

# POLY P R O B L E M

R E P O R T



# THE CIRCULARITY CODE

How digitalization helps with the plastic transition...  
AND HOW IT DOES NOT

WIDER  
SENSE

RÖCHLING  
STIFTUNG

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# IT'S NOT SCIENCE-FICTION

Is it still possible to save the planet? At those times when we start doubting the pace of socio-ecological progress, we often turn our anxious but hopeful eyes to technological innovations. This is no different in the fight against plastic waste than it is in the quest to reduce greenhouse gas emissions.

Experts agree that we need both; a sustainable shift that changes our way of life on the one hand, and technological solutions on the other. Ideally, social, economic and technological innovations should go hand in hand.

However, there's no room for science fiction in this scenario if we don't want the dream of yet-to-be-invented miracle weapons against ecological and social crises to paralyze our daily actions in the present. The POLY-PROBLEM editorial team has taken a very pragmatic look at what digitalization can do today to make our use of plastics more sustainable.

This may sound like a no-brainer, but the more complex a system is, the more elaborate the processes are, the greater the opportunities are for digitalizing a system's sustainable design and use. The plastics value chain is extremely complex. As are the materials used within it. Will the digital revolution accelerate the necessary changes when it comes to resources? And if so, how will this work in practice?

The needs and opportunities for using digital technologies and methods along the plastics value chain are diverse. Digital twins support product developers in designing sustainable plastic products. Huge databases help in assessing the overall ecological footprint of packaging material. Innovative data services can create a digital product passport based on production data gathered from different companies. Artificial intelligence not only optimizes material consumption in production but will soon also improve recycling processes. Apps will help consumers make conscious purchasing decisions. Waste collection and sorting managed by so-called waste workers in developing countries could be done more efficiently even as early as today.

Although we cannot claim our insights to be exhaustive, we've explored digital opportunities for the sustainable use of plastics by talking to experts and endeavored to combine them into a comprehensive overview. As a fair warning to the reader, we have not yet found the miracle device that will save us all, but one insight has emerged repeatedly: It is not a lack of technology nor immature technology that is the hurdle. It is the willingness to use it cooperatively that matters most. And that, in turn, is a fairly analogous problem.

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# WHY SMART PLASTICS NEED COOPERATIVE PEOPLE

Digital opportunities for design,  
production, use, and recycling

# KNOWING WHAT WORKS

## Ecological assessment and digital twins

Function and performance, sustainability, and pricing – in this triad, sustainability is becoming increasingly important for plastics processors in developing products for their partner industries. This requires a new, holistic view of products – a task hardly possible without digital support.

Due to increasing regulatory requirements coupled with consumers' growing sensitivity, industrial clients now require their suppliers to provide an ecological assessment, a so-called life cycle assessment (LCA), of the components they deliver.

With a plethora of different parameters at play, it seems almost impossible to develop a product today without resorting to data-supported modeling. How much greenhouse gas does the production process release? How does the weight of different materials affect the sustainability of the product? And what happens after the product's use stage? Is it possible to recycle or even reuse a certain component? These are just some of the many questions product developers have to answer.

"A plastic product's high degree of sustainability does not automatically translate into its recyclability. Sustainability is the result of the sum of many parameters, and a high degree of recyclability or reduced resource consumption due to recycling is only one aspect," Hans-Josef Endres says in explaining the problem. Endres is a professor at Leibniz University in Hanover where he heads the Institute for Plastics and Recycling Technology. The scientist gives a few examples to illustrate the problem: "Multi-layer plastic films are generally considered to be harmful to the environment because it's almost impossible to recycle them. In contrast, a mono-material is easier to recycle, but has to be much thicker in order to achieve similar barrier properties, which means it requires more material which in turn adds weight. To come up with a more sustainable

alternative would require that each application of the product be assessed on a case-by-case basis."

Take polyamide which causes nearly three times more CO<sub>2</sub> emissions during production than polypropylene. However, it allows the wall thickness of a product made from it to be several times thinner. At the end of the day, which property will ultimately matter more in terms of environmental compatibility?

In short: it all depends on the ecological assessment.

But asking such questions during product development is not yet common practice. "Until recently, it was normal for plastic products to be designed with functional and economic aspects in mind and for another department to assess the sustainability of the produced component afterwards," says Endres. This is changing.

However, the idea of using comprehensive data sets for an overall ecological assessment is by no means new. LCA databases have been around since the early 1980s. The most comprehensive and widely used database of this type today is GaBi, a platform created by U.S.-based Sphera. Others include Ecoinvent from Switzerland and cm.chemicals, a database originally developed in Aachen, Germany.

The range of software compatible with this data is huge. The phalanx of providers ranges from large software groups to small start-ups and open-source projects such as openLCA.

What they all promise is a “digital twin.” The name itself is telling since the software can be used to virtually simulate a future product, and includes various parameters such as the materials used and different production processes applied. Ideally, product developers run various production scenarios and materials to reach a product that will perform best in the holistic sustainability assessment.

The digital twin guides product developers, particularly in manufacturing industries, to find the ideal compromise between a product’s cost-effectiveness, performance, and sustainability.

The necessary data is available, as is the digital technology. However, what would be just a few clicks is not enough. “You can buy software. But the processes, including input and output flows and the resulting by-products and waste, must be correctly modeled and the results evaluated accordingly,” says Hans-Josef Endres, who has recently noticed a sharp increase in the need for advice that companies seek from his institute.

Dr. Hermann Achenbach, head of sustainability and circular economy at the SKZ Plastics Research Center,

also perceives this gap. He recognizes a need for many companies to catch up in order to be “digitally ready.” “Good analytical tools are one thing, but you also have to get interpretable data out of the machines the processor uses.”

As a result, manufacturing companies are faced with the challenge of having to invest in personnel and technology to implement the digital transformation for more sustainable production without being able to earn any profit from it in the foreseeable future. This is particularly a problem for suppliers. “Our customers expect recyclable products, but are rarely prepared to pay a higher price for them. And for us as suppliers, the potential green boost to our image doesn’t pay off either,” summarizes the head of development at a major plastics processing plant.

Hermann Achenbach, who is in constant contact with industry representatives, confirms this dilemma: “I’m afraid that we won’t have a demand-driven market for digital innovations along the plastics value chain for a long time. It will have to be driven by regulatory requirements for the foreseeable future.”



## Challenges for packaging distributors

# KNOWING WHAT'S IN IT

## The digital product passport also requires a cultural change

In order to understand how a plastic product is made and how it can best be recycled after its use, you need to compile a lot of information. Sounds easy enough? It's not.

The plastic packaging a product is contained in first goes through many production steps before that product reaches the store shelf. The plastics manufacturer provides the raw material while the compounder enriches it with additives to achieve the desired properties. The processor then "builds" the product, for example, a container for a cosmetic lotion. Finally, the bottler usually prints colors onto it or applies a label.

"Each of these processing steps has an impact on the product's recyclability. The relevant data is generated at different points in the value chain, but has hardly been automated to date," says Dagmar Glatz, describing the challenge. She is in charge of sustainability at Germany's dm drugstore chain and faces the issue on a daily basis.

The EU's Packaging and Packaging Waste Regulation (PPWR) stipulates that packaging must be made of at least 55% recycled and be fully recyclable or reusable by 2030 at the latest. And it's the distributor's job to prove it. "Of course, we can only guarantee this if we know exactly what happens at every stage of production," explains Dagmar Glatz. And this is exactly where the major problem lies. "It's not uncommon for data sheets to be sent back and forth as PDFs," reports the dm sustainability manager.

It's no wonder then that the digital product passport is currently a real buzz phrase in the industry. It refers to a digital application that automatically collects production data of the material being used, its properties and processing for a specific product, directly from the

machines of all companies involved in production and prepares it according to a common standard.

There is obviously no lack of technical solutions, but implementing them is still a major issue since it requires a new willingness to cooperate across sectors and companies.

As the managing director of ProData GmbH, a company that offers R-Cycle, a solution for creating digital product passports, Heino Claussen-Markefka knows what he's talking about. R-Cycle is a digital traceability standard for plastic products. The data service can obtain the relevant recycling data for a product directly from the machine, actually, from all companies involved in the production of the item in question. This data is collated and forms the basis of the digital product passport.

So much for theory. When it comes to practical implementation, however, it is not the technical issues that are causing problems, but legal ones. "Companies are reluctant to share their production data if only because it raises the question of who is allowed to store and evaluate this data, not to mention how to protect trade secrets," says Claussen-Markefka.

This means you do not only need new technology, but above all a new understanding of cooperation among companies. After all, the idea behind the digital product passport is to share product information across the entire value chain.

Dagmar Glatz would like to have digital product passports for her entire product range starting today rather than tomorrow. However, she believes it is only a matter of time before things will really take off. The stricter regulations alone make her hopeful. "Obligations to provide information on recyclability and recyclable product design are already extensive and will continue to increase. This will create an enormous amount of work for every company along the entire value chain, which you can only reduce through standardized and automated digital solutions," dm's sustainability manager believes.

It is crucial to find a common language, a protocol with which the data can be evaluated in a standardized manner and which will ultimately lead to a uniform and easy evaluation of the recycling options after a product's use phase.

Heino Claussen-Markefka cites the example of a shower gel container. It consists of a cap, the bottle itself, and the label. Eight different players are involved in the production and handling of these three components right through to filling – all pursuing different technical interests and speaking different corporate languages.

R-Cycle has therefore envisioned an open solution from the outset, based on existing standards set by the world's leading standardizer, GS1, such as the Global Trade Item Number (GTIN). A host of production companies and users should ensure that developments get as widely tested as possible.

While R-Cycle focuses on an open standard and wants to establish a new cooperation model in addition to a digital solution, other providers are focused on the integration of additional tasks and their solutions.

For example, recyda, a young company based in Freiburg, Germany, focuses its solution on evaluating recyclability by taking various standards into account.

recyda also makes it possible to bring together and evaluate all relevant data relating to the properties of a product's packaging, its recyclability, and its recycle content on one platform. The software also allows users to evaluate the packaging's compliance with laws and regulations on extended producer responsibility (EPR) applicable in various countries, including calculating country-specific taxes and duties.

Used proactively, digital technology can help design packaging with an optimized ecological and economic footprint.

The Dutch company circularise has positioned itself in a similar way. It claims to offer a package deal including both reporting and mass balance accounting together with a digital product passport.

With its Responsible Design and Production platform, software giant SAP is also pursuing an integrated approach. In this case, the focus is not on the digital product passport, but on compliance with legal packaging requirements, in particular automated EPR reporting and plastic packaging taxes. "Our solution brings together all relevant data from a company's entire packaging portfolio, links packaging data with logistics data, and can then use this standardized data model to generate various country-specific reports tailored to regulatory requirements," explains Katharina Schweitzer, consultant for circular economy solutions at SAP.

In a first step, the Walldorf-based company wants to help its customers meet increasingly strict and complex transparency and reporting obligations. In a second step, it wants to use the knowledge gained about a customer's packaging portfolio to start optimizing products in the design process. While SAP primarily targets international companies, it also relies on the fact that many large enterprises already work with SAP which means the data is already available, for example, from purchasing.



Like dm's sustainability manager, Dagmar Glatz, SAP specialist Katharina Schweitzer also expects a massive boost in digital solutions for more transparency along the value chain. "We are not yet at the point where the market is driving such solutions because there is money to be made from greater sustainability. But the lawmakers are exerting pressure. That's why companies are demanding tools," she says, describing the trend.

It is clearly not a question of if, but when the digital product passport will catch on and become the new standard. When it comes to digitalization, we face the same challenge as in other fields, be it education, public administration, or healthcare: It's not a question of powerful technology, but of having the right attitude.

# INTERVIEW



Christoph Kugler talks about  
plastics and artificial intelligence

Christoph Kugler is the group leader of digitalization at the SKZ Plastics Center in Würzburg, Germany. Among other things, the materials scientist explores the use of machine-based learning models for applications in plastics processing.

**Christoph, how can artificial intelligence in production contribute to greater sustainability and recyclability of plastics?**

There are several approaches. Let's take the use of recyclables in industrial mass production as a first example. The quality of recyclable waste often varies more than that of virgin materials. This sometimes leads to irregularities in the production process, which makes it difficult for many companies to use recyclates. That's why we're trying to digitally monitor the process in the machine so that the production process of a component will automatically adjust if certain quality parameters are not met. This is where artificial intelligence can come in handy.

**Would this ideally help increase the rate of recyclables used in complex plastic products?**

This is where the potential lies. If AI is able to permanently optimize a production process, this will also increase the percentage of recycled materials used.

**Sounds good. Where's the catch?**

Artificial intelligence needs to learn. It has to be trained over an extended period of time with production data. And no company likes to run experiments on its production facilities, at least not over a long period of time.

After all, the machines are there to earn money.

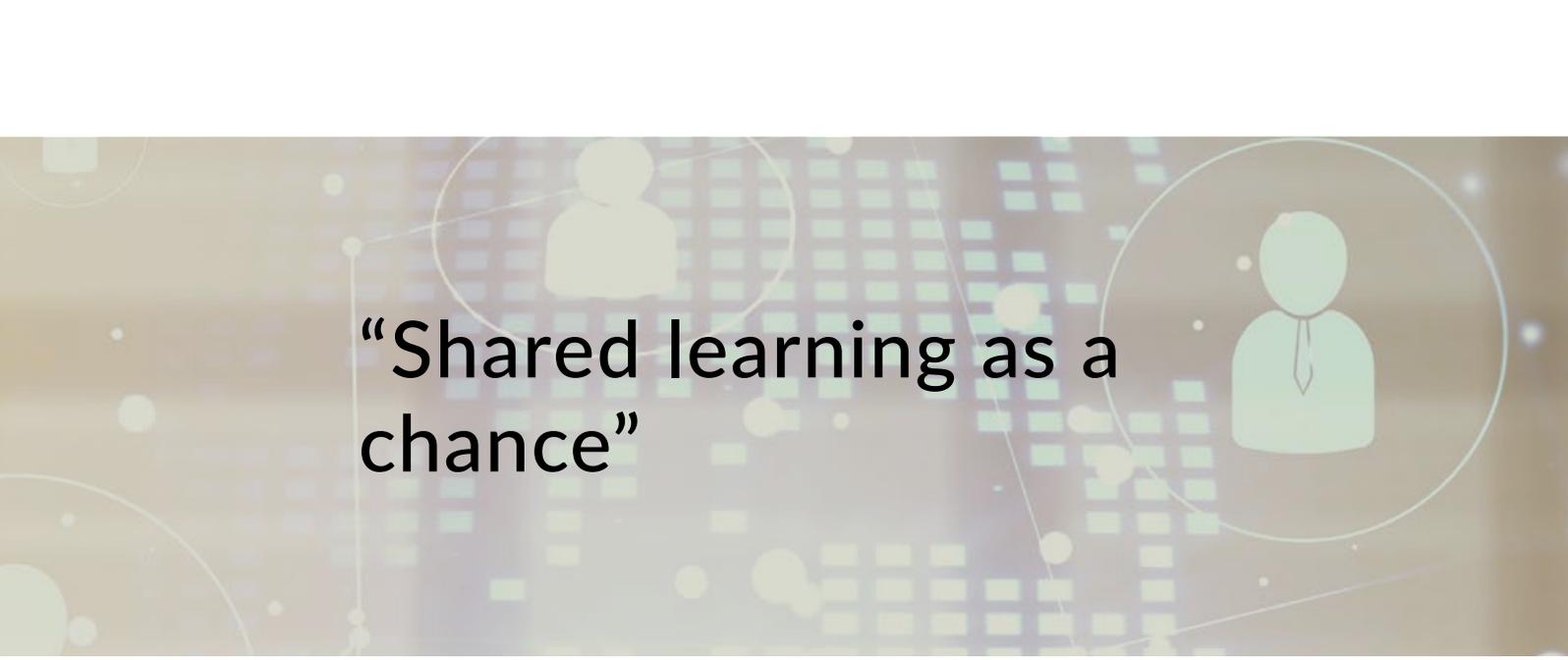
One idea for solving this problem is to use data originating from production facilities of many different plastics processors to train an AI program. To prevent producer A from gaining insight into the data of producer B, special methods such as federated learning are used. This allows an AI model to be trained on several systems without companies having to share their data openly. The Hamburg-based company Katulu specializes in this form of machine learning. We are currently working with them on several pilot projects.

**We've talked about production. But does AI also offer opportunities in the design and development of more sustainable plastic products?**

Definitely. I recently met with Digimind, a Berlin company that uses AI to reduce weight in packaging design in order to save material. They take the product's CAD data and optimize it through AI.

**But even that has to be fed into the machine first ...**

Exactly. The more data of packaging products we have available, the better it works in training the overall system. And that brings us back to shared learning. This is where we often fail in practice. There is simply not



# “Shared learning as a chance”

enough data available. The circular economy would benefit greatly, both in terms of the digital product passport and AI methods, if we collaborated more closely. An overarching, cross-company digital infrastructure is something that we constantly advocate for.

[Does that mean that digital progress in the circular economy is more of a cultural challenge than a technological one?](#)

Absolutely. Of course, it's no piece of cake to equip a 40-year-old machine park in such a way that you can get data out of it. But it's doable. But it all rests on the willingness to share data and develop solutions together.

[What further potential do you see in the use of artificial intelligence in terms of the sustainability of plastic products?](#)

AI will probably make it easier to substitute materials in the foreseeable future, i.e., to replace fossil-based raw materials with bio-based or recycled materials, for example. Efforts are being made to use AI to better illustrate similarities in different materials. Put simply, it will soon be much easier to simulate whether an alternative material will work just as well for a desired application as the fossil-based product.

[Will artificial intelligence also play a role in recycling?](#)

Yes, that is foreseeable. There are interesting approaches for using AI to help evaluate data obtained in spectroscopic processes. With their infrared sensors,

modern sorting systems are already quite good at recognizing and separating individual types of plastics. However, evaluating this data with the help of AI will significantly increase the machine's hit rate in the future. This offers an opportunity for cleaner material flows and ultimately more recyclable material of a higher quality.

[What about the practical implementation of all the technologies mentioned and the associated opportunities?](#)

On an academic scale and also in practical trials, all of the approaches mentioned have proven that the technology works. Now it depends on the availability of data and ultimately on the mindset of those involved.

**Do waste handlers and recyclers have a digital future?**

# KNOWING WHAT'S COMING

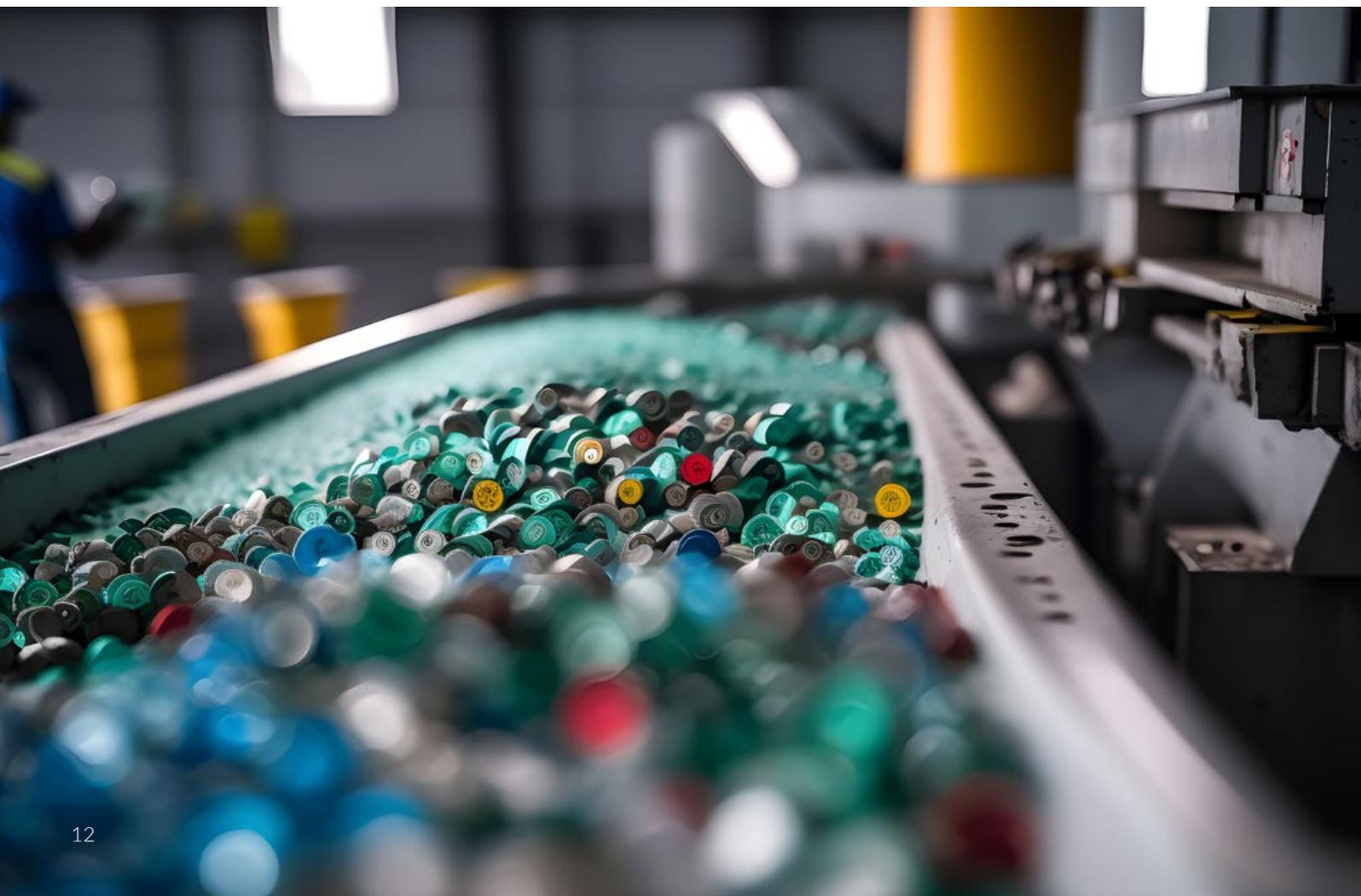
**We have the technology, but no business model**

Proceed with caution if you believe the myth of Germany as the world's recycling champion. More than half of the plastic waste that consumers separate and collect and that is then sent to sorting plants still ends up in an incinerator. At the same time, the industry is hungry for high-quality recyclates. Developing digital solutions to get us out of this dilemma just may be the holy grail.

"High-quality reusables require clean material flows. But the only way to get there is through improved household waste sorting," says Carsten Bertram, head of the Packaging Sustainability department at Henkel. Alongside many other large businesses, the consumer goods group is part of the HolyGrail 2.0 initiative. Its rather swanky name hints at the attempt to incorporate digital watermarks into packaging materials as

they contain a wealth of information, from the material's composition to instructions for sorting and recycling options.

If, in line with their vision, the technology catches on widely, sorting facilities will be able to read the digital watermark and ensure a much more accurate material input for recycling thanks to improved separation. The



list of names behind the HolyGrail 2.0 initiative reads like a who's who of the international consumer goods market, including Danone, Mondelez, Procter & Gamble, Unilever, Nestlé, and Pepsico, with hardly a big name missing. Add to this illustrious circle of big players, retail giants such as Aldi and Amazon and a few large packaging and chemical companies. The European Brands Association (AIM) coupled with the Alliance to End Plastic Waste are the driving force of this broad-based partnership.

Henkel manager Carsten Bertram attaches great importance to this partnership. "The success of HolyGrail 2.0 depends on broad acceptance by the industry. Opportunities for scaling lie in getting more packaging manufacturers, brands, and recyclers to participate in the initiative," Bertram emphasizes.

The practical feasibility and effectiveness of digital watermarks for sorting, identifying, and recycling plastic packaging has already been proven in practical tests. What is still unclear, however, is whether the recycling industry will be willing to convert its plants accordingly. And who will pay for the necessary investments?

Dr Markus Helftewes, managing director of Grüner Punkt, sees addressing these questions as a far greater challenge than developing the technology ready for series production. He openly admits that digitalization in the waste management and recycling sector is lagging behind other industries. "But the question is who is ready to bear the additional costs of such developments," says Helftewes who calls for increased government funding and, above all, long-term acceptance guarantees by the industry.

"Circularity doesn't come for free," Helftewes states. In other words, even if digital technology works in recycling, we still have no functioning business model for it,

at least not as long as recyclates are more expensive than virgin material."

Christian Schiller's business model is transparency. The founder of Cirplus, the 100% digital trading platform for recyclable material, is considered a digital pioneer in the plastics industry and has long been committed to more than just the success of his own start-up. He believes digital advancements on the path to a circular economy to be crucial. "In order to optimize recycling flows, we need to know exactly where which type of plastic is located, what it's composed of, its quality, and quantity, and all this as up-to-date as possible. No human brain can do that. This is precisely why digitalization and the use of artificial intelligence are necessary prerequisites for seriously closing the loops," says the Hamburg-based entrepreneur.

Legally binding norms and standards are a key requirement. "In order to bring waste and recyclate flows into the digital world, we need to find a common language so that we can generate clear and comprehensible data records and manage the complexity. This is the only way to build up reliable supply chains along the value creation chain around the globe and make a successful circular economy happen. That's why we initiated and financed DINSPEC 91446, the world's first standard for high-quality plastics recycling and digitization," says Schiller.

Optimizing material flows starts with collecting and separating trash and ends with the procurement of high-quality, recycled material. The use of digital innovation promises considerable opportunities across this entire spectrum. In this, as with product development and production, we have the classic chicken-and-egg situation. From an economic perspective, market incentives for the necessary scaling are still not there in many cases.

### Three questions for: Jochen Moesslein of Polysecure



## “MORE SHOW THAN REAL IMPACT”

Jochen Moesslein is the founder and mastermind behind Polysecure, based in Freiburg, Germany. His company develops technologies to invisibly mark plastics and other materials, with fluorescent markers being the best known among these. Combined with the appropriate sorting technology, also developed by

Polysecure, material and waste streams can be optimized. Companies can also use the markers to label their own products to make them traceable.

Jochen Moesslein is also known as a committed activist in his sector. His high-tech business applies digital tools as part of the solution. By his own admission, however, digitalization is by no means the magic pill that will cure all the ailments of the circular economy.

*Jochen, what are currently the biggest challenges of digitalizing the recycling sector?*

Digitalization is an overrated word. The technical challenges of recycling have little to do with digitalization. The important aspects of the circular economy are recognition processes, sorting, and processing, and digitalization plays no role in any of these. It's about being able to reliably differentiate materials in ten milliseconds, like separating food contact materials from non-food contact materials.

More than half of the stuff comes in chopped up chunks of material, so you can't even recognize the material via object recognition or artificial intelligence. We need a physical process that allows us to measure the material's composition directly and quickly.

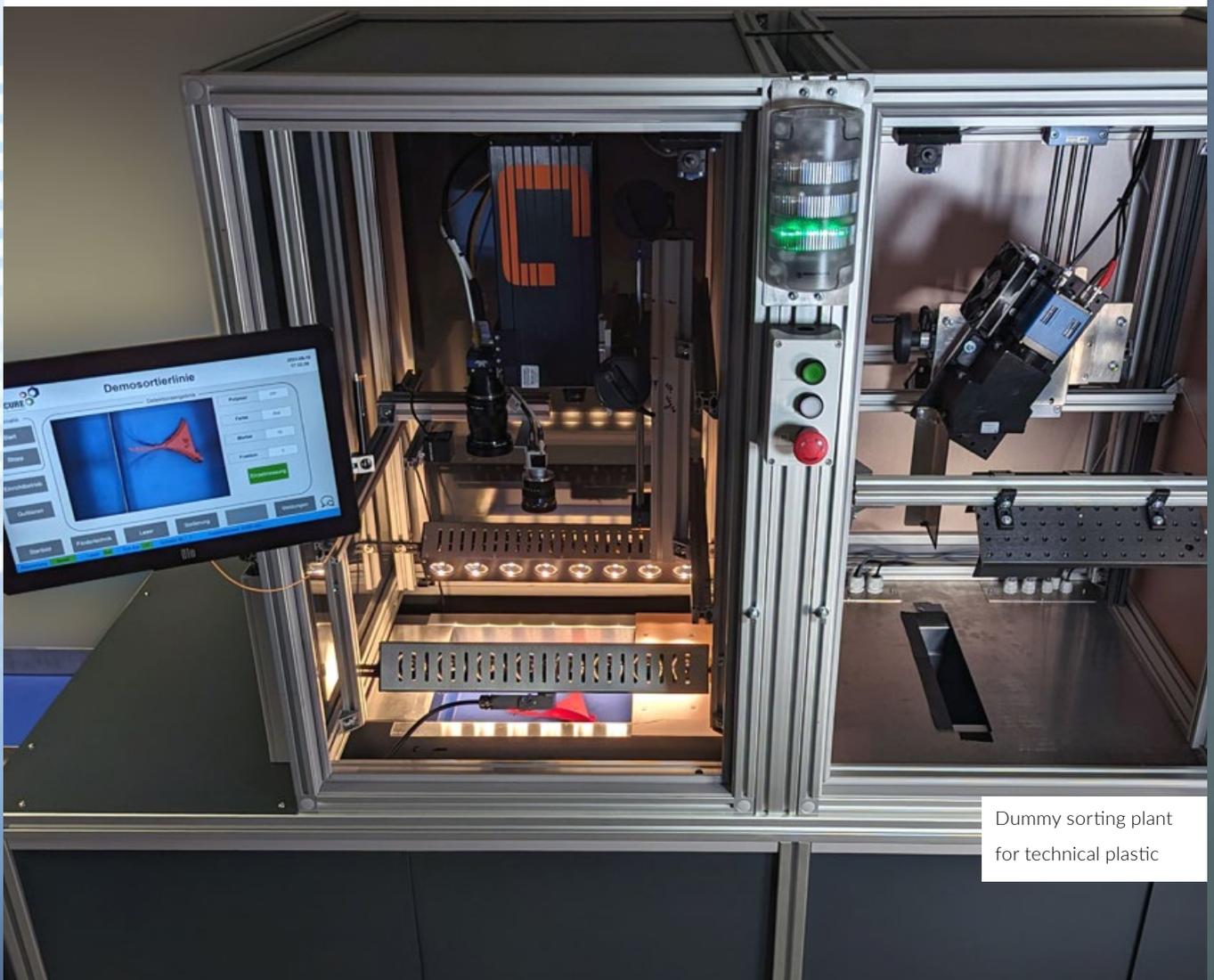
Mean voices might say that the digital hype in our industry has a greater impact on marketing than on creating actual impact. Sometimes I even get the impression that the unrealistic hopes associated with digitalization are delaying investments in other important areas of technology.

*You have been developing marker materials and detection technologies since 2009. What propelled you to found Polysecure?*

The initial impetus was to make materials more intelligent. Plastics, ceramics, paper – it's just a huge amount of recyclable waste, which we as consumers in Germany dump into the big yellow garbage can. I was simply driven by the question of how to turn this mess back into useful material.

[How do you see the market developing in the future?](#)  
Many businesses now see the value of using secondary raw materials. A lot of money is currently flowing into product passport databases. It would be at least just as important to invest more money in actual recognition technology. That's where the bottleneck is. What use is a database if you can't reliably link an entry with the corresponding database? I see great potential for our TrackByStars® technology. It can serve as an important "unique identifier." That's the technical term for a technology that identifies each object individually.

400 million tons of plastics are processed every year. About half is reused, the other half ends up as waste. If we were prepared to pay 100 to 200 euros per ton for sorting, we'd be looking at a volume of 20 billion or more. The market is obviously there.



Dummy sorting plant  
for technical plastic

# CLICKS FOR SMARTER CONSUMPTION

How digital tools can help us live a more sustainable life



## About games, incentives, and responsibilities

# APPS USED FOR RECYCLING

RecycleMich, ReplacePlastic, My Little Plastic Footprint, EcoNation, ReDo – the range of apps for raising consumer awareness spans wide. Some aim to raise awareness of their users' own plastic footprint and encourage consumers to improve their recycling skills while others hope to give them a strong voice as advocates of greater producer responsibility.

### Games and rewards

With easily accessible information and the use of reward or incentive systems, consumer app providers hope to support consumers in making an active contribution to an improved circular economy through their purchasing and disposal behavior. While all creators are convinced that pointing fingers will not lead to success, some of them are wagering bets on the idea of gamification, i.e., the transfer of typical game elements and processes into non-game contexts with the aim of changing behavior and increasing motivation.<sup>1</sup>

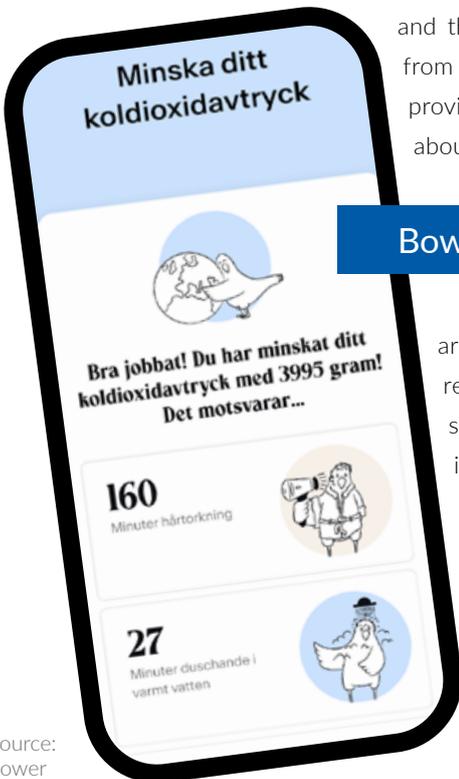
Take the Swiss EcoNation app, the Bower app from Sweden, the Reciclos app from Spain, and the RecycleMich app from Austria that not only provide information about correct waste separation, but also offer

rewards. Users can scan product packaging, collect points for correctly disposed recyclable materials, and exchange or donate the points they earn for rewards.

### Finding the right garbage can

It's no secret that even the uncrowned world champions of waste separation and recycling in the global North still have a lot to learn when it comes to separating trash. Currently, some 30 percent of waste ends up in the wrong garbage can.<sup>2</sup> In order to correctly use the yellow trash containers reserved for recyclable waste in Germany, you don't necessarily need to know whether the packaging consists of bio-based plastic, PET, or a complex composite material. However, a solid basic understanding is helpful if we want a more conscious consumer behavior to lead to cleaner material flows and higher recycling rates.

The results of an Omnibus survey (2020) came to the conclusion that nearly two thirds of Germans don't know exactly how to correctly separate waste and materials.<sup>3</sup> Young people in particular have more to learn than older generations.<sup>4</sup> Providing digital information on people's smartphones might be a great way to fill major gaps in their knowledge.

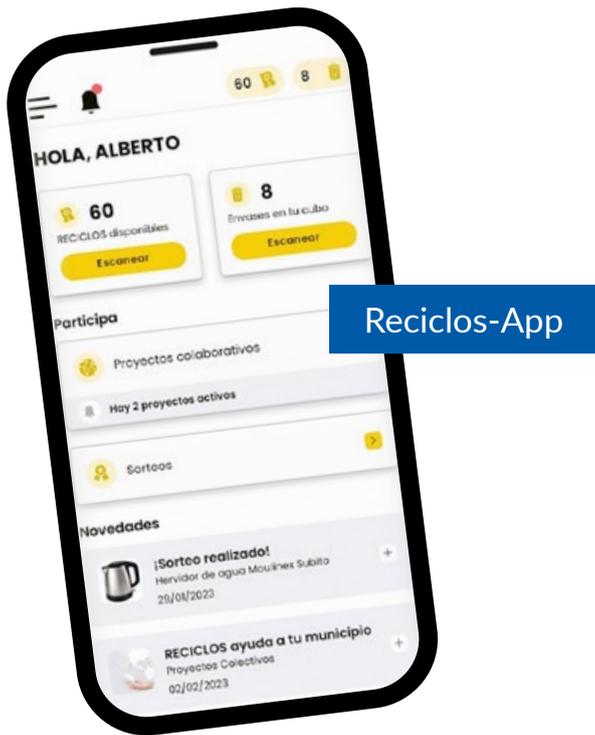


Source: bower



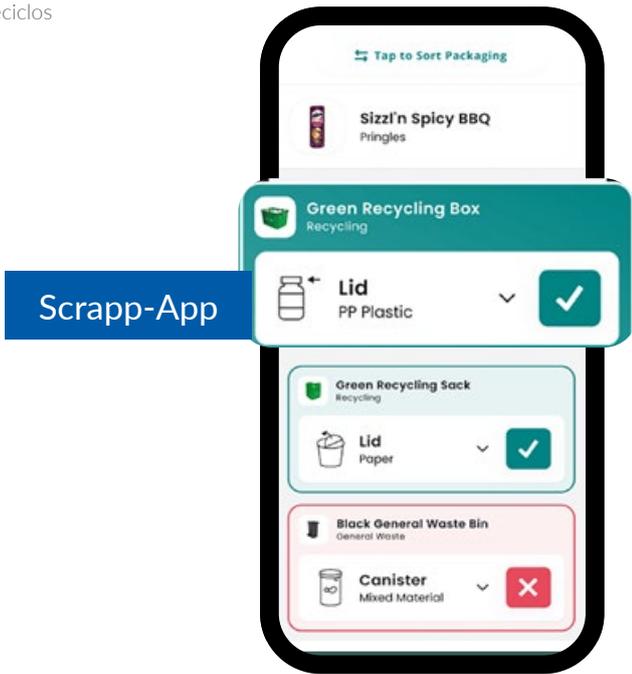
Source: econation

- 1 Business Dictionary (n.d.)
- 2 Kunststoff Magazin (2022)
- 3 Mülltrennung-wirkt (2020)
- 4 Ibid.



Reciclos-App

Source: Reciclos



Scrapp-App

Source: scrapprecycling

In the U.S. and the UK, the **Scrapp** app helps users find out which local garbage can to use to dispose their packaging waste. The Dutch app **My Little Plastic Footprint** helps consumers determine their **plastic mass index**, i.e., their personal plastic footprint, and suggests measures to actively reduce their plastic consumption in a fun way.

### Your voice in the stores

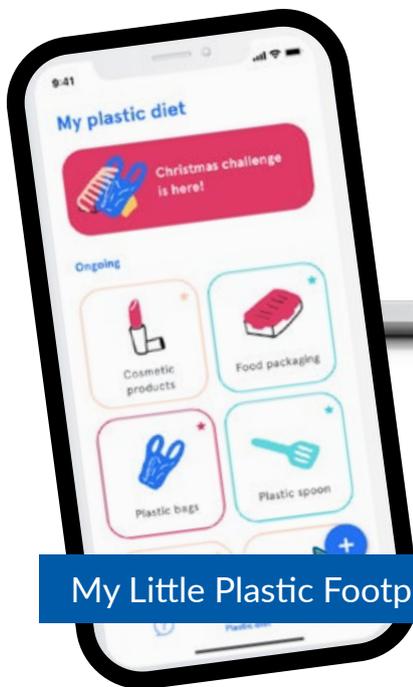
People who are annoyed by all the unnecessary plastic packaging they see on supermarket shelves need no longer despair. Giving consumers a voice has been the aim of **ReplacePlastic**, an app that has helped consumers to express their desire for plastic-free packaging directly to companies since 2018. “The founding idea of our organization, Küste gegen Plastik e.V., was to combat the large amounts of plastic waste that wash up on the North Sea coast,” recalls Jennifer Timrott of the ReplacePlastic initiative. “During our campaigns, we quickly realized that collecting plastic waste was not enough and that we needed to call on producers to step up to their responsibility.” Hence, the ReplacePlastic app was born.

Users can scan the plastic packaging of a product and send their feedback to the app operators, including suggestions for alternative, primarily reusable, packaging options. The app operators collect the user feedback over a one month period and then report it as a collective concern to the company that placed the item on the market. One requirement for this constructive feedback to be passed on is that at least 20 users must have scanned the same product packaging or that a period of one month must have passed since the last change request was submitted.



RecycleMich-App

Source: Raan Gruppe

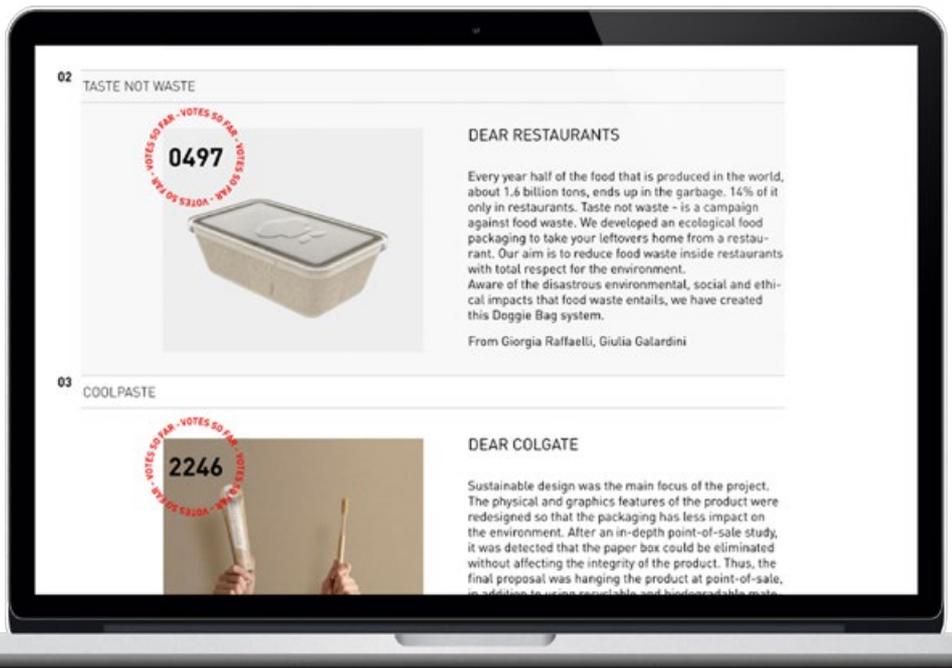


My Little Plastic Footprint-App

Source: mylittleplasticfootprint

“We want to enable people to make their voices heard, because in the long term, we want to achieve a shift from individual responsibility to producer responsibility,” explains Jennifer Timrott. In addition to the app, the organization also provides education and organizes informational campaigns. “It is important to us to teach young people about the many dimensions of the plastic crisis and to inspire them to choose reusable and plastic-free packaging options.”

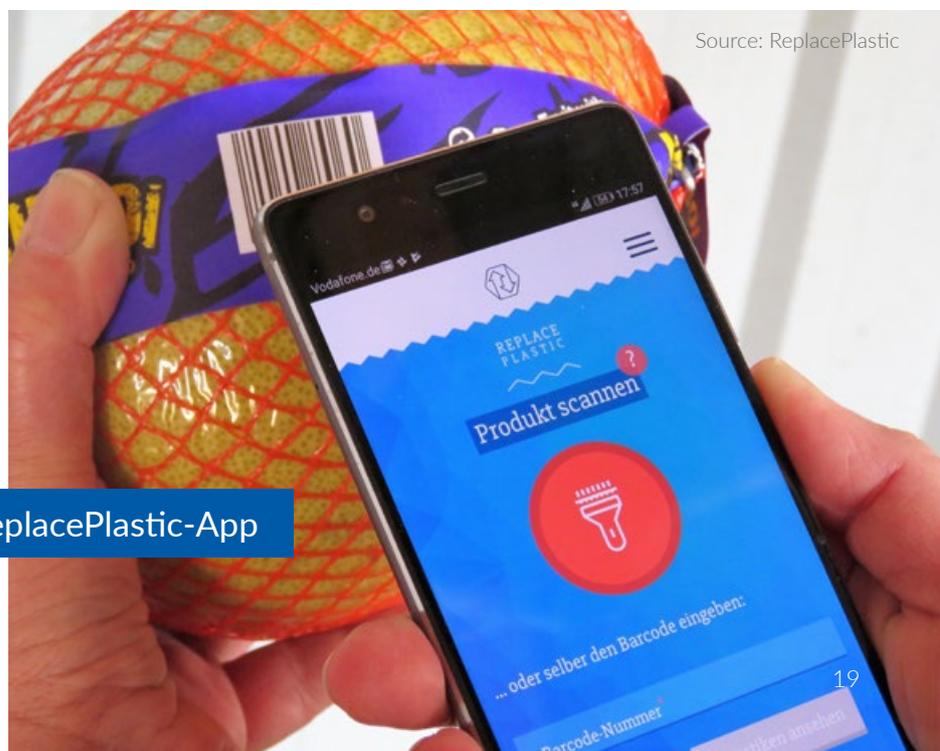
Another service that takes a participatory approach is **ReDo**, which will soon offer users a participatory platform on the path to plastic alternatives. On the online platform, users can submit sustainable redesign ideas for existing packaging in the form of profile descriptions, which other users in the ReDo community



ReDo-Plattform

Source: ReDo

can interactively vote on and make suggestions to further explore the idea. At the end of the process, the platform operators will be able to contact businesses and manufacturers with alternative suggestions for packaging designs.



ReplacePlastic-App

Source: ReplacePlastic

# INTERVIEW

Creator Stefan Siegl about the Austrian RecycleMich app



In order to achieve higher collection and recycling rates in the plastics sector, the RecycleMich initiative has teamed up with brand manufacturers of plastic packaging and successfully established itself in Austria.

[What is the mission of RecycleMich, and what problem analysis provided the foundation for launching the initiative and app?](#)

Our mission is to keep recyclable materials in the material cycle. With the RecycleMich app, we've created and launched an incentive system for consumers that combines digitalization with awareness-raising and educational work. The original idea sprang from the fact that Austria does not reach its desired collection and recycling rates. For example, the collection rate for plastics is only 70 percent, dropping to merely 30 percent in urban areas such as Vienna. Encouraging consumers to collect and sort their waste correctly was an important concern for us in this regard.

[Who was involved in developing the app and how is the app financed?](#)

Even before RecycleMich was launched in Austria at the start of 2021, we had worked closely with leading brand manufacturers from the beverage sector. Results from consumer surveys also went into the agile development process. The pilot test of the first digital recycling initiative ultimately took place in Vienna, because sorting waste correctly has been the biggest challenge there. Eventually, the initiative developed into an open platform for all those involved in the circular economy, including users, brand manufacturers, recyclers, cities, and municipalities. It focuses on all product packaging fit to be disposed of in the yellow trash bag used in Austria for recyclable waste.

Monthly contributions by brand manufacturers as well as contributions by Reclay Systems, a leading take-back system for packaging, currently finance the incentives and prices, operation of the app, and marketing efforts. In return, cooperation partners can list the initiative's activities in their sustainability report or on any sustainability agenda and benefit from various service packages. When working with manufacturers, we welcome any sustainability strategy they have. Over time, we have expanded opportunities for cooperation; in addition to becoming a partner, you can also become a supporter and, for example, sponsor prizes as a sweepstake partner. Consequently, RecycleMich has supporters who sponsor products as well as those who pay membership fees. This allows us to create low-threshold opportunities for cooperation that supports our mission.

[How do potential users learn about of the app and which target group does the app mainly appeal to?](#)

Initially, we ran broad-based marketing campaigns throughout Vienna using traditional media such as newspapers and radio broadcasting. However, it was targeted advertising via online channels, in the app store, and on social media channels that finally paid off. Our initial target group was 18 to 24-year-olds, but this quickly developed into the current main target group of 24 to 34-year-olds, with 35 to 44-year-olds being our second largest target group, including young families in particular. Those under 25 and over 44 come in last.



# Working hand in hand with big business

We differentiate between two groups. First, we have the idealists who want to publicly visualize their recycling performance to match their dedication to environmental and resource protection, and second, we have profit-oriented people, who are enticed by the app's prize-winning incentives. In order to reach as broad a target group range as possible, we additionally offer public education programs in recycling. Gamification in particular is a key element, for example in the form of special sweepstakes.

## [What data is collected from app users and to what extent is it processed further?](#)

The app only collects the minimum amount of user data required to correctly recycle recyclable trash and earn points, which means that based on our privacy policy, we store a user's e-mail address and password. Data such as home address and age are further required to participate in raffles. In addition, the scanned product codes can be used to identify which product brands from which category are purchased, scanned, and disposed of, how often, where, and when. From the data collected, we can identify trends, for example, that people collect a lot on the weekend.

Data on the disposal location is a particularly important factor since it can have an impact on information about sensibly placed recycling collection containers shown in the app, which differ in color from province to province in Austria. We work very closely with cities and towns.

## [How much plastic is recycled each year thanks to the app?](#)

In terms of the app's overall reach, we've quickly achieved success. We reached our original goal of achieving 100,000 scans by the end of 2021 after just two months. On our two-year anniversary, we celebrated over one million packages scanned or correctly disposed of thanks to the app. By weighing the number of points awarded as bonus points for recycling we can set priorities for recycling certain product groups. For example, we can decide to award more bonus points for scanning partner packaging and fewer for non-partner packaging. Surveys show that app users tend to buy products for which they get more points.

## [Since Austria will introduce a deposit system by 2025, how flexibly will the app be able to respond to changes in the future?](#)

Only 25 percent of all packaging placed on the market is covered by the deposit system, which means our app will by no means become superfluous. Our app may actually help increase participation in the deposit scheme. We can also get feedback from users through our various communication channels, and users can report new products that are not yet in the database. In addition, we can quickly make adjustments to the app's features thanks to its simple programmability. In the future, we will also focus on providing more information in the app, maybe specifically on the recyclability of products.

## Apps at a Glance

RecycleMich			
<b>Objective:</b> Ensuring clean material flows through proper disposal of packaging	<b>Function:</b> Providing information on waste separation when scanning product barcodes Collecting points for correctly disposing packaging Qualifying for sweepstakes	<b>Country:</b> Austria <b>Year:</b> 2021 <b>Number of users:</b> >1M <b>Target group:</b> individuals	
<b>Type and quantity of material:</b> Plastics, plastic composites, metals	<b>Cooperation partners/sponsors:</b> Coca-Cola, Fanta, granini, Monster Energy, Fa, innocent, Persil, Somat, Sprite, Weißer Riese, Red Bull, Pril, Pago, Hohes C, Fuzetea, Powerade		
EcoNation			
<b>Objective:</b> Ensuring clean material flows through proper disposal of packaging	<b>Function:</b> — Proving information on waste separation — Collecting points for correctly disposing packaging — Qualifying for discounts and prizes	<b>Country:</b> Switzerland <b>Year:</b> 2021 <b>Number of users:</b> >10.000 <b>Target group:</b> individuals	
<b>Type and quantity of material:</b> Plastics, plastic composites, metals	<b>Cooperation partners/sponsors:</b> Inui, Editoria33		
Bower			
<b>Objective:</b> Ensuring clean material flows through proper disposal of packaging	<b>Function:</b> — Providing information on proper waste separation when scanning product barcodes — Collecting points for correctly disposing packaging — Qualifying for sweepstakes, discounts or donating points	<b>Country:</b> Sweden <b>Year:</b> 2018 <b>Number of users:</b> 550,000 <b>Target group:</b> individuals	
<b>Type and quantity of material:</b> 55 million recycled packaging	<b>Cooperation partners/sponsors:</b> Ellen MacArthur Foundation, Coop, Nivea, Nespresso, Wello, Zespri, logitech		
Reciclos			
<b>Objective:</b> Ensuring clean material flows through proper disposal of packaging	<b>Function:</b> — Providing information on proper waste separation — Collecting points for correctly disposing packaging — Qualifying for prizes or donating points to social projects	<b>Country:</b> Spain <b>Year:</b> 2022 <b>Number of users:</b> 100.000 <b>Target group:</b> individuals	
<b>Type and quantity of material:</b> Beverage packaging made of plastic and aluminum	<b>Cooperation partners/sponsors:</b> Ecoembes, TheCircularlab		
Recycle			
<b>Objective:</b> Testing the Scottish deposit return system for one-way beverage containers	<b>Function:</b> — Providing information on proper waste separation — Collecting points for correctly disposing packaging — Qualifying for sweepstakes	<b>Country:</b> Scotland <b>Year:</b> 2022 <b>Number of users:</b> n/a <b>Target group:</b> individuals (aged 18-34)	
<b>Type and quantity of material:</b> Beverage packaging	<b>Cooperation partners/sponsors:</b> Scottish Grocer's Federation, Mastercard		

ReplacePlastic			
<b>Objective:</b> Communicate consumer demand for plastic-free and reusable product packaging design & increase producer responsibility	<b>Function:</b> — Providing information on proper waste separation — when scanning product barcodes — Passing on requests for plastic-free and reusable packaging alternatives — Collectively transmitting requests to manufacturers	<b>Country:</b> <b>Year:</b> <b>Number of users:</b> <b>Target group:</b>	Germany 2018 50.000 individuals
<b>Type and quantity of material:</b> 2 million scanned packages	<b>Cooperation partners/sponsors:</b> Deutsche Postcode Lotterie		
Scrapp			
<b>Objective:</b> Ensuring clean material flows through proper disposal of packaging	<b>Function:</b> — Providing information on the proper disposal of packaging when scanning product codes	<b>Country:</b> <b>Year:</b> <b>Number of users:</b> <b>Target group:</b>	UK, USA 2021 400M individuals
<b>Type and quantity of material:</b> 34 million scanned packages	<b>Cooperation partners/sponsors:</b> Microsoft, Packaging Europe, British Airways, University of New Hampshire, The Economist		

## CONCLUSION

# UNCERTAINTY WITH A SILVER LINING

Digital solutions aimed at consumers essentially take two different approaches. One is to inform and raise awareness, while the other aims at enabling participation and using and strengthening the power of consumer demand. The difference between the two is fundamental. Encouraging consumers to handle packaging correctly contributes to higher rates of recycling. The apps that involve consumers in influencing the supply side, namely waste prevention, are at the top of the waste hierarchy.

On the other hand, both dimensions currently lack any known cross-solution evaluation that can provide information about actual impact. What exactly does one million pieces of scanned plastic packaging mean in terms of actually recycled reusable materials, and can this information be used to measure any long-term rethinking among consumers?

We also need to critically examine the practice of using in-kind rewards, as it may inadvertently increase consumption as an undesirable side effect. While it seems indisputable that empowered consumers will have an essential role to play in a future circular society, any informed decision-making no longer seems conceivable in any area of life without digital infrastructure.

## Turnaround in the to-go sector: all digital or nothing?

# THE ADDED VALUE OF REUSEABILITY

Whether you're getting a salad from the self-service salad bar at the supermarket or a latte from the coffee shop at the train station, grabbing a quick bite from a fast-food restaurant or having a pizza delivered to your home, disposable packaging for takeaway food and beverages is ubiquitous. The German take-away sector produces nearly 800 tons of waste from disposable packaging alone. Every day. And the legal obligation to offer reusable packaging by 2023 has not changed that. Young providers of reusable systems want to turn the tide from single-use to a culture of reusables. They, too, rely on digital solutions.

They are called Recup, Relevo or Vytal, to name just the best known. They all share one basic idea: that restaurants and cafés should not be forced to buy their own containers for take-away use and set up their own take-back and cleaning structure. These reusable system providers supply the catering trade with containers for food and beverages and take care of the cleaning and resupplying.

For the idea to work, it is crucial to have as large a possible network of partner businesses as possible because it is the only way to ensure consumers' convenience of returning the containers not just where they got them from, but to any business within that specific reusable system. Recup<sup>5</sup>, for example, has more than 21,000 collection points.

Operating such complex systems is hardly possible in a purely analog manner. Thus, the transformation to reusable packaging is also powered digitally. To be sure, all providers use digital technologies, albeit to varying degrees.

Vytal<sup>6</sup>, headquartered in Cologne, Germany, has positioned itself as a particularly strong digital player. "The most important reason why we consistently rely on a digital solution is that it allows us to do without a conventional deposit-refund system," explains Dr. Fabian Barthel, the company's co-founder and managing director. Paying an analog deposit for reusable contain-

ers is a psychological hurdle for customers. If the charge is low, they have no incentive to return the containers quickly. If it is high, people are not willing to pay the money up front, Barthel explains.

Barthel attributes the fact that Vytal's purported return rate is over 99% to its full-on digital approach. Each container has an individual QR code. Users only register once in the company's app. Vytal will then be able to account for where each container is at any given time. And consumers can use the app to see how many single-use plastic containers they have already saved by using reusable containers.

The ReFrastructure<sup>7</sup> foundation is skeptical that a handful of successful reusable systems will go far enough to make reusable to-go containers the new normal. It wants to establish a cross-provider data infrastructure that enables users to return their used containers "anywhere", i.e., at return machines and return points both in public and private spaces. "Return anywhere" being the magic expression.

"We see a future infrastructure for reusables as a social common good," explains ReFrastructure's managing director, Markus Urff. Urff does not want to eliminate competition among providers, but rather take it to a higher level through the shared digital infrastructure. "BMW, Mercedes, and VW did not build their own road infrastructure, they all use public roads. There is a

5 <https://recup.de/>

6 <https://www.vytal.org/>

7 <https://refrastructure.org/>



Kick-off meeting of the Reusable Alliance<sup>10</sup> in December 2022. Initiated by ProjectTogether, the Reusable Alliance, and WWF, a broad alliance of businesses, communities, and initiatives wants to make reusables the standard with digital innovations playing an important role.

demand for more cars precisely because we have this public infrastructure. At the same time, this infrastructure boosts competition between providers.” By comparison, “digital multi-use infrastructure is ultimately a digital data highway,” he adds. Urff and his colleagues are concerned with nothing less than the question of what shape the platform economy will take in the future. If all providers were to use a common digital standard, ReFrastructure believes that logistics – from transport to dishwashing – could be organized much more efficiently and cost-effectively.

His non-profit organization is not alone in this approach. Several local pilot projects, including system providers such as Recup, Relevo, and ReCIRCLE, have launched tests, including in the Munich suburb of Haar.

“I don’t think we need a shared system,” says Vytal’s CEO Fabian Barthel. He also believes that it is unrealistic to expect restaurant owners to take back containers belonging to different systems regardless of the possibility of digital processing. Instead, Barthel envisions a large network of return machines in public spaces that accept containers from different providers and recognize the respective container’s IDs. This would require interfaces between the systems, but not a shared data platform. “We need to decouple the issuing and return processes,” Barthel is convinced. Pilot projects have already been launched in Berlin and Munich.

Once again, this is about more than just a technological issue. Is digitalization an opportunity for a new economy for the common good or a way to differentiate yourself from the competition?

Both beliefs have one problem in common: money. There is no viable business model for either a non-profit digital infrastructure or a network of return points in public spaces and the logistics behind them. At the end of the day, there’s no money to be made from returns. They only generate costs. Who should pay for the additional labor when disposable containers are cheap?

That means politicians must go a step further if they want to bring the obligation to provide reusable containers<sup>8</sup> to life. The various actors in this young market largely agree. One solution could be a hefty single-use tax<sup>9</sup> that subsidizes the financial cost involved in the return and dishwashing logistics of reusables systems.

Again, the digital transformation to reusable containers appears to be a joint venture of digital pioneers of this young economy, established players in the to-go market, and a policy that not only enacts laws, but also creates suitable conditions for their implementation. This is exactly what makes things complicated.

8 <https://www.umweltbundesamt.de/themen/neue-mehrwegangebotspflicht-fuer-speisen-getraenke>

9 <https://www.presseportal.de/pm/22521/5540782>

10 <https://mehrweg-einfach-machen.de/>

# LOADS OF WASTE. LOADS OF DATA.

How digital pioneers hope to renew the global waste management industry



# TRANSPARENCY PAYS OFF

For businesses, efficient waste management is a key pillar of a circular economy. Done right, it not only saves costs, but also reduces CO<sub>2</sub> emissions. A growing number of companies has recognized the potential of a centralized, systematic collection and analysis of waste data. Meike Lessau, circularity manager at Resourcify, knows that this had not been the case for a long time: “Waste is often neglected if it has nothing to do with the core product. Companies simply want to get rid of it quickly so that they can concentrate on the essentials of their business activities.”

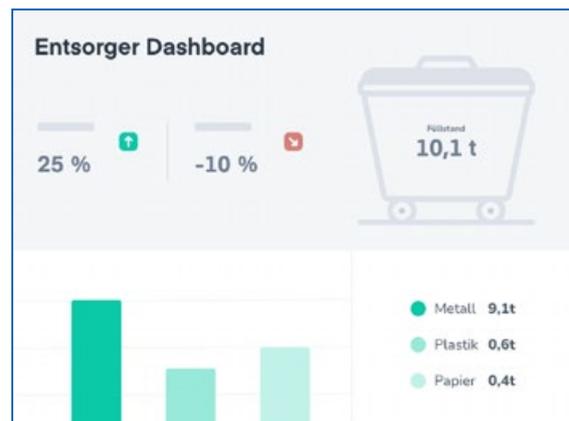
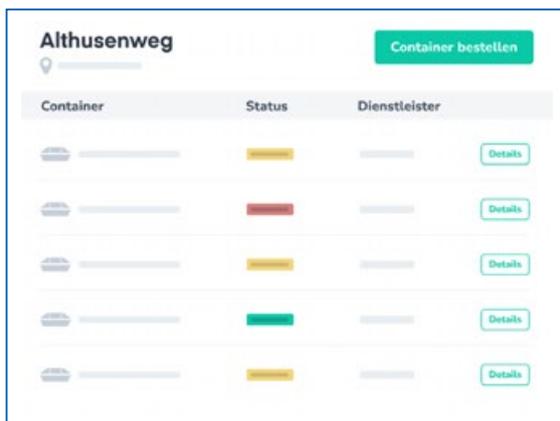
The Hamburg-based start-up, which is already active in seven European countries, helps supermarkets, DIY stores, airports, hospitals, and production facilities in a wide range of industries to manage their waste digitally and facilitate communication with waste disposal companies. The data is centrally collected on a platform in order to make transparent where the waste is generated and how it can be better recycled and perhaps even reduced. As a first step, customers enter their basic data on details such as container locations, responsibilities for waste collection, and emptying intervals.

**Resourcify** works with a partner network of over 450 waste disposal companies, which businesses can commission or whose services they can cancel on the platform with just a few clicks if, for example, waste con-

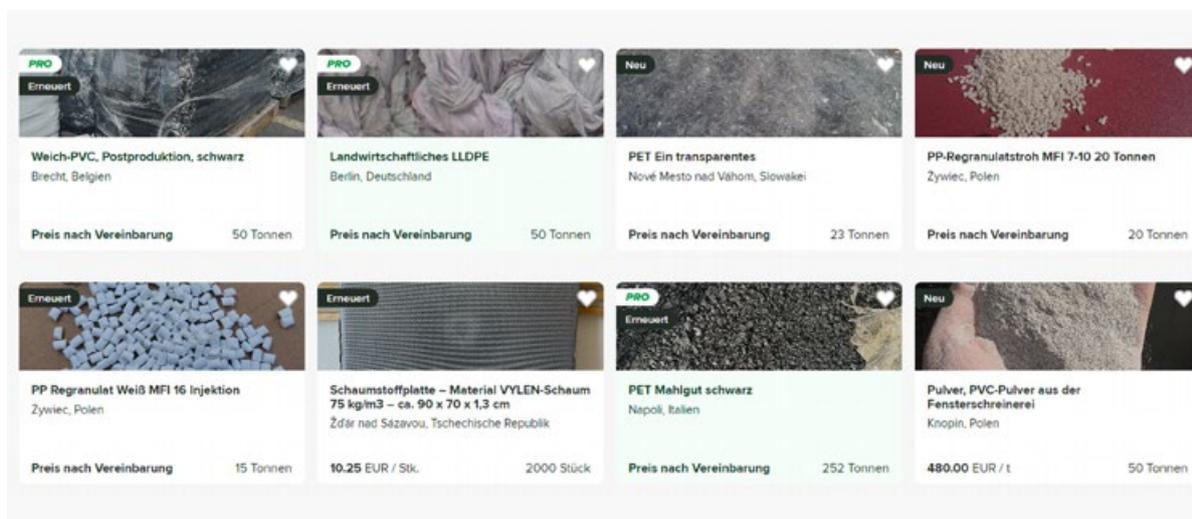
tainers are not full yet. “In the end, participating waste disposal companies use their own interfaces to upload the data on the quantities collected to the platform and store corresponding proof, including in the form of PDF documents,” explains Lessau.

This helps a branch company to quickly see how full garbage containers were at various locations at pick-up time and draw conclusions as to whether replacement intervals or container sizes provided by a particular branch need to be adjusted to either boost their material revenue or to cut transportation costs and therefore emissions.

The Czech start-up **Cyrkl** has also set out to optimize waste management for businesses, but takes it a step further. Cyrkl has created a digital marketplace where



Screenshots Resourcify



Screenshots Cyrkl

waste products or residual quantities can be offered for sale and the seller can negotiate the price and transportation costs with recyclers. The Cyrkl marketplace uses innovative technologies, data analysis, and machine learning to link supply and demand and provide advice on the circular economy and legislation in order to not only reduce waste and disposal costs, but also to recycle in sensible ways.<sup>11</sup>

Resourcify also offers a tool to create a complete waste report that you can forward to the relevant authorities. "Until now, most companies did it by hand, having to search through numerous folders for filed weighing slips in order to once a year create an overview of all types of waste down to the last detail. What used to be a tedious job will in the future be done at the touch of a button using accurate data. The data can in turn be used to identify optimization potentials at any time," Lessau proudly explains.

In view of new, stricter reporting obligations, such as those under the Corporate Sustainability Reporting Directive that has been in force in the European Union since January 2023, waste-related data on material flows, recovery routes, and recycling rates have become increasingly important for the sustainability assessment of businesses.<sup>12</sup>

In view of the global scale of the plastic waste crisis, such data, which will have to be collected and published in the future to comply with such regulatory frameworks, is particularly relevant to help stem the tide of plastic waste. Just like so-called corporate plastic waste disclosure approaches, to which some businesses have already committed, they not only create transparency with regard to investor risks and provide comparability for consumers, but also provide policy-makers with the information they need to derive effective measures and create incentives to promote a more sustainable use of plastics.<sup>13</sup>

11 EU-Recycling Magazin (2021)

12 European Parliament and Council of the European Union (2022), art. 29b (2) (a) iv

13 PREVENT Waste Alliance (2023) (3), p. 3, 11





Op-ed by Dominic Santschi, co-founder of Amplphi

# ACCOUNTABILITY NEEDS A CLEAR BOTTOM LINE

Pinpointing who is accountable for the global plastic waste crisis is a matter of controversy since blame is shifted among multiple parties, a lack of transparent material flows being one main culprit for fragmented liability.

Accountability for the global plastic waste crisis is a matter of controversy as liabilities are allocated in different ways, one of the main reasons being non-transparent material flows.

As things stand today, very few businesses know<sup>14</sup> which plastics are used in their products, where their waste is generated, and how these plastics are ultimately recycled. The resulting lack of knowledge is a problem, as it does not create an incentive for taking responsibility.<sup>15</sup>

Plastic waste accounting offers a promising concept for promoting greater transparency and a sense of responsibility in dealing with plastic waste.<sup>16</sup>

## The idea of plastic waste accounting

Plastic waste accounting records the amount and type of plastic waste that can be directly attributed to the activities of a company. Waste fees incurred, recyclability, and key figures such as recycling rates or the use of recycled plastics are included in the balance. This gives companies a transparent picture of where they stand in terms of plastic waste and creates awareness of their own contribution to the global plastic waste problem.

The idea of plastic waste accounting differs from the digital product passport in that data transparency is not only available for one product, but covers the entire

company. This holistic analysis allows businesses to compare the environmental impact of their various products and to put their consolidated key figures into perspective in comparison with similar businesses.

## How digitalization supports plastic waste accounting

As in the case of the food industry, where digitalization has already contributed to promising developments thanks to greater transparency,<sup>17</sup> it also provides potential in combating the plastic waste crisis.<sup>18</sup> The use of technology allows businesses to seamlessly record and track plastic packaging throughout its entire life cycle, making it possible to transparently map supply chains.

Businesses that have made a conscious decision to publish their waste accounting not only create transparency for the critical public, but also step up internal pressure to act. However, a heightened sense of responsibility is not enough if businesses don't walk the talk. Positive examples<sup>19</sup> show that by openly disclosing their plastic waste footprint, businesses and organizations tend to take ambitious measures to reduce their plastic waste, for example by driving resource savings and promoting the use of recycled plastic. This commitment not only has a long-term positive impact on the environment and improves a company's reputation, but can also foster the transition to a sustainable and responsible economy.

14 see POLYPROBLEM (2019)

15 see POLYPROBLEM (2020)

16 ETH Zürich – sus lab (2020)

17 Duda et al. (2023))

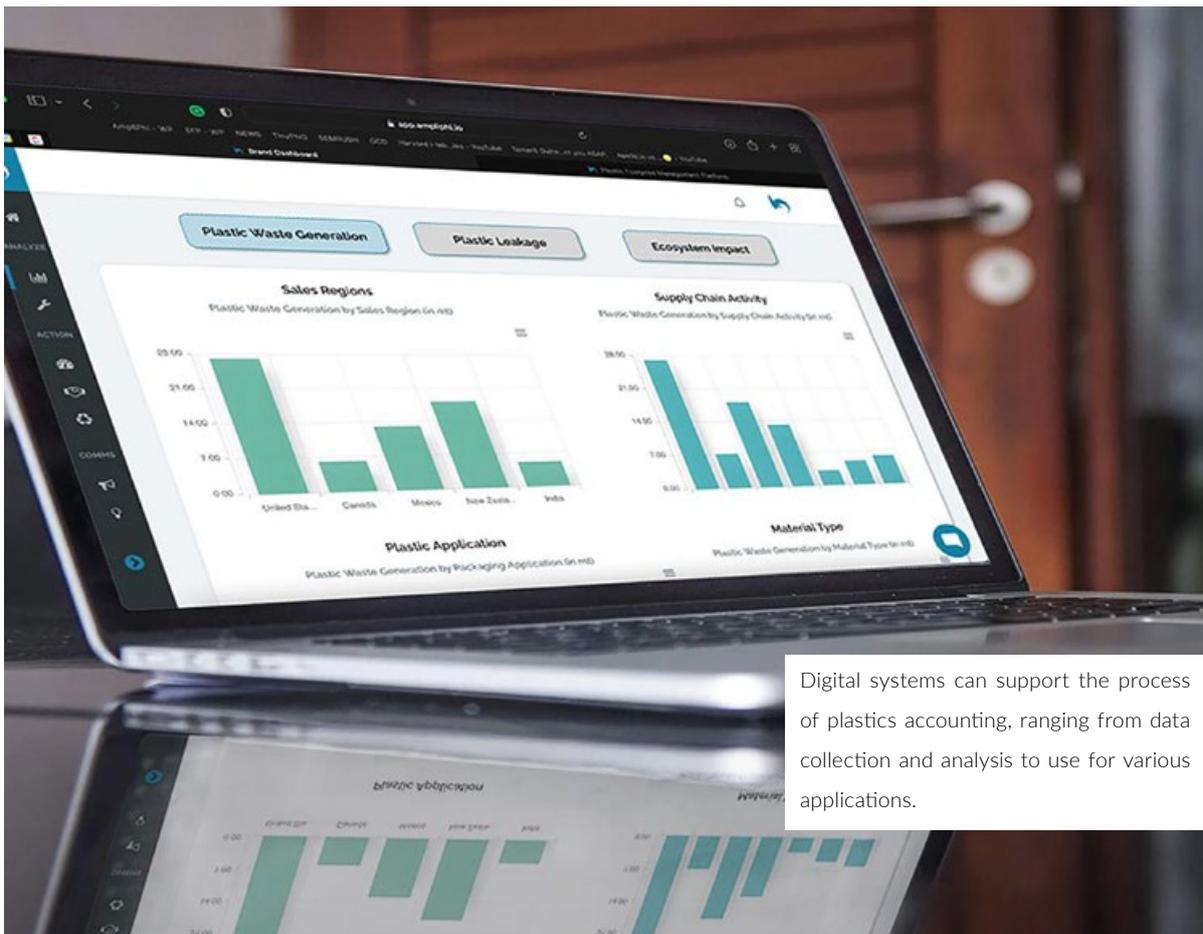
18 see ReiProk (n.d.)

19 Amplphi (2022)

### Plastic waste accounting, quo vadis?

The introduction of plastic waste accounting comes with a number of challenges. It requires a uniform methodology and standards<sup>20</sup> to ensure credibility and comparability between companies. In addition, companies must be willing to actually disclose their data<sup>21</sup> and

communicate the results of their accounting. This requires urgent rethinking and a cultural change in corporate practice. And, of course, it requires a willingness to face up to public pressure that comes with disclosure and the social expectation of businesses to take responsibility.



20 PREVENT Waste Alliance (2023) (3)

21 Ellen MacArthur Foundation (2022) (1)

# SMART CLEAN-UP

All too often, plastic waste still ends up where it doesn't belong and remains lost forever. In Berlin, for example, 66% of residual waste is disposed of incorrectly.<sup>22</sup> Separating trash by type pays off in two ways since many communities charge for residual waste by weight. Whether artificial intelligence, robotics, the Internet of Things (IoT), or blockchain technology, all of these high-tech approaches have a role to play when it comes to digitalizing urban waste management and making waste routes more efficient through better control, thereby saving time, costs, and CO<sub>2</sub> and creating more transparency by involving the public.

From New York to Amsterdam, Stockholm<sup>23</sup> and Songdo, South Korea, many cities have already set out to become smart waste management cities.<sup>24</sup> At the beginning of 2020, Villach, a city of 65,000 inhabitants in Carinthia (Austria) launched a pilot project as part of a public-private partnership model together with **Saubermacher Dienstleistung AG** to optimize municipal waste disposal with the help of artificial intelligence.<sup>25</sup> Sensors were installed in 1,100 glass recycling bins that regularly measure the fill levels so that the containers are only emptied when they are actually full.

In Berlin<sup>26</sup>, **Berliner Stadtreinigung (BSR)** has also tested wireless sensors on underground containers since 2020, which collect fill level data 24/7<sup>27</sup>. The data is then transferred to cloud servers, where it is analyzed using artificial intelligence and visualized on a dashboard in order to compute optimal routes which are then transferred to the navigation systems of the waste collection vehicles. The Berlin waste management company expects the system to increase efficiency by up to 30 percent in terms of punctual emptying and to reduce CO<sub>2</sub> emissions.<sup>28</sup>

Wirtschaftsbetriebe Duisburg published a case study in 2021 to evaluate the benefits of fill level sensors. They placed up to five types of sensors in 13 different garbage cans to evaluate the opportunities and limitations

of using sensors. Some of the tests run as part of the study revealed large deviations between sensor readings and the container's actual fill level, which the study attributed to outliers, such as cases where waste was placed directly underneath the sensor.

The study also shows that present intervals for emptying residential garbage cans and picking up different types of garbage such as residual waste, lightweight packaging, and paper, cardboard and carton are sufficient. Rarely is garbage picked up too early or too late. As a result, the analysis shows greater potential for the use of sensors in public garbage containers. This really goes without saying since it is more difficult to predict how quickly a garbage can in a public space will fill up than residential garbage bins.<sup>29</sup>

In Bangladesh, for example, the country's second-largest mobile network operator, Robi Axiata, has provided the city of Dhaka with five hundred sensors to monitor the fill levels of public garbage cans and inform the relevant authorities when they need to be emptied.<sup>30</sup>

Back to Villach in Austria. In order to analyze the material composition of waste with the help of AI and to determine residential separation rates, the city has tested so-called recyclables scanners (infrared cameras and sensors) in garbage trucks – as is being done in

22 Ott (2023), p. 5

23 Shahrokni et al. (2014)

24 Joshi (2022)

25 Goldschald (2021)

26 Hinweis Duisburg

27 BSR (2020); BSR (2021)

28 Ott (2023), S. 8

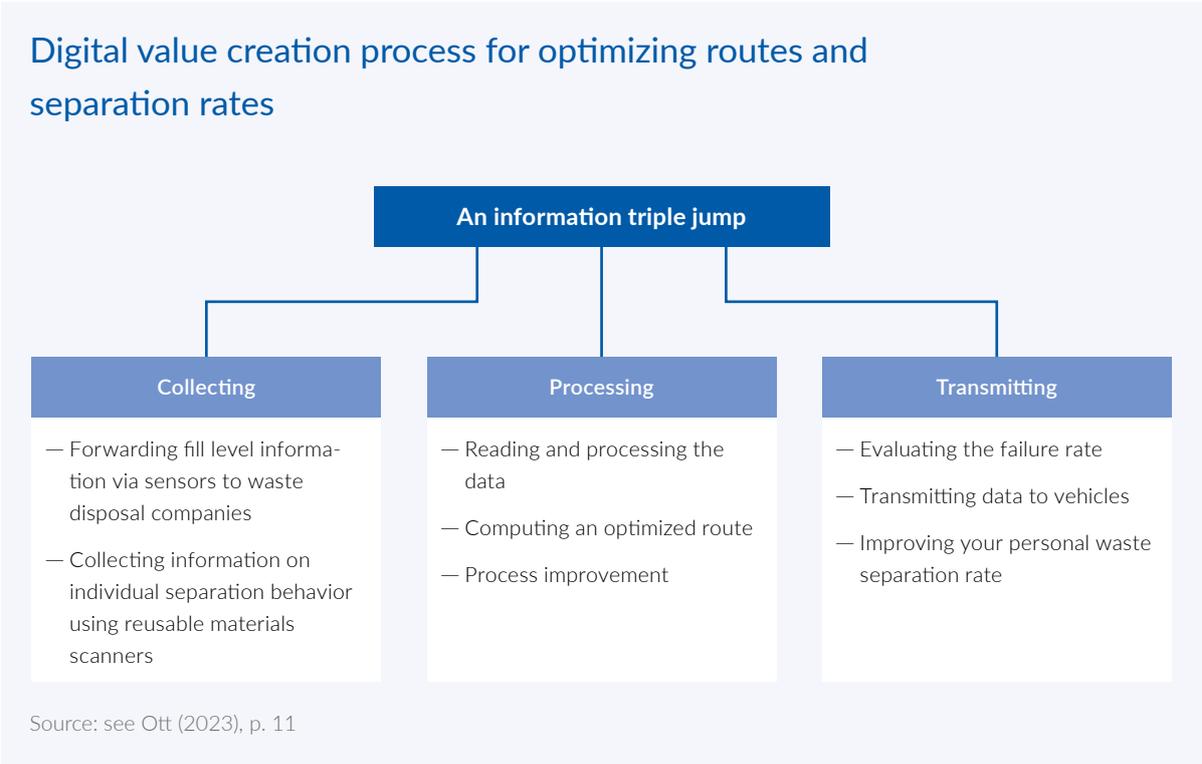
29 see Hoffmann et al. (2021)

Berlin.<sup>31</sup> In the case of Villach, chips with identification numbers were attached to designated garbage cans which not only allow data being assigned to the 450 households voluntarily participating in the pilot project, but the waste disposal companies can also receive direct feedback on their waste disposal through an app.<sup>32</sup>

In the long term, such waste monitoring and the transparent provision of corresponding analyses could offer opportunities to contribute to a sustainable improvement in separation behavior by providing more target group-specific information and education campaigns, with the prospect of lowering disposal costs for participants with an outstanding trash separating record.

One of the challenges the nationwide introduction of such systems faces is regional differences which are not only a concern for waste disposal companies, but also for waste producers, because some places provide

three different containers for recyclable packaging waste while others make do with only one. Anyone who's travelled abroad has probably seen for themselves that there are multiple different separation methods. In addition to providing information to educate the public, it is also important to avoid unnecessary complexity and focus on user-friendly solutions. This applies above all to places where waste separation has to be particularly quick and reliable, e.g., shopping areas, railroad platforms, or just before boarding an airplane.



30 Wilson et al. (2021), p. 30

32 Goldschald (2021), p. 3

31 BSR (2023), S. 11; Goldschald (2021), p. 3

## BIN-E – THE SMART GARBAGE CAN

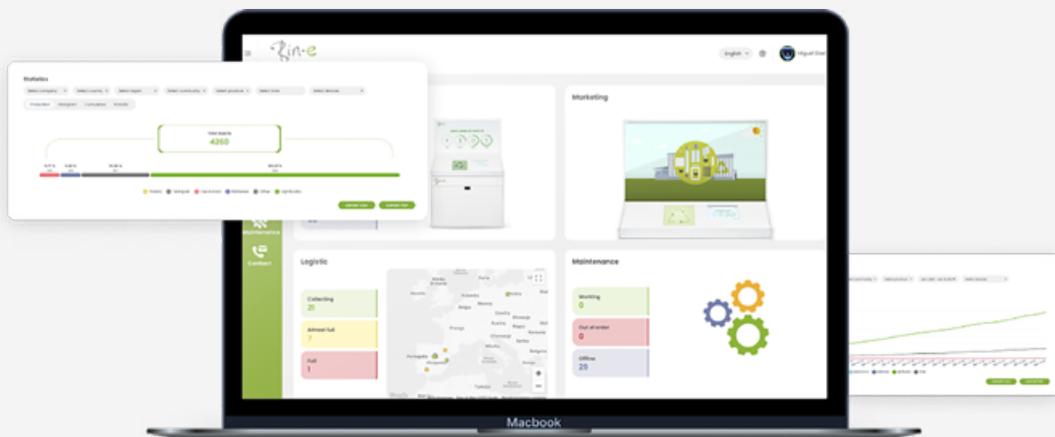
# 95 PERCENT SEPARATION RATES DESPITE TIME PRESSURE



“Incorrect waste separation is often due to ignorance or a lack of time. We don’t want to prejudge anyone or imply unwillingness, but rather offer a sensible solution,” says Jakub Luboński, CEO and co-founder of Bin-e. The Polish start-up has developed smart garbage cans, 250 of which are already in use in over 20 countries and have been tested at the Münster train station, for example.

To date, shopping malls and office complexes have set up the smart garbage cans. They use an image recognition system that takes a picture of the waste as it enters the can. AI then evaluates it in milliseconds in order to transport the trash to the right bin and press it. Sensors monitor the fill level of the four bins, sending a notification to the responsible facility management team when the bins need emptying.

A key question the Bin-e developers kept asking themselves was whether customers would even be interested in buying and maintaining these intelligent, yet expensive garbage cans despite getting no financial benefit out of it. After all, waste producers have not yet had to pay for using garbage cans. It therefore quickly became clear that added value had to be created for the operators of the garbage cans: “This is where the ‘smart’ comes into play. We provide our customers with real-time data on usage and waste composition,” Luboński reports. This data is then collected in a cloud and information on the waste collected and the technical condition of the smart garbage cans can be viewed on an app or dashboard. For Luboński, one thing is clear: “It’s not just about having the data, but also about knowing how to use it at the end of the day. For example, it helps to better control material flows or generate valuable data for CSR or EPR reporting.”



Source: Bin-e<sup>33</sup>

33 See Ishitava (n.d.): The Indian company Ishitava Robotic Systems also sells smart garbage bins.

# AT THE TOUCH OF A BUTTON

Digital progress is particularly important in regions of the world where established waste management and regular residential waste pickup services are still lacking. This might be our only chance to implement extended producer responsibility.

Sponsored by the UK government, the 2021 Digital Dividends in Plastic Recycling analysis found that 60 percent of the 63 digital applications examined in Africa, South Asia, and Southeast Asia serve the overarching purpose of connecting waste-producing private homes and businesses with waste collectors and recyclers – in most cases through an app.<sup>34</sup>

## Trash removal at the touch of a button

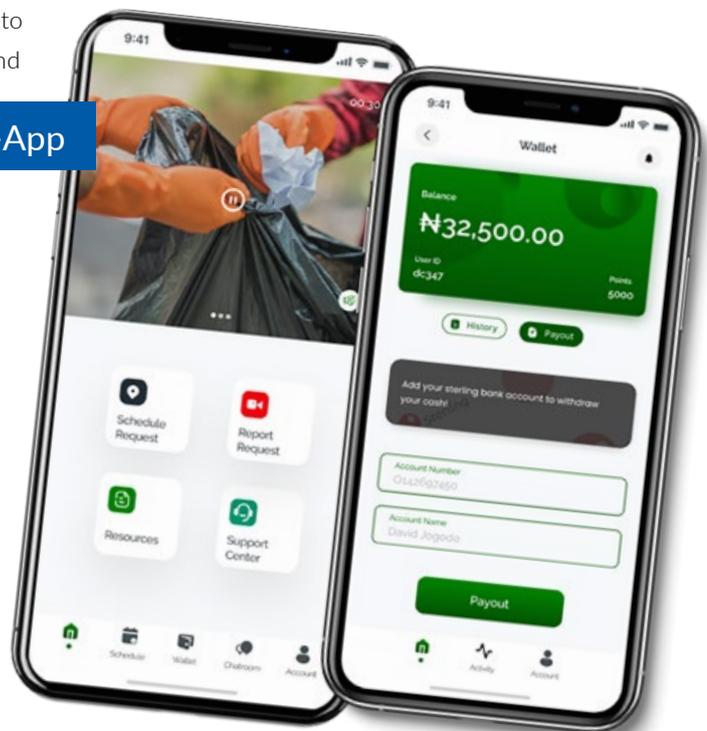
In many places, apps follow a principle similar to the solution offered by Nigerian provider **Pakam Technology**: An app instructs waste producers to sort and pack their recyclable waste at home or at work according to predefined categories, for example, plastics, cardboard, diapers, aluminum, multilayers, glass, or oil before they order a waste collector to pick up their waste at the touch of a button and enter in the types and quantities of trash in the app.<sup>35</sup>

To make the business viable for waste collectors, the garbage to be collected must often meet minimum volume requirements. **Veca**, a Vietnamese company that connects waste collectors and buyers through an app, only accepts pick-up orders of at least five kilograms. Waste producers are charged a fee for lesser quantities, which is intended to serve as a surcharge for collectors to cover travel costs and time.<sup>36</sup> **Duitin**, a similarly designed platform operated by the Indonesian waste disposal company PT. Tjatra Yasa Indonesia, stipulates a minimum weight of three kilograms.<sup>37</sup> After sending a pick-up request, the app automatically alerts

waste collectors, although it might take one to two days for the trash to actually be picked up.<sup>38</sup>

Pakam in Nigeria pays waste sellers digitally<sup>39</sup> for their work, while Veca in Vietnam also offers an optional cash payment, with prices to be achieved for the different types of waste being listed transparently in the app and regularly updated in line with market developments.<sup>40</sup> Duitin uses a digital currency as payment. Depending on the type and quantity of waste, waste producers can earn so-called Duitin coins or Duitin points, a type of loyalty point. The virtual coins or points can then be used to purchase digital products directly through the app.<sup>41</sup>

Pakam-App



Source: Pakam

34 Wilson et al. (2021), p. 28

35 Pakam (n. d.)

36 Veca (n. d.)

37 Duitin (n. d.) (3)

38 Veca (n. d.)

39 Pakam (n. d.)

40 Veca (n. d.)

41 Duitin (n. d.) (4)



Source: Veca

### Keeping it simple for easy access

As practical as apps may be for those who have a smartphone and the necessary skill set to use it, it seems necessary to design particularly low-threshold information and applications to cater to the sometimes low social status and educational disadvantages of waste workers in the global South.

With this in mind, **Circular Action**, an initiative of the globally active NGO **BV-Rio**, developed the **KOLEKT** app not just for, but together with waste pickers. It also works offline and requires virtually no text.<sup>42</sup> Other app operators cooperate with charities to give out smartphones as part of local government programs for job creation,<sup>43</sup> and Plastic Bank offers training opportunities to the waste pickers in its projects to expand their digital skills and use the various features effectively.<sup>44</sup>

### Demand determines supply

The increase in legal regulations on the implementation of extended producer responsibility (EPR) also makes digital applications interesting for businesses that are looking for solutions for their waste management but who cannot fall back on established public waste management systems. Providers have responded to this demand. For example, as part of the recycling programs Duitin offers, corporate customers can rally their employees to pool their points together by using a company code; a tracking function tracks how their own workforce is impacting the environment.<sup>45</sup>

Founded in 2021, **Octopus**, another Indonesian venture, is already tallying 150,000 users and cooperates with 60,000 waste collectors. It also works with over 20 brand companies, all of whom it supports in implementing their annual sustainability targets<sup>46</sup> by offering reporting services and audits.



Source: Duitin

42 Circular Action (n. d.) (1)

43 Shu (2022)

44 Interview statement by Peter Nitschke, Plastic Bank

45 Duitin (n.d.) (2)

46 Referred to as extended stakeholder responsibility in Indonesia.

The start-up also offers customized deposit systems (Octopus Deposit Return System), for example in cooperation with Procter & Gamble for used product packaging<sup>47</sup> or Softex (Kimberly-Clark)<sup>48</sup> for used baby diapers. Consumers pay a deposit when purchasing the products and get a refund when they arrange for the water bottles or baby diapers to be picked up through the Octopus app. A dashboard informs the brands about their customers' disposal behavior.<sup>49</sup>

### The idea of networking

A key challenge in setting up efficient digital structures is the strong fragmentation of the waste and recycling sector, as it is comprised of a large number of different players and interest groups: starting with private homes and trash collectors to collection points or buyers to aggregators, recyclers, and exporters, whose interaction often appears uncoordinated.

This is where the **Creating Value in Plastics Through Digital Technology** project of the **PREVENT Waste Alliance** in Indonesia, initiated by the German Federal Ministry for Economic Cooperation and Development (BMZ), has come into play. "Our aim was to establish a digitally linked recycling supply chain for plastics, starting with waste-generating households and extending to the global market," explains Peter Nitschke, global director for community partnerships at **Plastic Bank**, a cooperation partner of the four-part project consortium.

To improve waste separation directly at the source, the **German Institute of Development and Sustainability (IDOS)** has developed educational programs specifically designed for private homes to promote changes toward a more sustainable behavior. The Indonesian social enterprise **Waste4Change** has contributed a system for collecting separated trash at the household level and for local waste banks. "The waste separation rate has increased from 20 percent to 60 percent simply because households got a second garbage can that



Source: Circular Action B.V. KOLEKT

is picked up separately," Peter Nitschke explains proudly. Based on blockchain technology, the Plastic Bank app, which also guarantees the traceability of the quantities of plastics collected, their origin, the transactions made, and rewards given out, was used for the secure and fair payment of waste collectors.

With the introduction of a new quality standard for recyclates (DIN Spec 19446), the recovered and recycled plastic waste could finally be offered on the global market through the **Cirplus** digital marketplace, where full traceability guarantees buyers that recyclate was procured in a socially responsible manner. "Brand companies can buy reusable material and know that, for example, certain plastic waste was collected in a specific area by a certain number of waste pickers, who were paid an x amount, and received x rewards," Peter Nitschke explains. Consequently, 900 households,

47 Octopus (n. d.) (1)

48 Kimberly-Clark Softex (2021)

49 Octopus (n. d.) (1)

22 waste banks, and two recyclers have been trained to use the digital tools and some 10 tons of plastics have been collected and marketed as part of the project.<sup>50</sup>

Other promising examples of integrated supply chain management and marketplace applications include **Recykal** from India (see box) and the KOLEKT app for trading recyclable waste (see interview with Thierry Sanders).

For Plastic Bank, the most important takeaway from the PREVENT project was the need to build more on informal structures that already exist locally: “The structures simply need to be better linked with each other, and this is where we increasingly see our role in the future. For us, it’s not worth our time to open separate waste banks for each new location. Instead, we now approach more local businesses directly to offer cooperation,” says Peter Nitschke.

50 PREVENT Waste Alliance (2023) (1)



Not just for but together with waste pickers. When developing the KOLEKT app, Circular Action sourced knowledge and needs from future users.

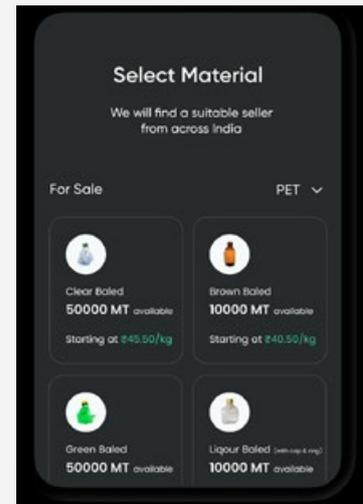
## RECYKAL

# INDIA'S ONE-STOP-SHOP FOR THE WASTE AND RECYCLING SECTOR

Founded in 2016, **Recykal** describes itself as India's first waste commerce<sup>51</sup> business by offering a digital B2B marketplace that brings together waste producers and processors from across the country. Its overarching goal is to ensure greater transparency and traceability in the waste and recycling sector while supporting businesses in meeting their statutory obligations under India's EPR and sustainability reporting requirements.<sup>52</sup>

To this end, Recykal offers a wide range of services along the plastics value chain, including for example, a deposit system for distributors or product sellers using QR codes<sup>53</sup> or smart solutions for waste collection centers, known as Recykal points. Their digital equipment is intended to ensure better predictability and planning capacities in order to contribute to the creation of jobs and the integration of waste pickers. Using a cloud-based software-as-a-service model, the service connects all the stakeholders in order to monitor the demand and availability of recyclable waste, handle stock levels, orders, and logistics, manage customers and partners in databases, compare sales prices, and make and receive digital payments as part of the transactions.<sup>54</sup>

In view of the growing demand for recyclable plastics and the increased risk of fraud in online transactions that comes with it, the app-based Recykal marketplace intends to provide quality and real-time tracking of orders. To achieve this, Recykal only lists reputable sellers and buyers in the marketplace system that it has verified itself. Registered buyers can then view the verified offers, compare prices, and decide to purchase a specific quantity of material. Recykal representatives inspect the material on site before it is loaded and shipped. Recykal likes to advertise that it takes full responsibility for the quality of the material until it reaches the buyer.<sup>55</sup>



Source: Recykal (3)



Source: Recykal (4)

51 World Economic Forum (2023)

52 Erukala (2023)

53 Recykal (n. d.) (1)

54 Recykal (n. d.) (5)

55 Recykal (n. d.) (2)

## MONITORING BY APP

# DIGITAL SOLUTIONS CREATE TRANSPARENCY AND TRUST

The use of digital solutions can create a higher level of transparency, which is becoming progressively more important for brands given their increasingly scrutinized supply chains and the growing interest in using socially responsible recycled plastics. The same applies to demonstrating compliance with statutory EPR obligations in terms of collection, recycling, and reuse rates.

The associated rise in the value of waste goes hand in hand with a need for certification in order to avoid fraud at various levels and build trust in the long term. This in turn creates a need for monitoring, reporting, and verification standards for the collection and recycling of waste.

“Standards have little value if they are not adhered to. At the same time, continuous documentation is time-consuming and costs money, something the waste and recycling sector lacks in many places,” Joel Tasche critically notes. The co-founder and CEO of the **CleanHub** platform knows what he’s talking about, as his Berlin-based start-up helps brands and consumers to offset their plastic footprint.

CleanHub works with local collection and recycling partners in India, Indonesia, Cambodia, and Tanzania. By using specially developed software, the start-up not only aims to make documentation easier, but also to ensure that the ongoing recording of the mass balances of waste streams along the entire logistics chain is comprehensible and accurate.

For this, photos of relevant data and weight records spanning the entire process of collecting plastic waste from the environment to its sorting and further transport are uploaded to the CleanHub app by all those involved. A real-time feed displays the data that enters the Cleanhub system. It can then be viewed on a real-time dashboard on the start-up’s website. This creates

the necessary transparency and trust among CleanHub customers, who in turn have digital proof of how much plastic was collected from the environment, when and where, and how it was processed or disposed of properly.

“What matters is to put the collected data, in our case pixel values, into context in such a way that it can be compared with data from various previous points in time to ensure it is correct. Machine learning or algorithms will play an even more important role in this in the future because they are able to recognize deviations independently,” Tasche explains. This will make it possible to detect errors and avoid fraud, for example by making it more difficult to book waste twice even though it has only been collected once.

When it comes to social aspects, such as ensuring occupational health and safety or fair pay, Tasche also warns that technology won’t do the trick all by itself. Compliance requires physical social audits directly on site. So it seems that we can’t run everything in the digital space, and perhaps we shouldn’t.

### Benefits of understanding

On the other hand, not every business welcomes the greater transparency afforded by digital data collection and its overarching benefits in fighting the plastic waste crisis. Skeptics fear the additional bureaucracy and expenses due to more red tape but this makes it all the more important to consider the perspectives of waste

pickers, recyclers, and aggregators and the benefits that digitalized processes can bring to their business.<sup>56</sup>

Supply chain management platforms that centralize data provide manufacturers, distributors, and recyclers with important analytical tools to better understand the composition of their material flows, trends in specific materials over time, and the state of their inventory. This is particularly useful for revenue planning and specific material demands, particularly in cases when there is a direct link to buyers or the global recycle market, providing direct insight into price developments.<sup>57</sup>

The ability to view and compare sales prices or premiums for their collected waste volumes makes the use of apps extremely attractive for waste collectors and the plastic waste trade in general. Having access to up-to-date information on where waste is located, being able to get direct orders for a waste pick-up service, or seeing their nearest customers also enables waste pickers to make their work more efficient and effective. Ideally, this will improve their chances of earning a regular income and even getting fair pay, as well as health and education services,<sup>58</sup> especially where digital solutions are linked to corresponding programs or aim to gradually integrate the so-called “informal sector.” However, this requires approaches that enable payment according to performance and not just according to the quantity collected, for example based on surcharges for the time actually spent collecting waste.

### Too much of a good thing?

“The benefits of digital solutions may seem obvious at first glance and may help to create better living and working conditions for people in emerging and developing countries. Digital solutions can also improve the prerequisites of a circular economy, for example by making material flows traceable and creating transparency for compliance with reporting obligations and

achieving recycling targets. In day-to-day business practice, digital apps can connect waste producers with waste collectors, for example, with the latter receiving incentives to collect low-value materials. But not all informal waste pickers have access to digital apps. That means that the multiverse of digital offerings does not serve everyone. We must be careful to ensure that no one is excluded from the new systems,” say Ellen Gunsilius, specialist planner for the environment and circular economy at **GIZ**, and her colleague Steffen Blume, project manager for reducing the entry of plastic waste into the world’s oceans.

They are involved in waste and circular economy projects in various countries and are part of the PREVENT Waste Alliance Plastics working group, in which many digital and circular companies also participate. The group has already counted over 20 national and international waste collection apps on the Indonesian market alone. Gunsilius and Blume deduce from this a need for harmonization and interoperability, as otherwise further progress would be slowed and resources would be invested in reinventing the wheel time and again.

In addition to a certain technical openness at the programming level of the apps<sup>59</sup>, this requires above all the willingness of market participants to cooperate for an overarching purpose. “If standards for digital solutions and data use are created, updated, and made accessible to governments and market participants, the added value would perhaps be recognized and they could contribute to improved environmental and living conditions through efficiency and economies of scale,” Gunsilius and Blume cautiously predict.

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57 See interviews with Peter Nitschke, Plastic Bank, and Joel Tasche, CleanHub

58 See Plastic Bank (n. d.)

59 Circular Action (n. d.) (2)

# INTERVIEW

Thierry Sanders, managing director of Circular Action B.v., about KOLEKT



## What motivated you to develop the KOLEKT app?

During my time in Bali, I came to witness the huge waste problem there. Not only many foreigners like me, but also schools, businesses, hotels, and restaurants have problems disposing of their waste properly. In countries like Vietnam, Indonesia, Brazil, and many others, you only have about four waste collectors for every 1,000 inhabitants. With their motorcycles and carts, they are constantly on the lookout for valuable recyclables on the streets. Many of them often waste a lot of time and fuel in the process. In the end, the Indonesian cab system inspired me to get together with waste pickers to tackle the problem.

## How did you develop the app?

In fact, I offered coffee and cigarettes to a waste collector and his colleagues to ask him if he would be interested in helping me develop a waste collection app similar to the taxi app. So, we worked together on designs for five days, and a month later I had developed a first pilot version of the app, which he was not at all happy with and complained about its various shortcomings.

This feedback turned out to be very helpful. Just to give one example: the waste collectors' smartphones often don't work very well because their cameras have a lower image resolution, for instance. In addition, the screen is not very easy to read due to the strong sunlight, which is why you need appropriate contrast to read the letters. In addition, many collectors only have limited Internet data plans, while others have only simple cellphones or even no phone at all. All of this needs to be carefully considered.

So, the basic requirement for KOLEKT was that it needed to be usable by people who have neither a phone nor a bank account and who often have to work offline. It's all about the lowest common denominator. The app is designed to be very simple, no instruction manual needed, and with very little text, and it works in Arabic, Portuguese, Vietnamese, and Indonesian.

## What exactly is the idea behind the app?

A very important point is that apps, especially for waste picking, will only be truly used if the user gets any added financial value out of it because waste pickers know exactly what they are doing and do not need any technical support to do their work. They have their own networks and know the dealers and their prices to whom they can sell the waste they've collected.

However, the ability to compare purchase prices given by different buyers makes an app interesting and drives price competition. Then you also have the multinational consumer goods companies who have to prove that they have collected and disposed of a certain amount of plastic. And if enterprises, such as Tetrapak in our case, are interested in having less-valuable materials collected, they need appropriate collection incentives for such low-value waste. In order to grant a low-value waste subsidy, you must ensure that you can pay a large number of people who have neither a bank account nor a cellphone. This is where KOLEKT comes into play.

KOLEKT caters to all three needs. Firstly, by providing a marketplace for the recyclables trade, secondly, by monitoring and offering proof to companies of where



# Designing an app with waste pickers over coffee

their waste ends up, and thirdly, by incentivizing the supply chain through granting rewards or subsidies to unbanked waste collectors.

To summarize, KOLEKT's mission is to facilitate the buying and selling of recyclable waste and to help pay waste pickers in order to enable them to earn an income above the local minimum wage.

## How do potential users learn about the app?

As a matter of fact, exclusively through word of mouth. First, we look for a recycler who can process the recyclable materials we want. We then sign a contract with them, and once we have the contract, we know the purchase price. Then we go down one level to the material compression companies that have a baler to ensure that transportation costs remain low.

So, we ask about the cost of baling and delivery to the recycler. And since they don't trust us, they will contact the recycler first to check whether the offer is correct. After confirmation from the recycler, the contract is signed. From here, we go one level further to the collection points and explain that the material compactor would like to buy waste from them and that they can find the location on the KOLEKT app. Then we show them the minimum and maximum price on the app and the signed papers. And they then call the material compactor to make sure everything is correct.

Finally, we explain the app's functions in detail. And then when a waste picker arrives at the collection point, they will be registered through facial recognition

or by OTP/SMS on their cellphone or asked if they can download KOLEKT to their cellphone to complete the sales transaction.

Basically, the aim is to foster reliability and trust that the price that was agreed in advance will be paid. But as soon as someone stops showing up or prices change, mistrust creeps in and the whole chain falls apart.

## How do waste pickers sign up with KOLEKT if they don't have a smartphone or cellphone?

The waste pickers are registered when they come for selling. If they do not have a phone, facial recognition in combination with their name suffices to create an account in our app through the buyer's phone. That means that the selling waste pickers' identity is confirmed by facial recognition on the buyer's phone. They then receive cash as well as points for the material sold. By logging the waste pickers on the buyer's phone, the accumulated points can be transferred to a third party, who pays out the value of the points in cash to them.

## How many people already use the app?

Our largest user group is waste pickers. In terms of the number of users, we have a pyramid structure: the waste pickers are at the bottom of the pyramid, followed by the collection points or buyers in the middle, while the aggregators and the recyclers or exporters make up the top.

KOLEKT currently has about 2,000 users, which admittedly doesn't seem like a lot. However, some



The KOLEKT app is available in various languages and is already used in countries such as Indonesia, Brazil, Vietnam, and Mozambique.

15,000 transactions have already been carried out with KOLEKT in the past twelve months, with a volume of around 1,500 kilos per transaction.

**What kind of data does the app collect? And what value do you attribute to the data, for example in relation to EPR reporting?**

The value of the data lies in the transactions and purchase notifications, but also in the ability to detect and prevent fraud. We use the app to collect photos, GPS data, sales and purchase confirmations, prices, weight, and details about the material. This is also the data that auditors want to see from companies. Ultimately, it's key for EPR reporting because the KOLEKT data can be used to prove how many tons of waste were delivered to the recyclers, how the recyclers processed the waste, and where the waste came from.

**What's next for KOLEKT?**

I think what matters most is to make clear to consumer goods manufacturers that the volume of packaging waste that gets collected will only grow if we let the real experts, the professionals, which is what waste pickers are, do their job by hand. They can't be replaced by garbage trucks or intelligent garbage cans, instead they must be paid fairly.

In the future, we also want to offer certificates, similar to Plastic Credits, as proof of collection and recycling for consumer goods companies. This would mean that auditors such as Control Union or TÜV could audit our systems to see whether collection and recycling have been carried out and documented correctly. In short, our aim is to develop into an auditing platform for waste.

## How digital tools can close data gaps

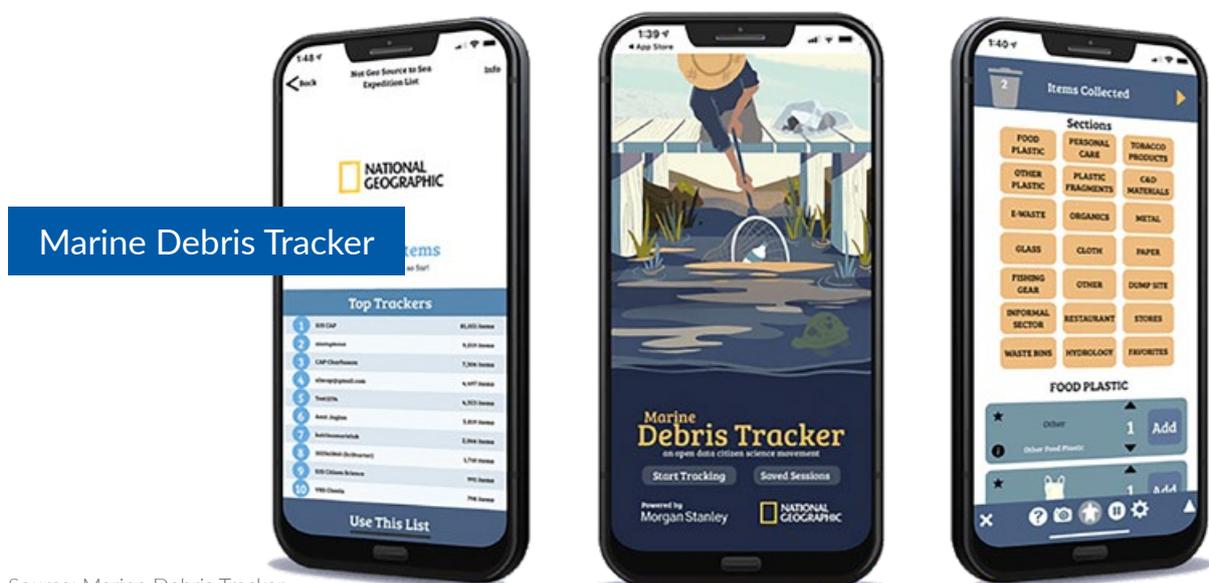
# ON LAND, ON WATER AND IN THE AIR

How much plastic waste is in the environment and our oceans? Where and when was this waste introduced? In which regions does it accumulate particularly heavily, and under what weather and environmental conditions does it spread and how? Answers to these questions could contribute significantly to a better understanding of the origins and ecological consequences of the plastics crisis and possibly even help to contain it. So far, however, there is still a huge gap in the data available, not to mention the lack of international monitoring standards, which would be absolutely essential given the global scale of the crisis.<sup>60</sup>

The use of digital technologies in local sampling and collection campaigns (e.g., beach clean-ups), visual surveys (e.g., on board a fishing boat), and remote sensing (e.g., using drones or aircraft) offers great potential for better mapping and quantifying the extent of pollution, determining the composition of waste, and monitoring or even predicting its distribution paths. However, as a prerequisite, you need a multitude of people who contribute to collecting this data.

### When clean-ups become citizen science

Compiling global statistics on marine litter and making the information freely accessible to the scientific community was the aim of the well-known US environmental engineer Jenna Jambeck when she developed the Marine Debris Tracker app in 2010. Based on the data collected with the help of the app, Jambeck was able to make the widely cited estimate in 2015 that more than eight million pieces of plastic end up in the sea every year.<sup>61</sup>



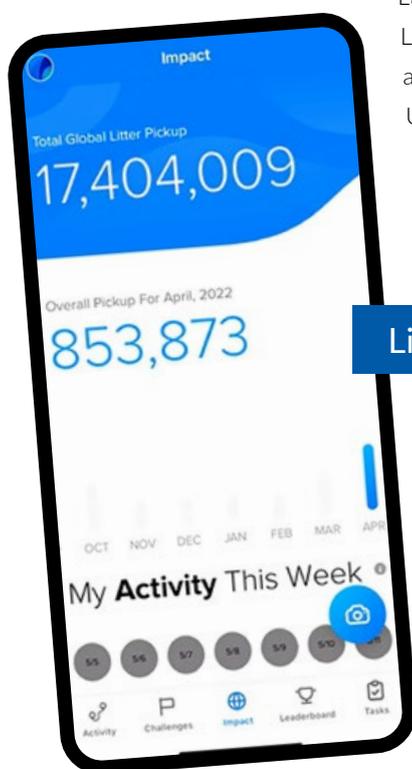
Source: Marine Debris Tracker

60 Interview statement by Tilman Floer, everwave; Matthias Wolf, dfki; Steffen Blume and Ellen Günsilius, GIZ, see Ostrowski (2021)

61 Ellen MacArthur Foundation (2022) (2)

The app has contributed to collecting and documenting<sup>62</sup> nearly 7.5 million pieces of trash worldwide (as of July 2023) thanks to a global user base of around 10,000 citizen scientists (as of 2021).<sup>63</sup>

The app lists a host of cooperation partners from the scientific, civil and educational sectors and provides individual waste and material lists, depending on their research interest. Once app users select a list, they can enter the waste items collected, although a photo is not necessarily required as proof. In order to meet scientific requirements, the app offers additional functions to ensure GPS accuracy for locating waste and to document the route waste collectors took. This function serves to provide analytical information about where and at which points no waste has been found. The data is then transmitted directly to the online database and can be accessed and downloaded from anywhere in the world.<sup>64</sup>



Litterati-App

Launched in 2015, the Litterati app, which was also developed in the US and is now used in 135 countries, pursues a similar goal: to understand why particularly

large or small amounts of litter accumulate in certain streets, parks, or neighborhoods in order to develop solutions for local

litter problems in collaboration with cities, food establishments, or brand companies. For example, data collected through the app, which has already been used to record 19 million items of waste (as of July 2023), helped to successfully introduce a cigarette tax in San Francisco where app users collected and documented more than 5,000 cigarette butts after the introduction of the tax initially failed due to a lawsuit filed by large tobacco companies. Thanks to the photos taken and documentation of the time of collection, the location, and brand of cigarettes, the urgency to introduce the tax was proven and ultimately held up in court.<sup>65</sup>

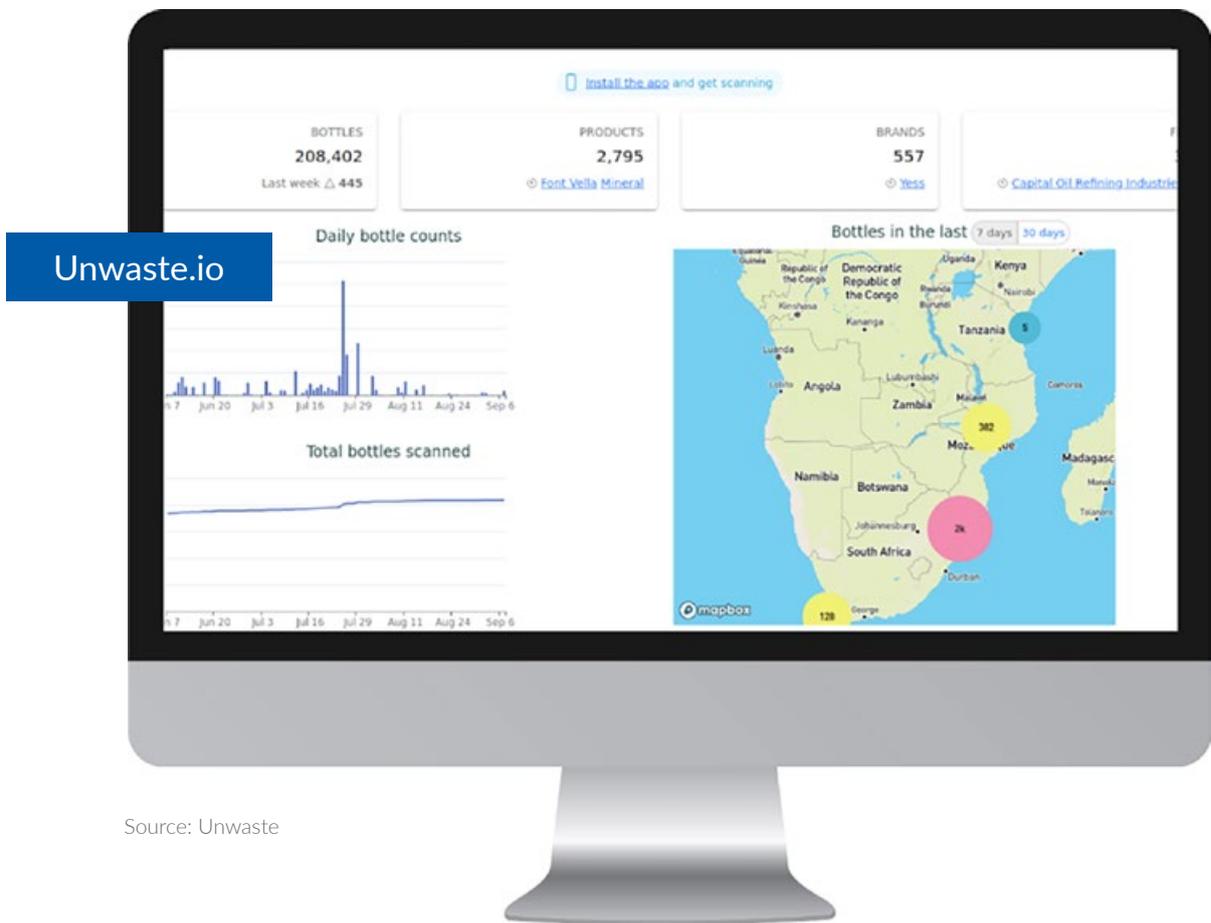
In addition to tracking waste, the app also offers insights into the amount of waste collected worldwide by the Litterati community as well as opportunities to organize collection competitions among app users or participate in research assignments.<sup>66</sup> As with the Marine Debris Tracker app, Litterati also provides free access to the data on collected waste, which is updated monthly and can only be viewed for the course of one calendar year at a time.<sup>67</sup> An analytical tool tailored to cities as part of the City Fingerprint Project also serves to allow decision-makers to draw conclusions about waste concentration areas, such as in shopping areas or illegal waste dumps, and thus provides the data-driven scientific basis for deriving effective measures to combat waste. This tool employs artificial intelligence to evaluate the image data collected with the help of the app.<sup>68</sup>

The London-based social enterprise Unwaste.io Ltd. has set out to collect valid and robust data on plastic bottles found in the environment and document the associated brands together with cooperation partners in Congo, Kenya, Malawi, Mozambique, Tanzania, Uganda, and Zambia. In support of this measure, local

Source: Litterati

62 Marine Debris Tracker (n. d.) (1)  
 63 Marine Debris Tracker (2021)  
 64 Marine Debris Tracker (2020)  
 65 TED (2017)

66 Litterati (n. d.) (1)  
 67 Litterati (n. d.) (2)  
 68 Litterati (n. d.) (3)



Source: Unwaste

partner organizations receive appropriate training to help them collect and process data and conduct background research on product data from brands, manufacturers, and retailers as part of their educational work and clean-up campaigns.<sup>69</sup>

The premise for this effort is an app that is used to scan the barcodes of plastic bottles and store the corresponding information, including brand, product name, weight, and manufacturer. The data is freely accessible on the Wastebase DATA platform, where it can be filtered according to manufacturer and brand

and is used to show waste hotspots.<sup>70</sup> In addition, monthly reports provide information on the top five bottle brands collected from the environment in the regions of the cooperation partners.<sup>71</sup>

Unwaste.io's approach is promising because the database provides local environmental activists and NGOs with solid evidence to put direct pressure on specific brands, industries, and politicians to come up with solutions or effectively implement EPR measures.<sup>72</sup> In this context, extending PET bottles to other forms of packaging also seems to make sense.

69 Unwaste.io (n. d.) (1)

70 Wastebase (n. d.)

71 Wastebase (2023)

72 Unwaste (2021)

## Remote sensing of plastic emissions

# FROM A BIRD'S EYE VIEW

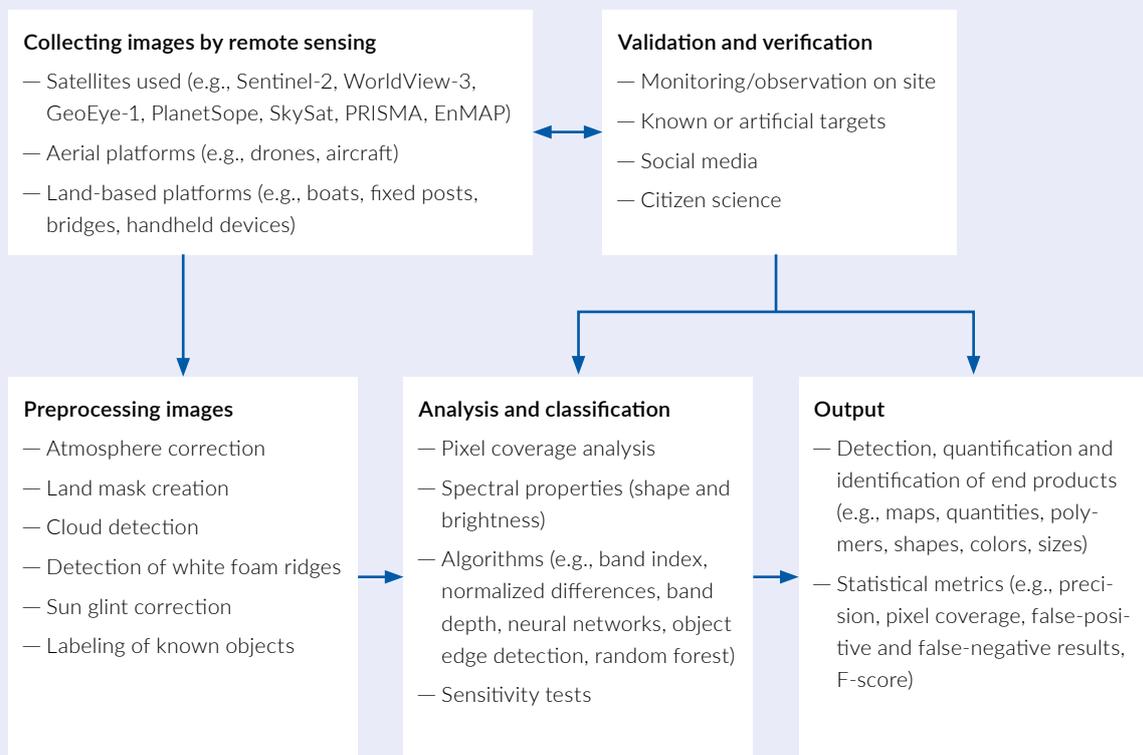
Although digital tools make documentation much easier, removing waste from the environment is tedious and usually done by hand; often selectively and above all, it requires committed individuals. Considering the enormous scale of the plastics crisis, complementary approaches are needed to remove pollution that has already occurred.

Remote sensing is playing an increasingly important role in this field. Surveillance cameras, aircraft, drones, and satellites record and examine the physical properties of an area from a distance by measuring reflected and emitted radiation.<sup>73</sup>

### AI as your right hand

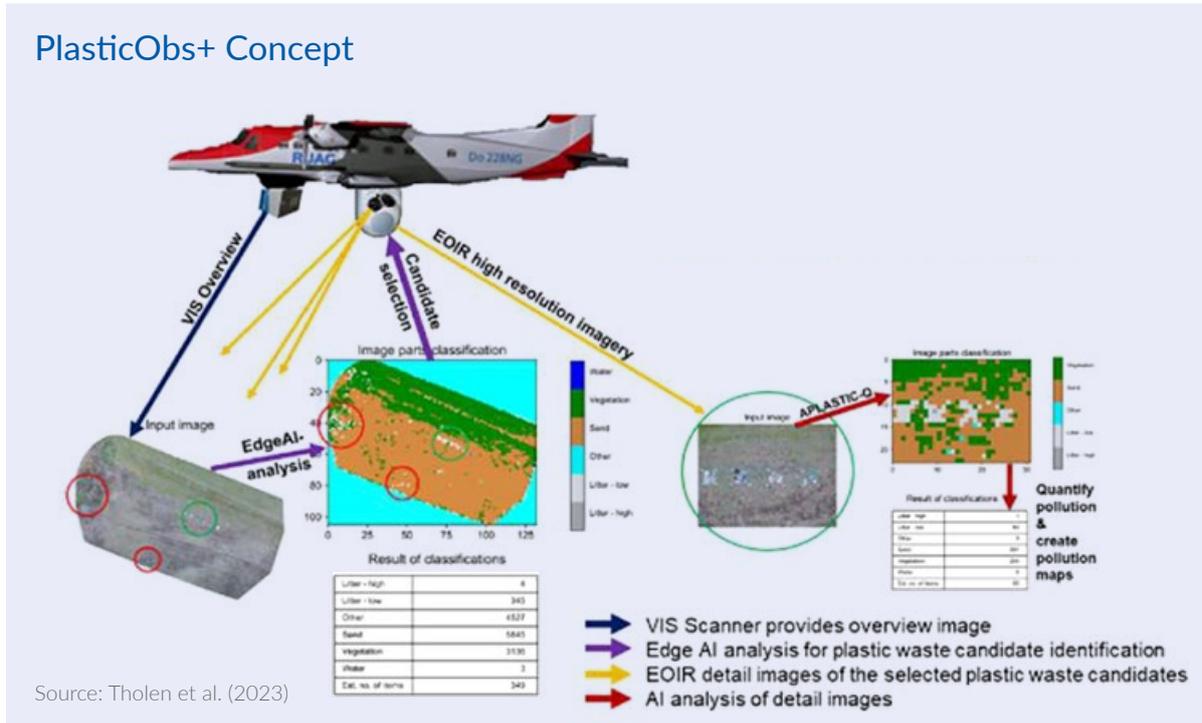
PlasticObs\_plus is a project that has set out to use aircraft to detect floating and washed-up plastic waste from the air in order to draw conclusions about its origins and distribution routes. "In the future, we want to

## Recording, analyzing, and deriving knowledge from remote sensing images



Source: Blume et al. (2023), p. 19

## PlasticObs+ Concept



develop a system where we continually fly over stretches of coastline and estuaries in order to track changes over time. To do this, we plan to use planes that are normally used to detect oil spills. They come with the necessary equipment and are already in the air anyways. We flew our first field tests on the island of Spiekeroog in November 2022,” explains Mattis Wolf, a scientist at the **German Research Center for Artificial Intelligence (DFKI)** and part of the project consortium alongside Dr Tilman Floehr, head of technology and co-founder of the German organization **everwave**.

**PlasticObs\_plus** uses airplanes to collect image data because they can guarantee a higher spatial resolution and the necessary data quality. Although satellite images can cover a larger area, they do not achieve the same level of detail. Drones, on the other hand, can only be used in a very stationary manner, have to be recharged regularly, and must be equipped with additional hardware.

Artificial intelligence is used to detect, classify, and quantify plastic waste, for which the DFKI as the overall project leader, is developing its own algorithm for analyzing image data. Although the manual evaluation of data is very time-consuming, training AI models reg-

ularly does pay off. The DFKI has already been able to prove in a study that artificial intelligence enhances remote sensing. When distinguishing between images with and without plastic waste, the AI methodology has an accuracy of 93.3 percent, topping the 92.6 percent achieved by humans using manual methods.<sup>74</sup>

“The planes are equipped with various optical sensor systems. Near-infrared, for example, can help recognize the difference between water and actual flotsam from a distance, as the absorption characteristics for water differ significantly in this spectral channel,” Wolf explains. After an initial AI analysis using a sensor with a wide aperture angle and lower resolution to identify potential litter patches, a second sensor is used to zoom in on the corresponding hotspots. “The high-resolution image data is then evaluated by another AI system. This information provides details about the type, quantity, and composition of the plastic waste which is particularly important for subsequent clean-ups that remove the trash,” Wolf says about the data processing.

Everwave can then take action on site, for example, with its own waste collection boats as part of the clean-up technologies used by the organization. Floehr believes in the cooperation with DFKI and the added

Artificial intelligence is used in the PlasticObs\_plus project to evaluate image data for plastic waste detection and classification in coastal areas.



value of the data: “Having a system that works on such a large scale gives us a better understanding of where and when we need to take action. And, of course, it gives us more planning security, as we can estimate in advance exactly what logistics we need for our boats and the waste collected. This not only saves time, but also money. At the same time, by evaluating the material we collect, we can validate and verify to the DFKI whether the AI analysis was correct, which in turn strengthens the system’s informative value.”

#### Common standards for more meaningfulness

Projects such as PlasticObs\_plus are promising when it comes to providing local environmental projects, governments, or authorities with information on the distribution routes, sources, and accumulation areas. Such information is needed to derive and implement measures to prevent the spread or even entry of waste into the environment. “Together with weather data or information on water flow velocities, we can identify entry paths and make predictions about the spatial and temporal distribution of plastics or observe seasonal differences. This methodology would also be useful for monitoring bans, as regular monitoring would provide information on whether, for example, the actual num-

ber of bags floating in the water has declined after the introduction of a plastic bag ban,” says Floehr, describing some of the possible uses.

In order to make possible applications and data generated by remote sensing for monitoring plastics in the environment as usable as possible across regions, Floehr calls for the standardization of methods, which he believes is imperative: “Experts from science, industry, civil society, government agencies, and aerospace must cooperate much more closely in order to create minimum standards for better comparability of data. Because without a basis for comparison, the data is not worth as much as it could be. If we managed to compare data from satellites with data from drones or airplanes and even with data from cellphones, we’d get much further.”

The “Advances in Remote Sensing of Plastic Waste” study by the German Society for International Cooperation (Deutsche Gesellschaft für Internationale Zusammenarbeit, GIZ) recently confirmed that this is still one of the biggest hurdles. It also lamented the fact that research projects and studies often use very different metrics to identify, classify, and quantify waste.<sup>75</sup>

“We are already working on the interoperability of different data sources together with the PREVENT Waste Alliance, for example,” Floehr says in this context.

Due to the positive feedback from international projects, Wolf also advocates for making algorithms freely

available (open source), so that proven data analysis methods can be used as widely as possible. The same applies to ensuring that the data collected and the insights gained from it are as freely accessible as possible. This is the only way they can best fulfill their purpose, i.e., to be used to curb the plastics crisis.

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75 See Blume et al. (2023), p. 39

## EVERYTHING IN ONE PLACE

Developed in 2021 in a collaboration project bringing together the German Society for International Cooperation (GIZ), the University of Leeds, the Swiss Federal Institute of Aquatic Science and Technology (Eawag), and the NGO Wasteware, the waste flow diagram (WFD) has already been used in over 100 cities to estimate the amount of waste entering the environment and improve local waste management based on scenarios.<sup>76</sup>

The tool's data-driven approach serves four overarching purposes:<sup>77</sup>

- Estimating the amount of plastic entering the environment
- Designing waste management projects, especially to prevent water pollution
- Monitoring the effectiveness of waste management interventions
- Providing support in decision-making for planning and improving municipal waste management

The underlying material flow analysis is based on primary and secondary data, observations, and surveys on the various levels of municipal waste management: waste generation, collection, transportation, processing, and disposal.<sup>78</sup>

As a result, the WFD maps the total amount of uncontrolled plastic waste, its various sources, and leaks as the reason for waste entering the environment and its final fate in the environment. The tool also enables comparisons between municipalities and thus promotes competition between cities for improved and environmentally friendly waste management.<sup>79</sup>

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76 Whiteman, Andrew et al. (2023), p. 6

77 Waste Flow Diagram (n. d.)

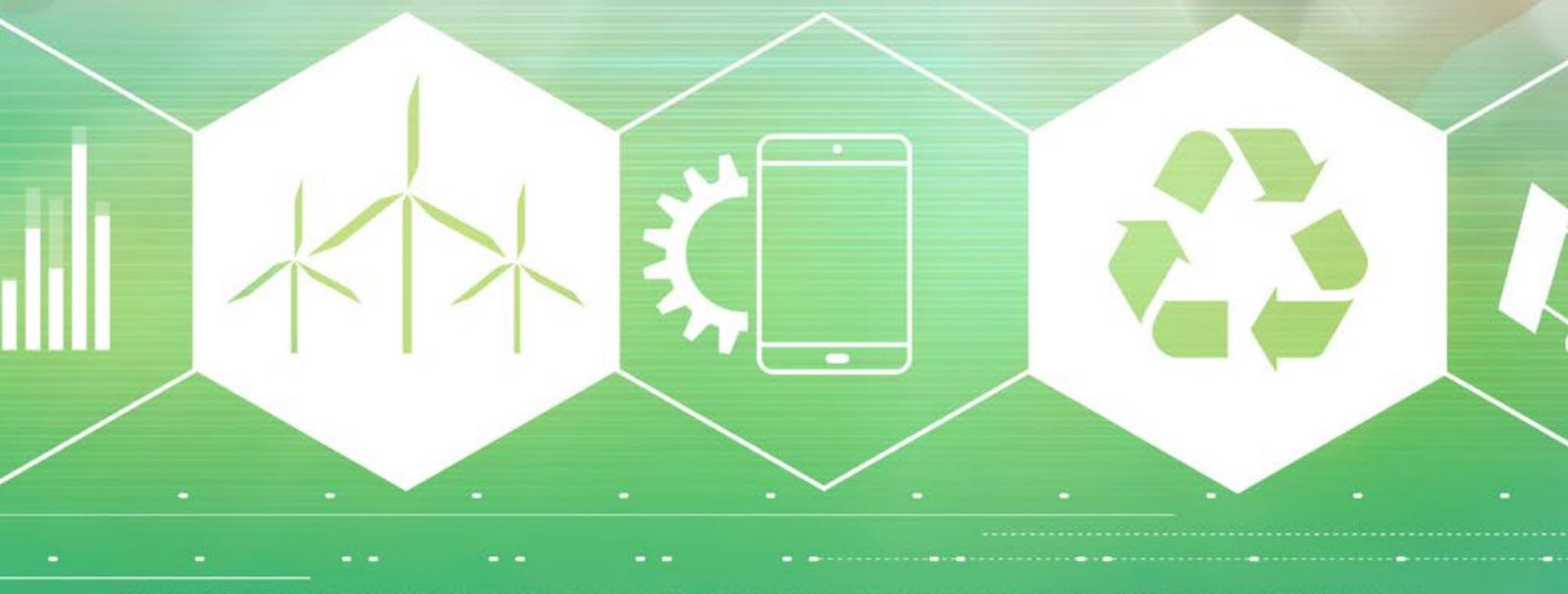
78 Whiteman et al. (2023), p. 6

79 Ibid. p. 8

A person's hands are shown holding a smartphone. A futuristic digital overlay is centered on the camera lens, featuring a circular grid of dots and a bright light emanating from the center. The background is a soft-focus image of a person's face.

# A CURSE AND A BLESSING

An interim  
conclusion



# THE DIGITAL TRANSFORMATION NEEDS RESILIENT INFRASTRUCTURE

It is not yet clear whether the digital transformation will help fight socio-ecological crises or if, on the contrary, it might even intensify and accelerate them. Just as artificial intelligence can be both a threat and an opportunity for the knowledge society, digital progress can support the transition to a more sustainable use of resources – or massively hinder it.

The ambivalence is obvious: increases in productivity thanks to digital technologies initially give our classic, growth-driven economic model an additional boost. But whether they can also be turned into a powerful tool on the way to a sustainable economy will depend on the political framework conditions on the one hand and the willingness of everyone involved to work together and integrate their different perspectives and competencies on the other hand.

It is no coincidence that the German Federal Ministry for the Environment presented an environmental digital agenda<sup>80</sup> at the beginning of 2020. This strategy shed light on the consumption of resources through digitalization itself. After all, the digital industry will soon be emitting more greenhouse gases than all road traffic combined. However, the 70 measures proposed in the ministry report also explore the interaction between technology, ecology, and society.

In the expert interviews we conducted for this POLY-PROBLEM report, one key message has emerged time and again: “good” digitalization, meaning one that fosters the careful use of resources, is not a question of technology but it’s all the more about attitude.

Will businesses be willing to share data in order to plan, design, produce, sell, and recycle products along the entire value chain in a more environmentally friendly way? Will it be possible to make use of shared data infrastructures and still stand out from the competition?

Technologically, this is not really an issue, most experts claim. Economically, however, it is, because it is still difficult to make money from sustainability. So, who will pay for and operate digital infrastructures that are not designed to step up productivity, but geared toward resource-conserving economic activities?

This is where politics come into play. Politicians can and should create incentives to establish digital infrastructures for greater sustainability as a common good in areas that lack viable business models. This applies, for example, to investments in digital progress in the area of waste management and recycling, but also to shaping a culture that emphasizes the use of reusables as the new normal.

Developers and providers of digital solutions are also called upon to work together if technological change is to deliver on the hoped-for boost in the transition to a sustainable use of resources. We need to agree on overarching standards in many areas in order to combine the sometimes remarkable developments in smart ways. Our research repeatedly brought to light the call for shared structures instead of isolated solutions.

This is not a surprising finding considering that the circular economy can only succeed if all the links in the value chain work together.

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<sup>80</sup> [https://www.bmu.de/fileadmin/Daten\\_BMU/Download\\_PDF/Digitalisierung/digitalagenda\\_bf.pdf](https://www.bmu.de/fileadmin/Daten_BMU/Download_PDF/Digitalisierung/digitalagenda_bf.pdf)

# POLY PROBLEM

## POLYPROBLEM: Knowledge. Transparency. Cooperation

POLYPROBLEM is a joint initiative of the non-profit Röchling Foundation and the consulting firm Wider Sense. Under the same name, the initiators published a study in 2019 that came to the sobering conclusion that despite lively public interest in the growing problem of environmental pollution caused by plastic waste, a global agenda is still not in sight. What's more, there is little continuous, comprehensive, or scientifically sound information on the issue.

Together with businesses, foundations, NGOs, the science community, and policy makers, POLYPROBLEM aims to close this gap and encourage cutting edge innovations for a plastic waste-free environment.

POLYPROBLEM works with scientists and practitioners to publish reports on the latest developments and most pressing questions surrounding plastics and the environment on a regular basis. Our aim is to provide more clarity, more transparency, and better orientation in complex fields of action, but also to shed light on startling facts or aspects that have not yet been brought to attention.

[www.polyproblem.org](http://www.polyproblem.org)



The Röchling Foundation is committed to plastics and the environment. It supports both research projects and civil society initiatives that contribute to the responsible use of plastics in the sense of a sustainable circular economy. The Röchling Foundation does not see itself as a mere investment partner, but is fundamentally active in establishing new, cross-sector collaborations and networks.

In addition, the Foundation also initiates its own activities that contribute to a holistic understanding and integrated solutions to the global challenge of plastics and the environment.

The Röchling Foundation was established in 1990 by the Röchling family who is also the owner of the Röchling Group, one of the leading international suppliers of high-performance plastics for automotive technology, industrial applications, and medical technology.

[www.roechling-stiftung.de/en/](http://www.roechling-stiftung.de/en/)  
[info@roechling-stiftung.de](mailto:info@roechling-stiftung.de)



By offering customized consulting services, from research to strategy design and implementation, WIDER SENSE helps businesses and foundations to effectively shape social change. In May 2015, Wider Sense was certified as a B Corporation. In recent years, WIDER SENSE has built up expertise in CSR, philanthropy, and social investment, and has developed a global network of strategic partners.

Thanks to its international outreach and multidisciplinary team, WIDER SENSE has worked with more than 100 clients on projects in more than 30 countries, who have contributed funds in excess of EUR 100 million directly toward fostering social change.

<https://widersense.org>  
[info@widersense.org](mailto:info@widersense.org)

# LINKS TO THE ORGANIZATIONS MENTIONED

Organisation	Abbr.	Link
Alliance to End Plastic Waste		<a href="https://endplasticwaste.org/">https://endplasticwaste.org/</a>
Ampliphi		<a href="https://ampliphi.io/">https://ampliphi.io/</a>
Berliner Stadtreinigung	BSR	<a href="https://www.bsr.de/">https://www.bsr.de/</a>
Bin-e		<a href="https://www.bine.world/">https://www.bine.world/</a>
Bower		<a href="https://getbower.com/">https://getbower.com/</a>
BVRio		<a href="https://www.bvrrio.org/">https://www.bvrrio.org/</a>
Circular Action Hub		<a href="https://www.circularactionhub.org/">https://www.circularactionhub.org/</a>
Cirplus		<a href="https://www.cirplus.com/">https://www.cirplus.com/</a>
circularise		<a href="https://www.circularise.com/">https://www.circularise.com/</a>
CleanHub		<a href="https://www.cleanhub.com/">https://www.cleanhub.com/</a>
Cm carbon minds		<a href="https://www.carbon-minds.com/">https://www.carbon-minds.com/</a>
Cyrkl		<a href="https://cyrkl.com/de">https://cyrkl.com/de</a>
dm Drogeriemärkte		<a href="https://www.dm.de/">https://www.dm.de/</a>
Deutsches Forschungszentrum für Künstliche Intelligenz	DFKI	<a href="https://www.dhi.de/">https://www.dhi.de/</a>
Duitin		<a href="https://duitin.id/">https://duitin.id/</a>
Ecoinvent		<a href="https://ecoinvent.org/">https://ecoinvent.org/</a>
EcoNation		<a href="https://econation.me/">https://econation.me/</a>
Ellen MacArthur Foundation		<a href="https://ellenmacarthurfoundation.org">https://ellenmacarthurfoundation.org</a>
European Brands Association	AIM	<a href="https://www.aim.be/">https://www.aim.be/</a>
everwave		<a href="https://everwave.de/">https://everwave.de/</a>
German Institute of Development and Sustainability	IDOS	<a href="https://www.idos-research.de/">https://www.idos-research.de/</a>
Gesellschaft für Internationale Zusammenarbeit	GIZ	<a href="https://www.giz.de/de/">https://www.giz.de/de/</a>
Grüner Punkt		<a href="https://www.gruener-punkt.de/">https://www.gruener-punkt.de/</a>
Henkel		<a href="https://www.henkel.de/">https://www.henkel.de/</a>
Institut für Kunststoff- und Kreislauftechnik, Leibniz Universität Hannover		<a href="https://www.ikk.uni-hannover.de/">https://www.ikk.uni-hannover.de/</a>
Ishitva Robotic Systems		<a href="https://ishitva.in/">https://ishitva.in/</a>
Kunststoff Forschungszentrum SKZ		<a href="https://www.skz.de/">https://www.skz.de/</a>
Küste gegen Plastik e. V./ReplacePlastic		<a href="https://app.replaceplastic.de/">https://app.replaceplastic.de/</a>
Litterati		<a href="https://www.litterati.org/">https://www.litterati.org/</a>
Marine Debris Tracker		<a href="https://debristracker.org/">https://debristracker.org/</a>
My little Plastic Footprint		<a href="https://www.mylittleplasticfootprint.org/">https://www.mylittleplasticfootprint.org/</a>
Octopus		<a href="https://octopus.co.id/id">https://octopus.co.id/id</a>
Pakam		<a href="https://www.pakam.ng/">https://www.pakam.ng/</a>
Plastic Bank		<a href="https://plasticbank.com">https://plasticbank.com</a>
Polysecure		<a href="https://www.polysecure.eu">https://www.polysecure.eu</a>
PREVENT Waste Alliance		<a href="https://prevent-waste.net/en/">https://prevent-waste.net/en/</a>
ProData GmbH / R-Cycle		<a href="https://www.r-cycle.org/">https://www.r-cycle.org/</a>
RecycleMich		<a href="https://www.recyclemich.at/">https://www.recyclemich.at/</a>
Reciclos		<a href="https://www.reciclos.com/en/">https://www.reciclos.com/en/</a>
Recup		<a href="https://recup.de/">https://recup.de/</a>
recyda		<a href="https://www.recyda.com/">https://www.recyda.com/</a>
Recykal		<a href="https://recykal.com/">https://recykal.com/</a>

Organisation	Abbr.	Link
ReDo		<a href="https://redo-please.com/das-projekt">https://redo-please.com/das-projekt</a>
ReFrastructure		<a href="https://refrastructure.org/">https://refrastructure.org/</a>
Resourcify		<a href="https://www.resourcify.com/de/">https://www.resourcify.com/de/</a>
SAP		<a href="https://www.sap.com/">https://www.sap.com/</a>
Saubermacher Dienstleistung AG		<a href="https://saubermacher.at/">https://saubermacher.at/</a>
Scrapp		<a href="https://www.scrapprecycling.com/">https://www.scrapprecycling.com/</a>
Sphera		<a href="https://sphera.com/">https://sphera.com/</a>
Umweltbundesamt		<a href="https://www.umweltbundesamt.de/">https://www.umweltbundesamt.de/</a>
Unwaste.io LTD		<a href="https://www.unwaste.io/">https://www.unwaste.io/</a>
Veca		<a href="https://www.veca.app/home">https://www.veca.app/home</a>
Vytal		<a href="https://www.vytal.org/">https://www.vytal.org/</a>
Wastebase		<a href="https://wastebase.org/">https://wastebase.org/</a>
Waste4Change		<a href="https://waste4change.com/">https://waste4change.com/</a>

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#### Interviews were conducted with the following experts:

- Bin-e**, Jakub Luboński, co-founder and CEO
- Circular Action B.V.**, Thierry Sanders, director
- cirplus**, Christian Schiller, co-founder and CEO
- CleanHub**, Joel Tasche, co-founder and co-CEO
- Der Grüne Punkt – Duales System Deutschland GmbH**, Dr. Markus Helftewes, managing director / vice president technology
- Deutsches Forschungszentrum für Künstliche Intelligenz (DFKI)**, Mattis Wolf, researcher
- dm Drogeriemärkte**, Dagmar Glatz, sustainability and packaging division
- everwave**, Dr. Tilman Floehr, head of technology and co-founder
- Gesellschaft für Internationale Zusammenarbeit (GIZ)**, Ellen Gunsilius, planning officer environment and circular economy; Steffen Blume, project manager marine litter reduction & circular economy
- Henkel**, Carsten Bertram, head of packaging sustainability
- Kunststoff-Zentrum SKZ**, Dr. Hermann Achenbach, head of sustainability and circular economy; Christoph Kugler, group manager digitalization
- Küste gegen Plastik e. V.**, Jennifer Timrott, board member
- Leibniz Universität Hannover**, Prof. Dr.-Ing. Hans-Josef Endres, managing director of the Institute of Plastics and Circular Economy
- Plastic Bank**, Peter Nitschke, global director for community partnerships
- Polysecure**, Jochen Mößlein, managing director and founder
- ProData GmbH**, Heino Claussen-Markefka, managing director
- RecycleMich**, Stefan Siegl, initiator
- ReFrastructure – Stiftung für digitale Mehrweginfrastruktur gGmbH**, Markus Urff, managing director and co-founder
- Resourcify GmbH**, Meike Lessau, manager circularity
- SAP**, Katharina Schweitzer, consultant for circular economy solutions
- VYTAL Global GmbH**, Dr. Fabian Barthel, managing director and founder

