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Closing the Loop for a Circular Chemical Industry

Global Impact Coalition

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Introduction

97%
of respondents reported experiencing supply chain issues in a chemical industry survey

The chemical industry plays a pivotal role in supplying feedstock materials to a wide range of manufacturers for nearly all goods, from food and medicine to apparel, automobiles and beyond. Because of this broad, cross-sector involvement, chemical companies are uniquely positioned to accelerate the transition toward a more circular economy. However, this same ubiquity also presents a challenge. The industry's deep integration across global value chains increases the complexity of navigating regulatory landscapes, geopolitical tensions, market volatility and strict logistical demands, all of which make the shift from linear systems more difficult.

Amid this complexity, supply chain disruptions are becoming more frequent. In a 2022 survey by the American Chemistry Council (ACC)[1], 97% of respondents reported experiencing supply chain issues. Such issues may include longer transit times, canceled bookings, container shortages and rising detention charges. These supply chain disruptions expose the limitations of traditional, linear logistics such as the lack of flexibility and coordination often needed for effective response. Circular supply chains, by contrast, can offer greater resilience. They help reduce climate impact and costs by retaining material value and securing steady supply streams, enabling companies to buffer against price volatility and reduce dependency on commodity markets. Further, transparency and collaboration – key principles of circularity – enable the identification and addressal of root causes of disruptions, as well as the streamlining of operations. This combination of self-dependency, end-to-end visibility and communication between businesses counteract linear supply chains' shortcomings.

Though it is evident that the chemical industry faces complex operational challenges that circularity could help alleviate, barriers to a circular transition often impede progress. Notably, the lack of clear downstream demand, limited stakeholder collaboration and underdeveloped regulatory frameworks obscure the economic rationale for a circular chemical industry.

Compounding this challenge is the industry's convention of making strategic decisions on a decades-long horizon. This practice stems from the chemical industry's capital-intensive nature. Economies of scale have been a historic and essential business imperative. However, rapid technological advances and the acceleration of information flows are already beginning to challenge the viability of linear supply chains, systems that many chemical companies already view as insufficient. Simultaneously, rising momentum behind extended producer responsibility (EPR) programs and stricter waste and recycling regulations are further strengthening the case for circularity.

This paper explores how the chemical industry can help close the material loop, addressing barriers to circularity by scaling enabling technologies, supporting effective regulations and developing critical infrastructure. This transformation will require cross-sector coordination and collaboration, but the benefits are apparent: strong, resilient and more secure value chains.

Authored by Ernst & Young LLP (EY US) and the Global Impact Coalition (GIC), this paper is part of a broader mission to deepen industry-wide understanding of sustainability and circularity. This paper outlines three pillars critical to overcoming the barriers to a circular chemical industry:

01.
Scaling Enabling Technologies: Chemical Recycling, AI and Alternative Materials

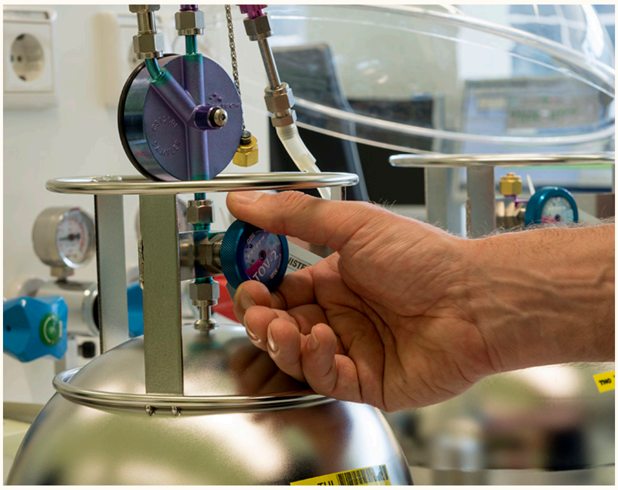
02.
Building Circular Systems Through Reverse Logistics and Regulatory Incentives

03.
Optimizing Economics and Mobilizing Partnerships

1 https://www.americanchemistry.com/better-policy-regulation/transportation-infrastructure/resources/acc-member-supply-chain-survey-report-q2-2022

01. Scaling Enabling Technologies: Chemical Recycling, AI and Alternative Materials

Enabling technologies – such as chemical recycling, artificial intelligence (AI) and alternative materials – are playing an increasingly important role in advancing the circular economy. These innovations can reduce environmental impact, improve end-of-life outcomes and unlock new efficiencies across the value chain. But, while many enabling technologies exist, they often struggle to scale due to lack of investment, supportive regulations or confirmed offtake agreements. This has been the case with a number of chemical recycling technologies such as pyrolysis that have not met initial estimates for scale-up[2]. In many cases, the technology exists but requires systems in place to support the business case and enable effective implementation. The full potential of these solutions will depend not only on their continued development, but also on their integration into broader systems of change.



— TNO Castel Milieulab

While many enabling technologies exist, they often struggle to scale due to lack of investment, supportive regulations, or confirmed offtake agreements.

› Recycling Technologies

Mechanical recycling is a well-established method of processing end-of-life materials, but it is limited in the range of inputs it can handle. It typically produces lower-quality outputs and struggles to process complex or contaminated waste streams. Chemical recycling, by contrast, is suitable for more challenging waste types and has the potential to yield high-quality non-virgin materials. While more energy-intensive and costly than mechanical recycling, chemical recycling methods such as pyrolysis can still significantly lower the cradle-to-gate greenhouse gas (GHG) emissions of plastic by 18% to 23%[3] compared to plastic produced from crude oil.

New reprocessing technologies are emerging as well. For example, in Italy, a global chemical company launched a molecular recycling facility[4] in 2020 capable of processing notoriously hard-to-recycle plastics, including mixed plastic packaging and flexible polyolefins. This facility reduces fuel usage, lowers process temperatures and energy consumption, and offers scalability. Another global chemical company has developed a polyester renewal technology (PRT) that, similarly, recycles hard-to-recycle plastics such as carpet fibers or polyester-based clothing. The PRT process leverages methanolysis to yield an output indistinguishable from materials made with virgin inputs. And it does so with even greater GHG emissions reduction compared to pyrolysis: In a cradle-to-gate lifecycle analysis (LCA), the intermediate material produced by methanolysis, dimethyl terephthalate (DMT), resulted in 29% lower GHG emissions[5] than DMT produced from conventional fossil sources.

2 https://globalimpactcoalition.com/scaling-pyrolysis/#:~:text=Pyrolysis%20offers%20a%20transformative%20pathway,for%20a%20more%20circular%20economy
3 https://www.sciencedirect.com/science/article/pii/S0959652623030251\
4 https://www.lyondellbasell.com/en/sites/moretec/
5 https://info.eastman.com/rs/820-JEE-456/images/PRT Methanolysis LCA One Page Overview 2024.pdf?version=0

— GIC Automotive Plastics Circularity Pilot

› Artificial Intelligence

AI is opening new possibilities in data analytics, decision-making and material sorting. One software company[6] has developed a platform that combines data and robotics to sort waste with over 95% accuracy. Its algorithms can identify material and packaging types, as well as provide detailed information on shape, size, weight, commodity value and brand. AI-powered robotic arms further increase efficiency: while a human in a standard Material Recovery Facility (MRF) can pick 20 to 40 items per minute, these machines can make thousands of picks per minute. These new technologies can greatly increase the quality and quantity of sorted waste material to facilitate much higher recycling rates and improve material yield.

At a German recycler, AI-powered sorting technology[7] has helped improve the purity of recycled plastic fractions, enabling the facility to meet stringent quality requirements for high-value reuse. This real-world application illustrates how advanced sorting can close the gap between waste generation and high-quality material recovery. By improving the quality and consistency of recycled materials, this technology delivers a more reliable recycled feedstock, supporting the transition toward a circular economy. An example of the application of this technology can be found in the Global Impact Coalition's Automotive Plastics Circularity project[8], which is working to improve the recycling rates of plastics from end-of-life vehicles using a new methodology to dismantle, shred and sort plastics to enable drastically improved recycling rates.

› Alternative Materials

Despite advancements in recycling, many materials still cannot be reprocessed efficiently. Inadequate collection systems and consumer-led disposal habits further limit recycling rates. To address this gap, chemical companies are investing in biodegradable alternatives, especially in areas where traditional materials hinder disassembly and recovery. Adhesives, coatings and sealants are particularly challenging[9]; essential across countless applications, they often make end-of-life recovery difficult. While mechanical fasteners like screws and nails can serve as alternatives to glues, they are not always viable substitutes. This makes the development of biodegradable adhesives a promising opportunity. For example, researchers have helped to develop an adhesive[10], suitable for a wide range of industrial and medical applications, that is not only made from carbon dioxide but takes a year or less to fully break down in the environment. Notably, the article does not clarify the conditions at which biodegradation of the adhesive occurs; there is a key difference between and advantage to materials that are biodegradable at ambient conditions versus at the elevated temperatures of a municipal composting facility. Polymers that are biodegradable outside industrial conditions remain remarkably rare.

There has also been renewed interest in biobased adhesives in recent years – not only for their circular potential, but also for health and safety reasons. Many synthetic adhesives and coatings, such as those based on urea formaldehyde (UF) resins, are associated with toxicity concerns. Biobased adhesives, derived from starches, lignin or animal and plant proteins, typically avoid volatile organic compounds (VOCs) and are generally considered safer[11]. Still, while biobased materials are a key aspect of circularity, these materials are not necessarily biodegradable and often interfere with recycling waste streams. Like the existence of materials that are biodegradable in natural conditions, the scope of materials that are both biobased and biodegradable remains limited. By advancing the development of materials that are both biobased and biodegradable, such innovations may further drive progress toward a more sustainable and circular economy.

6 https://www.forbes.com/sites/ganeskesari/2024/05/31/turning-trash-into-treasure-how-ai-is-revolutionizing-waste-sorting/
7 https://steinertglobal.com/showcases/re-plano/
8 https://globalimpactcoalition.com/project/automotive-plastics-circularity/
9 https://www.sciencedirect.com/science/article/abs/pii/S0143749621001901
10 https://www.bu.edu/articles/2019/sustainable-adhesives/
11 https://www.purdue.edu/newsroom/2023/Q3/solving-stickiness-sustainably/

02. Building Circular Systems Through Reverse Logistics and Regulatory Incentives

Regardless of how advanced technology becomes, without effective waste collection and reverse logistics, a circular chemical industry may remain unattainable. Even the most advanced technologies depend on consistent material recovery and feedstock supply. Yet the infrastructure needed to retain used materials is often lacking. This is largely because the chemical industry – like many other industries – has traditionally prioritized forward logistics, with minimal systems in place to facilitate reverse flows.

› Reverse Logistics: The Missing Link

Reverse logistics systems are important to closing the loop, but today, they remain underdeveloped. Even where natural collection points exist – such as brick-and-mortar stores in the consumer goods sector – a lack of financial or policy incentives prevent efficient take-back schemes. Regulation can help fill this gap, as evidenced decades ago in the chemical industry. Germany's Packaging Ordinance, introduced in 1993, required manufacturers to collect and recycle chemical packaging such as drums and tanks. This mandate spurred increased recycling rates and innovation in packaging design, demonstrating the power of legislatively mandated reverse logistics.

More recently, in 2019, Germany further developed the existing legislation and enacted a new Packaging Act[12], which raised recycling targets, established the national oversight body, Zentrale Stelle Verpackungsregister (ZSVR), and mandated packaging registration in a centralized system (LUCID). The Act strengthened enforcement and created transparency, expanding EPR to consumer goods packaging. Regulation can also support circularity by requiring products to be more durable, modular and standardized – key features for reuse, remanufacturing and refurbishment that are essential in a fully circular economy.

› Toward More Cohesive Global Frameworks

Despite these promising examples, navigating the regulatory environment remains a challenge for global chemical companies where operations often span multiple jurisdictions, each with its own laws governing production, sourcing and sales. Across the globe, circularity and chemical-related laws are not harmonized, enforcement is often inconsistent, monitoring limited and responsibilities vaguely assigned. The sheer volume of applicable regulations creates uncertainty and compliance challenges, particularly for chemical companies that operate globally.

Recent international efforts aim to create more coherent and effective regulations. For example, the Global Framework on Chemicals (GFC)[13], adopted in 2023, aims to protect the environment and human health through five strategic objectives and 28 targets that address the lifecycle of chemicals. Though it lacks strong enforcement mechanisms like many other global agreements, the GFC

> Even where natural collection points exist – such as brick-and-mortar stores in the consumer goods sector – a lack of financial or policy incentives prevent efficient take-back schemes.

12 https://verpackungsgesetz-info.de/en/
13 https://www.unep.org/global-framework-chemicals/framework

is a step forward in fostering alignment across borders. It also introduces standardized chemical classification and labeling, along with channels for technical knowledge-sharing. Another framework backed by the United Nations, the Global Plastics Treaty[14], aspires to end plastic pollution. Originally set to be finalized in 2024, negotiations have been extended to August 2025[15] due to ongoing debate around potential bans and restrictions on hazardous chemicals and unnecessary plastic uses.

While global frameworks often face difficulties in implementation, they can set the stage for national legislation that is both effective and harmonized. For example, the EU's Packaging and Packaging Waste Regulation (PPWR)[16], enacted in 2025, includes measures that reduce single-use plastics, set minimum recycled content targets for 2030 and 2040, and promote reusable packaging. It also requires takeaway vendors to accept customer-provided containers at no extra cost. As international agreements, such as the PPWR, continue to be written into law and further refined, the greater harmonization of compliance requirements will likely lessen companies' regulatory burdens and more effectively encourage circularity.

› Building Regulatory Confidence Through Circular Practices

Circularizing the chemical industry can reduce – not increase – the regulatory burden. While circular supply chains may still span vast geographies, their emphasis on eliminating waste, preserving resource value, and regenerating natural systems can ease compliance. Companies that embed circular principles into their operations are more likely to benefit from regulatory incentives such as tax credits, subsidies and streamlined reporting processes.

Ultimately, collaboration between industry and policymakers will be essential. By co-developing enabling infrastructure and policies, a regulatory landscape that supports circularity while facilitating compliance and operational resilience can be created.

14 https://www.globalplasticlaws.org/un-global-plastics-treaty#:~:text=A%20Mandate%20for%20a%20UN,of%20and%20during%20UNEA%2D5.2.
15 https://environment.ec.europa.eu/news/eu-regrets-inconclusive-global-plastics-treaty-2024-12-02_en#:~:text=After%20two%20years%20of%20negotiations%20and%20a%20week%20of%20talks,negotiations%20will%20continue%20in%202025.
16 https://eur-lex.europa.eu/eli/reg/2025/40/oj/eng

— GIC Ideation Session

03. Optimizing Economics and Mobilizing Partnerships

Even with emerging technologies and better regulation, a circular chemical industry will require economic viability and strong collaboration across the value chain. These two accelerators are closely linked: chemical companies are often hesitant to commit to capital-intensive changes without evident downstream demand from value chain partners. Securing offtake agreements and joining forces to derisk investments can greatly help build a stronger business case for circularity.

› Making the Economic Case

Enabling circularity at scale often demands significant upfront investment. Whether it's upgrading equipment to support "R-strategies" like remanufacturing and refurbishment, or developing more sustainable materials, the initial costs can be high. The risks are not just financial, but reputational: many materials currently in use have been optimized for both performance and emissions. For example, lightweighting (reducing packaging weight while maintaining functionality) has long been used to optimize resource efficiency. Any deviation – such as using alternative or recycled materials – can be perceived as an unnecessary compromise, often coming with significant cost increases or reduced performance that downstream players are unwilling to accept.

Organizations with higher circularity scores had lower default risk and better risk-adjusted stock performance

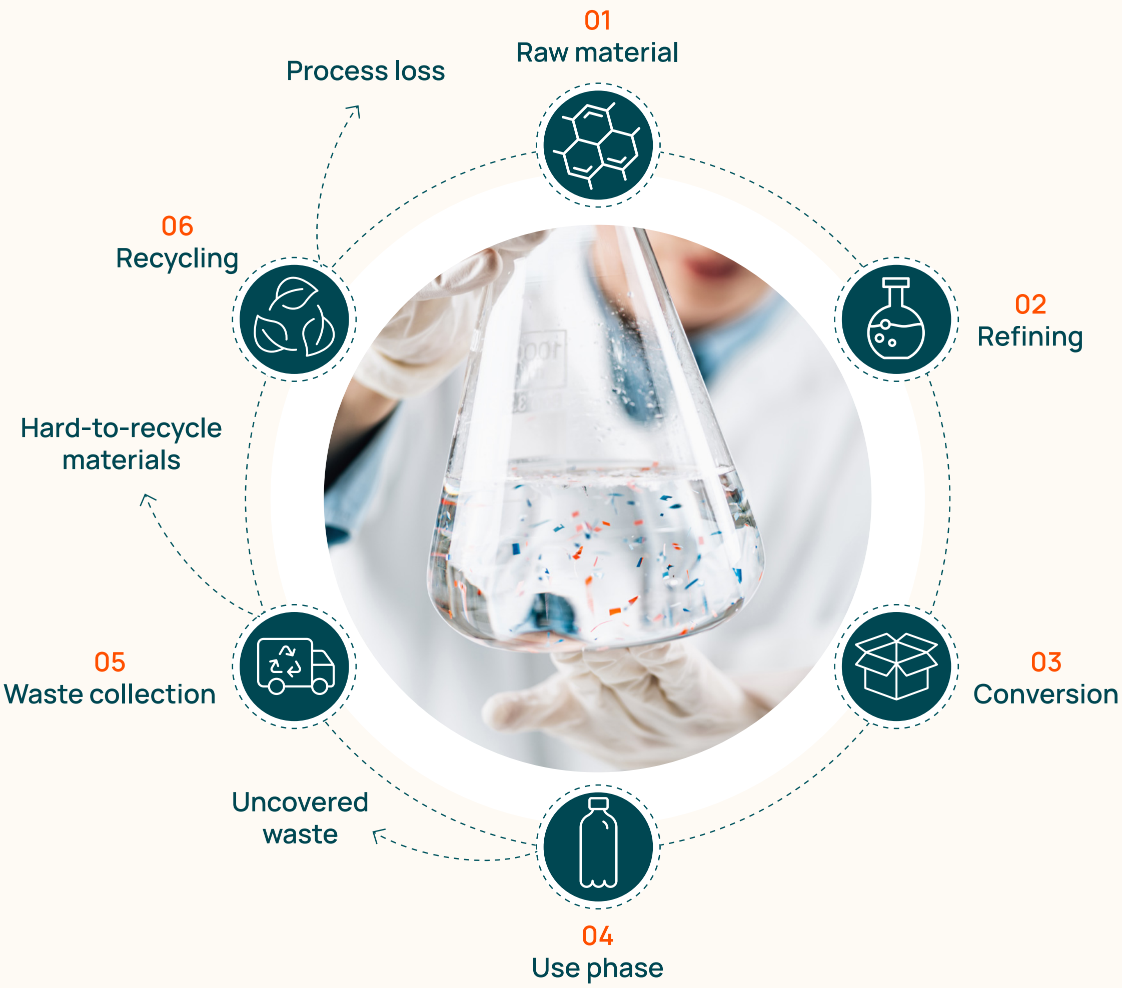
However, there is growing evidence that circular businesses are more resilient. A study by the Ellen MacArthur Foundation and Bocconi University[17], covering more than 200 publicly traded European companies across 14 industries, found that organizations with higher circularity scores had lower default risk and better risk-adjusted stock performance. In the face of rising geopolitical uncertainty, protectionist policies such as high tariffs and rapid digital transformation, the chemical industry is increasingly exposed to market volatility. Much of this uncertainty is no longer just a possibility but a reality; global chemical companies are currently facing significantly higher costs due to newly enacted duties[18]. Decoupling financial growth from resource consumption could offer companies greater long-term stability.

› Bridging Demand Gaps Through Collaboration

Still, long-term stability alone may not be enough to drive transformation. A more immediate value case for a circular chemical industry, one grounded in real market demand, is needed. Often, a lack of perceived downstream interest stems from limited engagement across the supply chain. To close this gap, chemical companies should understand the purchasing criteria, procurement processes, priorities and value frameworks of their customers.

Rather than competing solely on cost, companies should articulate and deliver value, be it through enhanced sustainability, product longevity, or compliance benefits. This requires a mutual understanding of supply chain needs and a willingness to co-create solutions. Stronger communication

17 https://www.ellenmacarthurfoundation.org/the-circular-economy-as-a-de-risking-strategy-and-driver-of-superior-risk
18 https://cen.acs.org/business/economy/New-US-tariffs-spare-chemicals/103/i10



and transparency can help chemical firms align their innovations with customer expectations and, in turn, stimulate demand for circular materials. Cross-sector initiatives, such as the First Movers Coalition[19], launched by the World Economic Forum at COP26, can help facilitate this collaboration across the value chain, enabling heavy-emitting industries to collaborate with downstream players with offtake agreements for low-emission materials.

› Unlocking Momentum Through Partnerships

Strategic partnerships and action-oriented consortiums can help this alignment happen in practice. For example, a global beverage leader partnered with a leading chemical company[20] to increase the use of recycled polyethylene terephthalate (rPET) in their bottles. Together, they not only advanced their own shared circularity goals but also built strong partnerships with waste management firms and invested in next-generation chemical recycling technology. This collaboration helped expand the market for circular products — encouraging others in the consumer goods and chemical sectors to follow suit.

Organizations like the Global Impact Coalition[21] (GIC) bring together leading chemical companies and value chain partners to collaboratively tackle barriers to scaling circular and sustainable solutions. Through a structured process that moves from ideation to project-specific working groups and eventually new spin-off ventures, the GIC helps companies build a compelling business case, catalyze investment and accelerate deployment of sustainable approaches. In doing so, it serves as both an incubator for new business models and a launchpad for scaling breakthrough technologies and advancing critical research. By turning ambition into action, the GIC is helping overcome critical roadblocks on the pathway toward a more circular chemical industry.

19 https://initiatives.weforum.org/first-movers-coalition/home
20 https://www.packagingdive.com/news/coca-cola-rpet-recycled-content-packaging-republic-services-polymer-centers/686818/
21 https://globalimpactcoalition.com/

Conclusion

While every sector faces hurdles on the path to circularity, the chemical industry must navigate a particularly complex terrain. Challenges such as limited enabling technologies, fragmented regulatory environments and substantial upfront investment costs are real but not insurmountable. Through a combination of continued research and digital development, more cohesive international legislation and deeper cooperation, chemical companies can accelerate their progress toward circularity: Technologies such as chemical recycling, AI-powered waste stream sorting and alternative materials are enabling the transition. Well-defined and enforceable legislation supports the establishment of clear circularity targets and may reduce the burden of compliance. Partnerships along the value chain and collaborative business coalitions can help offset transition risks and clarify the economic case for circularity. Ultimately, these three pillars can serve as a bridge between ambition and implementation.

Transitioning to more sustainable materials and circular business models will require upfront investment and a willingness to take calculated risks. But in the face of volatile markets, supply chain disruptions and shifting geopolitical dynamics, circularity is no longer just an environmental priority, but a strategic business imperative. Chemical companies that are advanced in circularity will likely be more innovative, adaptive and resilient in the long term.

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	Scaling Enabling Technologies	Building Circular Systems	Optimizing Economics and Mobilizing Partnerships
Relevance	Technologies are key to unlock the "second-life" potential for currently hard-to-recycle materials	Regulatory incentives and harmonized regulatory frameworks provide certainty for reverse supply chain development.	Coordination among value chain players helps define the circular solutions to scale and create the business case for investments.
Solutions	› **Recycling Technologies:** Chemical recycling has the potential to recover a wider range of materials with higher quality, while reducing emissions. › **Artificial Intelligence:** AI-powered sorting technology increases the efficiency and quality of recycled materials. › **Alternative Materials:** Both biodegradable and biobased adhesives offer promising solutions for challenging waste materials and safety concerns.	› **Reverse Logistics:** Redesigning the value chain in reverse is needed to treat "end-of-life" materials as feedstock for new materials. › **Cohesive Global Frameworks:** Harmonized global regulations and frameworks can reduce compliance challenges and encourage circularity in the chemical industry. › **Building Regulatory Confidence:** Circular supply chains can ease regulatory burdens and benefit from incentives.	› **Economic Case:** Circular businesses are often more resilient and can offer long-term stability by decoupling financial growth from resource consumption. › **Offtake agreements:** Engaging across the supply chain and co-creating solutions can stimulate demand and investment for circular materials. › **Partnerships:** Collaborations and consortiums can help scale circular and sustainable solutions, advancing technologies and critical research.

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About the Global Impact Coalition

The Global Impact Coalition (GIC) is a CEO-led platform driving the chemical value chain toward a circular, net-zero future. Incubated at the World Economic Forum, GIC turns sustainability challenges into commercial solutions through cross-industry collaboration. By co-developing and scaling new technologies and business models, GIC members tackle sustainability challenges no company can solve alone. GIC is guided by global leaders in the chemical and recycling industries.

For more information, visit GlobalImpactCoalition.com

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