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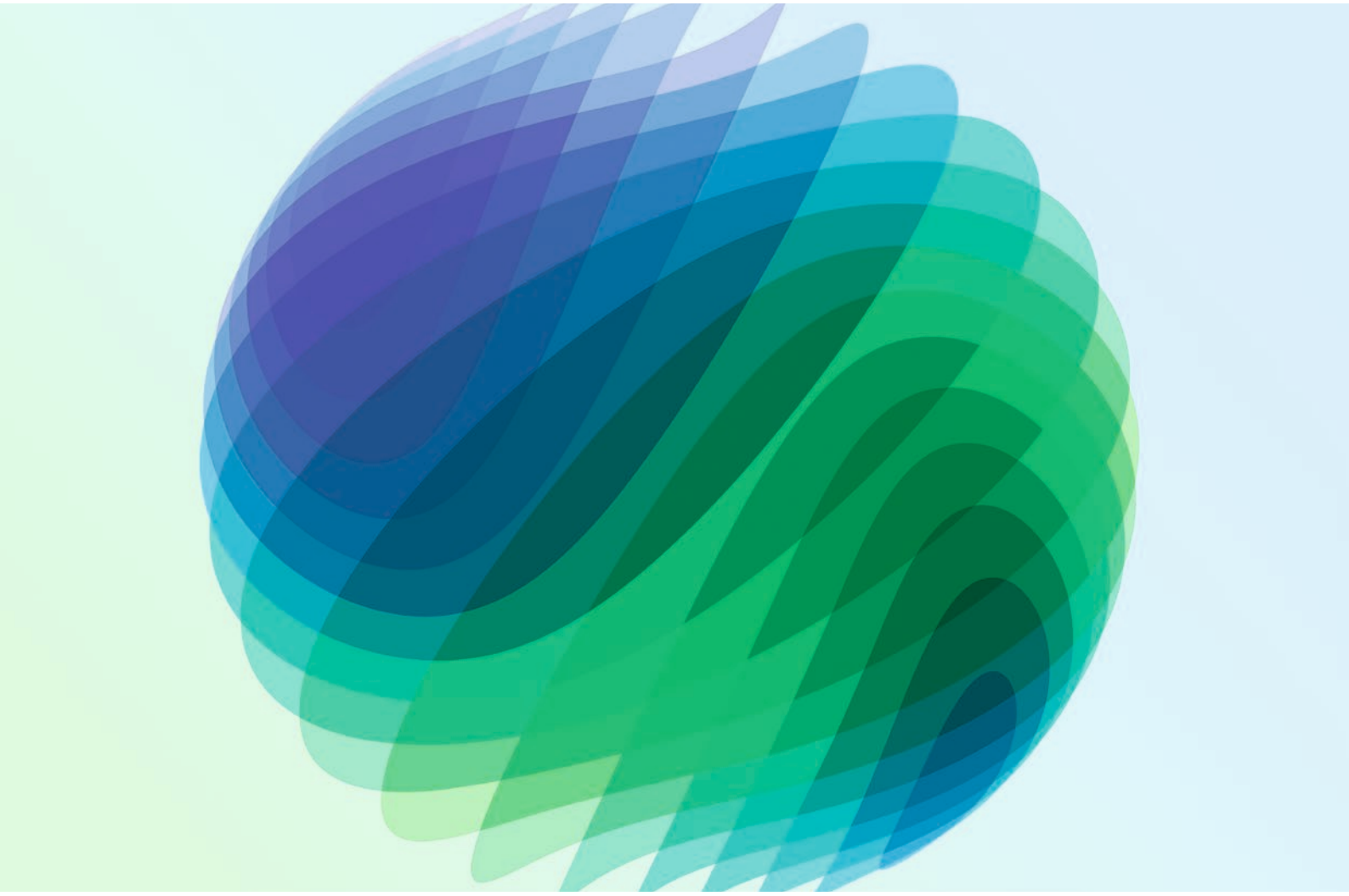
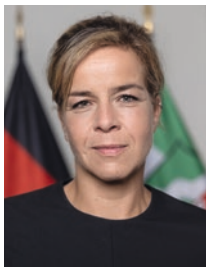


Innovations made in NRW
Circular Economy

VDMA

Content



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Mona Neubaur
Minister of Economic Affairs, Industry, Climate Action and Energy of the State of North Rhine-Westphalia

Dear Business Leaders

The energy transition poses particular challenges for North Rhine-Westphalia, as a state built on industry and Germany's most powerful economic region. But at the same time, it offers special potential for success as a trail-blazer on the way toward sustainability and climate-neutrality. The efficient use of raw materials and energy connects economic activity to stabilised business cycles, while keeping everything within planetary boundaries. North Rhine-Westphalia is in the best position to take on a pioneering role in the circular economy.

In this respect, being densely networked via value chains is a strength we can build on: The economy in North Rhine-Westphalia already thinks and acts in terms of complex structures. And thinking and acting at a circular level will become increasingly important in the future. Cycles that are as closed as possible are the goal of the circular economy, which will enable businesses to add and maintain value simultaneously: Using raw materials efficiently offers economic and environmental benefits.

We had the innovative companies in our state in mind when we set the goal of developing North Rhine-Westphalia into Europe's first climate-neutral, competitive industrial region. Many companies and initiatives are now making successful use of impressive solutions to turn the circular economy and energy transition into reality.

The articles in this magazine are fine examples of how this is done and provide encouragement to seize the further opportunities offered by the circular economy. In the hope that you enjoy some "well rounded" inspiration, I wish you happy reading.

Yours

Mona Neubaur
Minister of Economic Affairs, Industry,
Climate Action and Energy
of the State of North Rhine-Westphalia

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Wolf D. Meier-Scheuven
Network Spokesman
ProduktionNRW

Dear Reader

The mechanical and plant engineering sector operates worldwide, and is part of global value chains. It is simultaneously a supplier, a provider of solutions, and a user. Not only does the sector produce long-lasting and resource-efficient products itself, it also optimises its own processes and production locations. As an enabler, with its technology and processes our sector aids other industries in successfully implementing a circular flow economy and meeting environmental challenges.

Circular economy means preserving the value of products, materials and resources for as long as possible, and keeping waste generation to a minimum. Establishing a functioning circular economy relies on access to efficient and innovative technologies and solutions. The potential for mechanical and plant engineering is enormous here, but at the same time the implementation of a circular economy poses a host of challenges. We need solutions that accommodate and work with the complexity of the circular economy and industrial processes.

The transition to a circular economy calls for a new way of thinking for all actors along the value chain, and a comprehensive transformation of the economic cycle – a transformation which can only succeed if everyone plays their part. To do this, we need a new dimension of cooperation, coordination and communication along the entire value chain – from the production and recycling of raw materials, through product design and business models to consumer behaviour.

The fact is that the circular economy can only succeed with a joint effort. Another fact is that we're only just beginning. Here in the magazine, you'll find ideas from a number of directions that show how the issue can be tackled. Be inspired, and open up to the potential!

Wolf D. Meier-Scheuven
Network Spokesman ProduktionNRW

The circular economy as the basis for cost-efficient trading

The value of products, materials and raw materials must be kept in circulation as long as possible, while minimising the creation of waste: in other words, initiating material cycles instead of "consuming" resources. We need to adopt a new way of thinking – not only in the economy, in industry, and in policy-making, but also in the form of changed values in society: the Circular Economy!

Global consumption of raw materials almost tripled between 1970 and 2017, and will almost double again by 2060, according to figures from the OECD (Organisation for Economic Co-operation and Development). Raw materials are processed into consumables, clothing, building materials or electronics. In the current economic model, these products manufactured with high financial and labour input – and thus also the underlying raw materials – end up in landfills as waste or are simply burned or discarded.

In industry, however, the focus has been on structuring the individual production stages more efficiently: more environmentally friendly methods of sourcing raw materials, energy-saving production processes and improved recycling. But now a broader-based approach is required. The way to achieve this involves concentrating on the key principles, the "R strategies" of the circular economy.

The goal is to treat and structure all steps from sourcing the raw materials through to their (multiple) re-use as an interlinked process. In this sequence, recycling is just the last step. The circular economy also includes further R's: Reduce, Reuse, Repair and Refurbish.

Which "R" to use?

As they move toward the circular economy, many companies, product developers and customers are asking themselves how future innovative technologies can be designed and applied with the circular economy in mind. Putting it simply, which "R" should we use?

It's clear there is no one-size-fits-all answer. The use and implementation of these "R's" must be determined individually, and will be based on the functions and properties of the product in question, the principles already applied, and market demands. With investment goods, for example, the market often requires them to be repairable, and this is an established part of the deliverable. It is already therefore standard in most cases for B2B products to have a long service life and be repairable. The situation may differ with B2C products, where the circular economy offers various potentials. The general rule of thumb is that wherever pressure comes from the market and from customers, product manufacturers often act in response, and they are already practising the principles of the circular economy.

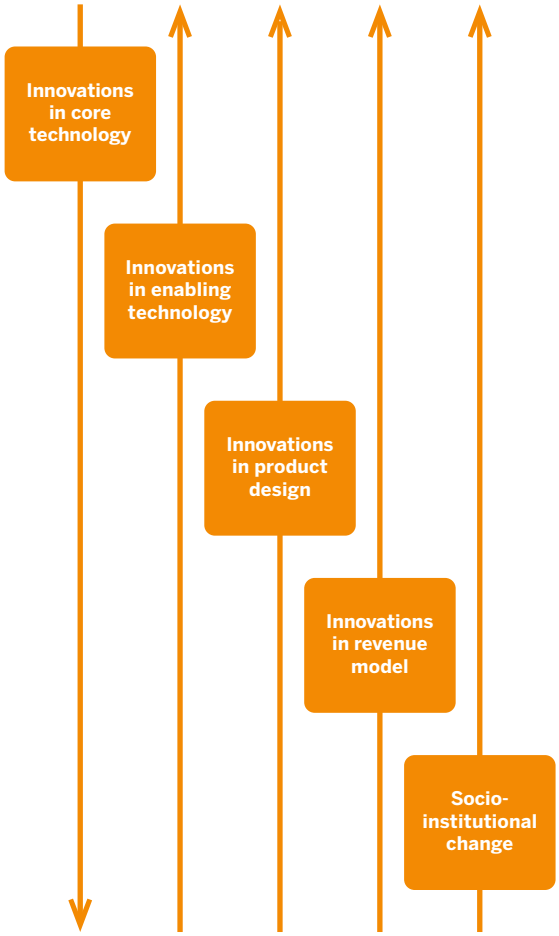
It is assumed that technological innovation is a central, key element at the material level ("recover and recycle"), and that it has already thoroughly matured through a process of improved product design and use ("refuse, rethink and reduce"). In the latter case it is expected that key functions throughout the product chain are already being fulfilled by way of socio-institutional changes (paradigm shifts). These include innovations in basic technology, the yield model and product design.

The environmental impact and the economic aspect are considered when assessing and implementing these criteria. Saving resources through improved material use or improved product design results in a cost saving. And developing new products and services in line with the circular economy also means establishing new business models.

For mechanical engineering, these "R's" are key elements in identifying potentials for optimisation in in-house

©: Circular Economy: Measuring Innovation in the Product Chain, by Potting et al. (2017), colours revised

Smarter product use and manufacture	Refuse	Make product redundant by abandoning its function or by offering the same function with a radically different product
	Rethink	Make product use more intensive (e.g. through sharing products, or by putting multi-functional products on the market)
	Reduce	Increase efficiency in product manufacture or use by consuming fewer resources and materials
Extend lifespan of product and its parts	Reuse	Reuse by another consumer of discarded product which is still in good condition and fulfils its original function
	Repair	Repair and maintenance of defective product so it can be used with its original function
	Refurbish	Restore an old product and bring it up to date
	Remanufacture	Use parts of discarded product in a new product with the same function
	Repurpose	Use discarded product or its parts in a new product with a different function
Useful application of materials	Recycle	Process materials to obtain the same (high grade) or lower (low grade) quality
	Recover	Incineration of materials with energy recovery



The graphic shows the breakdown of the "R's" into more efficient material use, extending useful life and reuse of products and components, better product design and use, and illustrates where the approach to innovation lies.

processes and products, potential to save resources, and to develop new services and thus also new business models.

New VDMA guideline

In its guideline "Circular business models for mechanical engineering and plant construction", to appear in late 2022, VDMA illustrates where opportunities can be found for mechanical engineering, and how companies can attend to this question. The guideline is being drawn up in collaboration with Wuppertal Institut für Klima, Umwelt, Energie gGmbH, which functions as an international scientific think-tank in the area of impact and application-oriented sustainability research.

The purpose of the guideline is to enable mechanical engineers to participate in the circular economy. It places a particular focus on the digital prerequisites for the circular economy. Taking the "R strategies" of the circular economy as its starting point, the guideline not only communicates knowledge on these approaches but also explains where the potentials lie for circular business models.

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The Machine – 40 x Circular Technology

If the plastics cycle is to be successful, products must be recyclable – but there's also a need for efficient machinery and equipment that can turn plastic waste into good quality recyclates, and then convert the recycled material into high-quality products. With "Die Maschine" (The Machine), 40 manufacturers of plastics machines and systems will be showcasing the technologies they've developed for the circular economy.

Machines demonstrate the crucial role of technology in implementing the circular economy within the plastics industry. To optimise manufacturing processes and continue enhancing their efficiency, mechanical and plant engineering technology needs to be highly advanced. In addition to keeping plastic products recirculating throughout the cycle, this also cuts CO_2 emissions. And without digitalisation, neither of these processes would be possible. It's thanks to digitalisation that innovations such as digital product passports and globally applicable traceability standards are possible. Networking of all components in the production line and data exchange via OPC UA is a prerequisite for optimising processes.

The global plastics industry has now launched the most significant change process in its history. With all of its power to innovate, the industry is working on the creation of a functioning circular economy for plastic products. This will conserve valuable raw materials, reduce CO_2 emissions and increase the importance of plastic waste as a major resource. "The Machine" provides an overview of key technology-related process steps in the plastics cycle. The exhibition showcases nearly 40 manufacturers of plastics machines and the highlights of the technologies they've created to support the circular economy. The lineup also features a number of companies from North Rhine-Westphalia (marked in orange in the graphic).

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Crushing
Separating
Washing
Drying
Herbold Meckesheim GmbH
KREYENBORG GmbH & Co. KG
KRONES AG
Lindner-Recyclingtech GmbH
Sesotec GmbH
Vecoplan AG
WEIMA Maschinenbau GmbH

Materials Handling
AZO GmbH + Co. KG
Coperion GmbG
KREYENBORG GmbH & Co. KG
motan-colortronic gmbh
ProTec Polymer Processing GmbH
Zeppelin Systems GmbH

Extrusion
battenfeld-cincinnati Germany GmbH
Brückner Group GmbH
Coperion GmbH
ENTEX Rust & Mitschke GmbH
EREMA Group GmbH
Gneuss Kunststofftechnik GmbH
Hans Weber Maschinenfabrik GmbH
Kiefel GmbH
KraussMaffei Group GmbH
LEISTRITZ Extrusionstechnik GmbH
REIFENHÄUSER GmbH & Co. KG
Windmöller & Hölscher KG

Foaming
ERLENBACH GmbH
KraussMaffei Group GmbH
KURTZ GmbH & Co. KG
LEISTRITZ Extrusionstechnik GmbH
ProTec Polymer Processing GmbH
Teubert Maschinenbau GmbH

Sorting
KRONES AG
Sesotec GmbH
STEINERT GmbH

Regranulation
battenfeld-cincinnati Germany GmbH
Coperion GmbH
ENTEX Rust & Mitschke GmbH
EREMA Group GmbH
Gneuss Kunststofftechnik GmbH
Hans Weber Maschinenfabrik GmbH
KraussMaffei Group GmbH
LEISTRITZ Extrusionstechnik GmbH

Injection Moulding
ARBURG GmbH + Co. KG
Billion SAS
ENGEL AUSTRIA GmbH
Herrmann Ultraschalltechnik GmbH & Co.
KraussMaffei Group GmbH
Leonhard Kurz Stiftung & Co. KG
Plasmatreat GmbH
Sumitomo (SHI) Demag Plastics Machinery GmbH
Wittmann Battenfeld GmbH

Blow Moulding
Kautex Maschinenbau GmbH
KRONES AG
W. Müller GmbH

Additive Manufacturing
ARBURG GmbH + Co. KG
Hans Weber Maschinenfabrik GmbH
Plasmatreat GmbH

R-Cycle – the digital product passport for sustainable plastics

Plastics recycling is too labour-intensive, too costly, and is hardly practised. What's the missing element? "Information." The multi-company initiative R-Cycle has developed a digital product passport for plastics, which will automatically identify recyclable products in the flow of waste material and enable quality recycling.

The digital product passport on end-consumer packaging can be read out using invisible codes (digital watermarks), which are distributed across the entire surface.

Plastics are unbeaten in terms of performance and versatility. There is hardly any aspect of life in which they are not used. As a safe packaging for foodstuffs, hygiene articles or medical products and medicines, polymers have become an essential element in our urban lives. But one problem has so far remained unresolved, preventing this success story from having a completely happy ending: recycling.

The discussion on sustainability is increasingly focusing on disposable plastic products. Even if most of the packaging in supermarkets is now fully recyclable, that doesn't mean it's actually being recycled. Even in a recycling-friendly country such as Germany, only about six percent of plastics from domestic waste finds its way into new products of the same or higher quality in the form of "post-consumer recyclate" (PCR). Most of it – more than 65 per cent – is recycled as heat: In other words, it is incinerated as a source of energy*. The rest goes into landfill, is exported or is "downcycled". Downcycling generally refers to thick-walled products such as garden furniture, or rubbish bags at best, but no new food-grade containers for yoghurt.

Information for waste sorting

To resolve this problem, we need to examine current waste streams. Fully recyclable packaging is not separated with enough precision. But that is precisely what is needed if plastics are to be recycled in high quality – as happens, for example, with the regulations governing PET drink bottles in Germany via the deposit system for disposable bottles. Bottles that are collected and grouped by type can then be reprocessed into new bottles consisting of up to 100% recycled PET.

But in a complex waste stream comprising all kinds of products, separation by polymer type, content and packaging purpose (e.g. foodstuffs, medications or chemicals), is not yet a possibility. Instead, the end result is a lower-grade mixture of various plastics, which is only of very limited use in the recycling process – if only because of the different melting points involved. There is insufficient information available to sort waste into the appropriate groups to enable it to be converted into a high-quality raw material that can be used in new products.

This is precisely the information that R-Cycle delivers, and the best thing about it is that it's already available. Production and filling machines, as well as ERP systems, record, write and analyse all conceivable information on all aspects of a given product. All you have to do is aggregate the relevant data and transmit it along the value chain.

* Conversio Study 2017, Plastics Material Flow Diagram, Germany (Stoffstromdiagramm Kunststoffe in Deutschland), Heinrich Böll Foundation Plastic Atlas.

The vehicle is what's known as the digital product passport. By providing an open and interoperable infrastructure for digital product passports, R-Cycle enables a genuine circular economy and highly efficient value chains. Data exchange takes place in accordance with the latest security standards, and includes no confidential information such as recipes. R-Cycle records and forwards only the relevant information. Process data or ingredients that have no impact on the recycling procedure are not included. The system also has various levels of authorisation: For example, end consumers cannot view the same information as the manufacturers.

To a certain extent, R-Cycle forms the basis for a highly developed recycling process by automatically recording properties relevant to recycling in an open standard format at the time plastic packaging is manufactured. This can be accessed via the appropriate markings (e.g. digital watermarks or QR codes) on upstream products and end products, for example packaging for end consumers. Digital watermarks are codes that are invisible to the human eye, which are distributed across the entire surface of plastic packaging and can be read by industrial camera systems or by Smartphone. Based on this additional information, industrial waste sorting plants can identify recyclable packaging in a matter of seconds and create recycling-friendly fractions sorted by type.

©: Reifenhäuser Group

All data relevant to recycling is recorded in the digital product passport in accordance with the GS1 standards.

Achieving precise waste management through a combination of fully recyclable packaging and lifecycle data from the digital product passport is the key to obtaining high-quality recyclates to create a genuine material cycle as part of the same or a similar application. R-Cycle was developed through to market readiness by a number of technology firms and organisations at all points in the lifecycle of plastic packaging. Currently, this multi-sector community consists of more than 20 partners. R-Cycle can be networked with any system or production facility, from film casting or injection moulding machines to processing, printing and filling machines, waste sorting systems and recycling plants.

Global standards for open data exchange

The tracing technology behind R-Cycle is based on GS1 standards, the leading global network for cross-industry process development and a founding member of R-Cycle. GS1 standards are used for more than six billion scanned bar codes every day. The underlying technology – the EPCIS standard – is already successfully applied in various sectors worldwide.

Under the aegis of GS1 Germany, based in Cologne, a start was made in early 2022 on the PDS4CircularPlastics project (Processes and data sharing approach for enabling circular plastics value networks).

The objective is to develop a GS1 guideline that describes process stages in plastics production that are relevant to recycling, and reflects the necessary attributes for data transfer along the value chain. The project is based on the insights of the R-Cycle Initiative on the automated storage of recycling-relevant data in digital product passports, and forms the starting point for circular economy-compatible processes and making them operational.

Efficient production thanks to the digital product passport

In addition to the effective improvement of product sustainability, manufacturers and processors of plastic packaging also benefit in terms of process efficiency, quality and compliance with duties to inform as required by law. In general, the production of plastic packaging and other products

R-Cycle

The R-Cycle Community

- AMB PACKAGING
- ARBURG
- BRÜCKNER MASCHINENBAU
- COMEXI
- ENGEL
- European EPC Competence Center GmbH (EECC)
- EREMA GROUP
- GS1 GERMANY
- ILLIG
- IN.PACK
- Institute for Plastics Processing (IKV)
- KAMPF
- KAUTEX MASCHINENBAU
- KOENIG & BAUER
- LIT FACTORY
- MULTIVAC
- OLBRICH
- PRODATA
- REIFENHÄUSER GROUP
- SCHUR FLEXIBLES
- SIDEL
- SIKOPLAST
- SILVER PLASTICS
- SUMITOMO DEMAG
- SYNCRO
- STEINERT

involves several companies. Systems and machines networked with the R-Cycle data platform can obtain accurate information from the digital product passport on the respective upstream products and update their own data accordingly, which adds value for customers in the downstream process.

Based on the data from the digital product passport, R-Cycle enables systems such as cutting, winding, packaging and filling units to self-configure automatically and in the best possible way. That improves efficiency in the production process as well as product quality, and reduces production waste. R-Cycle makes production processes more efficient, faster and more sustainable.

A further application in which the digital product passport can add value is the satisfaction of (upcoming) legal duties to inform, e.g. for calculating carbon footprints or in the area of Extended Producer Responsibility (EPR). Time-consuming manual calculations can be automated in this way to satisfy legal or customer requirements.

Finally, R-Cycle uses the potential offered by digitalisation for sustainable material cycles, as required at a policy level as part of the European Union's Circular Economy Action Plan, for example. The digital product passport makes all information from the value chain transparent and usable by everyone involved in the process. The result is an improvement in sustainability and efficiency, in sourcing information and in the production process itself.

Implementation in mechanical engineering

Following the first step – the development of an open data standard – comes the second and, simultaneously, the more challenging one: implementation in plant construction and utilisation in plastics production. There are already many digitalisation solutions that record and process data and make it available. These are, however, based mainly on vendor and/or sector-specific platforms. In day-to-day production, plastic packaging passes through numerous systems from a wide range of vendors as it moves from extrusion to printing, filling and sealing, and so implementing a multi-vendor digitalisation solution constitutes a challenge.

Christian Stelter, Senior Manager Digitalisation at Reifenhäuser Blown Film, a plant manufacturer and R-Cycle partner in North Rhine-Westphalia, says: "The major benefit with R-Cycle is that it offers open access for all conceivable types of lines or ERP system. At Reifenhäuser, it's very easy for us to use our existing, available OPC UA-based data connectors to make the relevant data available for the R-Cycle platform. We automatically transmit the data from newly produced film rolls to the platform via an IoT gateway. So, with little effort, we add value for our customers, enabling them to use data with their systems and simultaneously equip their products with a digital product passport. This interoperability is crucial in terms of being able to connect equipment manufacturers to their customers efficiently. As part of a project at our pilot facility in Troisdorf, we have already successfully used R-Cycle on a blown film system. The film we produced, and the associated data, was then processed by other partners into packaging for the end consumer. The finished PE bag, or pouch, has a digital product passport containing all the information that's relevant for recycling, which can be read out via a digital watermark."

The principle of the digital product passport is not limited to plastics. A number of other sectors have advanced even further in putting it into practice. For example, corresponding standards are currently being worked on in the battery manufacturing sector, to improve recycling and make the sector more environmentally friendly. Here, too, policy is the driver behind this technology. The forthcoming EU Battery Regulation is currently being fine-tuned. The plan is to make a "battery passport" compulsory for all

newly purchased batteries in vehicles, stationary storage systems and larger-scale industrial batteries in Germany and throughout Europe from 2026.

So a trend is taking shape, which mechanical engineers should include in their strategic agendas sooner rather than later. The R-Cycle Initiative shows how it can work. In addition to Reifenhäuser in Troisdorf, Kampf Schneid- und Wickeltechnik, Kautex Maschinenbau, Olbrich, Sikoplast and Steinert make up a total of six machine builders from North Rhine-Westphalia that are members of the R-Cycle Community and are involved in numerous pilot projects. Packaging producer Silver Plastics, GS1 Germany and the Institute for Plastics Processing (IKV) at RWTH Aachen University are also R-Cycle members located in NRW.

To transmit the information along the value chain, upstream products already have a digital product passport that can be accessed using a QR code. In this way, the processing machine can receive all the information and update its own accordingly.

Use and scaling of R-Cycle

The idea of R-Cycle came about in 2019 and was first presented to the public that year at K, the leading plastics and rubber exhibition in Düsseldorf. After just under three years of development, R-Cycle is now available as a market-ready solution, and is being used by the partner entities involved in many projects at their own research centres, and it is in test operation by selected customers.

Two aspects must be considered regarding the productive use of R-Cycle and the intended scaling: The standard developed by the R-Cycle Initiative was handed over to GS1 Germany in early 2022 with the goal of formulating a national guideline based on the insights obtained. This project, "PDS4CircularPlastics", and the publication of the Guideline are expected to be completed by the end of 2022. The formulation of an international guideline is planned as the next stage. The R-Cycle Community was established to give users and partners of R-Cycle a platform for ongoing refinement and maintenance of the future GS1 standard. The Community supports implementation of the standard by offering an advisory function in the context of regular consultations.

The second aspect is an appropriate infrastructure (hardware and software), to be able to operate the digital product passports and the data sharing that is required for the purpose in accordance with the defined GS1 standard. This can be built up in-house by any company, or be procured by any service provider, since the underlying standard is open-access via GS1.

At the same time, the turnkey R-Cycle infrastructure is already available on the market as a commercial "Software-as-a-Service" solution, and can be swiftly deployed accordingly.

R-Cycle also provides consulting services to assist with implementation, and customers can determine the extent of the third-party service for themselves. The objective is to apply a non-proprietary approach to achieve the highest possible acceptance on the market and so press ahead with international distribution and scaling, since the circular economy can succeed only if as many market players as possible are pursuing the same goal.

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Driving the circular economy forward with high-performance plastics

Energy chain recycling, an e-chain made from 100 per cent recycled material, plain bearings made from regranulated production waste, or a concept for sustainable mobility: motion plastics specialist igus aims to reprocess as many raw materials and discarded products as possible, so that precious resources are not wasted and can continue to be put to good use into the future.

At the company's main location in Cologne, igus develops and tests tribologically optimised – in other words, optimised for friction and wear – high-performance plastics for moving applications. The advantages of the tribo-polymers are clear: they're lightweight, low-maintenance and long-lasting, and they don't need lubrication. Thanks to the solid lubricants incorporated into the materials, regular relubrication isn't necessary and there's no accumulation of grime or dust. This also puts the igus materials high on the sustainability scale; a single litre of oil can contaminate a million litres of drinking water. But igus goes one step further, focusing on product development to enable the company to use resources efficiently in its manufacturing processes – enabling customers to design their moving applications more sustainably.

Yesterday's ocean plastic becomes tomorrow's mobility solution. That's the vision of the igus:bike project. igus worked with Dutch start-up mtrl to develop a first bicycle model.

From worn-out e-chain to recyclate

As part of the "chainge" programme, since 2019 igus has been collecting old energy chains and drag chains – its own products, and those made by its competitors – so that these items don't end up in industrial waste. Interested companies can send their old energy chains back to igus, and receive a voucher to a value calculated according to the weight of the chains. Recycling is even easier with the igus assembly service. With every new assembly order, igus automatically offers to organise the return delivery of old e-chains – with no additional cost or effort for the customer. More than 95 per cent of the companies that are currently taking advantage of the recycling offer are already established igus customers.

These customers receive information from their personal igus consultant to increase awareness of the programme. To attract new customers for the chainge programme, igus also uses a number of sales and marketing channels such as mailshots and flyer distribution. igus is currently running a campaign specifically for customers with

Turning old into new: Since 2019, igus has been using its chainge recycling programme to give old energy chains and drag chains a new life.

smaller quantities of scrap material, for whom it may not be worthwhile returning only 20 to 30 kg of material. Until this autumn, igus is offering these companies a free return slip. The campaign has seen very wide uptake, and aims to bring even more companies over to the recycling concept. Because this is how companies can make their own contribution to reducing plastic waste and improving recycling in industry.

To make the offer even more attractive, igus also plans to invest in more digitalisation, making the process even easier. And igus is also working to attract strategic partners such as major mechanical engineers and car manufacturers to participate in the programme. So far, more than 52 tonnes of scrap material have been collected worldwide. International customers deliver their e-chain waste to their local igus branches. The waste is then shipped and stored in a separate collection point at the Cologne location. The worn-out plastics are separated and sorted according to type, cleaned and regranulated so that the material can be reused. The aim is to direct as much material as possible to recycling, either in the company's in-house production or using a recycling partner who will recycle the material.

igus:bike concept for sustainable, urban mobility

The igus vision: the use of high-performance plastics instead of metal becomes widespread across more and more sectors. There are virtually no limits to the imagination, as the igus:bike concept shows. A bicycle made of plastics that can transport generations of people – with no lubrication requirement, maintenance-free and rust-free, and sustainably manufactured from recycled plastic waste such as fishing nets. In keeping with the motto: From ocean plastics to motion plastics. For the development of an initial bike model, igus has invested in Dutch start-up mtrl, which will start producing and selling the mtrl.bike by the end of this year. The igus:bike platform is another part of the concept. The launch has opened the doors for further partnerships and innovations. With the platform, igus aims to promote know-how about plastics in the bicycle industry, driving the circular economy forward across the globe. The company is confident that this will result in a positive change to the use of plastics in many other areas as well.

Products made from up to 100 per cent recycled material

In order to start making a difference earlier in the product lifecycle, igus has now developed the first products from recyclate and regranulated manufacturing waste. These products include the E2.1.CG cradle-chain and the ECO range of plain bearings. The cradle chain is made 100 per cent[1] from the post-consumer material igumid CG, which uses recycled material from the chainge recycling programme, among other things. And users can be assured there is no loss of quality. A raft of tests in the igus test laboratory show that the new e-chain has almost the same technical characteristics and load limits as the energy chain made from the standard igumid G material. A further advantage is that the cradle chain is offered at the same price as e-chains made from the standard material.

In the area of bearing technology, too, igus relies on recycling of resources, and offers plain bearings that consist of 97 to 100 per cent regranulate from the company's own production waste. Four iglidur substances materials, suitable for a wide variety of applications, are made from regranulate derived from in-house production waste. For the new plain bearing series, sprues or defective parts – a typical by-product in injection moulding production – are used. These parts are regranulated on site and fed back into the production process so that they can be injection-moulded into new plain bearings.

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[1] To meet quality standards, small amounts of new material may be admixed during the reconditioning process.

Plasma technology for 100% recyclable plastic packaging

Since June 2021, deep tech start-up IonKraft from Aachen has been working on the development of a coating system with technology designed for the packaging industry. Using plasma technology, the company aims to make plastic packaging for barrier applications recyclable, replacing multi-material solutions and fluorinated packaging.

The newly developed coatings are resistant to caustic agents and acids and provide a superior barrier, even where chemicals or gases such as oxygen are involved. The coatings have already been approved for food use by the FDA and EFSA, making them suitable for all packaging types in which sensitive products are to be stored and marketed. Such products range from food, pharmaceutical products and cosmetics to solvents of all kinds. The technology is the result of research on plasma polymer barrier films and anti-corrosion coatings carried out by the Aachen Institute for Plastics Processing (IKV, the Institut für Kunststoffverarbeitung). Now, with IonKraft, this work is being brought into industrial application.

Making packaging truly recyclable

In this day and age, plastics have become an indispensable form of packaging material. However, the environmental sustainability of this material depends largely on what happens to it after use. Few other materials offer as much potential for recycling as plastics. But certain sensitive goods place very high demands on their packaging. In many cases, a highly effective barrier against gases and other substances is necessary to guarantee adequate product protection. But the macromolecular structure of commonly used, low-cost packaging plastics creates permeability for precisely these substances. This means the packaging has to have thick walls, which reduces material efficiency.

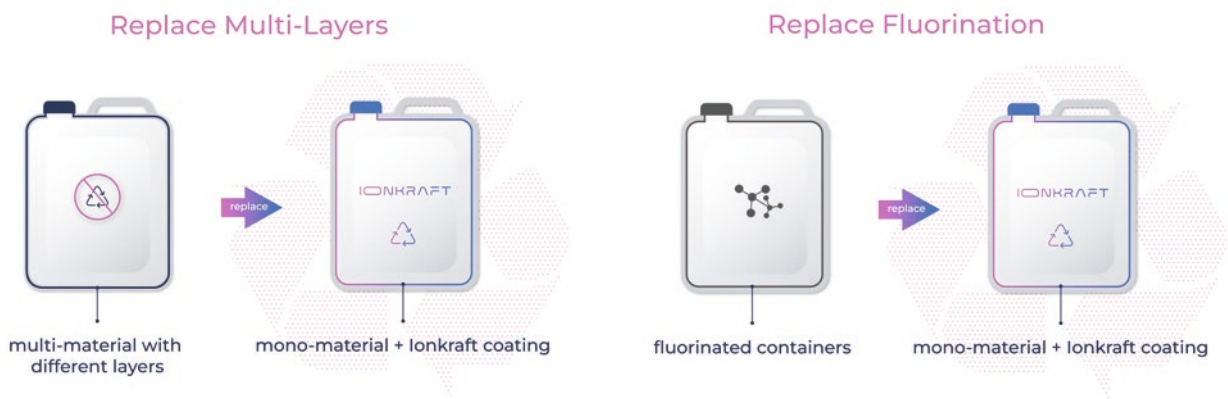
So for certain applications, the barrier properties required mean that packaging made of several different plastics is often used. These multi-material solutions can no longer be cost-effectively separated from one another, meaning the resulting post-consumer waste can only be incinerated or sent to landfill.

The IonKraft coating in the recycling process

The IonKraft coating offers a solution to precisely this problem. The chemically resistant SiO_x barrier coating is applied to mono-material packaging, making the packaging 100% recyclable. The packaging can be mechan-

©: IonKraft

The prototype coating reactor at IKV, pictured during coating of a 5-litre container.



©: IonKraft

The coating IonKraft has developed is chemically resistant, thus offering a recyclable alternative to multi-layer materials and fluorinated packaging.

ically shredded in existing recycling facilities and then processed into granulate for new packaging. The coating makes up only a small proportion of the volume, and is fully removed from the plastic in the washing processes after mechanical shredding. A monomaterial recyclate is created, which can be used for a wide range of new applications. With this new alternative to existing multi-material solutions and fluorinated packaging, the IonKraft coating significantly contributes to the circular economy.

In addition to developing the new type of coating, one of the company's central platforms is the development and production of a low-pressure reactor that can apply this coating to a wide variety of plastic packaging types. A diagnostics-based development routine, the origin of which goes back to the research work conducted at the Institute for Plastics Processing (IKV), is available to determine the necessary process adjustments at the end customer's location. Rather than experiential tests, coatings are developed based on diagnostics.

IonKraft's close partnership with the IKV and the RWTH Aachen has continued since the company was set up. IonKraft has access to IKV's measurement technology, laboratories and equipment to enable the company to carry out complex tests and analyses. In addition, the business venture was scrutinised by an external jury of experts prior to its establishment, and is extensively funded by the Federal Ministry for Economic Affairs and Climate Action (BMWK) through the EXIST Transfer of Research programme.

Modular system development is designed to save time

With the first reactor design, package sizes of up to 20 litres can be coated. This is equivalent to the requirements for packaging goods such as chemical products, pharmaceuticals, agrochemicals, oils, solvents and food. In the future, the coating system will be structured in a modular design. For one thing, this allows a significant reduction in cycle times by equipping the system with several separate coating modules which share the other peripherals such as vacuum pumps, gas supply and handling system. Secondly, the coating module should be modifiable for different packaging sizes, so that the reactor volume is only as large as needed. This is because the cycle time is largely determined by the creation of the vacuum in the reactor. The challenge lies in achieving the minimum effort and expense for adjustments to the design and overall compatibility of the relevant reactor components.

In real production, the coating system can operate immediately after the extrusion blow moulding line. The cycle times for coating – a matter of a few seconds – fit well with the cycle times for the production of large containers, allowing for a cost-effective process.

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Preparing to close the chain

Weidmüller is an expert in the transmission of power, signals and data in industrial environments. To aid the transformation from linear to circular value creation, this family-owned company based in Detmold has set up a separate department, led by Mark Edler as Vice President Global Environment, Health & Safety.

©: Weidmüller

Mark Edler, Vice President Global Environment, Health & Safety at Weidmüller

Mr Edler, what is Weidmüller doing in terms of the recycling economy?
We distinguish between two areas: post-industrial materials and post-consumer materials. "Post-industrial" is waste materials that accumulate during production, such as punching waste; "post-consumer" denotes products that are disposed of by the customer at the end of their useful life. Let's start with post-industrial. We've been dealing very successfully with this sort of waste for more than 15 years. But when we took a closer look, we noticed there were still things we could do better. Some things surprised even us.

What surprises could there still be with such well-established processes?
We process very special metal strips that are precisely tailored to a specific product. A good 50 percent of the waste is generated during punching. If we return this waste to the manufacturer sorted by type, they can use it directly to produce metal strips of this type again.

It also makes financial sense. We receive a 1:1 credit for material that's sorted by type. Unsorted material is significantly less valuable; in the worst case, the ratio is just 1:10. Thanks to the measures we're taking, our recycling rate for metal strips is almost 100 per cent. We also return almost all plastics to the loop.

The hurdles are high, though: one bin of single-origin material must not contain more than 50 grammes of other metal. And despite a lot of staff training, we kept having problems with too much missorting. That was frustrating, because we thought people were uninterested or weren't motivated. We were completely wrong about that. We analysed the problem with Prof. Dr Martin Schneider from the Chair of Human Resource Management at the University of Paderborn. The outcome was that an employee can, of course, read a label with material information on the machine and on the waste container and match them up. But when he's under stress – because of a machine malfunction, for instance – he can very quickly start throwing pieces into the wrong bin.

This phenomenon is called cognitive overload, and it has nothing to do with education or motivation. An unskilled worker is just as likely to do this as a senior manager. Instead of signs, we now use simple symbols, such as a red triangle on the machine and on the

waste container. This is easy to understand even under stress. Behind this lies a different way of thinking about humans and how they work. It's not that other people are unwilling, it's just that we need to organise things better.

So, changing perceptions instead of laying down rules...

Exactly. We also found this at our EcoDesign workshops. Since 2018, these workshops have been mandatory within our firm for every modified or newly developed product. At the workshops, product developers and sustainability experts get together and define manufacturing processes and specific product characteristics. It's here that we look at issues such as returnability or repairability, for example. At first, not all our colleagues were really amenable to these workshops. We now have about 90 such events every year, and we're finding that many of the criteria are being thought about as a matter of course even before the first meeting.

What requirements does EcoDesign impose?

A smaller variety of materials, for example. If you work with 45 different types of alloys, you have to collect 45 different materials. If you reduce the variety of materials, you have better control over the processes. We also make sure that materials can be separated easily. Another factor is repairability. This brings us to the post-consumer materials. The requirements are much higher there.

In what way?

When the product has left the factory, it's a whole new ballgame: How do we obtain the material? Who will collect it for us? And which manufacturers are willing to reuse this material that has been out there for 20 years? We don't actually know how heavily worn it became throughout its use.

©: Weidmüller

A good 50 per cent of the waste is generated during punching. Weidmüller returns its metal waste to the manufacturer of the metal strips, sorted by type.

Sounds like impossible tasks...

They're not impossible, but one company can't do it alone. This in turn implies that universally accepted standards are needed, and that's now happening. Quite a few industries are already developing standards – to make recycled plastics assessable, for example. That will become a reality in the not-too-distant future. For that reason, we're already initiating the preparatory processes and looking into, among other things, how to optimally reuse materials from used products. Then we have the interfaces to which suppliers or other manufacturers can dock in order to close the chain to create a truly circular economy.

Is that affordable?

That's putting the question the wrong way. Gone are the days when throwing things away was cheaper than recycling. Only with a circular economy will affordable products continue to exist. And it's also about ability to deliver. If a manufacturer somewhere in the world stops supplying us with a plastic, we have a problem. Every bin we put into the cycle is a bin of 'independence'. That isn't easy, especially in the post-consumer sector, but it's precisely there that there's a huge pool of resources. We try to work proactively in this respect, including from the perspective of what is voluntary today potentially being mandatory tomorrow. We therefore see the development as a great opportunity to maintain and increase our competitiveness.

www.weidmüller.de

ZF Bielefeld follows the 'Cradle to Cradle' principle

As one of the world's leading automotive suppliers, Bielefeld-based ZF remanufactures its products. The clutches produced in Bielefeld are taken back when they wear out, and the materials are used in new products.

At its Bielefeld site, ZF manufactures clutch pressure plates.

An old clutch pressure plate and a reconditioned product.

ZF Friedrichshafen AG is one of the world's leading technology groups in driveline and chassis technology, as well as active and passive safety technology. Sustainability is an integral part of the corporate strategy. The group's goals include full carbon neutrality by 2040.

The company is pursuing a raft of approaches in this area, including a comprehensive approach to the recycling of products at the Bielefeld site. The site's 220 employees specialise in reprocessing powertrain modules, manufacturing clutches, clutch plates, release systems and torque converters for the global aftermarket. The site produces around 180,000 pressure plates and discs, 10,000 torque converters and 27,000 ZF 'ConAct' pneumatic clutch release cylinders every year.

Environment and business complement one another

One goal of the ZF Bielefeld site is to have as much of the firm's entire standard product range as possible certified according to the Cradle to Cradle (C2C) principle, which denotes a continuous and consistent circular economy with certain criteria. The C2C certificate is officially recognised by the European Commission. Equally important is becoming climate-neutral.

The process of optimising sustainability at ZF Bielefeld began in 2017, with the C2C certification of the MFZ 430 clutch pressure plate. This product was chosen to gain initial experience with the entire certification process and to establish the necessary contacts. Since then, the location has been building local relationships under the slogan 'Green Vision', entering into partnerships, optimising internal processes and promoting its sustainability projects.

Significant reduction in the amount of waste

"Thanks to our system of used parts management, we get a significant proportion of our reconditioned clutch systems back every year," says Jörg Witthöft, ZF site manager in Bielefeld. "C2C certification has now been achieved for around 80% of our product range. ZF is a pioneer in terms of

the certification of complex products. The whole process has resulted in better product characteristics and cost savings through critical analyses."

At present, a new process is reducing waste even further. With the help of a recycling company, 160 tons of discarded used clutch linings are now being disassembled into their component parts and reused. In addition, all other waste is drastically reduced through various measures in the company's operations.

Jörg Witthöft (Site Manager ZF Bielefeld), Thorsten Krug (Technical Manager ZF Bielefeld) and Gerd Bobermin (C2C Team ZF Bielefeld) with a release system product (ConAct) – the first automotive sector product with electronic components to be certified according to the Cradle to Cradle (C2C) principle.

The majority of the product range is C2C-certified

Sustainability pays off every day. Generally speaking, 50 to 90 per cent less material is used for reconditioned parts than for a new part. In addition, the production of reprocessed parts entails up to 90 per cent less energy use. Each day, around 50 tons of old assemblies are sorted in the plant – equivalent over a year to the weight of the Eiffel Tower.

At the ZF Bielefeld site, a number of procedures have been established for the recovery of used parts. From variable deposit return schemes, the acquisition of used parts from garages and repair shops, through to instructing service providers who manage a return system for ZF. Advancements in digitalisation and evolving technologies are creating new opportunities – including standardised collection of used parts, warehousing or preparation for subsequent use.

"Every suitable used part has to find its way back. Every equipment assembly that doesn't require a reconditioning process must not be transported unnecessarily but must instead be fed into the recycling process on site", says Witthöft. "Only functioning reverse logistics processes can ensure closed product cycles in the long term and reduce or eliminate raw material losses in production."

Reusable materials bring in revenues

Another major focus is conserving resources. Each component for which the raw materials don't have to be extracted from the earth, and which can be reused, works to counter the scarcity of resources. The path to eliminating waste production in the long term has got off to an auspicious start: the quantity of waste at the site has been reduced by 35 per cent since 2019.

In partnership with the city of Bielefeld and specialised firms, the site has made part of the waste available to the market with systematic recycling. Careful separation of reusable material has not only reduced costs, but in some cases has even generated revenue which was able to be used elsewhere: in 2017, the plant also switched to 100 per cent green electricity.

Meanwhile, the environmental commitment of the ZF Bielefeld site has been recognised several times with various awards. Thanks to the motivation of the workforce, the location has for a number of years been a global leader in the employee suggestion scheme on the subject of sustainability.

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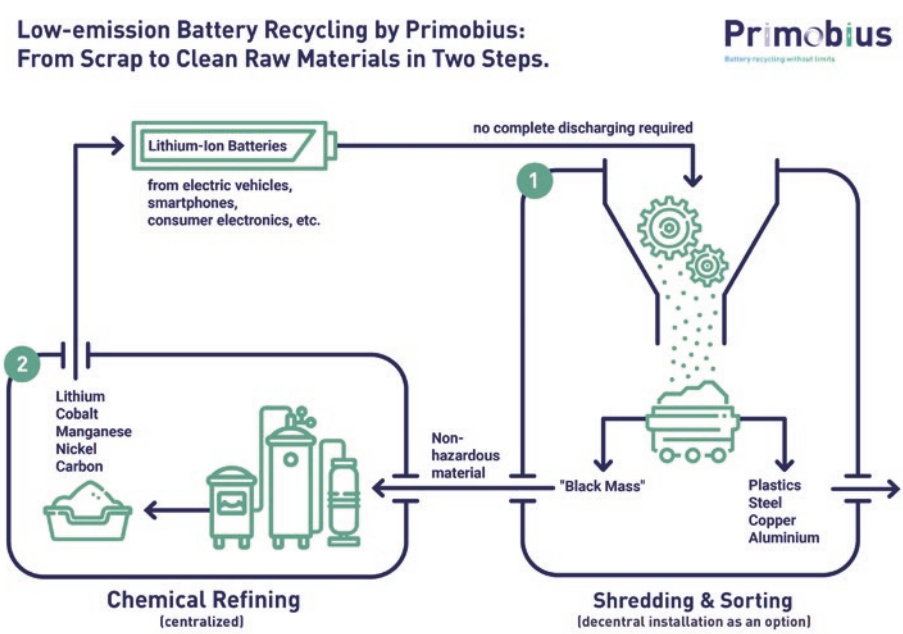
Efficiently closing the resource loop in battery recycling

Electromobility and the recycling of lithium-ion batteries (LiBs) are set to be crucial elements of a future-oriented circular economy. Reusing metals and raw materials is a major challenge that is a key factor in the sustainability of e-mobility as a whole – in economic, ecological and societal terms.

While almost 99 per cent of lead acid batteries are recycled today, the recycling rate for lithium-ion types is significantly lower. A similarly high rate of recycling must be sought. With a low-emission process and its own pilot plant, a young company from North Rhine-Westphalia is aiming to close the resource loop, offering an innovative recycling solution for battery manufacturers, the automotive industry and other sectors.

Primobius is a joint venture between the Australian company Neometals Ltd and German technology company SMS group. Neometals specialises in materials for electromobility and energy storage systems. As an experienced machine and plant manufacturer, SMS group's contribution is to ensure the rapid provision to the industry of an efficient, scalable recycling solution.

Together, the partners have developed a sustainable method for recovering valuable lithium, nickel, cobalt and other materials from old and defective lithium-ion batteries in electric vehicles or consumer electronics.



©: Primobius

Safe, energy-efficient process

The Primobius technique is based on a two-stage process and combines mechanical and hydrometallurgical methods. The crucial step towards sustainable battery recycling is the direct integration of hydrometallurgy into the overall design of a recycling factory. This means that the extracted material can be used directly for the production of new cells. Advantages here are the high level of energy efficiency, and the superior recovery rates for the metals and recyclable materials contained in the batteries.

As a first step, the facility shreds spent batteries of various sizes and types and sorts plastic and metal parts, separating out what is known as the 'black mass'. This contains the sought-after materials. In a second step, hydrometallurgical processes are used to extract lithium, nickel and cobalt, among other materials. The primary objective of the newly developed recycling process is to achieve a closed material cycle in which the production of problematic waste is virtually eliminated. According to the principle of a fully integrated value chain, all materials and raw materials can be reused.

©: Primobius

Recycling facility at SMS group's Hilchenbach site.

The advantage of the two-stage process: the purely mechanical shredding of the large volumes of used batteries can be done in smaller 'spoke' plants close to the site. Central 'hub' plants can be used to recycle the 'black mass' (hub-and-spoke principle). This approach saves on transport costs and lowers CO_2, and reduces the risk of fire and hazardous substances that is associated with larger quantities of lithium-ion batteries.

Recycling expertise at the SMS group's Hilchenbach site

Just one year after the JV was established, Primobius has set up a demonstration plant. At the SMS group production site in Hilchenbach, resources such as sizeable workshop space, personnel with experience in the field of mechanical and plant engineering, process technology and the necessary upstream and downstream processes were already available. In subsequent test campaigns, the Primobius team gained valuable experience, progressively optimised the material recovery rate, and prepared the demonstration plant for commercial operation.

Today Primobius is already operating the complete stage 1 mechanical separation area on a commercial basis. In line with the take-back process required by law, customers deliver their used or defective lithium-ion batteries to Hilchenbach for sustainable disposal. Any residual charge contained in the batteries is removed and the residual energy can be used within the recycling process. Modules from different production methods are pre-sorted and the necessary disassembly work is carried out by hand at corresponding stations.

As a result, following on from shredding and pre-processing, a mixed fraction consisting of copper, aluminium and plastic parts is created, along with the 'black mass'. For all products, purchase agreements are already in place with partners from a range of industries, who channel the materials back into the market. The valuable 'black mass' is still being sold, until it can be taken up for further processing by Primobius's own commercial refining unit.

Preparation for e-mobility

Germany, and Europe as a whole, doesn't yet have a well-developed infrastructure for lithium-ion battery recycling. But the market is growing fast. The location of Primobius' first recycling plant was therefore a very deliberate choice.

Horst Krenn, Primobius Managing Director: "We made a conscious decision to locate our first recycling plant in Germany. The central location in Europe and a good infrastructure, which suits us very well logistically, were crucial factors. We also expect that the need for recycling solutions in this country and in Europe will increase very sharply. If electromobility continues to boom and we have, first of all, a supply of production scrap and then vast quantities of end-of-life batteries coming back, we want to offer the solution with sustainable recycling technology."

Germany already has more newly registered electric vehicles than any other country in Europe. At the same time, enormous production capacities for battery cells are being built up in Europe. These operations urgently need materials such as lithium, nickel and cobalt which are set to come, increasingly, from European recycling sources.

Against the backdrop of sustainability and the reuse of valuable raw materials, industrial battery recycling can be a key component of the circular economy. A battery passport with seamless documentation would create the necessary transparency for everyone involved in the value chain. The insights that recyclers could gain regarding condition and recyclability would help in the process.

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Small pumps, major recycling potential

The recycling of raw materials is a driver of climate protection. Wilo, one of the world's leading providers of pumps and pump systems, has therefore created not only a sustainable product recycling system but also a returns process that its customers can use.

The magnets in the pump motors contain rare earths – these raw materials are "The oil of the 21st century".

Smartphones and EVs, computers and wind turbines. Most of the achievements of the modern world have one thing in common: They contain rare earths. These 17 metals, including neodymium and dysprosium, are among the most coveted raw materials in the world, and are mined almost exclusively in China. Already, however, it's becoming clear that newly mined supplies of these rare earths will not be enough to cover future needs.

That fact hasn't escaped Wilo, a Dortmund-based group, which is one of the world's leading premium suppliers of pumps and pump systems for building services, water management and industrial sectors. "Rare earths are the oil of the 21st century," says Thomas Fetting, Group Director Analysis, Repair & Recycling. "They're also found in the permanent-magnet motors used in our pumps and systems. If they aren't recycled, these rare earths will be lost forever."

30,000 components re-used every year

That's why Wilo has long been systematically recycling used products in its own recycling centre. The product analysis, repair and recycling team takes defective products – those returned via the claims process, for example – and works out the cause of failure and documents it for product development work. They are then repaired or, if necessary, disassembled. Then what? "We check which parts we can re-use for repairs or in new products," says Fetting. "In the process, we keep about 30,000 components in the circular economy each year."

Wilo supplies all worn and safety-relevant parts to its recycling partners. They ensure the materials are recycled, by melting or shredding them, for example. The rare earth magnets are an exception. For Wilo, including them with the materials given to its recycling partners is not an option. No recycling process is currently able to separate rare earths from other raw materials. So Wilo's recycling team manually removes the magnets from the pump motors and checks whether they can be used. If not, Wilo and its recycling partners ensure the rare earths are fed into the circular economy.

But Wilo gets back only a fraction of the pumps it sells in Germany through the claims process – these are an absolute exception. Nevertheless, the market offers major potential. "It's worthwhile proactively replacing old heat pumps with more efficient models," says Fetting. "It saves power and money. Every year, the specialist technicians in Germany remove a vast amount of old pumps capable of being recycled. And we want them!"

Wilo's sustainable used pump recycling process

The legal situation is that decommissioned legacy devices, including pumps, must be disposed of at certified collection points. Failure to do so can incur fines of up to €10,000 under Germany's Electrical Equipment Act. "Our customers therefore wanted a legally compliant and environmentally friendly way of getting rid of old pumps without lots of red tape," says Fetting. Wilo and its partners evaluated a range of solutions as part of a research project by the German Federal Environmental Foundation.

The result was a process that makes use of Wilo's three-level sales channels – i.e. one that also includes specialist wholesalers and the specialist technicians. Specifically, Wilo makes two broad options available. Large-scale specialist technician operations gather legacy pumps and ask Wilo to collect them; or small-scale specialist technician businesses take old pumps to wholesale firms that are Wilo's recycling partners, or arrange for them to take the accumulated legacy pumps away with their next new product delivery. In both cases, the old pumps are accepted by the specialist wholesalers and by Wilo at no cost, regardless of make, type, age or condition.

Every year the Wilo recycling team keeps about 30,000 components from legacy pumps in the circular economy.

Wilo's returns process ensures that old pumps are taken back in compliance with the law, and aims to make a specific contribution toward climate protection. Is it a success? Granted, initial experience indicated a high level of willingness to support the project, says Fetting. "But it isn't always easy to motivate partners to do the collection work. We're sticking with it, however, since we can't see any alternative to the circular economy." In fact, the stated goal is to use only rare earths from legacy products in Wilo's in-house production in future.

"Don't look at others"

Wilo has ambitious goals, but Fetting says it doesn't have to be that way, at least at the beginning. His advice for companies that want to commit more strongly to saving resources: "Just do it. Get your employees, suppliers and customers on board with you. Don't look at others, just be active yourself." Of course, saving resources has long played a part in product development for Wilo. "But," Fetting recalls, "the strategic combination of the analysis, repair and recycling units was the first step toward more 'circular economy' in our day-to-day business."

In-house processes have now been developed that cover all stages from development to recycling. The recycling team regularly provides Product Development with requests for new products. The results of another research project that Wilo performed recently with Cologne University of Applied Sciences and the Fraunhofer Institute for Material Flow and Logistics will also contribute to the process. In the "ResmaP" ("Using smart pumps to save resources") project, the participants investigated how Wilo smart pumps and the data gathered by these devices, including operating hours and faults, could help to save resources.

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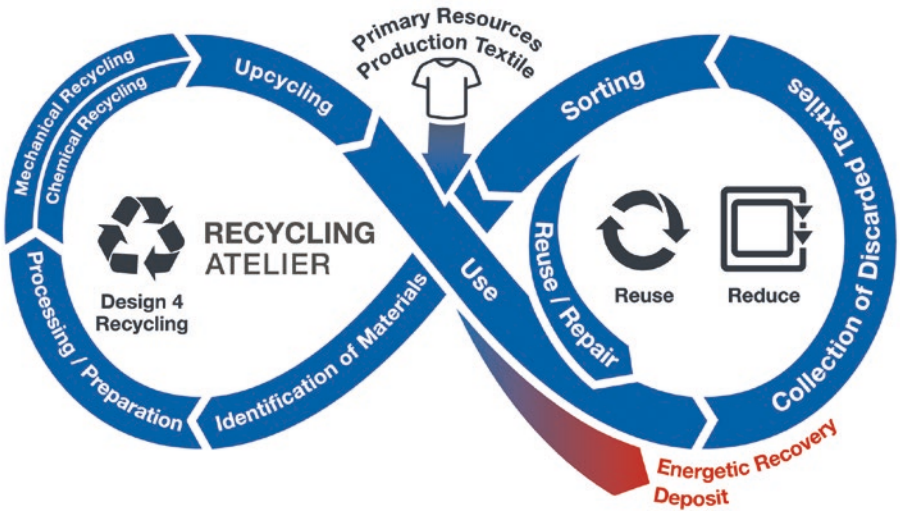
Circular Textiles – a paradigm shift in the textile industry

The textile industry faces major challenges – in terms of its raw material sources, its value-added processes and its business models. The textile machinery industry in North Rhine-Westphalia is a driving force behind the implementation of a circular economy in the textile sector.

About eight to ten per cent – in other words, about 4–5 billion tonnes – of global CO_2 emissions is generated by textile manufacture. The textile industry is responsible for about 92 million tonnes of textile waste each year, the bulk of which is either dumped or burned. Less than one per cent of the 100 billion textile items manufactured annually worldwide are recycled and reprocessed into high-quality products. That means the textile industry is still a long way from becoming a circular economy. In Germany alone, about four million tonnes of textile waste is generated each year, most of which takes the form of clothing or home textiles that are no longer used.

The EU has also published a "Strategy for Sustainable and Circular Textiles" as part of its Green Deal. The textile industry therefore faces a paradigm shift – in terms of its raw material sources, its value-added processes and its business models. What approaches are available to it to structure this transformation?



Expanded concept for a textile circular economy.

Alternative raw material sources

The production of chemical fibres such as polyester and polyamide has been based almost entirely on mineral oil, accounting for about 70 million tonnes a year worldwide. Alternative raw materials include organic-based resources. One innovative approach involves using agricultural residues that are not suitable for food production, or the development of polymers based on microalgae, for example.

Another highly promising approach involves using CO_2 as a raw material: Elastic yarns are used in 80 per cent of all clothing products and are thus, for the textile industry, a financial factor of global importance. Carbon dioxide is an easily accessible raw material for the manufacture of polymers, and is cheaper than many biogenic raw materials. As part of the CO_2 TEX project, sponsored by the German Federal Ministry of Education and Research (BMBF), an industrial consortium including the Institute of Textile Technology is developing a specific process chain to use CO_2 to manufacture elastic materials for sports and medical textiles.

Technologies already exist to use CO_2 to manufacture polyols that can be used as a raw material for thermoplastic polyurethanes (TPU). Initial elastic filament yarns made of these CO_2 TPUs have already been spun in relatively small quantities and have been put to use in textile applications. These yarns, however, are characterised by a particular "stickiness", which creates challenges for further processing to produce textile materials, making it harder for them to be put to industrial use.

This is where Oerlikon Barmag comes into play as a market leader in spinning systems for polyamide, polyester and polypropylene, in addition to texturing machines: To develop a stable and reproducible melt blowing process for these new TPU yarns, it modified the existing spinning technology for chemical fibres. Scaling up the production of these TPU yarns from pilot scale to 24/7 industrial production posed a particular challenge. This affects machine elements such as spin packs, filament cooling, godets for filament transport, and winding systems for rolling the yarns. These are the central modules on which Oerlikon Barmag's global market leadership is based. This project is a typical example of a future-oriented and substantial refinement of existing technologies aimed at transforming demands for sustainable production into industrial practice.

Today's waste – tomorrow's raw material for sophisticated products

Approaches previously in widespread use for textile "recycling" in the form of "downcycling" (e.g. cleaning cloths, carpet protection for painters) are not appropriate solutions for the huge challenges a textile circular economy involves. Used textiles are characterised by an extremely wide range of materials, which makes sorting into types for collection difficult. As a form of planned overproduction, fast fashion is flooding the market with lower-quality products that are not designed for long-term use.

Many different approaches are needed to put textile recycling into practice in line with the EU Directive, and this comes with a wide variety of challenges:

- Logistics of collecting and sorting used textiles
- Material identification and separation
- Mechanical, chemical processes for breaking down into individual fibres for fibre-to-fibre recycling
- Adapted processes for textile reprocessing for the recycled fibres, such as yarn and textile production, finishing and packaging

These challenges mean all players all along the value chain, from the raw material supplier to the consumer, need to re-think. Design for recycling is indispensable, i.e. long-lasting products in which recycling is already included in the design process by taking questions such as material mix and separability into account. New value-added and business models are also being developed to make the stages from the logistics of collection through to the production of new textiles economically scalable. This also creates new jobs, whose qualification requirements have not yet been defined.

The recycling workshop

The ITA Group worked with various key partners to develop the concept of a "recycling workshop" to deal with all of these challenges using an open innovation approach. The use of state-of-the-art sensor technology, robotics and artificial intelligence is being trialled at the recycling workshop. World-leading companies in the textile machinery industry in NRW are playing a key role in this activity. This is where the various stages in the process are trialled in the form of a Learning Factory at a laboratory and pilot scale, and preparations are made for implementing these concepts at an industrial level. The following specific companies in NRW are committed in this regard:

- Trützschler Group SE, from Mönchengladbach, focuses on the processing of recycled fibres in preparation for spinning mill use
- Saurer Spinning Solutions GmbH & Co. KG, from Übach-Palenberg, adapts spinning processes using innovations in the rotor spinning process
- Thies Textilmaschinenbau GmbH & Co KG, from Coesfeld, focuses on adapted bleaching and dyeing processes.

As the necessary enabling technology, digitalisation forms part of the solution strategy for these new concepts, whether it involves digital twins of the processes or the use of industrial AI applications.

With the CO_2 TEX project, an industrial consortium with the participation of the Institut für Textiltechnik, RWTH Aachen University aims to bring new elastic fibres based on CO_2Polyamid to market maturity and scale up production for industrial scale. In addition to Oerlikon Barmag, three other textile engineering companies from NRW are involved. These fibres can be used, for example, for stockings and medical textiles, replacing conventional petroleum-based elastic fibres.

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ProduktionNRW is the competence network for mechanical engineering and production technology in North Rhine-Westphalia and is managed by the VDMA NRW. ProduktionNRW sees itself as a platform for networking, informing and marketing companies, institutions and networks among themselves and along the value chain. Substantial parts of the services provided by ProduktionNRW are funded by the European Regional Development Fund (ERDF).

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