Circular **Plastics Economy**

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Reduce, Reuse, Recycle: Giving Plastics Value at Every Stage

Plastics are indispensable to our modern society, and their production will continue to rise in the coming years. They contribute to climate protection and resource conservation in applications such as lightweight construction and building insulation, they protect food in packaging systems and are also indispensable in medical technology. But that is only one side of the coin as plastics are also partly responsible for climate change and environmental pollution. The plastics industry is determined to no longer be part of the problem, but to become even more part of the solution.

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Michael Reubold
CHEManager

The transition to a circular economy is essential in order to conserve natural resources and prevent plastic waste from ending up in landfills, being incinerated and, above all, entering the environment and the oceans. Plastics Europe, the association of plastics manufacturers, wants to drive the industry's transition towards greater sustainability. The association sees plastic as a valuable resource that must be consistently recycled. Ralf Düssel, Chairman of Plastics Europe Germany, says: "Our industry is in the midst of a decisive transformation toward a defossilized economy. In the EU and Germany, we are called upon to establish a holistic circular economy for plastics. The aim is to decouple the production of plastics from fossil resources and to consistently recycle plastics. In this way, we conserve resources and protect the climate, while giving plastics value at all times."

Processes for Plastics Recycling

Plastics recycling plays a vital role in developing a more sustainable system by keeping discarded materials as resources instead of sending them to landfills. The European Union has set targets for mandatory recycled content, prompting innovation and investment in efforts to reduce waste and increase recycling efficiency. Plastics manufacturers- in a joint effort with peers and partners along the plastics value chain – are advancing new methods to recycle complex plastics and maintain material value throughout the lifecycle.

Plastics can be recycled by various methods, depending on the type of plastic and the recycling facility. Improvements in collection schemes and sorting technologies are essential to achieve higher recycling rates. Plastic waste recycling rates are ten times higher when collected separately compared to mixed collection schemes.

> *"Our industry is in the midst of a decisive transformation toward a defossilized economy."*
>
> **Ralf Düssel, Chairman, Plastics Europe Deutschland**

Mechanical recycling, due to its simplicity is the most common approach for recycling plastics like polyethylene terephthalate (PET) and high-density polyethylene (HDPE).

Chemical recycling, which converts plastics into raw materials by altering their chemical structure, enables greater scalability. Technologies include pyrolysis, gasification, hydrocracking, and depolymerization.

Dissolution recycling separates polymers from mixed plastic waste by dissolving them in solvents, recovering them in pure form without changing their chemical composition.

Technology Mix for Complex Plastic Waste

The recycling process used depends on various prerequisites and specific conditions. By using a combination of mechanical and chemical recycling processes, valuable raw materials can be recovered and recycled from even the most complex plastic waste. However, mechanical recycling should be prioritized when it is technically and economically feasible, as interfering more with polymer structures increases energy use. Chemical and solvent-based methods are suitable when mechanical recycling is not possible, such as with highly mixed or contaminated plastics, or when high-quality recyclate is needed for sensitive uses like food packaging.

Christine Bunte, Managing Director of Plastics Europe Germany, explains: "The recycling technologies are available. Significant progress has been made in mechanical recycling, for example through automated sorting and washing processes. This works well for single-type waste, but becomes more difficult with composite materials or heavily contaminated fractions. Further investment will be necessary here. Chemical recycling can be a solution for waste that is difficult to recycle. The processes exist and pilot plants are up and running, but industrial scale is still lacking."

What else is necessary to accelerate the transformation? According to Christine Bunte, effective market incentives are needed: "Binding recycling quotas and lower license fees for recyclable packaging could boost demand for recycled plastics. The use of high-quality recycled materials must also be specifically promoted in demanding applications, such as in the automotive and electronics sectors", she says.

Practical legislation that takes into account input from practitioners is also needed being introduced at both national and European level. Ralf Düssel explains: "In order to advance these technologies and projects, our industry also needs the backing of politicians and society. If companies are willing to make significant investments to build chemical recycling plants and implement renewable carbon technologies on a large scale, they need a regulatory framework that gives them planning security."

Building the Circular Plastics Economy Together

Achieving a sustainable, circular plastics economy requires collaboration, focus, and substantial long-term investment in technology and systems. Companies in the plastics value chain continue to work with a high degree of innovation on the transformation to a circular economy. They are innovating by developing advanced recycling methods and partnering with specialists in waste collection, sorting, and recycled material conversion.

> *"Binding recycling quotas and lower license fees for recyclable packaging could boost demand for recycled plastics."*
>
> **Christine Bunte, Managing Director, Plastics Europe Deutschland**

In this special edition we present some exciting examples of such collaborations and developments. They contribute to the transformation from a linear to a circular economy, in which plastics at the end of their life are not seen as waste, but as raw materials—as valuable resources.

Michael Reubold
CHEManager

K 2025: Explore the Future of Plastics

The final countdown to K 2025 began on June 30. Exactly 100 days later, the world's most important plastics trade fair will open its doors. Over 200,000 visitors from around 160 countries are expected to attend.

A highlight of the trade fair: the special show "Plastics Shape the Future", which Plastics Europe Deutschland is curating for Messe Düsseldorf for the sixth time. The last K years have shown that the special show is like a seismograph for the direction of the industry. Where does it stand and where does it want to go?

Seven Days of Concentrated Innovation, Discussion and Encounters

On seven themed days, the special show will focus on innovations, transformation, technologies and trends. Science slams, start-up pitches, expert talks and guided trade fair tours will make it possible to see how the circular economy and competitiveness can be put into practice. In addition, formats such as "Women in Plastics" and "Career Sunday" provide new impetus where change goes beyond technology.

Insider Tip: "Circular Thursday"

If you want to know how the circular economy works in practice, you should mark "Circular Thursday" in your diary. On Thursday, October 9, research and industry will come together to discuss the circular management of packaging, textiles, electrics and electronics and the construction sector, recyclate usage rates and how mechanical and chemical recycling can be optimally combined. We will look at different perspectives on and experiences with current regulatory projects such as the Packaging and Packaging Waste Regulation (PPWR), the End of Life Vehicle Regulation (ELV) and the Waste Electrical and Electronic Equipment Regulation (WEEE). The experts from the various application industries will discuss current challenges and provide an insight into their experiences as well as an outlook for the future: What can industry, politics and authorities learn from these experiences? What are the advantages and disadvantages of Closed Loop? How high should recyclate use rates be? Do we have enough waste to meet the specified use quotas?


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Bettina Dempewolf, Head of Communications Division, Plastics Europe Deutschland

Program of the Theme Days at the Special Showcase "Plastics Shape the Future" by Plastics Europe Deutschland

Date	Theme Day	Highlights
Oct. 8	Kick-Off Wednesday	Opening, Industry Outlook, Competitiveness, Facts and Figures
Oct. 9	Circular Thursday	Packaging, Textiles, Electronics, Construction – Mechanical & Chemical Recycling
Oct. 10	Climate Friday	CO_2 Balances, LCA, Additives, Monetization Of Sustainable Products, Circular Business Models, Competitiveness
Oct. 11	Smart Saturday	AI in use along the value chain: Material Development, Process Optimization, Recycling, Sensor Technology, Digital Product Passport, EU Data Act
Oct. 12	Career Sunday	Recruiting, Diversity, Science & Poetry Slam, Women in Plastics
Oct. 13	Innovation Monday	Start-up Pitches (Newcomer & Big Fish), Networking, Innovation Panel
Oct. 14	Visionary Tuesday	Circular Tech (Bioplastics, CCU, Recycling), Future Outlook 2050, Micro Plastics

Plastics Europe Deutschland
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PLASTICS EUROPE
Enabling a sustainable future

Partnership for the Circular Economy

Chemical Recycling: How Old Tires are Turned into New Car Parts

Neste, Borealis and Covestro are working together as project partners to close the material loop for the automotive industry. The project for the chemical recycling of used tires aims to transform what were previously considered inferior materials into high-quality secondary raw materials for demanding automotive applications. It provides important food for thought on the practical design of the EU's upcoming End-of-Vehicle (ELV) Regulation. The value chain is initially focused on ISCC Plus mass-balanced polycarbonate, but can also be extended to other plastics.

During chemical recycling, used tires are liquefied into pyrolysis oil, which is processed and then converted into acetone and phenol. High-purity polycarbonates are then produced from these two basic chemicals.

The circular economy is becoming the guiding principle of global industry. It is a powerful lever for combating climate change and environmental degradation and conserving scarce resources. The automotive and chemical industries are also working intensively on moving away from a linear approach and instead managing components, materials and raw materials in cycles. So far, tires have been a "stepchild" in this respect.

Well over a billion of them worldwide reach the end of their life every year and have to be recycled.

Tires mainly consist of several types of rubber and also contain fillers such as carbon black and silica, reinforcing materials such as steel and polyester as well as chemicals such as sulphur and zinc oxide. Due to this complex composition, used tires are difficult and costly to recycle. Until now, they have been sent to landfill or used as an energy source in cement production, for example, and incinerated, which is harmful to the climate. They are also processed in shredder plants to produce rubber powder or granulate, e.g. artificial turf, asphalt or floor coverings. However, the amount of used tires far exceeds the demand for such products.

Working together for the circular economy: Jeroen Verhoeven (Neste), Thomas Van De Velde (Borealis) and Guido Naberfeld (Covestro) want to use used tires as a source of raw materials for plastics to produce new automotive components (from left to right).

Chemical recycling is the key

"So far, there are hardly any recycling concepts that tap into used tires on a large scale as a valuable source of raw materials for high-quality chemical and plastic products, thus transforming the linear life of tires into a cycle. Neste, Borealis and Covestro have now changed that," says Guido Naberfeld, Senior Vice President, Head of Sales and Market Development Mobility at Covestro.

The partners have implemented a project in which the chemical recycling of used tires can be used to produce high-quality polycarbonates for demanding automotive applications, such as headlights or radiator grilles.

In general, the aim is to promote the circular economy in the plastics value chain and in the automotive industry and to raise it to a large-scale industrial level in the long term. The project represents a move away from a polycarbonate raw material base whose production and distribution has been optimized for decades and comprises millions of tons of petroleum-based raw materials and intermediate products. This alone shows why this is a flagship project and why all partners in the tire recycling value chain must work closely together to ensure that circular material cycles are successfully established.

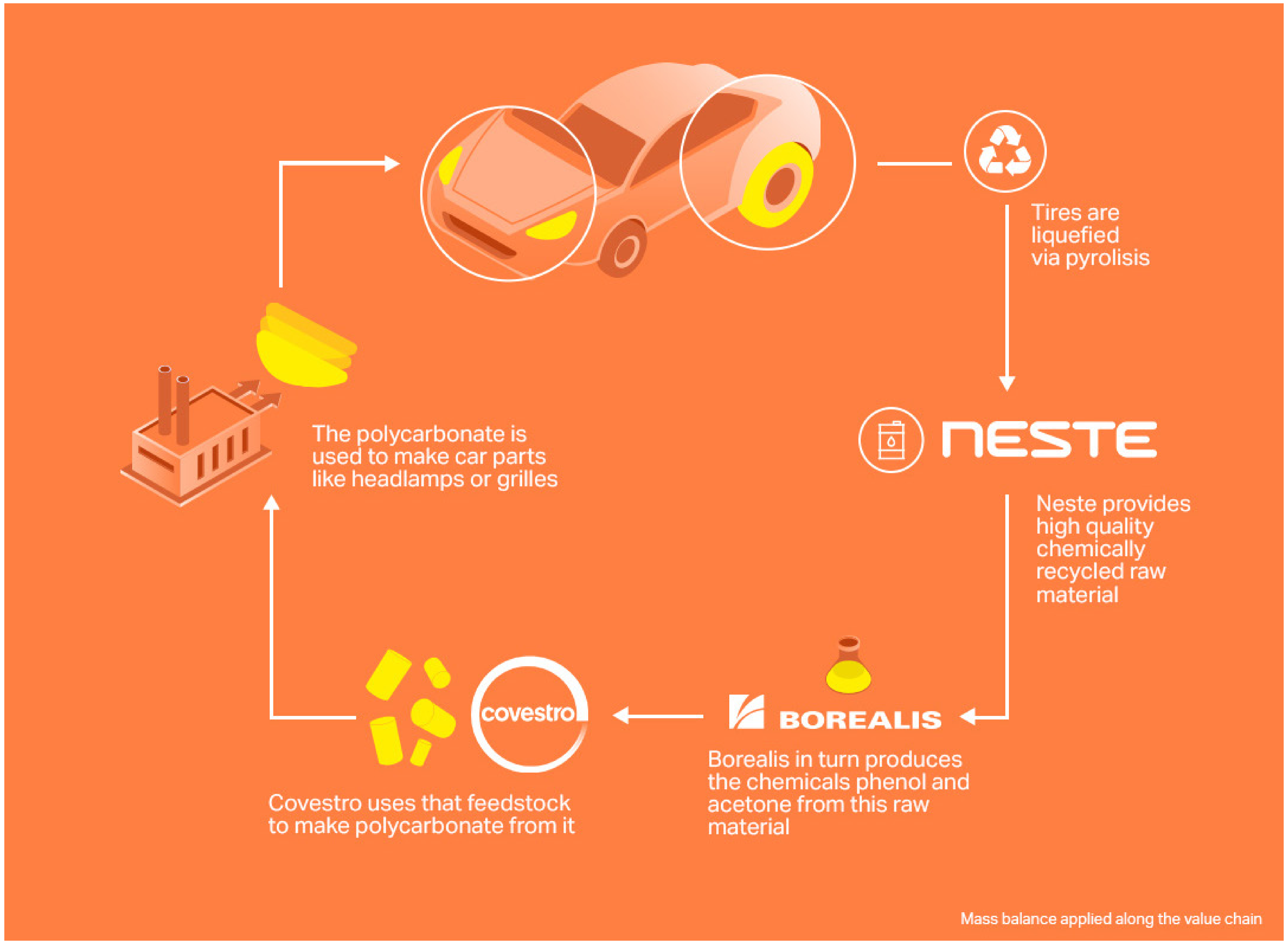
"So far, there are hardly any recycling concepts, which tap into used tires as a valuable source of raw materials on a large scale."

Food for thought for the upcoming ELV regulation

The project also provides important food for thought for the design of the upcoming EU ELV Regulation. Using a complex example, it shows how low-grade waste materials can be recycled to produce high-quality products for technically sophisticated automotive applications — such as highly transparent polycarbonate headlights. The partners thus emphasize that, as leading and globally active companies in the chemical industry, they react positively and creatively to legislative plans and support them.

At the same time, automotive manufacturers are encouraged to participate in order to help shape solutions for the future ELV regulation at an early stage and become part of newly emerging value chains.

The project also shows where the limits and weaknesses of the ELV draft currently lie and where it needs to be adapted and refined. For example, according to the current status of the draft, used tires as a source cannot be counted towards the plastic recyclate input quotas. This applies neither to the general quota of 25% nor to the special "closed-loop quota" (25% of the 25% quota based on end-of-life vehicles as a source). Chemical recycling via mass balancing must also be taken into account in the ELV in order to provide scalable and high-quality solutions for demanding plastics applications. This is not yet the case.



The tasks of the project partners in the cycle of chemical recycling of used tires.

Detailed, transparent and open cooperation

"The pilot project is uncharted territory for all parties involved and the start of a new quality of partnership within the value chain that goes beyond the usual marketing-sales relationships," says Thomas Van De Velde, Senior Vice President Base Chemicals at Borealis. "The ambitious goals of this project require a very detailed, transparent and open discussion and cooperation." The reason for this is the very complex value chains in the chemicals and plastics industry. Among other things, they are characterized by a large number of process steps that not every project partner can cover with their own expertise. Each partner is therefore dependent on the know-how of the other. One of the challenges is that not all of the framework conditions for the circular economy have been defined, such as the aforementioned ELV regulation or the concept of mass balancing. This means that many major players and customers in the chemical industry are still taking a wait-and-see approach. While the framework conditions are lacking on the one hand, they are surprisingly comprehensive on the other: recyclates not only have to meet the chain of custody and ELV conditions, but also comply with the Waste Framework Directive. The latter sets out key definitions — for example, what constitutes recycling and what constitutes a recyclate. However, the project partners agreed from the outset to start work straight away in order to be ready later when the framework conditions have been defined.

Mass balanced according to the ISCC Plus standard

As part of the collaboration, Neste processes pyrolysis oil, which is obtained from used tires, into a high-quality raw material for chemicals and plastics at its refinery in Porvoo, Finland. Borealis uses it to produce phenol and acetone. Covestro then converts the two basic chemicals with intermediate steps into polycarbonate. In the meantime, each project partner has produced the first batches of its products in accordance with its project order, meaning that the first polycarbonates obtained from used tires are now available. The recycled content is mass-balanced and allocated in accordance with the ISCC Plus (International Sustainability and Carbon Certification) standard.

Drop-in solution as an alternative

It is important to note that the polycarbonate raw materials obtained from tire recycling are chemically and physically completely identical to the purely fossil-based raw materials previously used for thermoplastics. This results in polycarbonates that have the same quality and the same physical and processing properties as their fossil counterparts. The materials therefore also have the same technical specifications and certifications. They can therefore replace their fossil-based counterparts as an alternative drop-in solution and produce components of the same quality while conserving resources. This advantage is crucial for increasing the acceptance of alternative products originally based on waste materials among OEMs and their customers.

At the moment, the project is still focusing on bringing the recycling of used tires in line with the expectations of the ELV Regulation. However, the partners assume that the ELV requirements will serve as a "blueprint" for other economic regions and industries to define their own regulations for the development of material cycles. In this respect, the pilot project has a much greater market significance and strengthens the global trend towards a circular economy. The project partners are certain that its success will trigger further investment in the circular economy and also ensure that more and more alternative raw material sources are developed for chemical recycling.

> *"The pilot project is uncharted territory for everyone involved and a departure into a new quality of partnership within the value chain."*

"As an engineer, I understand the processes behind the project and how we can turn old tires into transparent headlights — and yet as a consumer, I find it impressive that it really works," says Jeroen Verhoeven, Vice President Value Chain Development Chemicals and Plastics at Neste. "It is a very good example of how the concept of waste is changing in the circular economy. By working together with all players in the value chain, we can turn plastic waste or used tires into high-quality applications."

Also looking at raw materials for polyurethane

The project partners are also currently working on scaling up the recycling of used tires in terms of volume. The long-term goal is to close the material cycle for used tires. This is not just about polycarbonate as an end product. Raw materials for polyurethane — such as benzene or toluene — could also be obtained from used tires. Large-scale chemical processes are available for this. Polyurethane is ubiquitous in vehicle interiors, for example - whether as foam in seats, instrument panels, headliners or door panels. A further cycle could therefore be set up for its recycling that meets the requirements of the ELV Regulation.

Benchmark for the Material Cycle

Polystyrene is One of the World's Most Important Plastics in Terms of Volume

Polystyrene is one of the world's most important plastics in terms of volume. The thermoplastic polymers are used in many areas, including packaging and consumer goods as well as insulation or medical and diagnostic devices. What's more, polystyrene is more suitable for processing and reuse than almost any other polymer, says Frank Eisenträger, ECO & Market Development Manager at Ineos Styrolution. In the CHEManager interview, he discusses polystyrene recycling in general and the specific question of how best to recycle a yoghurt pot.

Frank Eisenträger, ECO & Market Development Manager, Ineos Styrolution

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CHEManager: Mr. Eisenträger, you are the contact person at Ineos Styrolution for all questions relating to polystyrene recycling. What makes polystyrene so special as a material?

Frank Eisenträger: Polystyrene, which is used for insulating buildings, in refrigerator interiors or for packaging dairy products, is more suitable for processing and reuse than almost any other polymer. The waste streams from the various applications are separated. In dairy product packaging, polystyrene is practically never dyed black and is only rarely used in multi-layer structures, making it very easy to select from plastic waste. With today's NIR methods, it can be easily and quickly identified and sorted out like hardly any other polymer.

Polystyrene can therefore be mechanically recycled in a similar way to PET, i.e. using the process with the lowest energy requirement of all recycling processes. However, in addition to mechanical recycling, chemical recycling processes are also suitable for polystyrene.

Why is chemical recycling needed if polystyrene can be recycled mechanically?

F. Eisenträger: The different processes complement each other! In the case of yoghurt pots, mechanical recycling will also become established for food contact applications, while depolymerization, one of several chemical recycling processes, also plays an important role for EPS/XPS waste streams, i.e. expanded or extruded polystyrene.

Could you explain this in more detail?

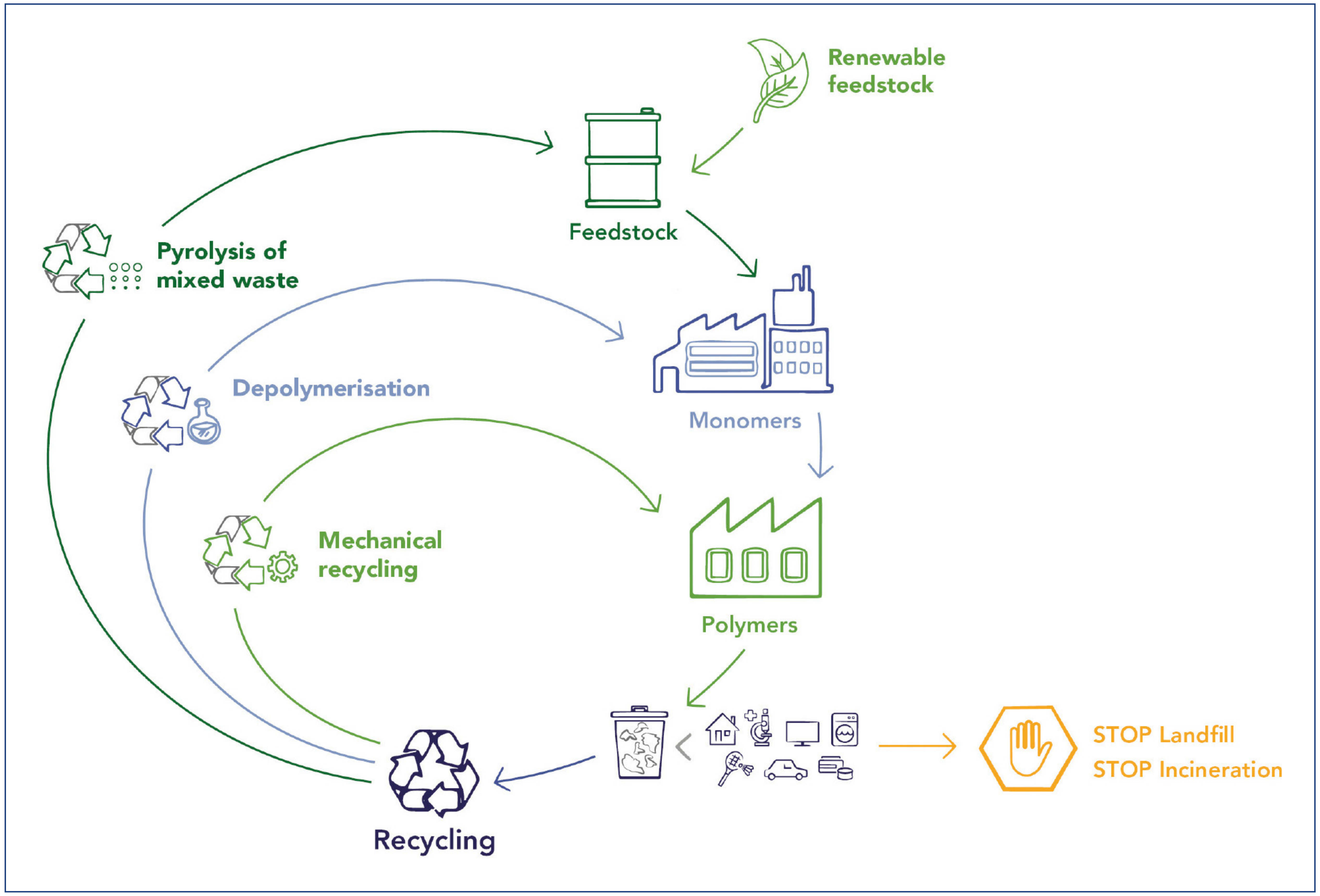
F. Eisenträger: Chemical recycling is more suitable for using EPS/XPS foams as a raw material. These consist of pure polystyrene without rubber and enable a higher yield. Mechanical recycling, on the other hand, is suitable for processing the impact-resistant high impact polystyrene — HIPS for short — contained in yoghurt pots.

On the other hand, EPS and XPS packaging, which is difficult to wash, is not suitable for mechanical recycling. However, if you want to bring all the polystyrene back into contact with food, both technologies fit together perfectly.

This kills two birds with one stone: the existing waste streams are fed specifically to the recycling processes that are best suited to them. For a given waste stream, the processes with the lowest CO_2 footprint can be specifically selected.

How mature are the chemical recycling processes for polystyrene?

F. Eisenträger: While Ineos Styrolution is conducting intensive research into all chemical recycling processes, we are already one step ahead in the depolymerization of polystyrene. Depolymerization, in which the polystyrene polymers are broken down into their smallest units, the styrene monomers, is no longer only being investigated in small pilot plants, but a first industrial plant is already being commissioned at our partner company Indaver in Antwerp. According to its own statements, Indaver will invest EUR 100 million in the plant with a capacity of 26,000 tons, including the planned expansions. Appropriate cooperation agreements have been concluded with us and other companies to purchase the styrene monomers produced so that the cycle can be optimally closed.



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Technologies for recycling polystyrene

What's more, chemical recycling also enables applications that are closed to mechanical recycling. Transparent general purpose polystyrene applications — GPPS for short — for food contact or in medical applications, for example, as well as acrylonitrile-styrene-acrylic ester copolymers — ASA for short — which are widely used in the automotive industry, do not currently have a waste stream that can be recycled! However, the styrene monomer obtained by depolymerization can also be used in these applications. There is therefore a synergy between mechanical recycling and depolymerization on the side of the starting products and on the side of the applications.

Does this also apply to contact-sensitive applications? What about food packaging such as the yogurt pots mentioned earlier?

F. Eisenträger: The 'Super Clean Process' from Ineos Styrolution is registered as a 'Novel Technology' in accordance with EU Regulation 2022/1616 and enables direct contact between the food and recycled polystyrene. Yoghurt pots are more difficult for consumers to reuse after emptying than PET bottles, for example. It can therefore be assumed that recycled goods are less likely to be contaminated. The Styrenics Circular Solutions initiative — SCS for short — has demonstrated this in an extensive study of over 10,000 cups analyzed under scientific conditions. Added to this is the fact that polystyrene benefits from the fact that applications such as dairy product packaging are typically found in chiller cabinets and have a short shelf life, which makes the migration of substances into the food significantly more difficult. This makes the mechanical recycling of polystyrene very suitable for contact-sensitive applications.

> *"Chemical recycling also enables applications that are closed to mechanical recycling."*

The EU Packaging Regulation stipulates that food packaging must contain at least 10% recyclate in future. Can these quotas be met with mechanical recycling alone?

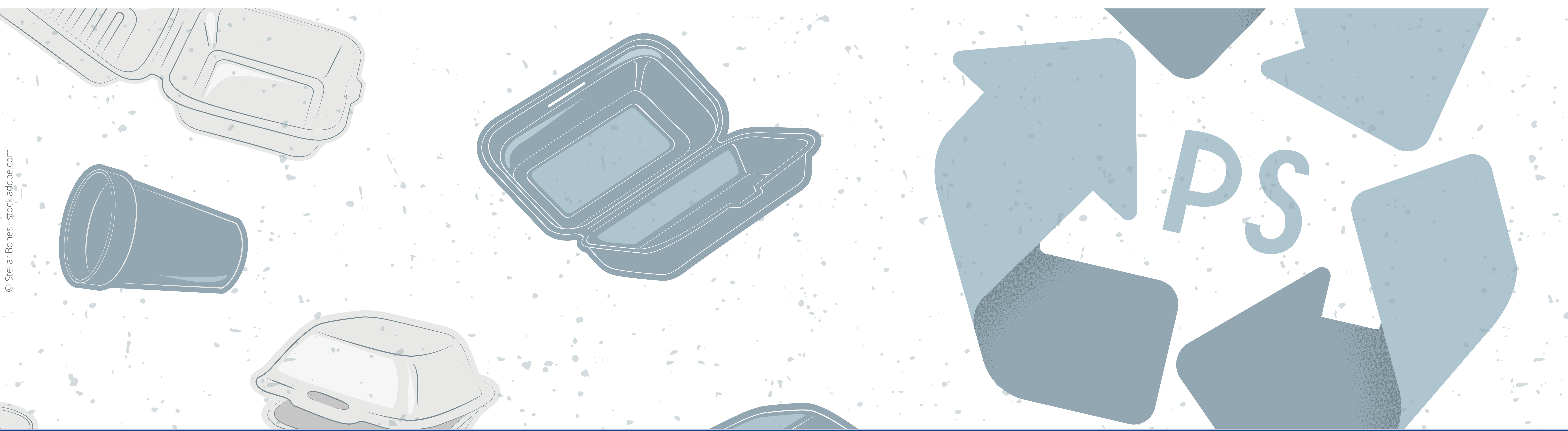
F. Eisenträger: The direction set in the EU with the Green Deal and in particular with the EU Packaging Regulation is aimed at reducing the environmental impact of packaging. Polystyrene will undoubtedly make its contribution and will be available for food-approved mechanical recycling. With the expansion of sorting capacities, the quantity also appears feasible. The required recycling quotas are within reach in countries with separate waste collection. In other countries, infrastructure is required for all polymers! As this is not currently the case for all alternative polymers, there could even be a higher demand for polystyrene.

Wouldn't it be easier for packaging manufacturers to switch to other materials, such as glass or paper?

F. Eisenträger: You can certainly argue why polystyrene should be the material of choice for dairy products such as yoghurt. However, a NABU study carried out by the Institute for Energy and Environmental Research — IFEU — in Heidelberg compared various glass and plastic options. Disposable glass quickly disqualified itself in all categories examined and glass recycling, although perfectly established, is too energy-intensive. 3K packaging often has problems with cardboard when it comes to mechanical waste separation, but wins in the climate change category. Polystyrene came out on top in the pollutant emissions category. If recycling is also taken into account here, i.e. thelow-CO_2 production of the material from recycled raw materials, which was not yet the case in the NABU study, the use of polystyrene is also a more than sensible, even superior alternative in comparison with reusable glass.

"The mechanical recycling of polystyrene is also very suitable for contact-sensitive applications."

However, the trend towards the less sustainable substitution of easily recyclable plastics with disposable glass packaging and fiber composites is currently dominating. As a rule, these not only result in a higher volume of waste, but also a higher ecological footprint and higher costs for the consumer. Consumers often have the impression that glass and paper are highly sustainable. But if you ask me, polystyrene has a good chance of emerging as a 'rising star' from the demand for circularity. For countless applications — especially food contact applications — polystyrene sets a new benchmark for a perfect material cycle with its diverse recycling options. ■



Best Practices for More Recyclate in Cars

How Car Manufacturers Can Implement the End-of-Life Vehicle Regulation (ELV)

The End-of-Life Vehicle Regulation (ELV) will oblige car manufacturers in the EU to source 25% of the plastics in new vehicles from post-consumer recyclate (PCR) from 2030. Of this, 25% of the PCR must also come from automotive waste. But how can the industry achieve these ambitious targets? Fabian Grote, Head of Technical Marketing Mobility at Covestro, and Erik Licht, Director New Business Development, Advanced Polymer Solutions at LyondellBasell, explain the challenges and opportunities that ELV brings for the automotive industry.

CHEManager: With the ELV regulation, the EU has set ambitious targets for the use of recycled materials in the automotive industry. How will this regulation affect the industry?

Erik Licht: The EU is systematically driving forward the transformation to a circular economy with the ELV. The new requirements offer the automotive industry a certain degree of planning security and at the same time oblige them to invest even more in the use of post-consumer recyclates. Initial progress can already be seen: manufacturers are increasing the proportion of recycled materials and adapting their designs to better integrate recycled materials. However, implementation remains challenging — especially due to the high demands on the material and the challenge for car manufacturers to procure sufficient PCR in reliable quality. In the Plastics Europe committees, we are working across companies to make politicians aware of the potential, but also the challenges, in the field of ELVs.

The automotive industry requires particularly high-quality post-consumer recyclate (PCR) for many components. In 2026, LyondellBasell's site south of Cologne will go into series production of Germany's first large-scale plant for the production of pyrolysis oil from mixed plastic waste from the automotive industry in order to produce new plastic granulate for vehicle interior parts.

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Erik Licht, LyondellBasell

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Fabian Grote, Covestro

For example, we are working to ensure that chemical recycling is included in the amendment as a supplement to mechanical recycling. This will enable us to close further material cycles.

This is likely to be crucial, as a wide range of polymers and composite materials are used in the automotive sector, from polyolefins such as polypropylene to high-performance plastics such as polycarbonate. Where are plastics used in today's vehicles?

Fabian Grote: Plastics can be found in practically every area of a modern vehicle, where they take on a variety of functions. In the interior, they are central to trim, seats and controls as well as dashboards and door handles. Air ducts and cable sheathing are also often made of plastics. On the outside, they are used for bumpers, front grilles, wheel arch linings, roof modules, sensor covers and trim strips. Under the hood, plastics perform tasks that require high temperature resistance and stability, for example in engine covers, fluid reservoirs or housings for control units. In terms of e-mobility, they are also indispensable in battery housings, cable systems and charging infrastructure. Last but not least, they are used in safety-relevant components such as crash structures, airbag or headlight covers, where they enable lightweight construction and safety at the same time.

In your opinion, what are the main challenges in using recyclates in the automotive industry?

E. Licht: One of the key challenges is quality assurance. Recycled materials must meet the same material properties and safety standards as primary materials, which is particularly crucial in safety-relevant areas. We can achieve this through chemical recycling. In this context, LyondellBasell is working with Audi, the Karlsruhe Institute of Technology — KIT — and SynCycle, for example, to produce plastic covers for seat belts with chemical recycling from PP compound for one of their models.

This is the first time that chemical recycling has been used for a series application in a closed-loop approach from mixed plastic waste from the automotive industry to plastic granulate for the interior of a vehicle. In 2026, Germany's first large-scale plant for the production of pyrolysis oil from plastic waste will go into series production at LyondellBasell's site south of Cologne.

In both chemical and mechanical recycling, the stability of the material composition is important in order to meet the requirements for series production. In addition to quality, the availability of PCR poses a further challenge. Establishing stable and traceable supply chains is also crucial, especially as 25% of PCR — i.e. 6.25% of the total plastic — is to come from used materials from vehicles in the future.

At LyondellBasell's ELV processing center in Lich near Giessen, automotive waste is sorted and processed so that the resulting post-consumer recyclate can be used again in automotive applications

That sounds like a complex challenge. How is the industry tackling this issue?

E. Licht: In order to achieve this goal as quickly and effectively as possible, both strong competitive and pre-competitive efforts and cooperation are required. This is why LyondellBasell is investing in a new processing center in Lich near Giessen, for example. This recycling center will convert ELV plastic waste into high-quality raw material for high-performance materials. On the pre-competitive side, LyondellBasell is also a member of the Global Impact Coalition — GIC — together with Covestro and other chemical companies in order to jointly promote solutions for the recycling of end-of-life vehicles and secure the market for closed-loop high-performance plastics.

How are car manufacturers supposed to achieve the high recyclate usage rates? Are there parts of the car where it is particularly easy to increase the proportion of recycled material?

E. Licht: The use of recyclates depends heavily on the requirements of the component. Areas in which the demands on surface quality, color accuracy or mechanical properties are less stringent are particularly suitable for starting out. Wheel arch linings, underbody covers or invisible interior components are examples where the use of recyclates is comparatively easy.

What does that mean in concrete terms? What would you advise car manufacturers to start with?

F. Grote: I would advise car manufacturers to start in less critical areas first in order to quickly gain experience with recyclates in series production. At the same time, they should invest in the development of recycling solutions that enable the use of recyclates in demanding components such as visible or safety-relevant parts. For such components, such as headlight covers or crash structures, material homogeneity, stability and long-term resilience are crucial — chemical recycling also offers exciting potential here.

Together with Neste and Borealis, for example, Covestro has already shown how old tires can be recycled into high-quality optical polycarbonate using pyrolysis, which can then be reused as a transparent plastic cover lens in car headlights, for example. The key lies in a step-by-step approach: Utilize the low-hanging fruit first while making targeted investments in more demanding applications.

Are there any other best practices that you would recommend to car manufacturers in order to successfully implement ELV?

E. Licht: I think that three things would be useful for car manufacturers in this context in order to prepare themselves optimally for the requirements of the ELV regulation.

Firstly, act early to secure the raw material flows you need for your future production. Other sectors such as the packaging and electronics industries are already much further ahead in the use of post-consumer recyclates than the automotive industry.

Secondly, advocate the acceptance of mass balances and the complementary use of mechanical and chemical recycling. These approaches are essential in order to be able to use a wide range of recycling technologies and raw material streams that meet the diverse material requirements of the automotive industry.

Thirdly, actively seek collaborations, especially with the chemical industry. Such partnerships can help not only to ensure the availability of PCR, but also to develop its quality and scalability to meet the high demands of the automotive industry. ■

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During chemical recycling, used tires are liquefied into pyrolysis oil, which is processed and then converted into acetone and phenol. These two basic chemicals are then converted back into high-purity polycarbonates. Covestro, Neste and Borealis are working together on this project to close the material cycle for the automotive industry.

PMMA as an Ideal Material for the Circular Economy

Recycling Network Drives forward Sustainable and Economically Efficient Recycling

The versatile material polymethyl methacrylate (PMMA) is particularly impressive due to its durability and outstanding recyclability. Röhm has already taken important steps to integrate its brand-name PMMA Plexiglas and other feedstock into a sustainable system and increase the recycling rate. Sustainable product design, chemical recycling and co-operation in a recycling network play a central role in this.

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Companies of all industries and sizes are working to reduce their carbon footprint, e.g. through recycling. This is because recycling reduces waste volumes and relieves the burden on the environment. It also enables sustainable products that can drive the decarbonization of numerous industries.

As part of its Track 2030 sustainability strategy, Röhm is pursuing ambitious goals that are geared towards long-term success through innovation and environmental awareness. The focus is not only on improving production processes, but also on a commitment to more environmentally friendly products and solutions. The aim is to increase recycling rates, minimize the carbon footprint and improve resource efficiency. These goals are incorporated into the entire product portfolio and the services offered. The use of circular or bio-based raw materials is a key lever for reducing emissions by 30% by 2030 compared to 2020.

All production sites in Germany and China that manufacture the monomer methyl methacrylate (MMA) or PMMA are certified in accordance with the ISCC-PLUS standard for the use of sustainable raw materials.

Sustainable Properties of PMMA

The PMMA brand Plexiglas is particularly valued for its versatility and outstanding optical properties while already offering many sustainable characteristics: it is highly recyclable, long-lasting, and features excellent weather resistance.

These qualities make PMMA a preferred choice in industries that demand top-tier optics, functionality, and aesthetics combined with durability.

Challenges in Mechanical Recycling of PMMA

It is therefore not surprising that PMMA is often used in applications where optical quality and surface gloss are crucial. Until now, recycled content has often been excluded from such applications due to concerns that aesthetic quality might suffer from the mixing of different plastics during recycling. However, new regulatory requirements and upcoming changes, such as the "End-of-Life Vehicles Directive" (ELV) or the "Corporate Sustainability Reporting Directive" (CSRD), necessitate a shift in thinking. Consequently, demand is increasing for products with higher recycled content and a significantly reduced carbon footprint.

Circular Economy and Recycling Rates in the PMMA Sector

The challenges of plastic recycling are evident in the automotive industry: of the total 150 to 200 kg of plastic per vehicle, only 2 to 4 kg is PMMA on average. This has historically resulted in minimal economic incentive to specifically isolate the material from waste streams. Even when post-consumer PMMA waste — plastic products discarded by end users – is carefully collected, there is a potential risk of cross-contamination. Such mixing with other plastics or foreign substances — such as polycarbonate — can significantly affect the optical quality of the recycled material.

Pilot Projects and Sustainable Design Approaches

Despite these challenges, Röhm has launched several pilot projects in collaboration with partners

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Lukas Dössel is Director Circular Economy at Röhm in Darmstadt. He began his professional career at Evonik in 2011 in the PMMA polymers area. Over the course of his career, he has held various management positions, including Laboratory Manager and Product Manager. He then worked for Röhm as Commercial Director in the USA.

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Sven Schröbel is Head of Sustainability Management in the Molding Compounds business unit at Röhm. During his more than 30-year career at Röhm, he has gained extensive experience in various functions, including material testing, business development and product management in the automotive sector.

along the value chain as part of its sustainability commitment. These initiatives included mechanically recycled post-consumer waste from the automotive industry, such as taillights. The results show that even after 20 years of use, the material can be reintroduced into the circular economy. However, the cleaning and sorting process is relatively labor-intensive.

A key takeaway: Smart and sustainable design of end products — such as taillights — could significantly improve material recovery rates in the future.

Design changes that facilitate separation of recycled material, such as the use of mono-material systems and avoiding multilayer structures, can enhance recycling efficiency. However, such measures to increase recycling rates take about 15 years to have their full effect, as the material has a long service life. Therefore, it is crucial to implement these design adaptations promptly to lay the foundation for a more sustainable circular economy.

Chemical Recycling and Mass Balance as an Opportunity

A promising solution for immediately increasing PMMA recycling rates is chemical recycling combined with mass balance. In this process, the material is broken down into its chemical building blocks, which, thanks to newly developed technologies, can be separated from contaminants and reused.

The final product achieves the quality of virgin material, making it suitable for high-end applications once again. This approach enables more efficient PMMA recycling while maintaining the quality of the end product.

Utilizing Post-Consumer Waste as a Raw Material

Market studies estimate that the annual PMMA consumption in Europe is around 400 kt, with the proportion of material being recycled currently below 10%. Given the limited availability of post-industrial PMMA waste, a market for recycled raw materials can only be expanded if post-consumer sources are also integrated. So far, the development of a functioning circular economy has been hindered by the lack of logistics and sorting infrastructure, as well as partners willing to actively participate in closing the loop.

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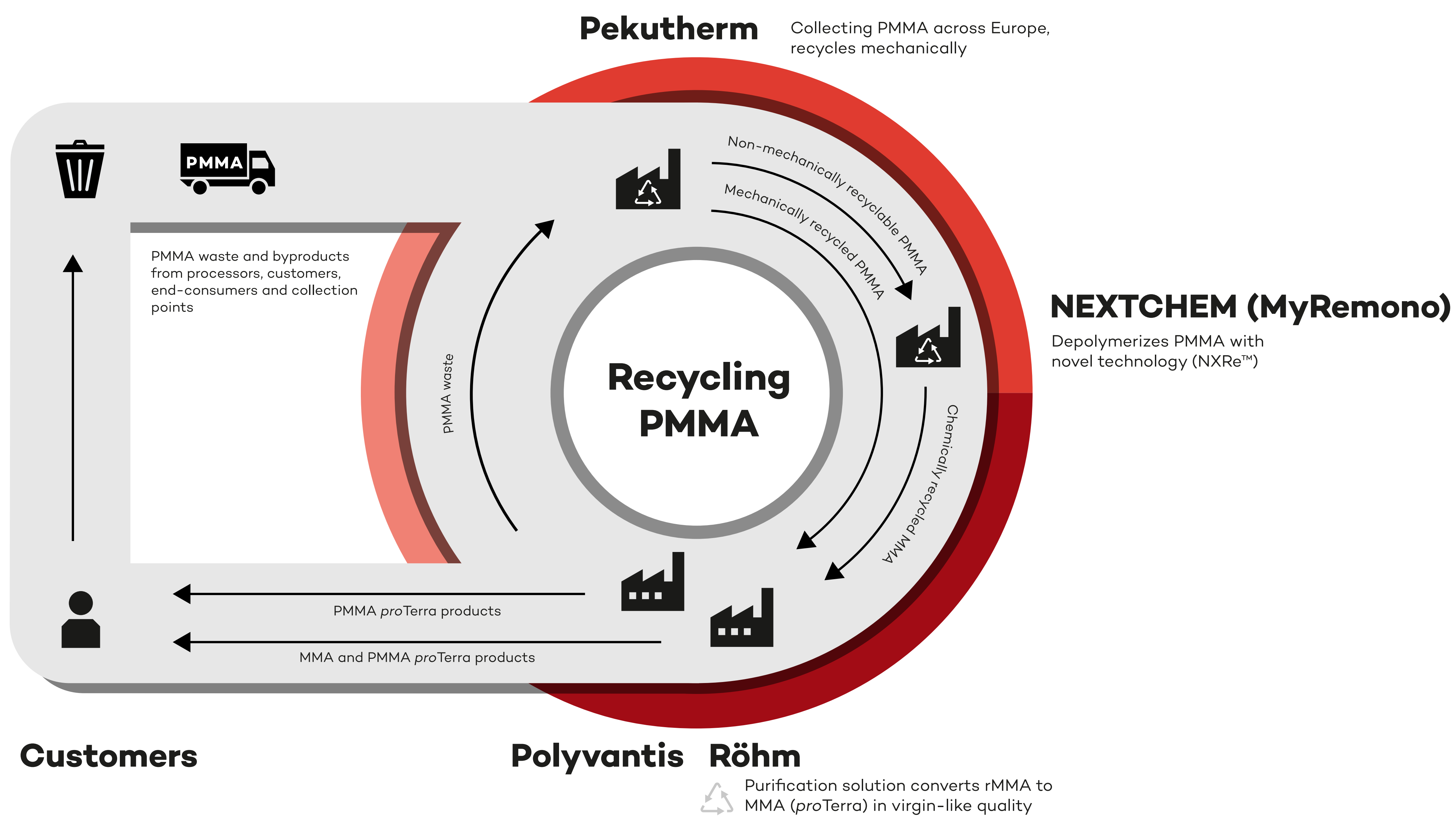
EUROPE-WIDE ALLIANCE FOR PMMA RECYCLING



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Companies Pekutherm, Nextchem (MyRemono), and Röhm have taken on this challenge and formed a pan-European alliance for PMMA recycling. The concept works as follows: PMMA is first collected from customers, consumers, and recycling centers. Then, using newly developed technologies, it is processed into PMMA and MMA of virgin quality, which can be used to produce new plastics — thus closing the loop.

PMMA is known for its long lifespan, during which it does not suffer from weather-related aging. However, attached contaminants can complicate later mechanical recycling. In such cases, PMMA can be broken down into its chemical precursor MMA with low energy consumption and high yield using the innovative NXRe technology from MyRemono, a network partner. This monomer can then be purified using a process developed by Röhm and reprocessed into PMMA of virgin quality.

Joint Effort for a PMMA Circular Economy

Through their collaboration, the alliance focuses on four key strengths:

1. Efficiency: In a multi-stage collection and sorting system developed by network partner Pekutherm — suitable even for small businesses — the best recycling technology for each material is selected. Certified specialists in Europe assess whether the materials are suitable for mechanical recycling.

2. Simplicity: Participating companies benefit from an easy-to-use system with collection boxes and logistics included. For recycling companies, the sorted collection of PMMA becomes economically attractive.

3. Flexibility: The applied processing methods are highly adaptable — even contaminated or mixed PMMA waste can be recycled into virgin-quality products thanks to innovative technologies.

4. Customer Choice: Clients can decide how they gradually advance their own decarbonization efforts and reliably source sustainable PMMA products. The alliance's stated goal is growth: all processors, customers, and consumers of PMMA in Europe are invited to join the network.

A significant increase in recycling rates at the end of a product's lifecycle can be achieved through an intelligent combination of mechanical and chemical recycling. Success hinges on close collaboration along the value chain and the willingness to rethink established processes. This includes developing products designed for recyclability (Design for Recycling) and systematically collecting and reintegrating post-consumer waste. The recycling network partners have laid the foundation for this transition. ■

Solvent-Based Recycling of WEEE Waste

New processes can increase the use of recycled materials in electrical and electronic equipment

The electrical and electronics industry is the fourth largest consumer of plastics after the packaging industry, the construction industry and agriculture. The use of recycled materials is set to increase in all of these areas of application in the future. Currently, recycled plastics are mainly used in the construction, packaging and agricultural sectors. Only around 3% of post-consumer recyclates find their way into electronic and electrical appliances.

© Trinseo

Klaus Wohnig (Atmedio, l.) and Benjamin Porter (Trinseo, r.) are involved in the Dissolution Recycling Of Plastics Initiative (DROP-IN) for the acceptance and further development of solvent-based recycling.

How can the use of recyclates in electrical appliances be increased? An interview with Benjamin Porter, Global Sustainability Business Development Manager at Trinseo, and Klaus Wohnig, Managing Partner at Atmedio and founder of the dissolution recycling initiative DROP-IN, about the potential and limits of solvent-based recycling of waste electrical and electronic equipment (WEEE).

CHEManager: According to Plastics Europe, the association of plastics producers, the use of post-consumer recyclates in electronic equipment in the EU was 3.2% in 2022. Why is so little recycled material still used in the electrical and electronics industry, the fourth largest consumer of plastics?

Benjamin Porter: There are a number of technical challenges that make it difficult to use recyclate in electrical appliances on a large scale. In contrast to short-lived packaging, plastic components in electrical engineering are designed for long time horizons. Cables, pipes and fuse boxes in buildings often have a useful life of 20 to 30 years. It is therefore very difficult for recyclers to estimate the exact composition of the components at the end of their life. In addition, electrical appliances must comply with strict product regulations, for example for flame retardancy, the prevention of short circuits, tracking resistance or the reduction of fumes. These requirements also apply to the use of recycled materials.

Personal Profile

Klaus Wohnig is Managing Partner at Atmedio and founder of DROP-IN, the Dissolution Recycling of Plastics Initiative. The business graduate is a member of the board of the German Association for Secondary Raw Materials and Waste Management (BVSE) and the Federal Association of the German Waste, Water and Raw Materials Management Industry (BDE).

Personal Profile

Benjamin Porter is Global Sustainability Business Development Manager at Trinseo and a member of DROP-IN, the Dissolution Recycling of Plastics Initiative. Prior to his current position at Trinseo, the graduate engineer worked for Lubrizol and Tecnaro, among others.

Opening of Trinseo's dissolution plant in Terneuzen, NL, in May 2023

Safety and consumer protection requirements are tending to increase in the electronics industry. Is it even possible to increase the use of recycled plastics in electrical appliances under these conditions?

B. Porter: Yes, as we are dealing with complex components in electrical applications, new approaches could offer significant added value here. Digital product passports, for example, could give the recycler access to the exact composition so that they know in advance exactly what composition they are dealing with and are also prepared for future legal frameworks, such as compliance with REACH, RoHS, Basel and the Stockholm Convention. There is also great potential for solvent-based recycling processes for electrical appliances. If these processes are scaled up, WEEE waste could be recycled much more efficiently.

Can you explain in more detail what these solvent-based recycling processes are all about?

Klaus Wohnig: In the so-called dissolution recycling of WEEE waste, it is exposed to a solvent after mechanical pre-treatment. This liquid can diffuse into the polymer matrix and dissolve the desired fraction. Insoluble components, such as other polymers, but also metals, glass or ceramics, are not changed by this solvent. They remain as solids in the solution and can be separated. The resulting fraction can then be further refined using standard filtration processes, for example to remove interfering components such as printing inks, stickers, coatings, but also fillers such as color pigments, flame retardants or reinforcing fibers. Finally, the solvent is removed from the target fraction and a regenerated polymer fraction is obtained, which often comes very, very close to the quality of virgin material.

What are the advantages of dissolution recycling of WEEE waste compared to other recycling processes? And for which plastics are these processes particularly suitable?

K. Wohnig: We see the dissolution process as a supplement to conventional mechanical processing methods, not as a competitor.

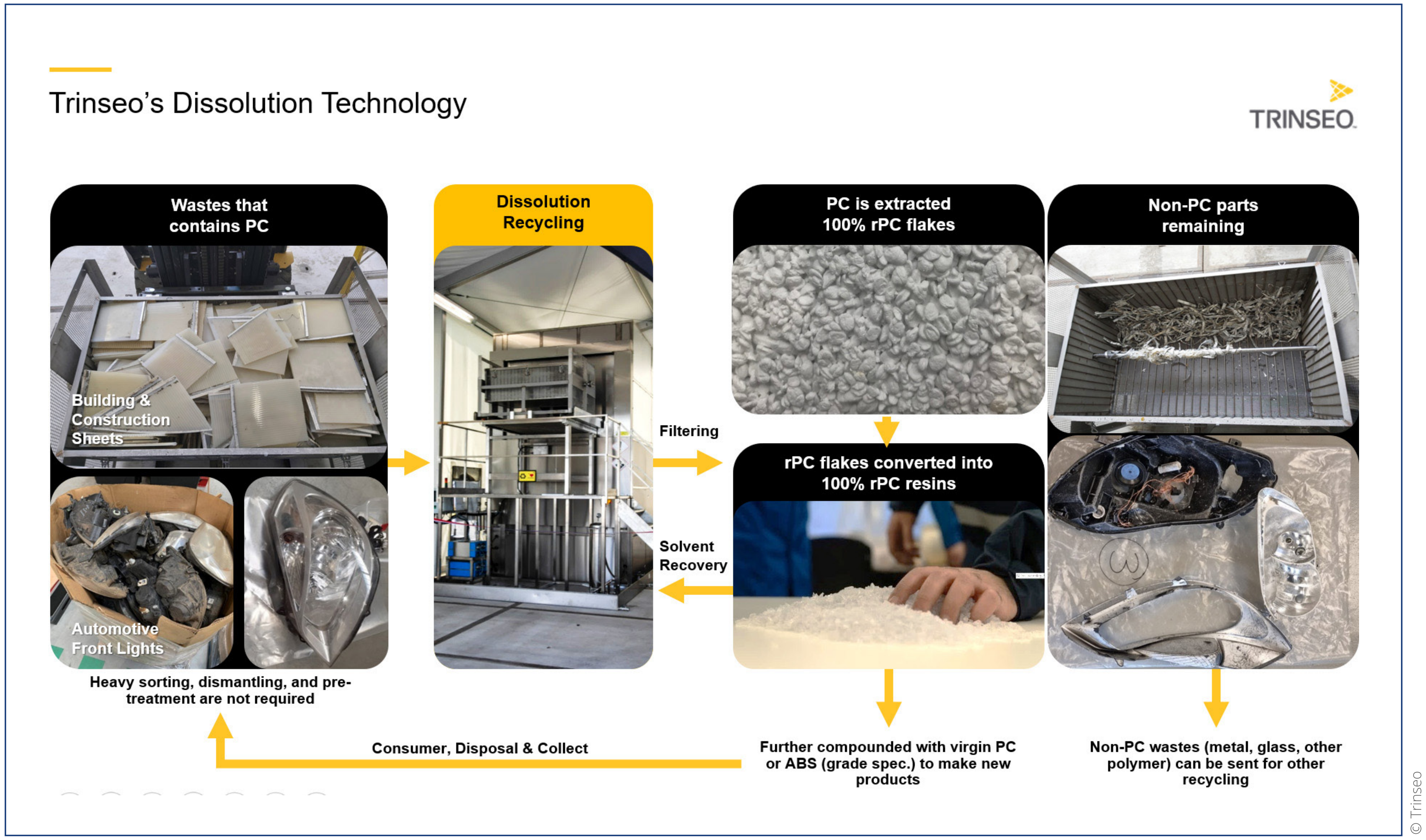
It is suitable for a wide range of target polymers. In the field of technical applications, it will be particularly relevant in the near future for PC, ABS and PS, but also for PA and PP, as it will enable future regulatory requirements to be met. In addition, the solvent process, which is categorized as physical recycling, is characterized by the fact that it is not only economical, but also particularly climate-friendly and resource-saving.

What advice would you give to companies that process large quantities of WEEE waste? How can they integrate solvent-based processes into the recycling process?

B. Porter: The most important thing is to first get a good overview of new technologies and recycling processes. The field of plastics recycling is currently experiencing incredible momentum.

I would therefore advise companies to get in touch with the Dissolution Recycling Of Plastics Initiative (DROP-IN), in addition to visiting specialist conferences and trade fairs, in order to get an overall picture of current developments.

DROP-IN may result in interesting synergies and pioneering new business models, such as take-back schemes or the design of EPR systems. This will help companies to recover more raw materials from their WEEE fractions in the long term. ■



Typical use case for solvent-based recycling: The separation of polycarbonate from mixed PC-containing waste streams.

From Compliance to Recyclate Strategy

How Companies can Prepare for the New EU Packaging Regulation

The new EU Packaging and Packaging Waste Regulation (PPWR) aims to minimize the amount of packaging and packaging waste, reduce the use of primary raw materials and promote the transition to a circular economy. However, the regulation imposes new regulations and increasing compliance requirements on the plastics industry and demands high recyclate usage rates. How realistic are the targets? What solutions are available? And what exactly do companies need to do now? Carolina Gregorio, Sustainability Director for the Packaging & Specialty Plastics business unit at Dow in Europe, explains what is important now and how the industry can best prepare itself.

CHEManager: Ms. Gregorio, what are the most important points of the PPWR? What new requirements does it bring?

Carolina Gregorio: The PPWR creates a clear roadmap for more sustainable packaging in Europe: all packaging must be recyclable by 2030, and on a large scale by 2035. Binding recyclate use quotas have been introduced and will be gradually increased: to between 10% and 35% by 2030 and up to 65% from 2040.

At the same time, the PPWR aims to minimize packaging, ban single-use formats and set reuse quotas. It also calls for an ecological adjustment, known as ecomodulation, of fees within the framework of Extended Producer Responsibility—EPR for short—based on recyclability, and proposes mandatory labeling to inform consumers about the sustainability of packaging.

This offers the opportunity to work across supply chains to develop innovative, recyclable packaging solutions that meet both sustainability goals and economic requirements.

When does the PPWR come into force? By when do companies have to be compliant?

C. Gregorio: The PPWR has been in force since February 2025, although some obligations will only apply from August 2026 and—for the most part—from

2030. This provides a solid window of opportunity to plan, test and gradually implement adjustments to packaging. Important milestones, such as mandatory recyclability and recyclate use quotas, are scheduled for 2030. This gives time to coordinate internal processes and work with suppliers to secure the necessary materials and adapt production methods.

What happens if you fail to comply?

C. Gregorio: Manufacturers who fail to comply will no longer be allowed to place their packaging on the EU market. There are real risks, such as financial penalties and market restrictions, which can be mitigated by taking early action. Above all, however, compliance with the PPWR opens up new opportunities: consumers place more value on sustainable packaging, and proactive action can strengthen the image and competitiveness of manufacturers and brand owners.

How are the high recyclate usage rates to be achieved? Where does the required recyclate come from?

C. Gregorio: In order to achieve the ambitious quotas, mechanical and chemical recycling must be combined, continuously improved and expanded. Mechanical recycling is suitable for clean, homogeneous streams, while chemical recycling is essential for complex, contaminated packaging waste. However, mechanical recycling has limitations in the production of food-grade and high-quality recycled plastics for packaging with high quality requirements. Chemical recycling offers advantages here, but mechanical recycling

© Dow

Carolina Gregorio, Sustainability Director Packaging & Specialty Plastics, Dow Europe

is more cost-effective and has a lowercarbon footprint. Mechanical recycling should therefore be preferred and chemical recycling should be used as a supplement to complement the limitations of mechanical recycling. With the complementary use of both technologies, sufficient high-quality recycled material can be secured to meet the quotas - also for food packaging. Strong links with recyclers, investment in innovation for recyclable materials and the expansion of recycling and collection infrastructure through effective use of EPR revenues are crucial to ensure a long-term supply of sufficient recyclate.

What best practices are suitable for meeting recyclate input quotas?

C. Gregorio: These start with product design, i.e. how recyclable the packaging is designed, for example by using mono-materials or reducing components that hinder recycling. Research departments and product designers must work closely together to select and combine materials in such a way that they can be mechanically and chemically recycled. For example, integrating post-consumer recyclate from mechanical recycling into non-food packaging at an early stage, while testing recycled plastics from chemical recycling for sensitive applications, creates a comprehensive, solid strategy. Cooperation with recyclers, investments in raw material partnerships and research into bio-based materials will also ensure flexibility in the future.

What do companies need to do to meet the quotas in particularly demanding applications such as food packaging?

C. Gregorio: Food packaging requires particularly high standards. For mechanical recycling, this means complying with legal food contact criteria and EFSA approval, which is often not feasible on an industrial scale. For this reason, chemical recycling processes should be used more intensively to produce recycled plastics of high virgin quality. In addition, for example, food-grade PET recyclate - rPET — could also be used for certain applications, such as packaging trays.

PPWR Timeline

In rPE and rPP-based food packaging in particular, active participation in projects to scale up food-grade recycled plastics from chemical recycling more quickly is absolutely necessary. And, it is also important to advocate for clear regulatory calculation rules at national and European level to promote all recycling technologies.

How do production processes need to be adapted?

C. Gregorio: Process adjustments will vary, but can be managed through a proactive approach, early testing and close collaboration with equipment manufacturers and customers. Packaging lines may need to be recalibrated to handle recycled materials with different properties, and sealing or forming processes may need to be adapted for mono-materials. The qualification of new recycled materials and packaging based on them should certainly be tackled as early as possible with the relevant customers. And: New labelling systems are required in order to comply with the harmonized labelling rules of the PPWR.

What do you expect from the new federal government? How could companies be supported in implementing the PPWR?

C. Gregorio: Plastic and packaging producers need support in the form of clear and simple regulatory guidelines, financial incentives and investment in infrastructure to improve the collection and sorting of plastic waste. This is crucial in order to increase the supply of secondary raw materials. Policymakers can also promote platforms where industry and regulators work together to develop solutions. Simplified permits for new recycling technologies and the promotion of innovative, clean and circular technologies in public investments would further accelerate the transition. If we succeed in combining the innovative strength of the industry with supportive political measures, the PPWR challenge can ultimately become a decisive competitive advantage.

What could a concrete strategy look like here?

C. Gregorio: A clear action plan for plastics processors and packaging manufacturers could look like this:

First, the packaging portfolio should be reviewed to understand the current materials, their recyclability and recyclate use.

Collaboration with recyclers and suppliers is important to secure future supplies of recycled and bio-based plastics through contracts or partnerships. Collaboration must also consider new innovative business models to finance the necessary investments.

New packaging should always be designed with circularity in mind, with manufacturers switching to mono-material packaging structures, simplifying designs and testing new materials. In Europe, there are already some financial incentives for this transition.

Production processes should be modernized by adapting machinery and quality controls to better handle recycled content.

With regard to documentation and reporting obligations, a reliable data system is needed to track material flows.

And: Overall, there should be much more internal and external communication, cross-departmental collaboration and cooperation with external partners to promote a continuously improved understanding of the upcoming circular economy. ■

The Future of the Textile Industry

Every year, over 100 million tons of textiles are produced worldwide, but less than 1% of them are returned to the cycle as new garments after use. The economic potential is obvious: in Europe alone, over 5.8 million tons of used textiles are produced every year. So far, hardly any is recycled.


© BASF

Dag Wiebelhaus, Head of Product Innovation, Monomers division, BASF

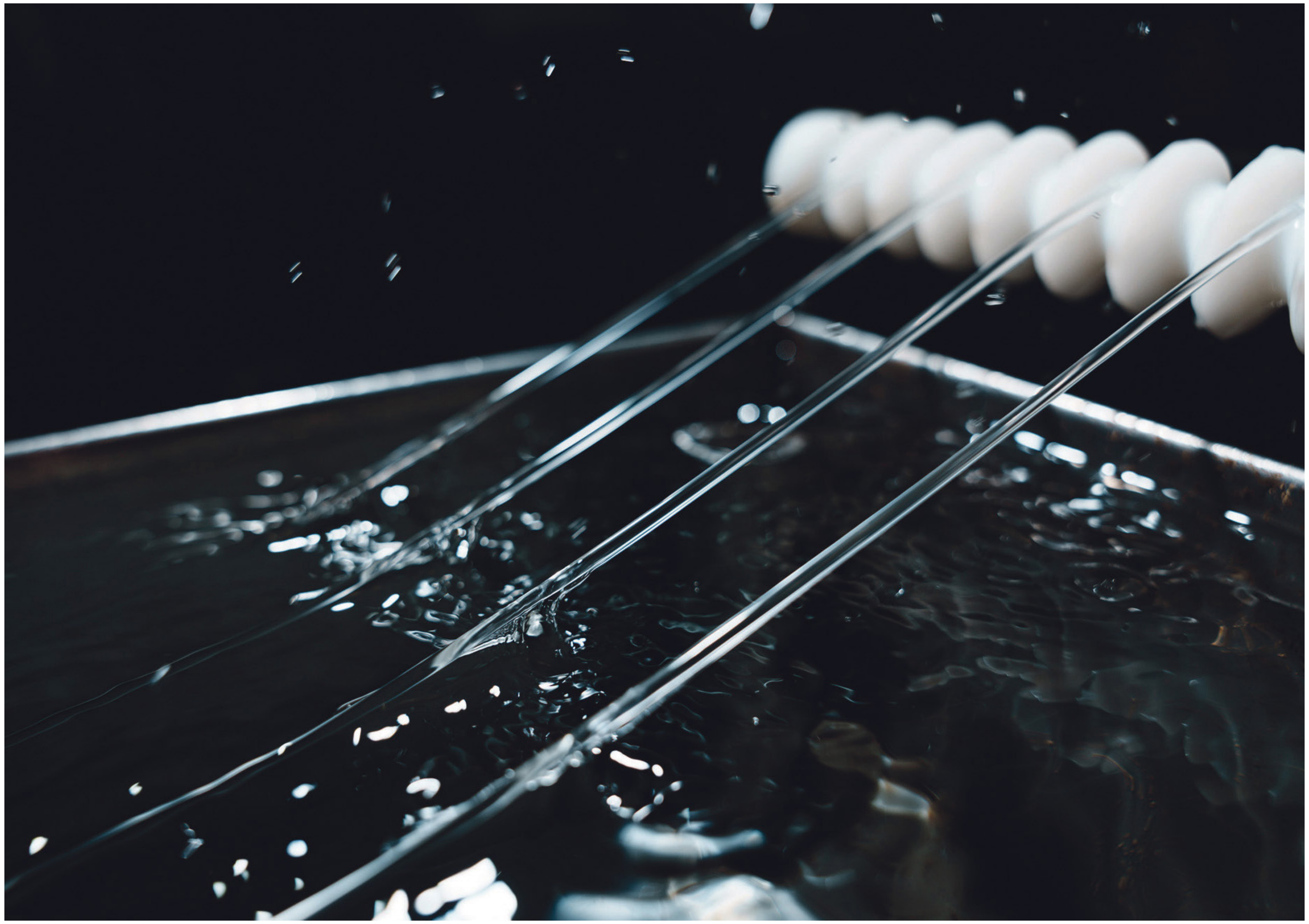
Why has this potential remained untapped? And how can the carbon bound in textiles be better recycled in future? An interview with Dag Wiebelhaus, Head of Product Innovation in BASF's Monomers division and head of the Loopamid project, with which the chemical company aims to close the loop for textile waste.

CHEManager: Mr. Wiebelhaus, the textile industry causes a waste and CO_2 problem, but textile recycling has only played a marginal role so far. Why is that?

Dag Wiebelhaus: The textile industry faces the challenge of reconciling economic profitability with social responsibility and environmental sustainability. On the one hand, the demand for cheap, quickly produced clothing has increased. On the other hand, there is an opposing trend: increasing regulation with regard to sustainability and social responsibility.

Personal Profile

Dag Wiebelhaus studied chemistry at RWTH Aachen University and joined BASF's research department after completing his doctorate in 1998. After holding positions in marketing, purchasing, and new business development in various business areas, he was appointed Head of Product Innovation in BASF's Monomers division in 2014.



© BASF

BASF's Loopamid process helps meet the growing demand for sustainable polyamide 6 fibers in the textile industry. The technology enables textile-to-textile recycling for polyamide 6 in a wide variety of fabric blends. The product, Loopamid, is a recycled polyamide 6 based exclusively on textile waste.

Governments and consumers are demanding more transparency in supply chains and more sustainable production methods. In addition, the overproduction of textiles is leading to an enormous waste problem. Many items of clothing are quickly thrown away, which not only causes ecological but also economic costs. Companies have to deal with the consequences of overstocking and the need for effective recycling, which requires additional investment.

What are the biggest challenges? And are there any solutions?

D. Wiebelhaus: The completed T-REX project has just presented the latest findings on this. The Textile Recycling Excellence project — T-REX for short — is funded by the EU and deals with the development of a circular economy for textiles. The aim is to create a blueprint for the large-scale recycling of textile waste by establishing a closed recycling loop for used household clothing. The project shows that the challenges of textile recycling are manifold. The efficiency of sorting is currently low and manual sorting remains costly. Automation could improve the quality of the recycled material. There is a lack of high-quality recycled material, which is often difficult to obtain and expensive. High operating costs in Europe and inefficient processes increase overall costs. Recycling can significantly reduce the environmental impact of textile fiber production, but efficiency and environmental footprint vary greatly depending on the material and technology. In addition, economic incentives should be created to spread the responsibility for textile waste management evenly throughout the value chain. Furthermore, realistic targets for the proportion of recycled materials and harmonized standards for recyclability are required.

"The overproduction of textiles leads to an enormous waste problem."

What market potential do you see for textile recycling?

D. Wiebelhaus: In our estimation, there is definitely market potential in the textile recycling sector. However, as the collection and sorting of used clothing is still in its infancy in many countries, BASF is currently still using industrial textile waste from the production of polyamide textiles for the production of our Loopamid. Our aim is to increase the proportion of used clothing as soon as more is available. Polyamides, also known as nylon, are widely used as synthetic polymers in fashion and sportswear. BASF has developed a new high-quality polyamide 6 called Loopamid, which is produced entirely by recycling textile waste. We are actively committed to increasing the availability of used clothing waste for the production of Loopamid and are working closely with our partners along the textile value chain.

> *"Products must be designed in such a way that they can be recycled more easily at the end of their useful life."*

How will the EU Waste Framework Directive affect textile recycling?

D. Wiebelhaus: The EPR system for extended producer responsibility introduced as part of the EU Waste Framework Directive will be beneficial for textile recycling. The costs for collection, sorting and recycling will be included in the price of the textile and distributed along the value chain. How exactly such an EPR system can be set up is currently being discussed. As soon as the regulatory requirements are in place, such as the EU Waste Framework Directive and the EU Ecodesign Regulation, we believe that nothing stands in the way of scaling up textile recycling.

Many textiles are made from mixed fabrics. Which textiles are already easy to recycle, and which are less so?

D. Wiebelhaus: Textile waste is always a complex mixture of many different materials and therefore a complicated raw material for any chemical recycling plant. There are different types of fibers, both natural and synthetic, as well as additives and dyes. All of this can be found in used clothing collections. But even industrial textile waste is of similar complexity when it comes to so-called cut waste. There are already established mechanical recycling approaches for cotton, where cotton textiles are processed into cleaning cloths or fleece, for example. The technologies for chemical recycling of synthetic fibers are largely developed, but scaling up to an industrial scale is only just beginning.

What products can still be made from old textiles?

D. Wiebelhaus: Textiles can be reused in many different ways and transformed into new products. Other textile products can be made from old textiles, such as bags, carpets, insulation materials or felt products. This is known as "downcycling", where subsequent reuse is difficult.

What needs to be done to increase the proportion of recycled material in new textiles?

D. Wiebelhaus: Companies within the textile industry should definitely work together. Initiatives and partnerships can help to accelerate research and development in this area. One example was the T-REX project, which worked with twelve partners to achieve one goal: To make the textile industry circular. A major aspect of this was the collection and sorting of used clothing. This is still a challenge. Another important aspect is design for recycling. Products must be designed in such a way that they can be recycled more easily at the end of their life. This means that designers and manufacturers choose materials that increase recyclability. Our first Loopamid jacket, for example, which we developed together with Inditex, is designed in such a way that it can be fully recycled again.

How should textiles be designed so that they can be optimally recycled?

D. Wiebelhaus: Of course, it would be easiest for all textile cycles if all products were made from just one material — this is not the reality. The process is complex. Many textiles are not made from pure polyamide, for example, but from mixtures of different materials, which can make the recycling process more difficult. Separating the polyamide from other materials in these blends can be a technical challenge. BASF can recover PA6 from mixed textile waste in a robust process with high yields. Our technology can process waste with only 80% purity, whereas many technologies today require a significantly higher purity of the textile waste used. ■

Alternative Naphtha

Pyrolysis Oil from Chemical Recycling of Plastic Waste as Fossil Feedstock Substitute

Relevant shares of renewable chemicals and polymers are not possible without "alternative naphtha". Without a shift away from fossil naphtha, there will be no significant defossilization of the chemical sector. Pyrolysis oil, which is obtained by chemical recycling of plastic waste and tires, is an important "alternative naphtha" for refineries and steam crackers.

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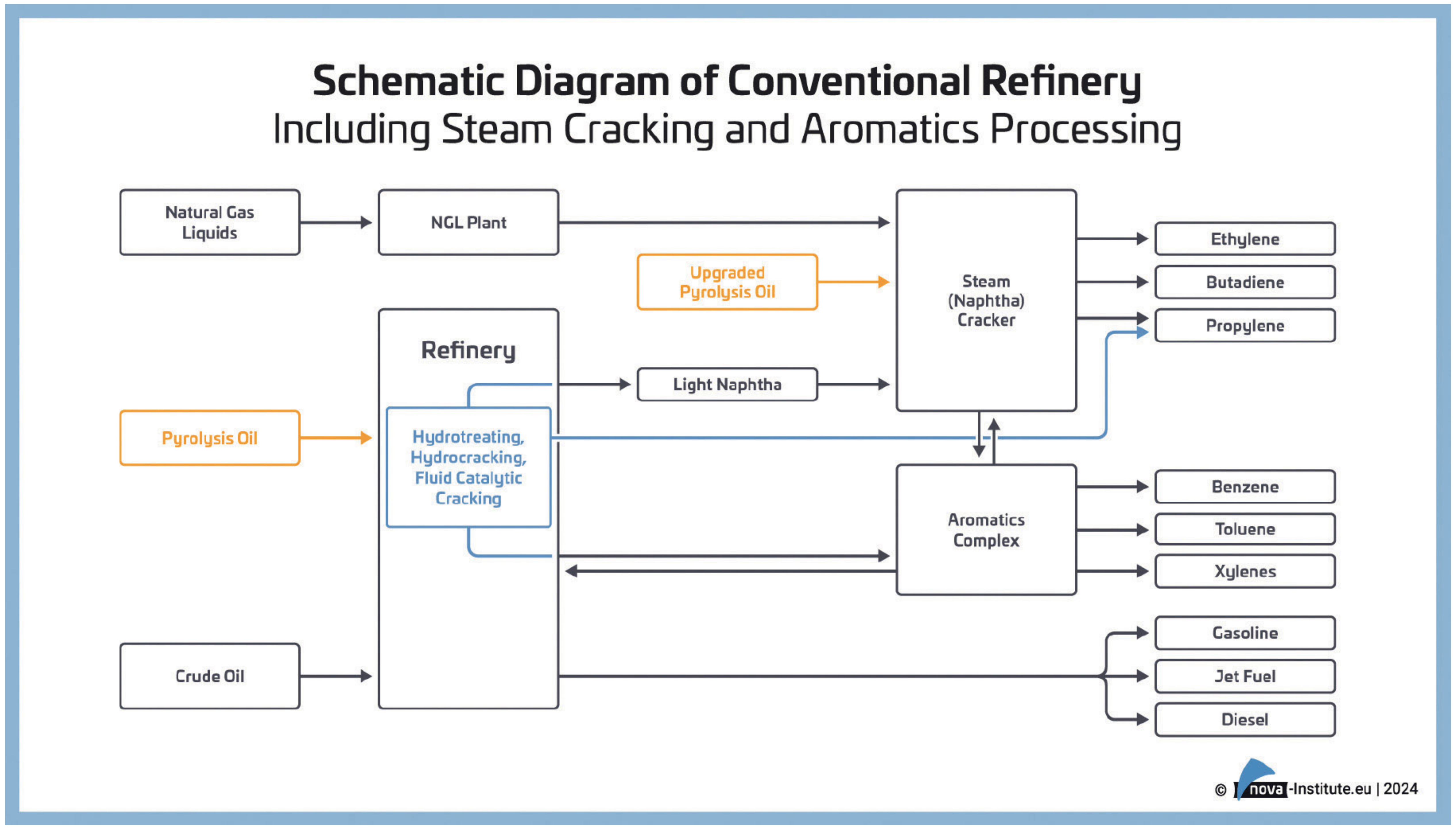
The recycling of plastics is currently under discussion for several reasons:

- as a means of treating plastic waste and thus reducing environmental impact
- to meet the recycling targets of brand manufacturers and EU and member state laws/regulations on plastics recycling
- to close the loop and recycle plastic waste from the packaging sector into plastics, especially for food contact applications that are difficult to achieve with mechanical methods

Possible concerns about chemical recycling relate to potential process emissions, high energy requirements, life cycle assessment (LCA) results, and the fact that chemical recycling can be seen as a justification for further increasing plastic production. However, the resistance in Europe must be seen in the context of the EU target to reduce the proportion of municipal waste sent to landfill from 18% in 2020 to 10% or less of total municipal waste by 2035.



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Carbon contained in chemicals and downstream products

© Nova Institute

Michael Carus, Managing Director and Founder, Nova-Institute

Plastics Recycling: Important and Necessary

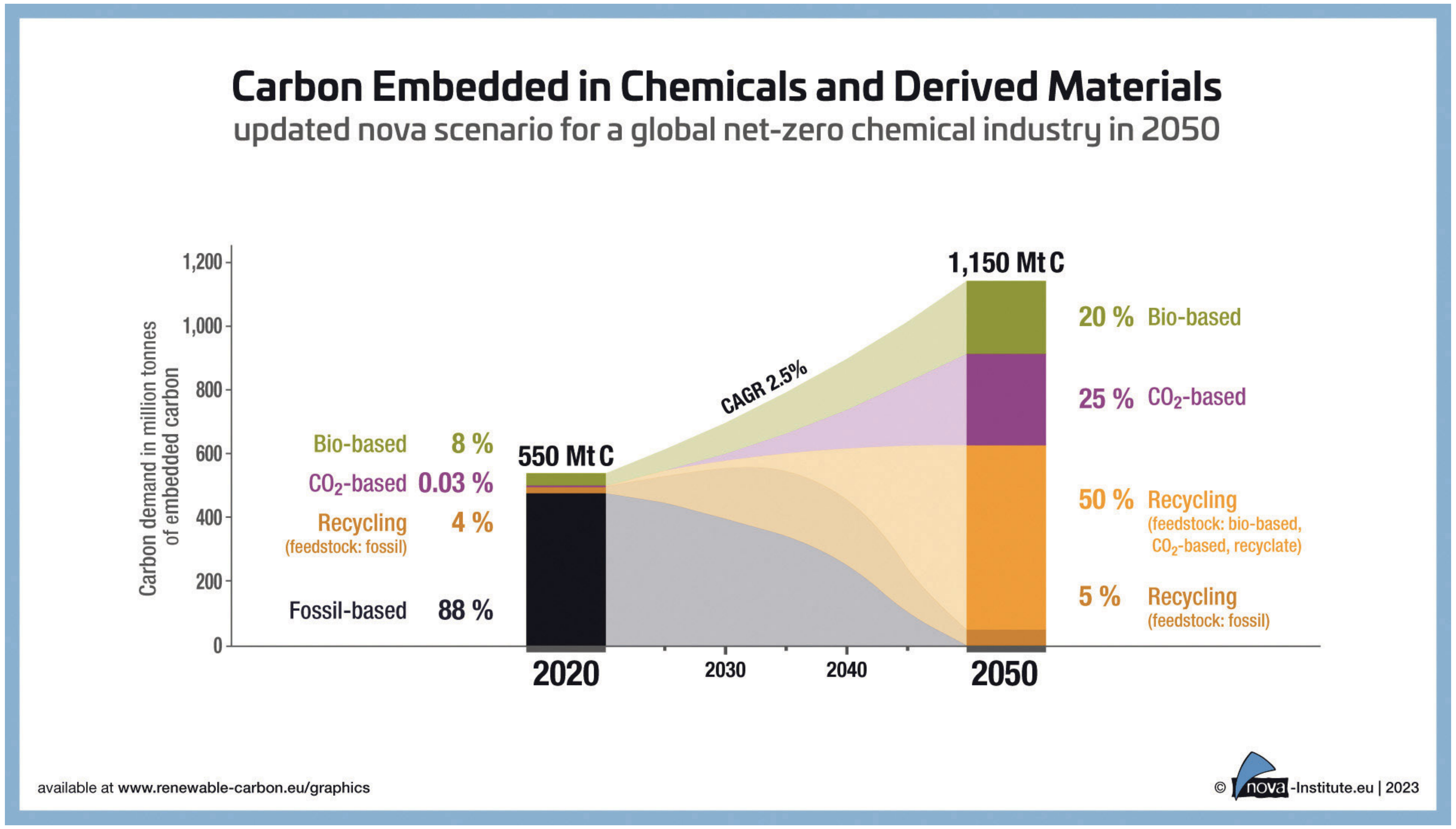
The graphic shows a scenario of how a global net zero of fossil chemicals could be achieved by 2050. With an expected overall growth in demand for chemicals and plastics by 2050, 55% of the carbon demand by 2050 is met by recycling, as the availability of bio-based carbon is limited and CO_2-based pathways are more expensive. This scenario is in line with several Net Zero scenarios, which almost all show high shares of chemical recycling.

Legal Requirements as a Driver

Pyrolysis as a recycling method offers great advantages in meeting the quality standards required for packaging materials in contact-sensitive applications. Although the new legislation has not yet been officially adopted (expected to be adopted in spring 2025), pyrolysis is expected to play an important role in achieving the ambitious recycling targets of the new EU legislation and will strongly support the production of PyOil from used plastics and tires.

Back in March 2023, it was reported that the EU will indeed support "feedstock recycling" for the recycled content requirements of beverage bottles and that a "fuel use excluded" approach will be a sub-condition of the mass balance approach. This was reaffirmed this year—otherwise the high recycling rates and food contact cannot be achieved.

Mass balancing enables the allocation of recycled secondary raw materials as recycled content to selected target products.



Mass balance and attribution without fuel use

Gillian Tweddle, Stripe Consulting and external expert, Nova-Institute

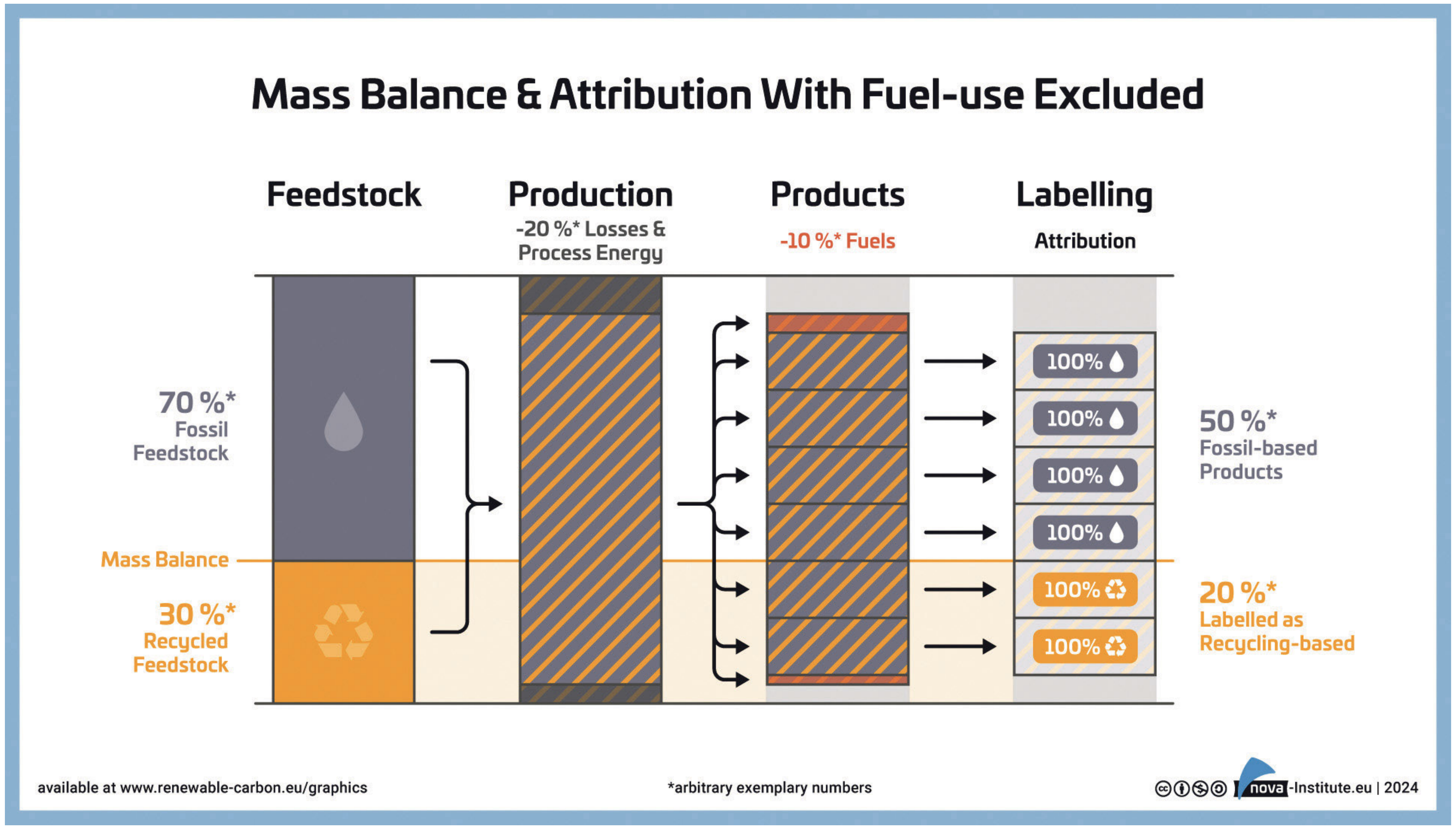
The allocation can be shifted between the products according to fixed rules. Process losses, process energy and recycled secondary raw materials that flow proportionately into the production of fuels (fuel-use excluded) are deducted and therefore cannot be counted as recycled content in target products.

Pyrolysis Process and Refinement

A wide range of plastic sources, from post-industrial and post-consumer plastics and mixed waste (including bio-waste), including multi-layer thermoplastics and thermosets, biobased plastics to used tires, can be processed by pyrolysis to produce a very wide range of products.

The technologies developed or under development for pyrolysis itself are very diverse and can include rotary drums, stirred tanks, fluidized beds, microwaves, horizontal screws or water/steam cracking technologies reacting at temperatures of 350 – 900 °C. At the Nova Institute's next Advanced Recycling Conference on November 20 and 21, 2024, numerous advanced technologies for the recycling of plastic waste will be presented.

The chemical composition of the total liquid fraction produced, referred to as pyrolysis oil or PyOil, reflects the plastic raw material, the pyrolysis technology used and the operating conditions. It can produce a wide range of C chain lengths from C1 to C34 with high levels of unsaturated hydrocarbons and also contain high levels of impurities (N, O, S, Cl, Br, F — described as heteroatoms —, Si, P and metals).



Schematic diagram of a conventional refinery

The amount of pyrolysis oil produced per ton of plastic waste processed varies considerably. Based on data from technology providers, a typical conversion factor of 50 – 60 % can be assumed.

Unprocessed but pre-treated and fractionated pyrolysis oils can be fed in small quantities into steam crackers (light fraction C5 – C9) or refineries (co-processing); the quantities must be so small that a dilution effect enables processing with conventional feedstocks despite the degree of contamination and differences in composition.

The processes for processing the pyrolysis oil, which allow a high percentage blending with conventional feedstocks for steam cracker feedstocks, are very similar to those carried out in a conventional fossil fuel refinery. These include hydroprocessing, consisting of hydrotreating and hydrocracking or isomerization to reduce carbon chain lengths to approximately C5 – C9 naphtha-like pyrolysis oil, which is similar to fossil naphtha. Additional and alternative catalysts are required to remove toxins and heteroatoms compared to the processes used in existing refineries to process conventional feedstocks.

Pyrolysis oil co-treated in refineries can be further processed in the refinery's hydrotreating, hydrocracking or fluid catalytic cracking (FCC) units. One product of FCC processing is propylene.

Market Aspects

The global production capacity for PyOil in partnership with refineries and steam crackers as users of this material has been estimated at less than 500 kt per year until 2023. By 2026, more than 50 projects with such global off-takers are planned to increase the total capacity for PyOil production to 1,500 kt/a. However, not all of these projects are expected to be realized as technology development and production costs, availability of suitable feedstock and transportation costs continue to pose problems.

For PyOil, the products of pyrolysis plants can be collected and mixed to obtain larger quantities of raw materials, as 20 kt/a is a typical processing capacity for plastic waste per plant.

Finally, higher costs compared to fossil-based production due to smaller processes and new technologies mean that end users have to pay higher prices for products containing renewable raw materials. In addition, customers must be willing to accept the mass balance approach and the crediting of renewable carbon. ■

The article is based on the report "Alternative Naphtha - Technologies and Market, Status and Outlook" by the Nova Institute.
You can download the full report from the Renewable Carbon Initiative website: www.renewable-carbon.eu/publications

Advertorial

Trinseo's Advanced Recycling Technologies Help Accelerate Circularity

Trinseo's complementary recycling technologies —dissolution, depolymerization, and mechanical recycling — support the development of a more circular economy by reclaiming valuable plastic waste.

These recycling technologies are facilitated by our recycler, Heathland B.V., and expand our access to post-industrial, post-consumer recycled plastic waste streams. This facility manages the mechanical recycling of polymethyl methacrylate (PMMA), polycarbonate (PC), acrylonitrile butadiene styrene (ABS) and polystyrene (PS).

Additionally, our demonstration facility in Rho, Italy, returns polymethyl methacrylate (PMMA) to its constituent monomer, achieving over 99% purity. This process is derived from our participation in the EU-funded MMAtwo Consortium and expands the types of acrylic applications that can be recycled. The resulting recycled methyl methacrylate is ISO14021 certified for 100% recycled content and can be used in the production of recycled-containing PMMA resins and sheets.

We also have a long-term offtake agreement with Indaver that secures 50% of their chemically recycled styrene production through proprietary depolymerization technology. This feedstock is used in styrenics, including ISCC PLUS–certified rPS resins via mass balance allocation, suitable for food contact (subject to EFSA approval).

Our PC pilot and ABS dissolution facilities in Terneuzen, Netherlands, use solvent-based extraction to recycle these polymers from mixed waste streams. This ABS dissolution process comes from participation in the EU-funded ABSolEU project.

Trinseo's dissolution-based recycling technologies can reduce CO_2 emissions by up to 80% compared with virgin PC/ABS production, based on PEFCR-aligned cradle-to-gate studies.

Trinseo's approach—combining partnerships, acquisitions and proprietary innovations—positions us as a leading contributor to driving the industry transformation toward a circular economy. ■

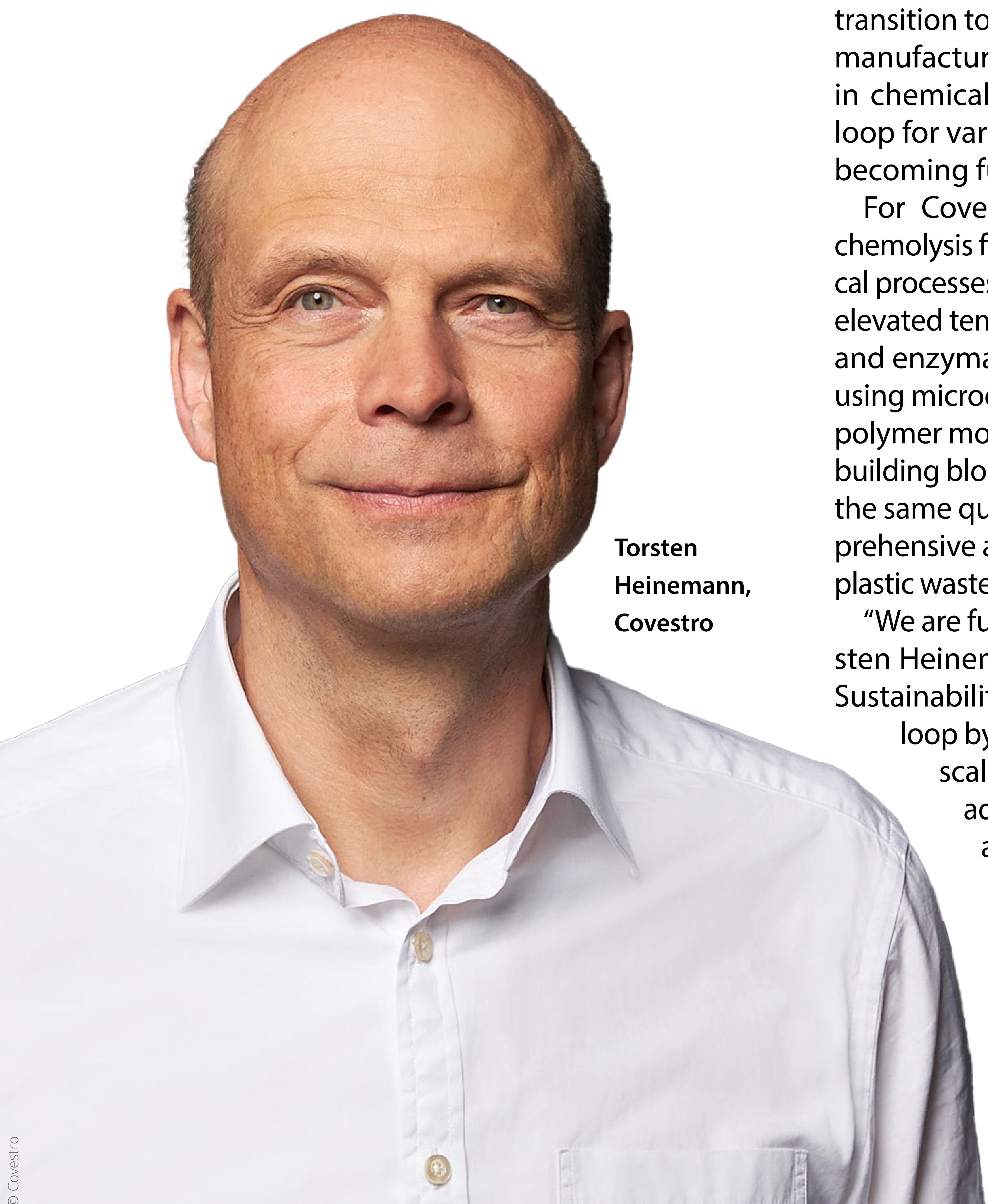
TRINSEO™

Ben Porter, Trinseo

Advertorial

Breaking Bonds, Building Circles

Visit Covestro at K 2025 in hall 6, booth A75 and Gallery S03



Torsten Heinemann, Covestro

© Covestro

The chemical industry sits at the forefront of the transition to a circular economy. German materials manufacturer Covestro is driving advancements in chemical recycling technologies to close the loop for various plastic materials, with a vision of becoming fully circular.

For Covestro, chemical technologies include chemolysis for recovering raw materials with chemical processes, smart pyrolysis to extract chemicals at elevated temperatures in the presence of a catalyst, and enzymatic recycling to recover raw materials using microorganisms. These technologies convert polymer molecules back into raw materials or their building blocks, enabling new products of (close to) the same quality as virgin materials. With this comprehensive approach, Covestro addresses different plastic waste streams and end-market requirements.

"We are fully geared towards circularity," says Torsten Heinemann, Head of Group Innovation and Sustainability at Covestro. "Our goal is to close the loop by developing appropriate technologies, scale them, and make them marketable to address the growing demand for sustainable solutions."

Among the standout initiatives are the „Foam Recycling Ecosystem Evolution" (FREE) project, coordinated by Covestro in collaboration with Ecomaison, Secondly, and Federal Eco Foam. The project's innovative approach begins with efficient sorting at dismantling facilities, followed by targeted mechanical and chemical recycling processes. Via the chemical recycling process both original raw materials — the polyol and the precursor to the isocyanate TDI — can be recovered with high purity.

© Covestro

Another such initiative is the EU-funded CIRCULAR FOAM project, coordinated by Covestro, which brings together 25partners from nine countries. It aims to build a circular value chain to close material loops for polyurethane insulation from end-of-life refrigerators and buildings based on chemical recycling.

These initiatives show clearly: It takes strong partnerships and collective systemic work to establish the infrastructure, as well as all technological and non-technological foundations for complete value chains necessary to make a true circular economy a reality. How this reality might look can be witnessed at Covestro's booth at the K2025, where various products made from alternative raw materials will be on display. ■

covestro

Advertorial

PLEXIGLAS makes your design shine. Every day.

RÖHM
TRADITIONALLY
INNOVATIVE

Visit Röhm at K 2025 in hall 6, booth E23!

Röhm is one of the world's leading companies in methacrylate chemistry. Around 90 years ago, Dr. Otto Röhm developed polymethyl methacrylate (PMMA), later known under the brand name PLEXIGLAS. Since then, this versatile material has proven itself in demanding applications and laid the foundation for the company's long-standing success.

Today, Röhm continues this success story with innovations and sustainable solutions. One example is the highly efficient and resource-saving LiMA technology for producing methyl methacrylate (MMA), which sets new standards in manufacturing.

Röhm is also a pioneer in sustainability and circular economy. By founding a Europe-wide recycling alliance for PMMA, the company reinforces its commitment to developing future-ready solutions.

Components made from PLEXIGLAS molding compounds meet the highest standards in form, function, and aesthetics—especially in surface design and light integration. This makes them a sought-after material for a wide range of everyday applications. Their balanced property profiles and excellent processability in all injection molding and extrusion processes contribute significantly to this success.

At the K trade fair, Röhm presents the inspiring design potential of PLEXIGLAS molding compounds under the motto: "PLEXIGLAS makes your design shine. Every day."


© Röhm

Come and see for yourself—visit our booth!

Automotive

Exterior and lighting designers are increasingly integrating light strips into the front of vehicles to create distinctive lighting signatures. The light guide on the Lucid Gravity electric sedan, made from PLEXIGLAS Softlight by REBO Lighting & Electronics, impressively demonstrates how long and slim a light guide made from PLEXIGLAS molding compound can be. It showcases the material's exceptional light-guiding properties and processability for large components. Additional design examples highlight its versatility in automotive applications.

Lighting

We present the highly energy-efficient "Tiara LED Pro" streetlight from Lena Lighting, featuring a multi-lens array made from PLEXIGLAS Optical HT. This specialty molding compound stands out for its high light output, UV and weather resistance, and temperature stability.

Home Appliances

We showcase the Arçelik yogurt maker with a robust, glossy black housing made from impact-resistant PLEXIGLAS Resist. The design team has developed a robust, glossy black housing with a seamlessly integrated black panel display using impact-resistant PLEXIGLAS Resist in a neutral gray specialty color.

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