into product design and highlight these features in their branding.

According to a roadmap published by the American Chemistry Council, approximately 97% of sustainability-oriented consumers indicate a willingness to switch to a more environmentally responsible vehicle brand, and roughly 60% are prepared to pay a premium exceeding 6% for a sustainable vehicle.[17] Unlike the textile industry, material innovation aligning with environmental performance may become a competitive differentiator in the automotive market.

4 Corporate strategies regarding virgin plastics

Beyond consumer-driven demand for sustainable packaging, corporations are committing to reducing their reliance on virgin plastics. According to the Ellen MacArthur Foundation's Global Commitment Progress Report, more than 1,200 organizations have pledged circular economy goals since 2018. Collectively, these companies represent approximately 20% of all plastic packaging produced worldwide and have set ambitious targets for 2025.[18]

Signatories have already demonstrated measurable impact and compared to the broader market; these companies have outperformed in key areas: reducing virgin plastic use, making packaging reusable, recyclable, or compostable, increasing the share of post-consumer recycled content and expanding production of recycled plastics.

The top three priorities for these corporations are: decreasing virgin plastic use in packaging, increasing recycled content across all packaging applications, and eliminating problematic or unnecessary plastic packaging. Additional progress areas involve transitioning toward reuse models and ensuring that 100% of packaging is reusable, recyclable, or compostable.

Despite meaningful progress in sustainable materials and practices, substantial structural challenges persist. Adoption remains uneven across the global market, with only a subset of industry leaders making significant commitments. Many organizations face financial and operational barriers, as sustainability initiatives often require sizable upfront investment in innovative technologies, infrastructure modernization, and workforce training. In addition, companies frequently lack robust systems for tracking and quantifying sustainability performance, making it difficult to demonstrate measurable returns to justify continued capital allocation or secure long-term stakeholder support. Complex, multi-tier supply chains further complicate implementation, as aligning all partners with a company's sustainability objectives can be both resource-intensive and operationally disruptive.[19]

Political dynamics have added another layer of complexity. Heightened scrutiny has increased the reputational and political risks associated with public sustainability commitments, prompting some companies to scale back or "greenhush" their initiatives. In most cases, these adjustments reflect strategic risk management rather than a reversal of underlying sustainability priorities. Firms are recalibrating their public positioning to reduce exposure to political polarization or regulatory uncertainty while continuing to pursue operational improvements internally.[20]

At the same time, companies that set aggressive sustainability targets to catalyze innovation often encounter execution challenges when those goals outpace existing infrastructure or technological readiness. Misalignment between ambition and operational capacity can undermine progress. Coca-Cola illustrates this dynamic: the company's pledge to achieve 100% recyclable packaging by 2025 and 50% recycled content by 2030 has proven difficult to meet. A 2023 environmental update showed global recycled content at only 27%, leading the company to extend its timeline to 2035 and scaling back certain commitments.

Ultimately, sustainability performance is shaped not only by internal capabilities but also by external pressures from consumers, investors, and regulators. Companies that fail to adapt risk falling behind more agile competitors that integrate ESG considerations into long-term strategy. For investors, these dynamics present opportunities to identify firms positioned to benefit from emerging technologies, improved supply-chain transparency, and growing demand for environmentally responsible products across the value chain.

5 Policy and Implications for a Circular Economy

Circular economic policies vary significantly across regions, becoming a driving force for the changing landscape of current supply chains and growing consumer demand towards alternatives. Thus, positively impacting both the regulatory environment and investment opportunities. Europe has adopted the most stringent framework, while the United States pursues a more pragmatic and fragmented approach. China, as a leading producer of plastics, also has introduced measures, though enforcement challenges remain.

5.1 Europe

Europe has positioned itself at the forefront of circular-economy regulation with the strictest legislation around the world. Two major legislative instruments are driving the changing landscape away from plastics: the Packaging and Packaging Waste Regulation (PPWR) and the Single-Use Plastic Directive (SUPD).

The most recent version of the PPWR was adopted in February 2025. It replaces the earlier Packaging and Packaging Waste Directive (PPWD). Effective from August 2026, it introduces binding obligations for businesses placing packaging on the EU market. The regulation covers the entire packaging lifecycle, from design and labeling to reuse systems and extended producer responsibility, with the goal of driving circularity, reducing waste, and harmonizing rules across Member States.[21]

Table 2: Recycled content and packaging waste targets in the PPWR[22]

	Targets by 2030	Targets by 2040
Recycled content		
Made from PET as a major component, except SU plastic beverage bottles	30%	50%
Made from plastic materials other than PET, except SUP beverage bottles	10%	25%
Single-use plastic beverage bottles	30%	65%
Other plastic packaging	35%	65%
Packaging waste prevention targets	At least 5%	At least 15%

The SUPD was adopted in 2019 and targets the environmental impact of single-use plastic products. Measures include market restrictions, consumption reduction, mandatory recycled content, and requirements for companies to cover litter clean-up costs.[23]

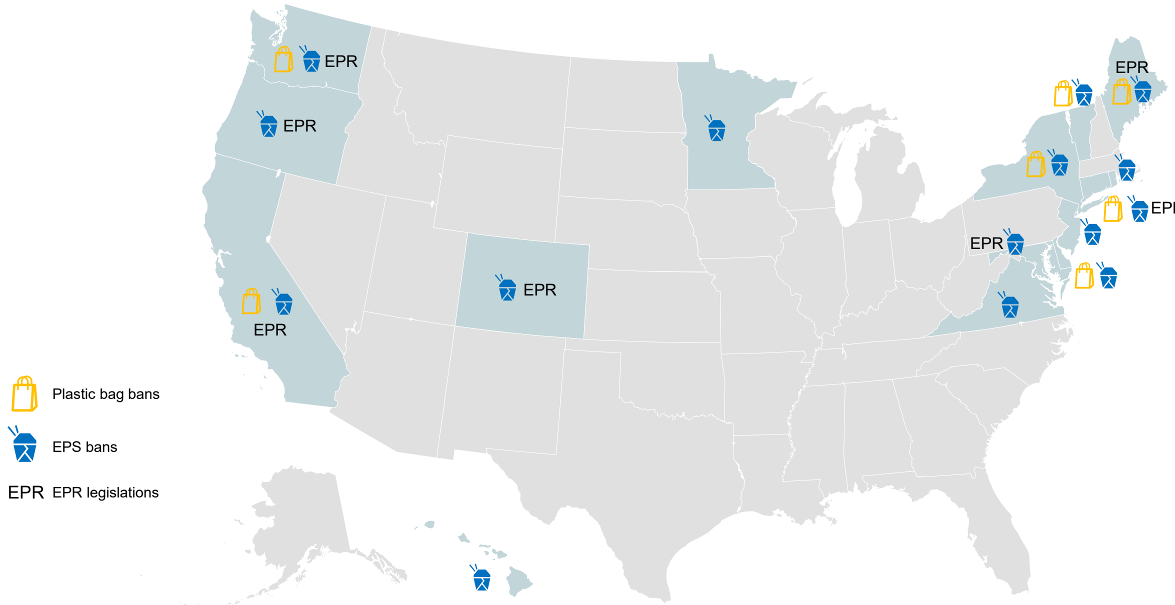
While these policies open pathways for plastic alternatives, challenges remain. Even fiber-based alternatives are considered in-scope under PPWR and SUPD due to plastic linings that complicate recycling. For investors, this creates opportunities to back start-ups and companies developing barrier coatings and advanced materials that enable recyclability and biodegradability without compromising performance.

In 2024, Ionkraft, a manufacturer producing chemically resistant barrier coatings offering product protection while being 100% recyclable, secured ~Euro 3.5 million in a round co-led by M Ventures, TechVision Fund, and joined by High-Tech-Gründerfonds. The financing round is intended to be used to support the market launch of the technology and prepare future scaling.

5.2 United States

The United States' approach to plastics regulation is less centralized, with progress occurring primarily at the state level. Most legislation targets such specific products as single-use plastic bags, straws, and expanded polystyrene (EPS) foam, alongside emerging Extended Producer Responsibility (EPR) legislation.

Figure 6: Map with plastic bag, EPS and food service, and EPR legislation by state



California's SB 54 is one of the strictest EPR laws in the country and covers one of the largest markets as California accounts for about 15% of the United States' GDP. SB 54 mandates a 25% reduction in single-use plastics and requires that 100% of in-scope materials be recyclable or compostable by 2032. The law shifts responsibility for plastic pollution from consumers to producers. However, like Europe, packaging alternatives with plastic linings remain in-scope, complicating compliance.[24]

Although targets are impressive, implementation challenges are significant. SB 54 was sent back for revision after cost estimates reached $36 billion, raising concerns about excessive burdens on businesses.[25] The state's recycling agency, CalRecycle, is revising the draft regulations, with implementation now targeted for 2027.[26]

For investors, catalyzing capital in California creates a hopeful precedent for other states across the United States, especially because the presence of national brands operating across multiple states creates a unique opportunity. These companies must navigate diverse regulatory environments simultaneously, driving demand for scalable solutions in recyclable packaging, compostable materials, and compliance-focused innovation. Investors who back firms capable of delivering cost-effective, adaptable alternatives stand to benefit from both regulatory tailwinds and consumer preference shifts.

In this context, the United States market represents a dual dynamic: regulatory uncertainty at the state level, paired with strong incentives for national brands to adopt sustainable solutions that are biodegradable, which can meet varying compliance requirements.

5.3 China

China, as one of the largest producers and consumers of plastics, has introduced the Plastic Pollution Control Action Plan to strengthen oversight across the plastics value chain. The plan targets single-use plastics in key consumer sectors such as retail, e-commerce, take-out, and express delivery, while also emphasizing recycling and disposal.[27] For investors that are focused in APAC, this creates an opportunity as companies that can deliver scalable, cost-effective alternatives may find strong demand in China's vast consumer market.

6 Cost-competitiveness and market economics

To assess which alternatives deliver the greatest environmental benefit, CREO has evaluated plastic alternatives across six key dimensions: cost, performance, and four sustainability KPIs: recyclability, compostability, biodegradability, and emissions. This framework provides investors with a structured lens to compare virgin plastics against emerging substitutes.

6.1 Historical costs

Virgin plastics prices have historically been volatile, reflecting their dependence on global crude oil and natural gas markets. Geopolitical events, supply chain disruptions, and energy price fluctuations contribute to instability, making virgin plastics less predictable than recycled alternatives.

This volatility directly impacts the recycling industry. When virgin plastic prices fall, recycled plastics lose competitiveness, reducing demand and profitability for recyclers. Conversely, when virgin prices rise and remain stable, recycled alternatives become more attractive and economically viable.[28]

Across the value chain, plastics tend to concentrate costs at the upstream stage, while sustainable alternatives carry premiums across multiple stages, making them comparatively more expensive.[29]

Regional dynamics also matter. In late 2024, Asia and Europe offered recycled HDPE at slightly lower prices than virgin HDPE, while North America lags, driven by slower adoption of recycling infrastructure.[30]

6.2 Performance

Plastics continue to set the benchmark for versatility and performance, offering consistency in mechanical strength, thermal properties, and predictability. Alternatives often face challenges in meeting these standards, with variability in durability, heat resistance, and quality. For producers and consumers, this performance gap remains a key barrier to substitution.

Table 3: Comparing virgin plastics and others in performance.

Criteria	Plastic	Fiber-based	Circular plastics (PHA)	Circular plastics (PLA)	Niche alternatives
Mechanical properties (strength, impact resistance)	✓	✓	✓	✓ (lower strength properties, however, can be improved by blending virgin material)	✓ (Can be improved with additives)
Thermal resistance	✓	✓ (Can be improved with additives)	✓	✓ (Can be improved with additives)	✓
Chemical compatibility (resistance to acids, solvents, environmental exposure)	✓	✓ (Can be improved with additives)	✓	✓ (Can be improved with additives)	✓ (Can be improved with additives)
Transportation	✓	✗ (Plastics have lower shipping costs due to lighter weights)	✓	✓	✓

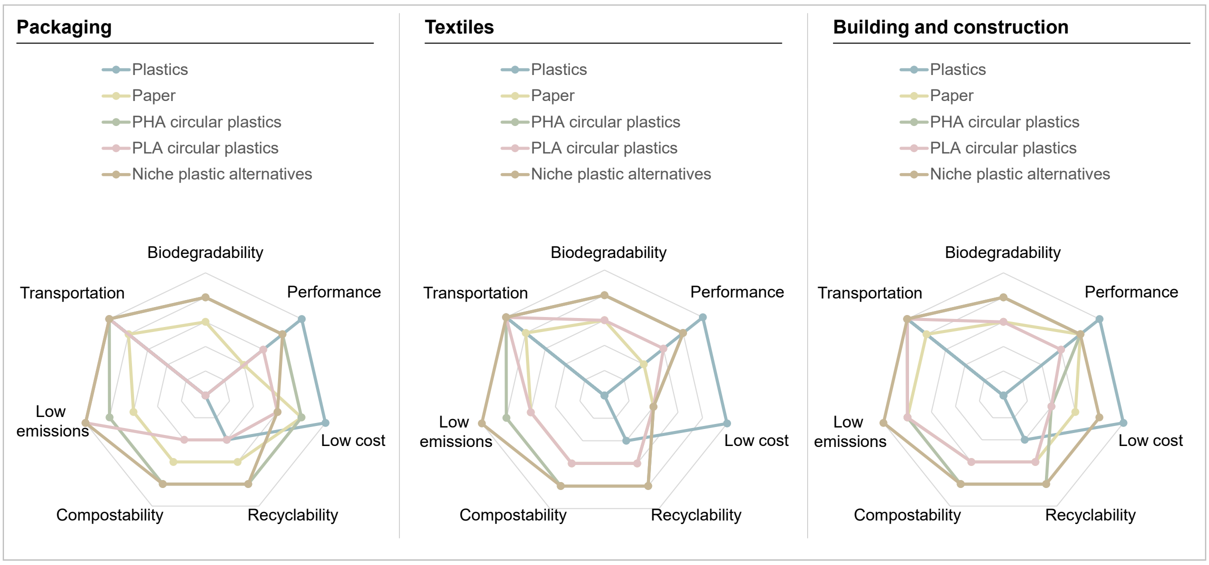
6.3 Potential substitution by end-use

CREO's comparative analysis integrates cost, performance, and sustainability KPIs to evaluate substitution potential across the top three major end-uses for plastics.

In packaging applications, plastics dominate on cost and performance, but alternatives outperform on such sustainability metrics as biodegradability, compostability, recyclability, and emissions. Niche plastic alternatives and PHA present the strongest competitive case in this segment.

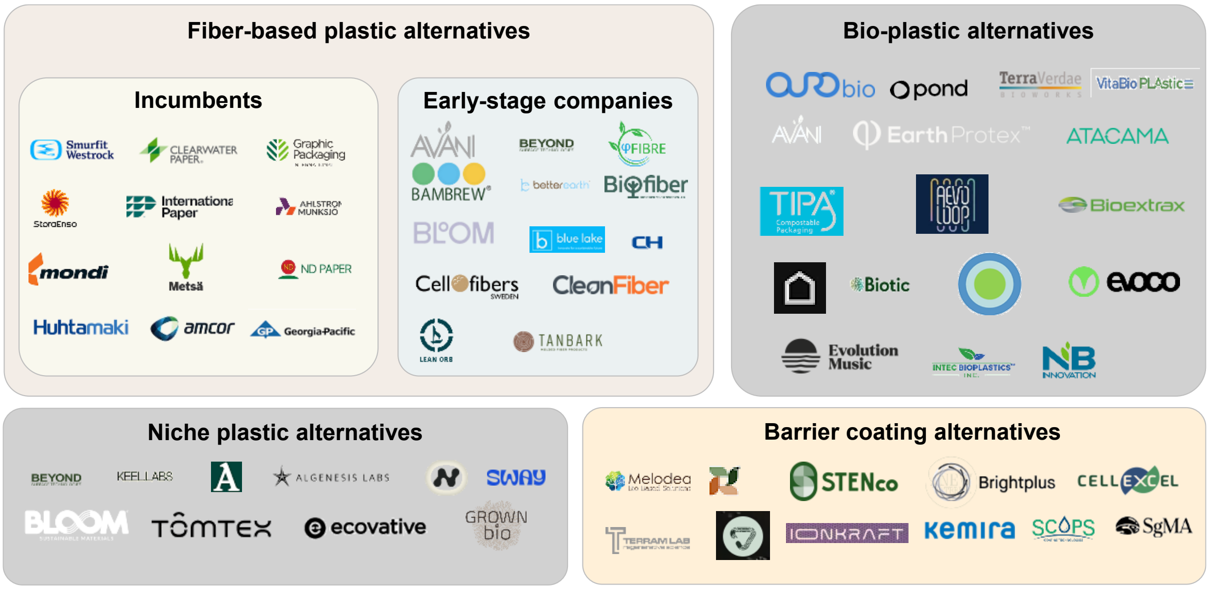
Similar to packaging, niche and PHA alternatives take the lead in consumer product segments and building and construction end-uses, particularly as consumer demand for sustainable goods accelerates. Plastics remain dominant due to performance requirements, but regulatory and innovative pressures may create future opportunities for alternatives.

Figure 7: Radar chart of performance, cost, and sustainability standards among different alternatives



6.4 Technological breakthroughs in the industry

Figure 8: Market map for the different alternatives to plastics



Innovation is reshaping the competitive landscape. Fiber-based alternatives and recycled plastics are currently the most established leaders, but niche applications are gaining momentum.

However, in order for many of the fiber-based solutions to carry traction in the market, barrier coating innovation is needed. Emerging technologies aim to eliminate plastic linings in fiber-based products, improving recyclability and biodegradability while maintaining comparable performance standards.

Fiber-based incumbents are currently dominating the field. R&D initiatives in-house are creating more avenues for gaining market share as regulation and corporations adopt sustainability requirements.

Start-ups are also gaining traction as regulation pushes for circular solutions. Start-ups developing seaweed-based, mycelium-based, and other novel alternatives are also attracting attention, particularly in packaging applications where regulatory pressure is strongest. These applications are closer to circular solutions, however, are capitally intensive to mechanically process and produce, compared to plastics. Investors have the potential to capture opportunities by investing in these novel alternatives and increasing supply, therefore potentially bringing the premium-costs down.

For investors, these breakthroughs represent early-stage opportunities with potential for outsized returns, especially as regulatory frameworks tighten and demand for scalable alternatives grows.

7 Plastic-alternatives investment strategy

The escalating plastic crisis emphasizes the urgent need for innovative solutions that can provide viable substitutes for conventional plastics. While consumers, corporations, and regulatory frameworks are gradually paving the way for substitution, progress remains uneven. Slow consumer adoption, corporate retrenchment on circular economy targets, and regulatory delays continue to limit the scale and speed of impact necessary to meaningfully reduce plastic dependence. There are a variety of opportunities that stand to gain benefits as markets mature and the cost of alternatives declines.

PHA bioplastics are among the most promising drop-in replacements for conventional plastics, as the alternative offers a fully biodegradable solution, critically different relative to PLA and other fiber-based alternatives. PHA currently remains relatively expensive to produce, which makes broad commercial adoption difficult today. However, this is a supply-side problem. As production capacity scales and producers optimize fermentation processes, price parity against virgin plastics becomes increasingly achievable. There is room to capitalize on this market if one views the cost premium as a temporary barrier, in which case it would be logical to back producers and technology positioned to benefit from the volume pricing.

Fiber-based packaging has been constrained by its inability to repel grease, moisture, and oxygen without the application of a plastic or PFAS-based coating. As plastic regulations tighten across Europe and North America, this forces the legacy market to find compliant alternatives by 2030. Barrier coating technologies enable fiber substrates to perform on par with plastics and represent a near-term investment opportunity, driven primarily by regulatory urgency. For investors, since fiber-based alternatives are an established, high-volume industry, it provides an opportunity to capitalize on growing technology for potential M&A or partnerships with leading incumbents. Companies offering functional, scalable, and regulation-compliant coating are well-positioned to capture rapid market share.

The European Union has established one of the most aggressive regulatory stances for sustainable packaging in the world. The SUPD and PPWR collectively create a pathway that de-risks market adoption for alternatives. Regulations of this kind are a powerful accelerant for private capital, as they remove the ambiguity that often delays investment decisions and provide a signal for material innovators. For investors, Europe functions as a beachhead market, where regulatory tailwinds create favorable outcomes for plastic replacement and accelerate the go-to-market timelines. Those in the industry have labeled this legislation as a game-changing regulation with clear timelines and quantifiable targets. Industry leaders are now facing an “adapt or perish” wave of change. This strategy can later be replicated in decentralized or less regulated markets, like the United States, with a focus on California, and APAC regions.

Consumer demand for sustainable packaging has been reported to be measurable and growing. However, what makes this market particularly compelling is the dynamic between consumers and corporations. When consumers select brands and products that demonstrate sustainability, it creates pressure on corporates to rethink their packaging strategies. Alternatively, corporations can procure sustainable alternatives at scale to normalize newer alternatives and lower the cost to make these alternatives more accessible to cost-conscious consumers. To resolve this “chicken-and-egg” dilemma, material producers, coating technology providers, processing infrastructure, etc. will need capital to grow into a meaningful portion of the market.

Although an emerging packaging solution at present, seaweed and mycelium are some of the most exciting plastic alternatives. Both materials offer exceptional sustainability profiles, as they are biodegradable, can be produced with minimal land use, carbon input, and highly customizable for a variety of end-use applications. However, these still remain niche products with small markets and with higher production costs than virgin plastics. This challenge parallels PHA, as the path to gaining market share is driven by capital deployment to drive volume, which could further drive down costs. PHA is positioned closer for a leap to maturity and realistically, seaweed and mycelium are long-dated (post 2030) alternatives to scale. Companies in these areas will be seeking patient capital to unlock mass deployment.

8 Conclusion

The transition away from conventional plastics is an environmental and health imperative that could create a significant investment opportunity. While plastics pose substantial risks to human health and ecological systems, viable alternatives are emerging across multiple industries, each with distinct economic and performance characteristics.

Fiber-based materials and recycled plastics are currently the most commercially mature pathways, yet long-term; these materials’ competitiveness relies on continued innovation, particularly through barrier coating technologies that eliminate plastic linings. Novel alternatives, derived from seaweed, mushrooms, and other feedstock, remain in pilot stages of being commercially viable. However, these applications are cheaper than bioplastic alternatives and are not disrupted by regulatory pressure.

Global plastic regulations signal a clear directional shift that is expected to reshape competitive dynamics across the value chain. Companies that delay adaptation face mounting compliance costs, reputational risk, and potential market displacement.

For the market overall, the opportunity centers on strategic capital allocation toward a diversified portfolio of competitive alternatives to conventional plastics. Addressing the plastics challenge will require a broad set of solutions rather than reliance on a single breakthrough. The alternatives landscape remains difficult to rank by speed or scalability as many emerging materials face supply-side constraints. Increased investment in fermentation technologies, barrier-coating innovations, and biomass cultivation could help reduce production costs and move these materials closer to cost parity with virgin plastics.

This transition demands collaboration across value chain stakeholders. Private capital is essential for scaling production capacity. Policymakers must establish consistent standards across fragmented markets. Consumers and corporations must integrate sustainability into core purchasing and operational decisions rather than placing it on the backburner to profitability. With alignment across these stakeholders, cost and performance gaps between plastic alternatives and traditional plastics have the potential to narrow significantly.

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