



Resource-efficient Circular Economy

Innovative Product Cycles (ReziProK)

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AddRE-Mo

Value retention scenarios for the urban electromobility of people and goods through additive manufacturing and remanufacturing



Resource-efficient Circular Economy –
Innovative Product Cycles (ReziProK)

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With almost one million electric bicycles sold in Germany in 2018, sales figures rose by 36 percent compared to the previous year. However, what happens to electric bicycles at the end of their product life remains obscure. The “AddRE-Mo” project addresses this problem by researching the prototypical development of a value retention network for urban electromobility. The aim is to investigate the decentralized recycling of electric bicycles by combining additive manufacturing processes and remanufacturing.



Value retention networks for urban electromobility

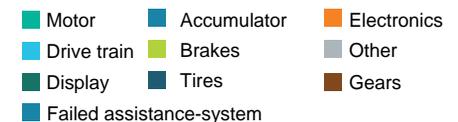
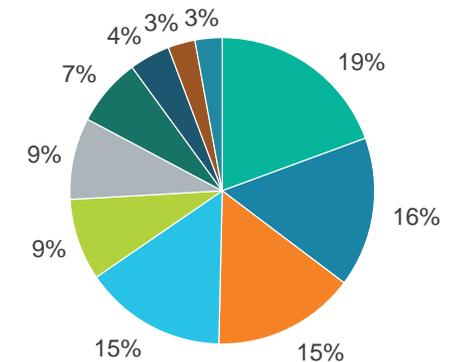
The amount of resources used per vehicle, e.g., energy or material, plays a central role in sustainable market development. For this reason, the “AddRE-Mo” consortium, which consists of companies and research institutions, aims to develop value retention networks for urban electromobility.

In the future, used products (cores) will be remanufactured using additive manufacturing processes and remanufacturing to enable closed product cycles in a decentralized approach. Remanufacturing increases resource efficiency over the entire product service life and creates the opportunity to produce more cost-effective, remanufactured electric bicycles.

Suitable business models and solutions for the return of components and their remanufacturing are being developed to recycle components efficiently. Simulations and scenario analyses will be used to analyze ecological, economic, and social effects on the future value network.

Conducted stakeholder analysis

The opinions of 513 users, 45 workshops, and 14 experts were collected for a comprehensive analysis of potentials and obstacles. In the process, important insights were gained for the future design of value retention networks. More than 80% of the users surveyed expressed interest in purchasing products with remanufactured components. The experts and workshops surveyed also see great potential in remanufacturing. Around half of the workshops stated that the motor is a suitable component for remanufacturing and that dam-



Percentage distribution of damage patterns according to workshop survey (n=44)

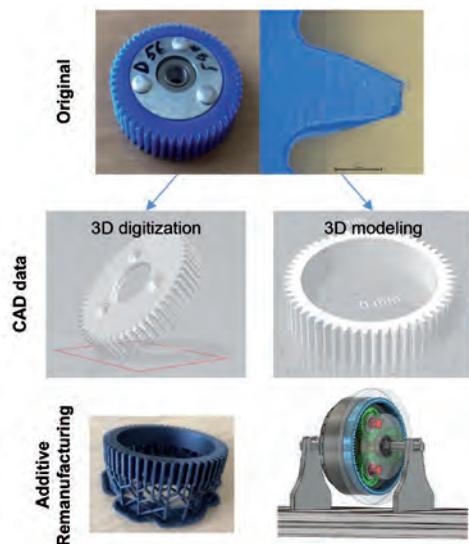
age occurs mainly in the two most cost-intensive components, the motor, and the accumulator.

The results of the stakeholder analysis were summarized in the study “Future trend sustainable electric bicycles? – Survey on the Circular Economy in the Electric Bicycle Industry”.

Design for additive Remanufacturing

The integration of additive manufacturing technologies into the remanufacturing process is essential for establishing a local and resource-efficient value retention network for electric bicycles. Based on the stakeholder analysis and the identified requirements for the design of future value retention networks, the project consortium evaluates selected components concerning their potential for remanufacturing using additive manufacturing processes.

The findings obtained cover the remanufacturing process, from creating a CAD file through the additive manufacturing process to comprehensive tests. The results will be incorporated into guidelines for the design of additive remanufacturing.



Exemplary process chain of additive remanufacturing

Competent Network

The “AddRE-Mo” project consortium bundles the know-how to form future value retention networks. The industrial partner Electric Bike Solutions GmbH contributes its expertise in converting and repairing electric bicycles. The industrial partner O.R. Lasertechnologie GmbH develops recommendations for “Design for additive remanufacturing”. The Wuppertal Institute and the Project Group Process Innovation of the Fraunhofer IPA focus on the implementation of additive remanufacturing. Their findings are taken up by the Cluster of Environmental Technologies Bavaria and disseminated to the public.

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Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

As part of the FONA Field of action 6:
The circular economy – efficient use of raw materials, avoiding waste

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AddRE-Mo – Value retention scenarios for the urban electromobility of people and goods through additive manufacturing and remanufacturing

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Picture credits

P. 1 above: Electric Bike Solutions GmbH & maxon advanced robotics and systems ag
P. 1+2: AddRE-Mo

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The project “AddRE-Mo” is funded within the funding measure “Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)”.

“ReziProK” is part of the research concept “Resource-efficient Circular Economy” of the Federal Ministry of Education and Research (BMBF) and supports projects that develop business models, design concepts, or digital technologies for closed product cycles.

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Wuppertal Institut für Klima, Umwelt, Energie gGmbH

All Polymer

Fibre reinforcement to increase the resource efficiency of high-quality, fully recyclable plastic products



Resource-efficient Circular Economy –
Innovative Product Cycles (ReziProK)

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In “All-Polymer”, fibre-reinforced composites (KFVW) are used to upgrade recycled plastics. The cooperation of sustainability researchers, polymers, recycling and fibre composite experts from different industries, aims to establish closed loop recycling management systems that lead to a considerable reduction in CO₂ emissions and plastic waste



More recycled plastics

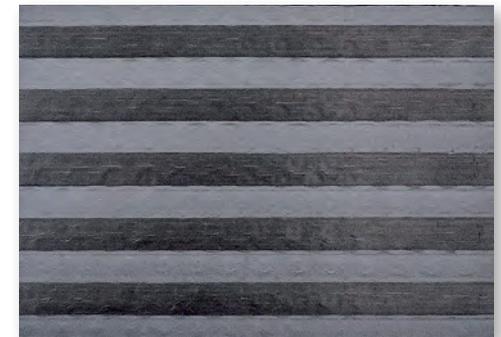
In view of major sustainability problems, the recyclability of plastics is currently at the forefront of many companies’ innovation efforts. The need to increase the resource efficiency of plastics and, in particular, to help recyclable plastics become more widely used is correspondingly great.

The “All-Polymer” project, in which three companies and two research institutes are participating, is pursuing this goal. Five other companies are involved as associated partners. The participating companies will produce typical components from the three largest sectors of the plastics industry – the automotive, packaging and construction industries – from recycled plastics and upgrade them by KFVW. By dispensing with energy- and cost-intensive, not fully recyclable carbon and glass fibres, CO₂ emissions in production will be reduced. The same is achieved by energy-efficient production and further processing by KFVW.

New potential for fibres

The project aims at increasing the performance of recycled plastics in lightweight construction. As a result, the proportion of recycled material in existing products can be increased and new product segments for recycled plastics can be opened up. As the KFVWs are singlesorts and are therefore 100 percent recyclable, a complete recycling cycle can be established. The higher performance also ensures energy savings during the product life cycle.

To maintain the mechanical properties defined in advance, the components are fibre-reinforced. For this purpose, existing as well as new processes such as additive tape laying – the automated laying of polyethylene-



Section of a recycled panel with tape reinforcement.

fibre-reinforced tapes on flat structures – are used. The fibre-reinforced components made of recycled plastic are analysed for their mechanical properties and fed into the process at the respective recycling companies. In addition, the influence of the fibres on the properties of the recycled material is being investigated.

The recycled fibre-reinforced components are to be used again as starting material to create a cycle. Even the use of a small proportion of fibre-reinforced material leads to a considerable improvement in the mechanical properties of the component, so that this approach is already worthwhile for products in the low-price segment due to process simplifications, material savings and increased use of secondary plastics.

First results

The adhesion and performance of UD tapes on various test specimens was investigated. Potential improvements in design, process design and material composition were identified and implemented in development loops. During process development, it became clear that welding the tapes to the components is far superior to bonding, since bonding does not provide sufficient adhesion for long-term use under typical conditions of use, according to the current state of knowledge.

The status of circularity at the companies involved was determined and priorities set in order to exploit identified opportunities for improvement.



Prototypes reinforced with tapes.

Project team from industry and science

In All-Polymer, the project participants from industry and science are working in a division of labour in order to achieve their recycling goals. The companies HAHN Kunststoffe and BSB Recycling deal with the investigation of existing recycling materials from various sources as well as the recycling of the fibre-reinforced components. Infinex Kunststofftechnik, HAHN Kunststoffe und Röchling define the prototypes and, if necessary, develop new processes for the use of the polyethylene-fibre-reinforced tapes. A+ Composites and DSM investigate the production of the fibre-reinforced tapes and their modification for use with secondary plastics. The process integration and process development of the other partners is accompanied by A+ Composites.

The tasks of the materials physics group at the University of Koblenz Landau are the improvement of the fibre adhesion with the matrix as well as the characterisation of the components, materials and tapes and the development of the recycling process. The Chair of Sustainability Management at the TU Kaiserslautern will deal with government incentive systems, the development of business models and the investigation of ecological implications.

The project “All Polymer” is funded within the funding measure “Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)”.

“ReziProK” is part of the research concept “Resource-efficient Circular Economy” of the Federal Ministry of Education and Research (BMBF) and supports projects that develop business models, design concepts or digital technologies for closed product cycles.

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As part of the FONA Field of action 6:
The circular economy – efficient use of raw materials, avoiding waste

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All-Polymer project partners

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Circular by Design (CbD)

Sustainable product design of consumer goods using the case study refrigerator/freezer



Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

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A recyclable product design for refrigerators/freezers that is both energy and resource efficient is the main goal of Circular By Design. For this purpose, different scenarios are developed with the focus on repair and reuse as well as recycling paths that are as closed as possible. The combination of the resource efficiency analysis with a multi-regional extended input-output model should in future allow estimating product recyclability already at the design stage, thereby supporting a Design-for-Recycling optimization.

Recyclability

In order to ensure a stable supply of raw materials to the German economy in the future, rethinking the use of primary and secondary raw materials and life cycle-wide material flow management is urgently needed. In 2010, for example, only 14 percent of the raw materials used in Germany were obtained from scrap, with recycling costs of over 50 billion euros. For materials such as aluminium, steel or copper, which are found in many consumer goods, in 2016 the proportion of secondary raw materials was just 40 percent in total production in Germany.

One of the main reasons for this is the fact that in the creation of new products (product design), the ability to recycle and recover materials at the end of their life cycle (EoL) has hardly been considered. This is where Circular by Design starts, using a refrigerator as an example of a household appliance to show what material efficiency potential exists with regard to the recovery of the raw materials contained in it, both in terms of product design and the selection of materials.



“LagasyS” – Ein Lagersystem für gekühlte und ungekühlte Lebensmittel

Laboratory for Design

The first-time combination of the resource efficiency analysis (process simulation of recycling processes at micro level) of the Helmholtz Institute Freiberg for Resource Technology and the multi-regional extended input-output model (WI-SEEGIOM, macro level) of the Wuppertal Institute for Climate, Environment and Energy should allow in future the prediction of a product design suitable for the recycling economy. This will be demonstrated using the example of one of the most frequently used and already well characterized consumer goods, the refrigerator/freezer, with participation of the manufacturer Liebherr-Hausgeräte. Under lead of the Folkwang University of the Arts (FUdK), the aim is



Refrigeration appliances have high potential for the circular economy.

to run through various scenarios within a living lab design process during the project period. Models are to be designed and simulated whose design allows almost complete recycling and reuse of individual components, thereby opening up new market and business models such as repair, cash-back, leasing, etc.

With the cooperation of the project partners Becker Elektrorecycling (BEC) and Entsorgungsdienste Kreis Mittelsachsen (EKM) and based on the current reference product, which is particularly focussing on energy efficiency, it will be shown by quantifying the actual losses where the raw materials are lost, how these losses can be reduced by a suitable product design and how raw materials can be kept in circulation in the long term. In addition, the legal and practical feasibility of design concepts is discussed with industry experts.

First results

The Living Lab is working and the publication on the cultural history of cooling has been produced.

The first version of a simple evaluation model of the virtual recycling process is already available. This includes both the physical first treatment for refrigeration units (shredding and pre-sorting) and the further treatment steps of the metallic material flows (metallurgical treatment) and is modelled by process simulation. For further qualification, the model requires detailed product and material information as input in order to provide statements on the recyclability, quantified by indicators for material recovery, environmental impact and resource consumption. For this purpose, test designs are currently being drawn up for the manual disassembly of individual devices as well as for a large-scale test at a recycler.

reziprok.produktkreislauf.de/en

Social benefit

A transferable design concept for the recycling of the materials used in consumer goods is expected to be developed using the example of a refrigerator/freezer prototype. If one takes a look at the proportion of steel, copper and aluminium, these together represent almost 60 percent of the weight of the refrigerator/freezer to be recycled, plus plastics with a weight share of around 35 percent. This corresponds to a material value of secondary raw materials of around 25 million euros per year, just for the produced tonnage of a refrigerator/freezer producer. A saving potential is assumed that can be achieved by reducing the amount of materials used, substituting non-sustainable materials such as PU foam or coolants, improving the collection of metallic waste and increasing the proportion of secondary raw materials in consumer goods.

The project “Circular by Design (CbD)” is funded within the funding measure “Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)”.

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Funding measure

Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

As part of the FONA Field of action 6:
The circular economy – efficient use of raw materials, avoiding waste

Project title

Circular by Design (CbD) – Sustainable product design of consumer goods using the case study refrigerator/freezer

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P. 1: Liebherr
FUDK

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EKM – Entsorgungsdienste Kreis Mittelsachsen GmbH, Freiberg

ConCirMy Configurator for the Circular Economy



Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

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In Germany, around half a million tonnes of end-of-life (EOL) tyres accumulate annually and only a small proportion is used as recycled material for the production of new tyres. Within the framework of ConCirMy, it is being investigated whether and how tyres can be optimised with regard to the goals of a circular economy without compromising on quality. A tool is being developed to provide information on environmental compatibility to various stakeholders in the supply chain which can be taken into account in purchasing decisions.



Recycling of EOL tyres

EOL tyres represent a valuable resource and can be returned to the material cycle through recycling. Vehicle manufacturers are also interested in increasing this proportion – a motivation based, for example, on the End-of-Life Vehicles Directive, according to which 85% of end-of-life vehicles by weight must be reused or recycled and 95% must be recovered. These requirements are also important with regard to the development of new vehicles and their components, the pressure is increasing with the transformation to electromobility because some components are difficult to recycle.



Recycling of end-of-life tyres.

Merging core system

The aim of the ConCirMy project is to develop a product configurator which informs users about the environmental impacts and other sustainability aspects of the product (raw materials used, possibilities of recycling or reuse) in the life cycle of the tyre and enables them to consider this information in their purchasing decisions. These can be accessed by different user groups situated at different levels in the supply chain – consumers, designers, recyclers – and taken into account in decision-making alongside other important factors such as functionality and cost.

Ultimately, the aim is to support the production and purchase of more sustainable products, the development of more environmentally friendly designs and the move towards recycling and reuse. The configurator acts as a unifying core system that makes specific information available to different actors in the supply chain. Technically, both the integrated environmental assessment of products and components in a product configurator for the end customer and the comparative implementation of different calculation approaches are new.

Socio-economic analyses are conducted in order to learn about consumer preferences and demand potentials for bio- and circular economy-based automotive components, including related sustainability aspects. Recommendations are derived for the various supplier groups of the targeted circular economy system. For the successful implementation of the circular system, business models are developed. Furthermore, the need for standards to support the development of the supply chain towards a circular economy is examined.

First results

First research has demonstrated that tires are a highly complex product and that there is no established product classification including information about raw materials. Therefore, a key result of the project is the development of a generic tire model, which serves as basis for the product configuration. Furthermore, the concept for sustainability assessment was expanded with an interface to a life cycle assessment database (Ecoinvent) and an interface for retrieving data from ERP systems.

Further research has showed that the use phase of a tire has the biggest impact on the environmental assessment of its whole life cycle. In order to be able to integrate information from the use phase, several variants of sensor data collection were examined and implemented as a prototype in the form of an app. In parallel to the technological developments, surveys on acceptance factors were done into two phases and socio-economic analyses were carried out.

Interdisciplinary project consortium

CAS Software AG, DECHEMA e.V., the Department of Innovation Economics at the TU Berlin and the German Institute for Standardization (DIN) are working together on the “ConCirMy” project to develop an interconnected and sustainable assistance system.

CAS brings expertise in software development and is developing the configurator in cooperation with all partners.

DECHEMA e.V. conducts market research on the product life cycle as well as on the current handling and recycling of used tyres in Germany and creates life cycle assessment studies which form the basis for evaluation of environmental impacts in the configurator tool.

Using socio-economic analyses, the Department of Innovation Economics at TU Berlin determines acceptance factors and demand potentials for sustainable automotive components, develops recommendations for the different players in the circular system, and develops business models for its successful implementation.

DIN reviews the project results with regards to potential standardization needs. For this purpose, an overview of existing norms and standards is prepared.

Funding measure

Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

As part of the FONA Field of action 6:
The circular economy – efficient use of raw materials, avoiding waste

Project title

ConCirMy – Configurator for the Circular Economy

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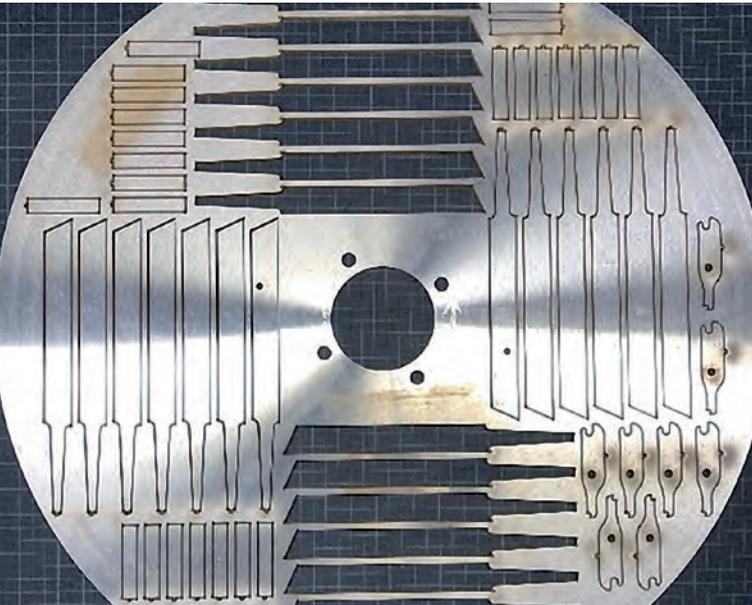
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CoT – CIRCLE OF TOOLS

Development Steel Tools and testing of Demonstrators designed for a Circular Economy



Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

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The sustainable use of natural resources is currently one of the greatest challenges facing society. According to a circular economy, raw materials should be kept in the economic cycle as long as possible, waste should be avoided. The central concern of the CoT project is to close regional material cycles in the metalworking industry by means of re-manufacturing and re-purposing of worn metallic products.



Material cycle of the metal industry

In general, the Circular Economy (CE) is seen as an essential strategy to effectively reduce the consumption of raw materials and resources. One well-known possibility is recycling. Upstream of this are concepts such as re-manufacturing and re-purposing, through which materials can be used longer in the economic cycle. In the CoT project, the cooperating research institutions and companies from Wuppertal, Solingen and Remscheid want to close a material cycle of the local metal processing industry in this way.

The aim is to reduce resource and energy consumption and to demonstrate economic advantages for the companies. The challenges are manifold: A process has to be developed that is based on the use of purely returned and qualitatively high-alloyed tool steel either in the original manufacturing process or to integrate it into other manufacturing processes across companies.

The main progress here takes place in avoiding remelting as part of the dominant recycling process in the steel industry. Although this is desirable and part of a circular economy, it goes hand in hand with high energy and resource consumption. A key aspect here is the recycling of scrap that is not sorted by type.



Diskussion der Einsatz- und Anwendungsmöglichkeiten innerhalb des Projektteams.

First results

At the beginning of the project, the project team determined suitable target products on the basis of material characteristics and the suitability of the geometry. This was followed by essential metallurgical investigations to derive findings for the manufacturing process. Finally, it was possible for the first time to manufacture blades from machining knives with the help of separating manufacturing processes (re-purposing).

In the case of re-manufacturing, the existing challenge is to analyse and adapt the manufacturing process accordingly. The concept for producing a smaller machining knife from a worn one is currently being researched.

The first ecological investigations show possible saving potentials, but also decisive hotspots of the process. In addition, the essential structures of the existing and the envisaged business models could be captured.



Erste Klingenrohlinge, entnommen aus einem Kreismesser.

Interdisciplinary competence

The CoT project unites a total of six project partners in its inter- and transdisciplinary team. Companies from the Wuppertal, Solingen and Remscheid, this region is known for its cutlery and tools, are working closely with two research institutions. Using the products of the companies TKM GmbH, Kirschen Werkzeuge and Freund & CIE, it will be demonstrated, with the support of PlanConsult GmbH, how a return and further use of the material can be designed via re-manufacturing and re-purposing. Furthermore, demonstrators will be produced by the respective companies through re-manufacturing and re-purposing.

Scientific researcher from the University of Wuppertal and the Wuppertal Institute are responsible for the scientific investigations. The focus is on the metallurgical analyses of the tools and cutting products as well as the ecological and economic potential.

Funding measure

Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

As part of the FONA Field of action 6:
The circular economy – efficient use of raw materials, avoiding waste.

Project title

CoT – CIRCLE OF TOOLS
Re-manufacturing of worn circular knives

Project duration

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P. 1: TKM 2019

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Cover-Picture: Circular knife with exemplary arrangement of blades.

The project “CoT – CIRCLE OF TOOLS” is funded within the funding measure “Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)”.

“ReziProK” is part of the research concept “Resource-efficient Circular Economy” of the Federal Ministry of Education and Research (BMBF) as part of the FONA Field of action 6: “The circular economy – efficient use of raw materials, avoiding waste” and supports projects that develop business models, design concepts or digital technologies for closed product cycles.

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PlanConsult GmbH, Wuppertal

The focus of “DIBICHAIN” is the collection of product life cycle data in order to make the product development process fair, secure and economical. The basis is the block chain model, in which data is stored in a decentralized manner and without sovereign rights. However, current block chain models are usually too slow to scale to large data volumes. This is where the research in the “DIBICHAIN” project starts.



DIBICHAIN

Digital image of circulation systems using blockchain

Software demonstrator

”DIBICHAIN” aims to investigate the application of blockchain technology for the digital representation of product cycles in contrast to other distributed ledger technologies (DLT).

- Blockchain for integrated life cycle analyses and for use as a basis (data backbone) for sustainability driven design applications.
- Clear identification and traceability of products of the entire product life cycle.

First of all, the main differences between the individual DLTs will be highlighted in order to subsequently evaluate the suitability of the individual technologies for the selected case study. The aim is to deepen the knowledge base for the application of a block chain for a circular economy in order to enable further and more in-depth research projects that will open up the full potential for DLT in this context. A software demonstrator is to be developed, which contains the following application scenarios using the case study of the “Bionic Partition”:

Innovations in decentralized data storage

Traditional data management currently works via centralized servers. If a user uploads an image to his social media page, this image is stored by a centralized server at a location usually unknown to the user. If the user now wants to delete his image, he must trust the server provider not only to make the data unreachable, but also to actually delete it from the server. Since the modern world and also the so-called Internet of Things

- (Back-)tracing of selected materials, from the extraction of raw materials to their return to material cycles.
- Ensuring compliance with social and ecological standards of the entire product life cycle.

Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

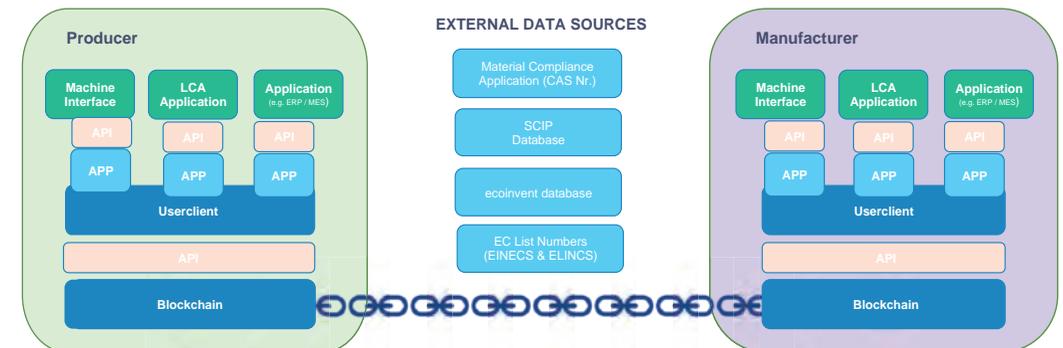
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Federal Ministry of Education and Research

FONA

Research for sustainability



The architecture of the DIBICHAIN

Standards / Regulations

IPC 1754

Sorgfaltspflichtengesetz

ISO 14000 (part. 14040)

would no longer function without server data storage, it is almost impossible to circumvent this completely. Decentralized storage, i.e. distributed over many individual users instead of on a single server, would be one approach to solve the problems mentioned above.

The potential of DLT can currently only be guessed at. The application of DLT would be a refinement of the not yet fully explored “Web 3.0”. The project as a whole is being worked on according to the waterfall model, while the software development is carried out using the so-called scrum method. Scrum is an agile project management method, which is primarily used in software development.

First results

First, the application scenarios (use cases) were developed with the partners for a specific focus. These are “material and process tracking” and “end-of-life & recycling”. The following aspects were elaborated:

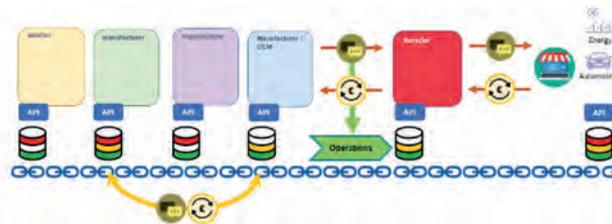
- Tracking of materials with simultaneous protection of IP and privacy requirements
- Modular structure for connecting various operational software (no vendor lock-in) for processing the data, e.g.
 - Life Cycle Assessment data
 - Material / Dismantling
 - Quality information
- Incentive and marketing opportunities for participants

This approach is intended to reach the broadest possible field of potential participants – i.e. recyclers. In the long term, product development will also benefit. Existing information sources and standards such as SCIP Database, Ecoinvent Database, EC List (ELINCS) as well as the standards IPC 1754 and ISO14040 and others are taken into account.

The innovation team

The five participating companies each contribute their own expertise to the project, some of which has been acquired over many years, in order to achieve the best possible results. This knowledge includes classical software development, blockchains, recycling management, ecology and product development. The project is divided into five work packages. The administrative part is followed by focus groups, analyses and finally the development of the software and its evaluation.

The goal of the project partners Airbus, Altran, Blockchain Research Lab, Chainstep, iPoint is not only to highlight the differences of current DLTs, but also to design a new technology that can be evaluated in a final application scenario, the software demonstrator. Thus, “DIBICHAIN” aims to develop a technology that can be used by companies worldwide for modern, decentralized data storage.



Graphic of the entire chain over product life cycle participants of the blockchain network in an example.

The project “DIBICHAIN” is funded within the funding measure “Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)”.

“ReziProK” is part of the research concept “Resource-efficient Circular Economy” of the Federal Ministry of Education and Research (BMBF) as part of the FONA Field of action 6: “The circular economy – efficient use of raw materials, avoiding waste” and supports projects that develop business models, design concepts or digital technologies for closed product cycles.

Funding measure

Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

As part of the FONA Field of action 6:

The circular economy – efficient use of raw materials, avoiding waste.

Project title

DIBICHAIN – Digital image of circulation systems using blockchain

Project duration

01.07.2019 – 30.06.2022

Funding reference number

033R241

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643.284 Euro

Internet

reziprok.produktkreislauf.de
dibichain.com

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Networking and transfer project “ReziProK”

Design

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Picture credits

P. 1: Airbus / Altran

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P. 2: Airbus / Altran

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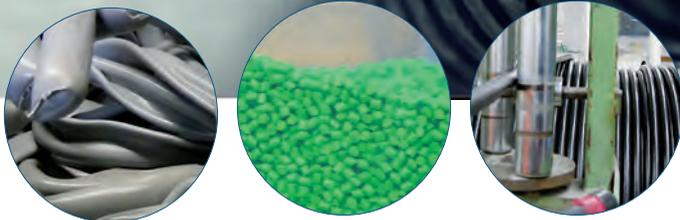
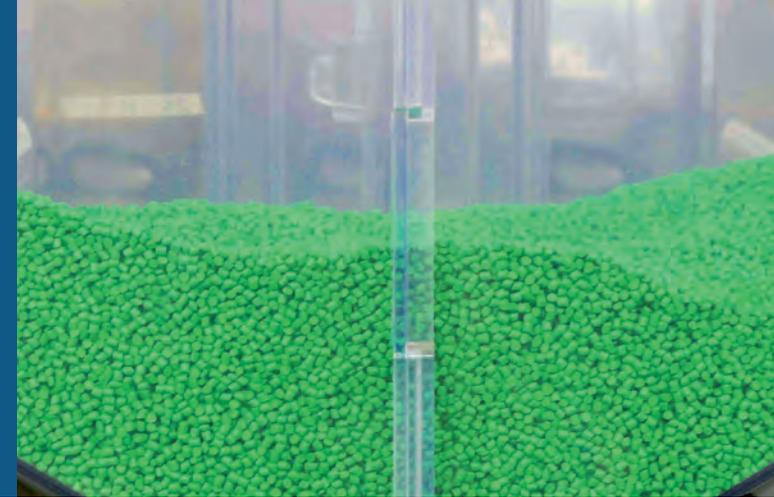
PROJECT PARTNERS

Blockchain Research Lab gemeinnützige GmbH
CHAINSTEP GmbH
iPoint-systems GmbH



DiLink Digital solutions for industrial plastic circuits

DiLink research enables plastics producers to create high-quality products from recycled plastics, avoid plastic waste and close material cycles. To this end, the latest sensor technologies and digital software solutions are being developed and linked in order to be able to collect, analyse and further develop valuable data on the quality of plastic waste and the recyclates produced from it, and to use this data in the right places.



Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

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Closed loops

DiLink contributes to the closing of material cycles in the plastics industry. The sensor technologies further developed in DiLink and the digital solutions tailored to them will collect the data required to close material cycles and enable the dissemination and processing of the data obtained. In this way, a more resource saving model of plastics use can be established.

Currently, large quantities of secondary plastics – recyclates – cannot be processed at all or only to inferior products. Information deficits in the markets regarding the quality and availability of the recycled materials are a main reason for this. With the right data on the attributes and quantity of plastic residues and the recyclates produced from them, and with the possibility of passing on this data digitally along the value chain, plastics manufacturers, commercial enterprises and recyclers can be put in a position to keep such plastics in circulation as high-grade materials.

The large number of different sources of residual materials for recycling can be reflected in the product quality of the recyclates. Sometimes product properties vary from batch to batch. This can make processing difficult within the framework of the tailor-made processes of the producing companies. With the help of the DiLink-sensors

to be developed, these fluctuations in product quality can be detected and avoided or digitally documented, so that recycle purchasers can obtain the relevant information on the materials and thus procure the right material or adapt their processes accordingly.

Digital recycling solutions

In a first step, the exact needs of the industry are determined through interviews and on-site appointments. The corresponding solutions are then developed, mapped on the software side and connected in suitable systems, for example by using and testing them in company co-operations. At the same time, an assessment of the sustainability of the developed solutions is carried out to ensure that the effort does not exceed the potential benefit.

By means of DiLink's innovative solution approaches, plastic recyclate can be used more safely and reliably in the future. The additional information, together with the rapid availability of digital data along the value-added chain, will enable companies to play a pioneering role in the rapidly growing recycling market and thus secure the international competitiveness of Germany as a business location.

First results

In the survey of the companies, insufficient purity, interfering factors in the recycled plastics and information deficits were named as the biggest hurdles for recycling.

Inline impact strength measurement has been successfully tested. Currently, the lower resolution limits of the technique are being evaluated. Further tests with materials as used in application are taking place. Successful trial runs have also been carried out for inline spectroscopy. A test with recyclates of different “qualities” is currently underway.

For both technologies, tests in real production environments are planned for early summer. As a software solution, the infrastructure for data acquisition, storage and management has been implemented. The associated user interface is being developed in consultation with the users.



Interdisciplinary team of experts

An interdisciplinary team has been formed for this task. On the research side, the three-year project is carried out by SKZ – Das Kunststoff-Zentrum, the Research Institute for Rationalisation at RWTH Aachen University (FiR) and the Wuppertal Institute for Climate, Environment and Energy (consortium leader). From the industry, the company partners INFOSIM, experts in the field of industrial software development, as well as the companies Hoffmann + Voss and MKV Kunststoffgranulat, which have extensive experience in plastics recycling, are involved.

The solutions developed from DiLink research can be used by the entire plastics processing industry as well as by other companies where plastic waste is generated to provide or use more recycled plastics.

Funding measure

Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

As part of the FONA Field of action 6:
The circular economy – efficient use of raw materials, avoiding waste.

Project title

DiLink – Digital solutions for industrial plastic circuits

Project duration

01.06.2019 – 31.05.2022

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Networking and transfer project “ReSWInn”

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Picture credits

P. 1: Wuppertal Institut für Klima, Umwelt, Energie gGmbH;
HOFFMANN + VOSS GmbH

P. 2: Wuppertal Institut für Klima, Umwelt, Energie gGmbH

Status

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The project “DiLink” is funded within the funding measure “Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)”.

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MKV GmbH Kunststoffgranulate

DiTex

Digital Technologies as Enabler of a Resource-efficient Circular Economy



Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

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Workwear leads to enormous quantities of identical textiles. The logistics around workwear can be an optimal starting point for nearly closed-loop material flows.

Instead of buying business clothing, resource-efficient use of materials may be supported by the business model of textile rent/leasing. DiTex therefore tests and evaluates three circular textiles made of recycled fibres as well as circular business models during an eight month test phase. The aim is to generate transferable knowledge for application concerning quality, resource efficiencies and sustainability effects.

Circular product designs & tracking

Business shirt, polo shirt and bed linen are produced sustainably in this feasibility study. The product design already considers upcoming requirements for fibre regeneration.

In summer 2021, trial wearing starts at a selected police service (business shirt), rescue service (polo shirt) and in federal police accommodation (bed linen). Fixed points of distribution and return enable well-organised logistics. For precise tracking, the DiTex textiles receive an “intelligent label”. Material properties and durability will then be examined and extensively tested, including but not limited to laundry servicing and wearing tests.

The project aims for high-quality “closed-loop” recycling solutions by means of chemical fibre-to-fibre recycling.

A smart label enables accurate tracking.



First findings: sustainability benefits of multiple recyclable textiles made from recycled fibres

In September 2020, the first prototypes of the recyclable and leasable DiTex textiles were presented.

The overview life cycle assessments yield clear evidence for resource protection and sustainability advantages of the selected design concepts compared to conventional reference textiles. Particularly significant improvements in the water footprint and surface footprint will be gained by substituting cotton with recycled polyester (share in the business shirt: 38%, in the polo shirt: 100%) and recycled lyocell (share in the bed linen: 50%).

The sustainability assessment also shows that rebound mechanisms at product level, in the usage phase and over the entire life cycle may counteract possible resource efficiency gains. Various important factors such as resource and energy efficiency as well as minimal material waste are to be considered during fibre extraction, manufacturing and the recycling process.

Prerequisite for the avoidance of rebound effects is a complete substitution of virgin fibre textiles by qualitatively and functionally equivalent textiles made from recycled fibre materials. In addition, the following goods and services may not be offered at lower prices than their conventional counterparts: the circular textiles themselves, associated services, as well as textile raw materials and intermediates.



Textile yarn is also recyclable

Focus on industry and application

The Institute for Ecological Economy Research (IÖW) coordinates the network; manages the process- and cost analyses and conducts the market dialogues as well as the evaluation of the eight-month pilot phase. All partners are involved in the product design and market dialogues. WILHELM WEISHÄUPL e. K. and Dibella GmbH take over upscaling and test production of the textiles. As a service provider, circular.fashion UG contributes IT solutions and know-how. The Hohenstein Institut für Textilinnovation gGmbH and the Faculty of Textiles and Design at Reutlingen University are responsible for textile testing and the product specifications for the rental textiles. The ifeu – Institute for Energy and Environmental Research prepares overview Eco balances. As an associated partner, MEWA Textil-Service AG & Co. Management OHG supports the acquisition of large-scale consumers as test users of the textiles and the testing of the rental or leasing business model.

Central outcomes of the project: Preparation of a broad collection of materials offering the know-how required for a change to recyclable sustainable workwear.

Funding measure

Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

As part of the FONA Field of action 6:
The circular economy – efficient use of raw materials, avoiding waste.

Project title

DiTex – Digital Technologies as Enabler of a Resource-efficient Circular Economy

Project duration

01.08.2019 – 31.07.2022

Funding reference number

033R228

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Internet

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Publisher and editorial office

Networking and transfer project “ReSSWInn”

Design

PM-GrafikDesign

Picture credits

P. 1: IÖW; Markus Hein/pixelio.de
P. 2: Bruno Glätsch/pixabay

Status

March 2021



Cover-Picture: Front Pilot Test: the project DiTex evaluates recyclable service clothing.

The project “DiTex” is funded within the funding measure “Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)”.

“ReziProK” is part of the research concept “Resource-efficient Circular Economy” of the Federal Ministry of Education and Research (BMBF) as part of the FONA Field of action 6: “The circular economy – efficient use of raw materials, avoiding waste” and supports projects that develop business models, design concepts or digital technologies for closed product cycles.

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Hohenstein Institut für Textilinnovation gGmbH
ifeu – Institut für Energie- und Umweltforschung

EffizientNutzen

Data-based business models for cascade use and extended product use of electronic products



Resource-efficient Circular Economy –
Innovative Product Cycles (ReziProK)

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Research for sustainability

The increasing production of new electronic devices, combined with the lack of repairs, refurbishing and re-manufacturing processes, leads to considerable negative environmental impacts and loss of resources. The project “EffizientNutzen” takes up this challenge and develops, based on real case studies, innovative, data-based business models for the extended product use and cascade use of electronic products.



The global challenge

The production of new electronic products in so-called low-wage regions is currently often cheaper than repair, refurbishing and re-manufacturing processes in high-wage countries such as Germany. In addition, ever shorter innovation cycles are generating new customer needs. Despite the desire of many people for used equipment or repair solutions, repair or refurbishing is not usually considered, even for high-quality electronic products. As a result, old products are replaced by new ones after a limited period of use and, at best, recycled as material or energetically recovered. The extent of this global problem reached a new peak in 2016 with 44.7 million tons of electronic scrap.

Data-based business models

Against this background, the project “EffizientNutzen” will develop innovative data-based business models for cascade use and extended product use of electronic products. This is done by means of two central lines of ac-

tion. The first case study focuses on the development of a viable business model for the manufacturer-neutral repair of high-quality electronic products as a service in the field of multimedia products, e.g. loudspeakers, radios, televisions, electronic toys; the second focuses on the development of business models for the take-back and, if necessary, refurbishment of electronic products for re-marketing in the context of product service systems, using the example of high-end laptops.

The repair and reconditioning processes carried out in the project, as well as the data and knowledge gained in the process, are incorporated into the development of an information portal and support the derivation of new types of business models for the circular economy. The portal realizes the offer of repaired or refurbished electronic products as a product service system as well as the marketing of the gained data and knowledge. The information portal enables an efficient exchange of information and serves as a link between the real case studies as well as between experts and external stakeholders.

First results

In the development of business models for repair and circular remarketing solutions, the focus is on a systematic inclusion of ecological and economic aspects, including the identified barriers and challenges in the two market sectors.

- The market for reused equipment was widely researched using the example of notebooks and the flow of goods (sourcing, sale) was documented.
- Attitudes towards the purchase of used IT equipment and the commissioning of repairs were surveyed.
- The market structures of spare parts supply were analysed for the cascading use of electrical and electronic equipment.

Finally, customer requirements were identified, which will be considered in the further development of business models. In the practical study on repair, for example, the reduction of repair costs and prices is being investigated by optimising and redesigning processes.



The project team of “Effizient Nutzen”.

Value-added and revenue models

In the design of business models, digitalisation strategies, systems for simultaneous production and retro-production as well as networks and spare parts strategies are also included and supplemented by revenue models.

Economic and ecological impact analyses will be carried out to determine the economic viability and suitability for reducing the environmental impacts. The knowledge gained in the project will be transferred to other application domains and recommendations for the design of circular economy systems and the design of business models will be made available in the form of a guideline.

Funding measure

Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

As part of the FONA Field of action 6:

The circular economy – efficient use of raw materials, avoiding waste.

Project title

EffizientNutzen – Data-based business models for cascade use and extended product use of electronic products

Project duration

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Networking and transfer project “ResWiInn”

Design

PM-GrafikDesign

Picture credits

P. 1: TU Braunschweig

P. 2: TU Braunschweig; oben: pixabay-dokumol

Status

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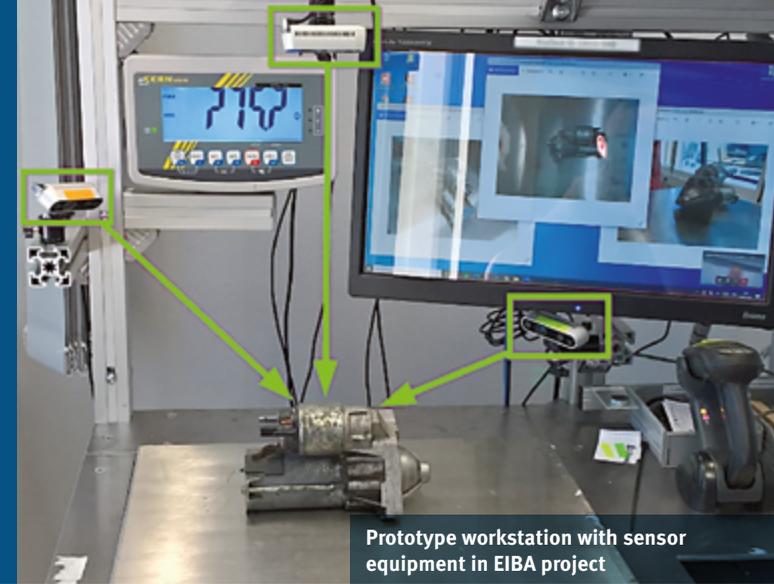
PROJECT PARTNERS

Robert Bosch GmbH, Hildesheim; Circular Economy Research GmbH, Oberursel; TEQPORT Services GmbH, Solingen; Technische Universität Braunschweig, Institut für Automobilwirtschaft und Industrielle Produktion, Lehrstuhl für Produktion und Logistik (AIP); Technische Universität Braunschweig, Institut für Werkzeugmaschinen und Fertigungstechnik, Professur für Nachhaltige Produktion & Life Cycle Engineering (IWF); Technische Universität Clausthal, Institut für Software und Systems Engineering (ISSE)

reziprok.produktkreislauf.de/en

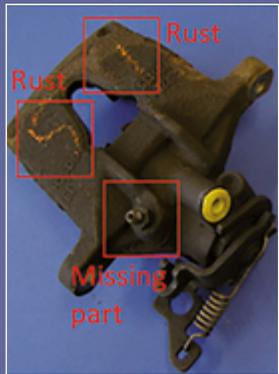
Sensory acquisition, automated identification and evaluation of used parts on the basis of product data as well as information about previous deliveries

The transition to a circular economy and the reuse of products requires an efficient collection and identification of used products. What do they consist of? What is usable? Every product is unique due to its history. Nevertheless, it is often similar to its successors. To facilitate the process, an artificial intelligence (AI) supports the identification of the product in the “EIBA” project.



Prototype workstation with sensor equipment in EIBA project

floating caliper



floating caliper



**Resource-efficient Circular Economy –
Innovative Product Cycles (ReziProK)**

SPONSORED BY THE



Teamwork with artificial intelligence

At the end of a product’s use phase, there are various disposal or processing strategies. Products can be recycled or processed and reused, depending on their type and condition. For this purpose, they must be clearly identified and evaluated. The challenge is that many product models differ only slightly from one another and are difficult to identify due to contamination and wear. In addition, the professional personnel has only a few seconds to identify and evaluate them.

In order to support people in their work, the “EIBA” project consortium wants to develop a system to assist them in identifying and evaluating the products. Sensor-based data is evaluated with the help of artificial intelligence in combination with other information and formulated into a decision recommendation. Thanks to the dual control principle of man and machine, both the error rate during identification and the strain on people are to be reduced.

Self-learning technology

The aim of the “EIBA” project is to develop a system for the identification and condition assessment of used parts. This will make an important contribution to closing the cycle through digital technologies. By using methods of artificial intelligence – such as machine learning as well as deep learning – the system should be able to identify products and compare them with other available information. By continuously expanding the data, it should also be able to adapt to new products and requirements.

One innovation of the project is to complementary combine the competences of man and machine to enable higher process security and efficiency. The resulting system will be analysed according to sustainability aspects: What has changed for the worker? What additional environmental burdens are initially caused by the use of machines, and how great are the environmental benefits gained through increased efficiency?

First results

The development of the system is based on the example of used car parts (cores). In order to include also challenges and requirements of other products in the development-process, extensive interviews with companies of other industries such as textiles, printer cartridges or semiconductors were conducted. Another important focus in the project is machine vision in which some very promising first results were achieved. Based on image data of approx. 1400 different used parts the AI was able to identify 85% correctly in performance tests. By using a hierarchy of specialized neural networks, the recognition rate could even be improved to more than 90%. As these performance tests have been conducted in controlled conditions, a validation facing the challenges in real industrial environment is pending. For that purpose, all workstations in one C-ECO location have been equipped with cameras and digital scales which have been connected to the identification-software.



Humans and artificial intelligence complement each other in the project “EIBA”.

With this setting, data availability will be enhanced to generate further training data to improve the AI’s capabilities and to adapt better to „real life” conditions. An additional challenge is the efficient integration of the sensors and AI in the working process. For that the current process has been analyzed in detail to create a concept for the adaption. Here the focus is on the presentation of the AI results in the human-machine-interface and on restructuring process steps using the new available data.

Interdisciplinary teamwork

The challenges in the “EIBA” project are a result of the complex combination of the latest information technology, application-oriented process know-how and knowledge of market requirements for an efficient circular economy which can be globally scaled. To address that, engineers from different disciplines work together to look at the challenges from different perspectives and make the best possible use of the potentials.

Funding measure

Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

As part of the FONA Field of action 6:
The circular economy – efficient use of raw materials, avoiding waste.

Project title

EIBA – Sensory acquisition, automated identification and evaluation of old parts on the basis of product data as well as information about previous deliveries

Project duration

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Picture credits

Bosch/C-ECO

Status

March 2021



Cover-Picture: “Turn old into new”: old part and refurbished part, ready for a second life in the vehicle.

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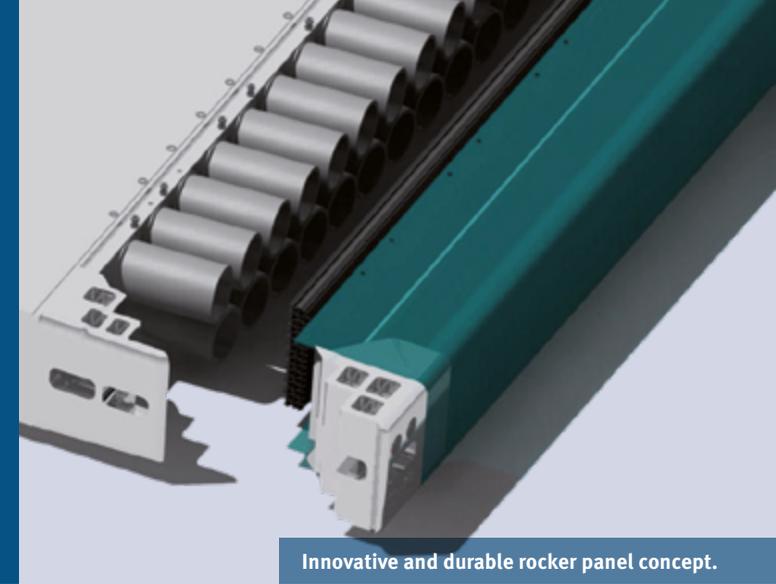
PROJECT PARTNERS

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TU Berlin, Fachgebiet Montage- und Handhabungstechnik
acatech – Deutsche Akademie der Technikwissenschaften

KOSEL

Reusable open source design kit for electrically powered pool vehicles

Automotive manufacturing is energy- and resource-intensive along the international value chain. A longer service life of vehicles is therefore of great ecological and economic benefit. The innovative solution of the cycle-oriented open-source construction kit for electrically powered pool vehicles of the “KOSEL” project contributes significantly to resource conservation and circular economy through remanufacturing and reuse.



Innovative and durable rocker panel concept.

Durable modules

On average, passenger cars are exported or scrapped after less than 15 years of use. By doubling the mileage, automotive customers could significantly reduce emissions from vehicle production and also the depletion of raw materials. For this reason, “KOSEL” aims to develop particularly durable modules, for example by using low-corrosion and low-fatigue materials such as fiber-plastic composites. Against this background, the project has ambitious technical, economic and ecological goals.

Reusable vehicle platform

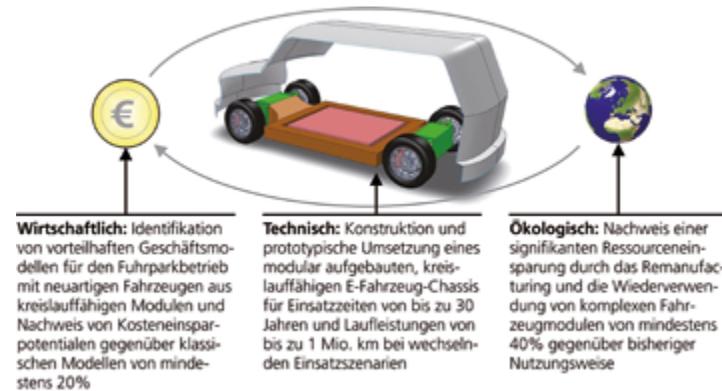
In the technical area, the design and prototypical implementation of a modular, recyclable e-vehicle platform for periods of use of up to 30 years with mileages of up to one million kilometres will be carried out. In the economic area, the identification of advantageous business models for fleet operation with new types of vehicles from recyclable modules and proof of cost savings potential compared to classic models. In the ecological field, significant resource savings are to be demonstrated through remanufacturing and the reuse of complex vehicle modules.

First results

Work on the modular system is progressing continuously. Particular attention is being paid to durable structures and open-source interfaces. New types of crash absorbers are being used that can absorb a lot of kinetic energy while being lightweight. These, as well as the structure-determining rocker panel, are manufactured using a cost-effective pultrusion process.

Different approaches are being taken to the chassis and drivetrain. A central electric motor is used on the front axle to drive the wheels, which are mounted on a leaf spring. The rear axle uses a swing-arm axle with adjustable leaf spring, for which a patent application has recently been filed.

Consideration of business models shows that economic viability is a given due to the long service life. From an ecological point of view, resource consumption is reduced.



The project aims of “KOSEL”: A circular construction kit.

Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

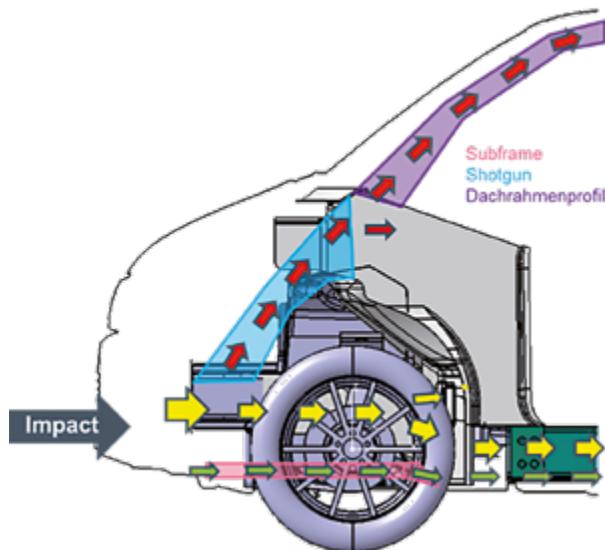
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Results and their use

The cycle-compatible “KOSEL” mobility concept is intended to serve as a model and trigger further developments in the mobility sector. Especially with an elaborated, cycle-capable e-vehicle platform as a standard solution, development costs and risks can be reduced. The open-source interfaces will also make it attractive for a number of suppliers to provide suitable standard components.

In the long term, the lead company EDAG intends to support young companies in the rapid and cost-effective development of vehicle products based on the modular system. For the fleet operator BSMRG GmbH, the planned longer operating times and reuse options will lead to cost reductions in vehicle operation and thus contribute to competitiveness. For INVENT GmbH, sensor integration and condition monitoring are of particular relevance for a long service life of the components. At Röchling Engineering Plastics, the aim is to supply customers with more durable and robust products and thus to open up new markets.



Crash load paths in the front vehicle.

The Environmental Economics Department of the Technical University of Dresden is developing a method for ecological and economic optimization using life cycle assessment for the new vehicle concept. For the Fraunhofer IWU and the Emden-Leer University of Applied Sciences, the results to be obtained in this project are an important intermediate step on the way from basic research to concrete implementation in practice, i.e. technology transfer.

The results expected from this project form the basis for a foreseeable future utilization by various contractual partners in the automotive industry. In addition, licenses will be granted to interested third parties as far as possible.

Funding measure

Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

As part of the FONA Field of action 6:

The circular economy – efficient use of raw materials, avoiding waste.

Project title

KOSEL – Reusable open source design kit for electrically powered pool vehicles

Project duration

01.07.2019 – 30.06.2022

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033R242

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1.780.878 Euro

Internet

reziprok.produktkreislauf.de

Publisher and editorial office

Networking and transfer project “ResWInn”

Design

PM-GrafikDesign

Picture credits

P. 1: Fraunhofer IWU

EDAG Engineering GmbH

P. 2: Fraunhofer IWU

Status

March 2021



The project “KOSEL” is funded within the funding measure “Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)”.

“ReziProK” is part of the research concept “Resource-efficient Circular Economy” of the Federal Ministry of Education and Research (BMBF) as part of the FONA Field of action 6: “The circular economy – efficient use of raw materials, avoiding waste” and supports projects that develop business models, design concepts or digital technologies for closed product cycles.

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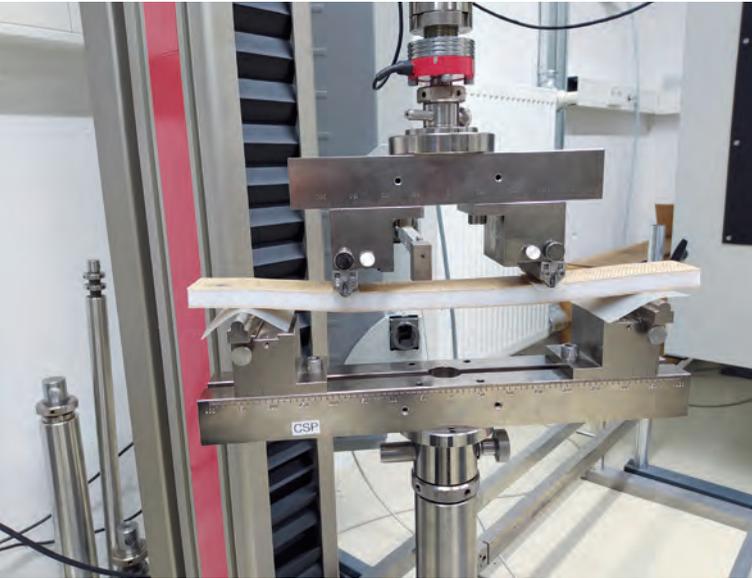
BSMRG GmbH

Fraunhofer IWU

Hochschule Emden-Leer

TU Dresden

LEVmodular Light Electric Vehicle modular – with new mobility for resource-efficient recycling



Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

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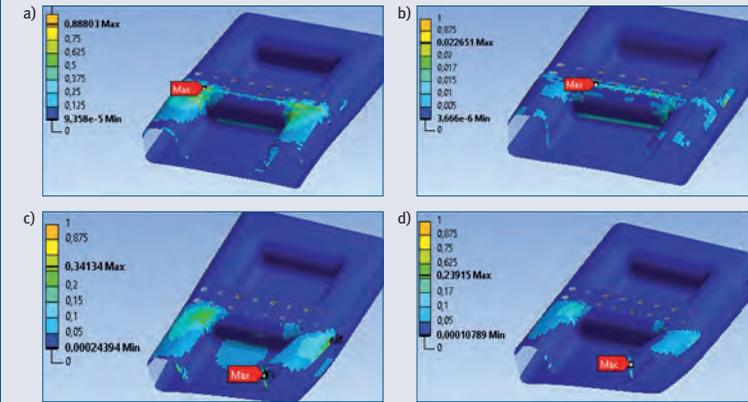
Light Electric Vehicles (LEV) differ fundamentally from established vehicle concepts – not only in terms of the consumption of operating energy and resources, but also in terms of production, use and recyclability. Based on a roadworthy prototype vehicle of registration class EU L7e, the “LEVmodular” project examines alternative vehicle concepts for their potential contribution to a circular economy.

Sustainability in production and versatility

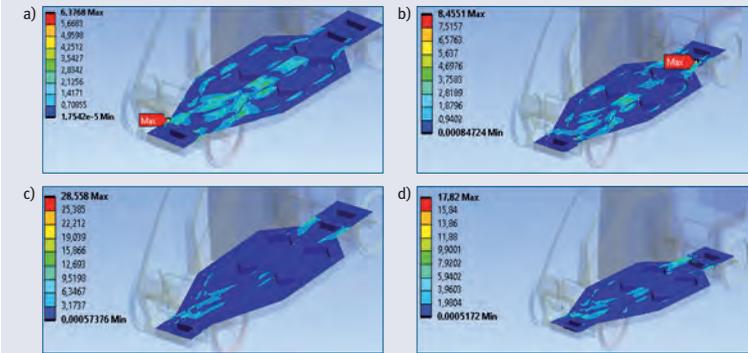
Light electric vehicles offer the opportunity to rethink vehicles – from the use of innovative materials and decentralized production in relatively small batch sizes to new mobility concepts. Using this example, the project partners are investigating the conditions under which the vehicle supply industry can contribute to a new mobility.

The project consortium contributes to the challenges that not only densely populated cities are facing in the face of increasing traffic density – whether it be parcel delivery over the last mile, ecological passenger transport in all weathers or equipment carriers for municipal services. In order to support the turnaround in traffic, vehicle concepts are needed that support a circular economy both from the point of view of life cycle assessment and in terms of their possible applications.

By aiming to derive further vehicle variants on the basis of the “Cargo Cruiser II”, the project partners are answering questions on the recycling-economic feasibility of LEV. On the other hand, expected barriers to acceptance compared to alternative vehicle concepts will be minimised by a Real-World Laboratory approach.



FEM Submodell, the Inverse Reserve Factor is showing failure behavior in laminate structure, for load cases a) Static load, b) Braking load, c) Curvature load and d) Combined load



FEM Globalmodel, showing maximum equivalent stress [MPa]: a) Static load, b) Braking load, c) Curvature load and d) Combined load

Light vehicles from the middle class

In view of the already highly developed efficiency in conventional vehicle construction, the approaches pursued should provide alternative contributions to the vehicle market. With the consistent further development of a muscle-powered electric light vehicle, the project participants want to pave the way for a value creation in production and use in line with the circular economy.

Two construction methods are being examined for their potential for circular economy feasibility by varying aspects such as material classes, production technologies

and location strategies. For this purpose, instruments of component design and optimization (Finite Element Method) and Life Cycle Assessment (LCA) are used.

For the economic investigation of the application areas of novel materials and semi-finished products suitable for recycling management, an existing LCA database is supplemented by as yet unknown production processes. For this purpose, the real-laboratory approach is used to interact with partners in the vehicle construction industry as well as with potential users and owners of light vehicles. Industrial design methods are used to achieve high user acceptance. Materials and semi-finished products that appear promising for use within a recycling economy are then examined comparatively at the design level in two methods of construction.

First results

Real Life testing the Cargo Cruiser II in City of Berlin gave new inputs for the construction in fibre composite of Cargo Cruiser III. The material-behaviour in composite construction was investigated by evaluation of different failure criteria using a Finite Element Modell in global- and submodel scale. The load cases therefore were defined for 45 km/h and a load capacity of 300 kg.

The fibre composite structure actual is under construction and test drives with CC III are planned in City of Dessau. Parallel to construction of CC III the needed data for Life Cycle Inventory and analysis of Environmental Impact Assessment focusing CO₂ equivalent was collected. First findings from LCA showing the relevance of energy mixes – in production and in use phase of Light Electric Vehicles. From Insights by doing LCA a new approach for end of life use of natural fibre composites is brought in to discussion. To realise a mechanical monitoring of the fibre composite (Structural Health Monitoring) a set-up of sensor and Long Range Wireless Access Network (LoRaWAN) compatible measurement device was identified and tested.

Innovative spirit and efficiency

Based on the “Cargo Cruiser II” prototype, vehicle variants for different urban usage scenarios are derived and transferred into a modular vehicle design. Prototypical vehicle variants are used to gain empirical findings on aspects such as usability of the vehicle variants, ergonomics of the muscle-powered electric drive and user acceptance. By holistic consideration of the Life Cycle Assessment, statements on the recyclability of the considered construction methods are expected.

Based on solid experience in lightweight vehicle construction, the company Olaf Lange, Berlin, in close cooperation with FVK GmbH, Dessau-Roßlau, contributes significantly to the approval-compliant design of the vehicle construction. FVK GmbH focuses on manufacturing, maintenance and conversion of the vehicle modules in accordance with recycling management requirements. The Fraunhofer IMWS in Halle (Saale) is responsible for the material optimisation and investigation of the suitability for recycling as well as the coordination of the entire project.

The project “LEVmodular” is funded within the funding measure “Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)”.

“ReziProK” is part of the research concept “Resource-efficient Circular Economy” of the Federal Ministry of Education and Research (BMBF) as part of the FONA Field of action 6: “The circular economy – efficient use of raw materials, avoiding waste” and supports projects that develop business models, design concepts or digital technologies for closed product cycles.

Funding measure

Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

As part of the FONA Field of action 6:

The circular economy – efficient use of raw materials, avoiding waste.

Project title

LEVmodular – Light Electric Vehicle modular – with new mobility for resource-efficient recycling

Project duration

01.07.2019 – 30.06.2022

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033R245

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666.541 Euro

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PM-GrafikDesign

Picture credits

Fraunhofer IMWS

Status

March 2021



Cover-Picture: Investigations of fibre components in the project LEVmodular.

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LifeCycling²

Reconfigurable design concepts and services for resource-efficient (re-)use of e-cargobikes



**Resource-efficient Circular Economy –
Innovative Product Cycles (ReziProK)**

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Research for sustainability

E-bikes and e-cargobikes are already an integral part of our mobility. The strong spread of electrically assisted bikes is accompanied by the question of resource-efficient recycling after initial use. In the joint project “LifeCycling²”, solutions for further use and recycling of complete wheels and individual components are being developed and tested. This also includes the development of services and recycling measures.



Persona characteristics and user stories

Resource-efficient mobility

The volume of traffic for individual mobility and transportation of goods is increasing worldwide. E-bikes and e-cargobikes are suitable for lower-emission mobility, especially in innercity areas. However, the lower use of resources during the use phase of e-bikes and e-cargobikes is currently countered by a lack of solutions for the continued use of resource-intensive components such as batteries and the recycling of the complete bicycle.

Since e-bikes and e-cargobikes will be considered electronic scrap in the future, concepts must be developed to recycle individual components in a targeted manner or to transfer them to secondary uses. In order to increase the resource efficiency of e-cargobikes beyond their first use, the partners in the joint project “LifeCycling²” are researching and testing solutions for the targeted further use and upgrading of products and components and for material recycling. Effectiveness and innovations will result from interdisciplinary cooperation and the strong linking of services and products.

Controlling life cycle options

The project LifeCycling² aims at improving the life cycle-spanning resource efficiency against the background of the increasing spread of e-cargobikes. Technical concepts are to be developed to extend the service life by means of product updates and upgrades and to optimise the intensity of use through sharing solutions. In addition, measures for the life cycle-oriented design of e-cargobikes and methods for the definition of life cycle strategies will be developed and organizational measures for the targeted recycling of electronic components will be investigated. The design concepts developed for hardware and software systems will be implemented and tested in practice in the form of demonstrators for pilot projects. In addition, technical solutions and services will be developed and tested as software-based



Battery systems of various producers have been analysed.

services to improve usage behaviour and resource efficiency during initial use by means of upgrades to enable resource-efficient reuse of the entire bike or individual components. In LifeCycling², four fields have been identified:

- **Product:** upgrading, residual value assessment and secondary use of e-cargobikes.
- **Components:** Recycling and conversion of accumulators and drive components.
- **Material:** separation and recycling of materials.
- **Information and control:** Collection and provision of information to increase the Resource efficiency.

First results

Several use cases for e-cargobikes and personas have been derived within Design Thinking workshops. The use cases are the central element within the development of the e-cargo, the battery, the business model, information services and recycling processes. A distinction is made between commercial use for the transport of goods and private use for the transport of goods and people (and other living beings). As for business models, both leasing and sharing have been identified. Initial sets of requirements were collected with the help of structured influencing factors.

In another strand, an analysis of commercial battery systems and cells for e-bike drives has been carried out. The recycler was able to collect and provide old batteries and battery systems from various manufacturers. By analysing them, it could be determined that there are no standards regarding the cell designs used (cylindrical cells, prismatic cells, pouch cells) as well as the mechanical and electrical system design (e.g. housing, sensory system).

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Solutions in pilot projects

The approaches are being developed in an interdisciplinary way in a network of two university institutes and four industrial partners and tested in pilot projects. From the pilot projects and findings, generally valid recommendations for action, strategies and technical measures as well as processes for the development and implementation of product, component and material cycles for e-bikes and e-cargobikes will be derived. Researchers from product and software development and accompanying social research are involved in the joint project. The industrial partners contribute expertise in the fields of recycling, safety of accumulators, leasing and service solutions for e-bikes and e-cargobikes as well as data acquisition, evaluation and visualisation.

During the project, associations, citizens, bicycle manufacturers and mobility providers will be involved in the collection of requirements and evaluation of future application scenarios for e-cargobikes.

The project “LifeCycling²” is funded within the funding measure “Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)”.

“ReziProK” is part of the research concept “Resource-efficient Circular Economy” of the Federal Ministry of Education and Research (BMBF) as part of the FONA Field of action 6: “The circular economy – efficient use of raw materials, avoiding waste” and supports projects that develop business models, design concepts or digital technologies for closed product cycles.

Funding measure

Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

As part of the FONA Field of action 6:

The circular economy – efficient use of raw materials, avoiding waste.

Project title

LifeCycling² – Reconfigurable design concepts and services for resource-efficient (re-)use of e-cargobikes

Project duration

01.08.2019 – 31.07.2022

Funding reference number

033R232A–F

Funding volume of the project

1.498.994 Euro

Internet

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Publisher and editorial office

Networking and transfer project “ResWInn”

Design

PM-GrafikDesign

Picture credits

NFF/Massel; TU Braunschweig/Cudok

Status

March 2021



Cover-Picture: “LifeCycling²” explores solutions for sustainable mobility.

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LongLife

New business models for an extended use of technical systems based on a simple, decentralized condition assessment and prognosis of the remaining service life



Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

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Components, such as bearings, springs e.g. in machines, are often replaced significantly before they reach the technically possible service life and are sent too early to material recycling or disposal. Using selected applications, the partners in the consortium want to show that a decentralised condition assessment with a prognosis of the remaining service life can lead to longer use and thus make a contribution to improved resource efficiency.

Sustainability instead of short-term effects

We have defined two Use-Cases for the project “LongLife”. On the one hand, the drive spindle of an injection unit from a shoe machine and on the other hand mechanical components of an industrial high-speed roll-up door. Components in technical systems, such as bearings, drive belts and springs are regularly replaced according to a maintenance schedule, although in some cases they could be kept in use much longer. One reason for this is often the uncertainty regarding the actual condition of the components and their expectable remaining service life, because such information cannot be obtained with existing means and data or because the cost-benefit ratio is unacceptable. A further barrier is that the business models of the involved companies are often not geared to such extended use of the components. For example, manufacturer’s main interest is usually to sell new products rather than supporting the re-use of used products, not least due to warranty issues and margins. As a result, this leads to unnecessary costs and burdens the environment through increased resource consumption.



Application example: a high-speed roll-up door.

Increased certainty regarding the remaining service life

The partners of the “LongLife” consortium want to remove barriers for a longer use of technical components and thus contribute to a significant saving of resources. This is to be achieved by combining technical and business management elements. On the one hand, methods and tools will be developed for the most reliable possible prognosis of the remaining service life of used technical components. On the other hand, innovative reference business models are to be developed that build on these results and provide tangible benefits for all partners that are involved in the extended use of the components.

The application partners’ motivation is to quickly obtain an assessment of the condition of the considered components when problems occur with the overall system. Based on this, it can then be decided whether the component has to be replaced or still can be used for a longer period of time so that, for example, an extra on-site service can be avoided, especially when technicians have to travel abroad. As an additional service, the users of the components should be provided with information regarding the options for emergency operation until the next regular service.

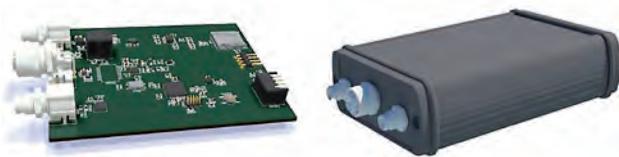
First results

In cooperation with Efaflex GmbH, the manufacturer of high-speed doors, the relevant components for a failure (tension spring, drive belt, strap) are closely examined.

For this purpose, a high-speed roll-up door was set up and put into operation for tests in a laboratory area of the University of Bremen. The control unit of the high-speed door was used to read out and visualize a wide range of parameters, such as motor temperature, speed, torque, etc. This provided initial information about the current state and operating conditions of the components. First findings on the state and operating conditions of the components have already been obtained. Additional sensor technology is currently tested to enable targeted time-discrete condition determination.

With regard to the drive spindle in the second use case, relevant sensor data were identified and supplemented via a test bed available at DESMA. The results were incorporated into the development and case-specific adaptation of the mobile test station. This contains standard sensors, can communicate with further sensors and establishes the connection to the “LongLife” platform.

In parallel, an AI model based on Bayesian networks are developed to predict the remaining service life. This model maps the typical wear patterns of the considered use cases and assigns characteristic features to these patterns that can be detected by sensors.



Design study of the mobile test equipment.

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In addition, initial building blocks of reference business models were defined, which can be used to configure business models that can include several partners in the value chain. In addition to the partner who provides the forecast system (system holder), these can be component manufacturers, plant builders, plant operators or maintenance service providers.

The innovation of the project approach

The innovative approach combines a decentralised collection of relevant data, an AI-based learning forecast via a dedicated platform and the possibility to configure business models. This motivates value chain partners to apply the forecast and provide the necessary data. As a result, longer use of technical components is promoted, in line with the objectives of the “ReziProK” funding measure.

The project “LongLife” is funded within the funding measure “Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)”.

“ReziProK” is part of the research concept “Resource-efficient Circular Economy” of the Federal Ministry of Education and Research (BMBF) as part of the FONA Field of action 6: “The circular economy – efficient use of raw materials, avoiding waste” and supports projects that develop business models, design concepts or digital technologies for closed product cycles.

Funding measure

Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

As part of the FONA Field of action 6:

The circular economy – efficient use of raw materials, avoiding waste.

Project title

LongLife – New business models for an extended use of technical systems based on a simple, decentralized condition assessment and prognosis of the remaining service life

Project duration

01.07.2019 – 30.06.2022

Funding reference number

033R246A-E

Funding volume of the project

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Publisher and editorial office

Networking and transfer project “ResWInn”

Design

PM-GrafikDesign

Picture credits

P. 1: DESMA Schuhmaschinen GmbH
CoSynth GmbH & Co. KG

P. 2: BIK Universität Bremen

Status

March 2021



Cover-Picture: The project “Longlife” combines residual life testing on selected components.

CONTACT

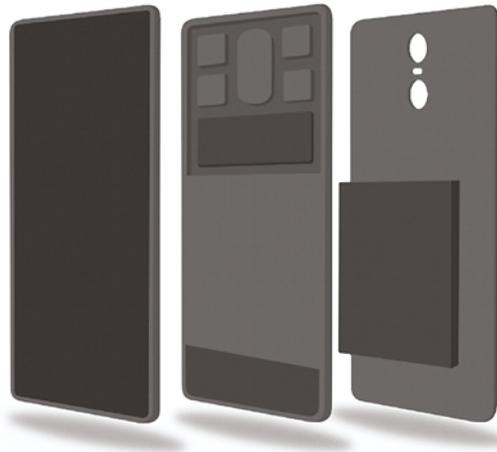
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MoDeSt

Product circularity through modular design – strategies for long-lasting smartphones



Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

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Modular smartphones have the potential both to reflect technical progress through upgrades and to meet changing consumer needs. This enables a longer service life, which reduces the number of devices and their environmental impact. In order to develop the positive potential of modular design and minimize undesirable consequences, “MoDeSt” develops technical, social and economic pre-conditions and solutions for modular concepts.



Extended use-time

According to Bitkom, at least 57 million people in Germany use a smartphone in 2019. Smartphones contain a variety of valuable metals, but also conflict resources. Most of the environmental impact is caused by the production of smartphones.

Modular smartphones require specific user skills, such as knowledge about repair options. This enables users to absorb technical innovations through upgrades, which pave the way to longer use-times. In order to exploit the positive potential of modular design and minimize negative effects such as increased consumption, the „MoDeSt“ project is investigating the technical, social and economic prerequisites for modular concepts and developing solutions for circular and socio-ecologically sound modular technologies.

Holistic approach

The innovative project involves a broad, transdisciplinary consortium. The integration of research and practice as well as technical and social science competences form the basis for a holistic approach to the research task.

The project is split into five closely interlinked work packages. First, conventional and modular smartphones are investigated and evaluated in the technical analysis with regard to various aspects of a circular economy. In the next step, life cycle assessments will be carried out

which, by means of scenario building, depict different usage, repair and disposal practices and evaluate them with regard to material and resource efficiency. Thus, user expectations and practices are investigated qualitatively and quantitatively. Existing business models for modular products are analysed and new approaches are developed.

The modular approach will be further developed based on these joint findings on environmental, usage and business model-related issues. Concrete technical revisions as well as the development of general eco-design criteria for modular smartphones are aimed at.

First results

A review of the smartphone market since 2000 was conducted. This showed the enormous variety of models and manufacturers on the market, reaching its peak in 2014 with a total of 839 new models. Despite this multitude of different devices, a clear trend is visible regarding technical features. Besides the continuously increasing amount of memory and storage, higher display resolution and battery capacity seen in most devices, the market has developed towards significantly larger displays. This was the result of a better utilization of the front (screen-to-body-ratio), as well as larger, but flatter devices. Removable batteries, while being the norm a few years back, have become a niche product.

Smartphones are increasingly taking over features from other objects (e.g., alarm clocks and sound systems). Smartphones are thus modular in their role, but rather static from a technical point of view. Even sufficiency-oriented users are constantly discovering new features, then proceeding to integrate them into their everyday practices. Expectations regarding performance and features are generally high. Even ecologically-oriented users replace their devices if performance is not optimal anymore. Value-based communication, therefore, is not enough. Modular product service systems (PSS) should focus on the functional expectations and use patterns of different user groups.

Generally, different modular smartphone architectures are possible. These must be aligned with use patterns and business models. Similarly, PSS must also be designed in a modular manner to offer complementary services to prolong the active use time of the devices. Modularity has various advantages for all actors in the value chain. But ecological advantages are not a sure-fire success, but must become an overall strategy. Modular designs and PSS must also be supported by policymakers by taxing resource consumption to create conditions for a greater modularization of devices in supply chains and value creation models.



The variety on the smartphone market is enormous

Involved partners and results

The transdisciplinary consortium comprises four scientific partners, Fraunhofer IZM, TU Berlin and the CSM of Leuphana University and IQD of Johannes Kepler Universität Linz (associated), as well as two industrial partners, SHIFT GmbH and AfB gGmbH.

The results of the project will be used to increase the distribution of modular devices on the market. They can serve manufacturers of smartphones as important development indicators. The results of the business model design can be used by manufacturers, sales partners and circular service providers to implement economic potentials of modularisation strategies and thus provide impulses for a longer service life. The methods applied can provide important impulses for participatory market research in the technology/ICT sector and promote the development of integrative circular economy strategies. Within the framework of scientific publications, the results are made available for the further development of the discourse on the transition to an integrative circular economy.

Funding measure

Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

As part of the FONA Field of action 6:

The circular economy – efficient use of raw materials, avoiding waste.

Project title

MoDeSt – Product circularity through modular design – strategies for long-lasting smartphones

Project duration

01.07.2019 – 30.06.2022

Funding reference number

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Funding volume of the project

1.208.320 Euro

Internet

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Publisher and editorial office

Networking and transfer project “ResWInn”

Design

PM-GrafikDesign

Picture credits

P. 1: SHIFT 2019

Maksym Yemelyanov-stock.adobe.com

P. 2: TU Berlin 2020

Status

March 2021



Page 1 picture: A view into the future: modular smartphones.

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“ReziProK” is part of the research concept “Resource-efficient Circular Economy” of the Federal Ministry of Education and Research (BMBF) as part of the FONA Field of action 6: “The circular economy – efficient use of raw materials, avoiding waste” and supports projects that develop business models, design concepts or digital technologies for closed product cycles.

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PROJECT PARTNERS

SHIFT GmbH; TU Berlin, Fachgebiet Transdisziplinäre Nachhaltigkeitsforschung in der Elektronik; Leuphana Universität Lüneburg, Centre for Sustainability Management; AfB gemeinnützige GmbH; Johannes Kepler Universität Linz (JKU), Institute for Integrated Quality Design (associated partner)

OptiRoDig

Optimisation of raw material productivity in the foundry and steel industry from products of the recycling industry by using modern mathematical methods, networking and digitalisation



Resource-efficient Circular Economy –
Innovative Product Cycles (ReziProK)

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In the foundry and steel industry, around 45 percent of the raw material requirements are already covered by secondary raw materials. This proportion should and can be increased. A prerequisite is that the smelters know the exact composition of available scrap types and can procure them in a targeted manner. For this reason, the “OptiRoDig” project aims to develop a digital network system that enables data exchange between the recycling industry and steelworks for optimized melting processes

Metal recycling with potential

Metal scrap is produced in large quantities as waste from metal processing, e.g. chips, punching waste, material residues. Usually, their exact composition and any impurities they may contain, e.g. oils, are not known exactly. However, this information is a prerequisite for the smelters to be able to use specific scrap qualities for the production of a certain alloy without having to add expensive alloy surcharges.

Foundries and steelworks or smelters want to purchase the raw materials suitable for their melting processes in a targeted and cost-effective manner. Today’s common procedure – inquiry, quotation, order – is time and personnel consuming. In addition, the desired material data is often not available in a timely manner.

In the course of OptiRoDig, a digital network system is to be developed between the recycling industry and the smelters. In this system, extensive analysis data of available secondary raw materials – metal scrap – will be provided. This database should enable the smelting works to procure suitable raw materials, to optimise their melting processes and thus to use higher proportions of secondary raw materials in a targeted manner.

Digitisation and networking

For interactive data exchange and automated process optimization in the melting plants, both the data to be recorded and various software tools must be developed

Optimierungstool

Material & Menge

Zielmaterial auswählen: 1.2379 Menge: 2000 MATERIAL HINZUFÜGEN

Form-Restriktionen

Anteil Stückschrott: 100% Anteil Späne: 100%

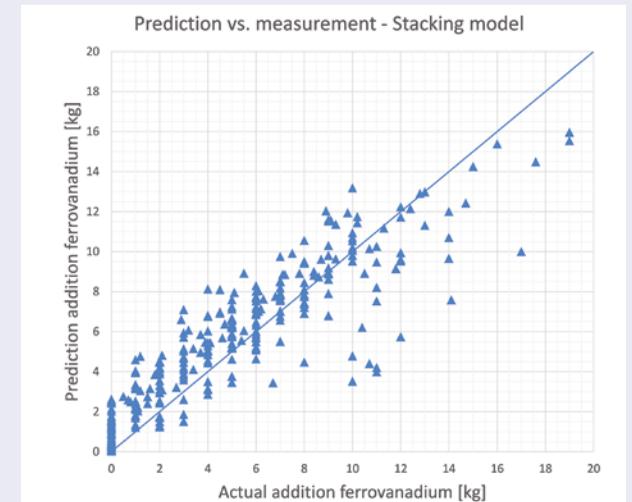
Ergebnis

BERECHNUNGSZEIT: 0,069 SEKUNDEN

Die Berechnungen konnten erfolgreich beendet werden. Es wurde eine optimale Lösung gefunden.

Charge ↑	Form	Kosten pro kg	Beschreibung	1.2379 [kg]	Gesamtkosten [EUR]
S0016634	Stückschrott	0,13	CrMo ab 0,6% bis 1,1% Mo	790	102,7
S0016685	Stückschrott	0,12	Cr-Stahl der WN 1.4113	161,79	19,41
S0010404	Späne	0,32	HSS mit Co Schlämme	392,21	125,51
S0014766	Stückschrott	0,2	1.2379 Abfälle/Gesenke	0,5	0,1
S0016569	Späne	7,56	Mo-Staub ab 50% Mo	26,66	201,57
S0014700	Späne	0,15	HSS Späne Allgemein	7	1,05
S0016303	Stückschrott	0,16	CrMo ab 0,6% bis 1,1% Mo	390	62,4
S0014032	Späne	0,03	CrMoV-Schleifwolle	231,83	6,95
Preis pro Tonne [EUR/t]		259,85		2000	519,69

Screenshot optimizing tool.



Comparison prediction (ML) and measurement of additional alloy FeV.

and coordinated. In OptiRoDig an innovative digital system is to be developed for this purpose, via which the raw material data and process requirements are made available digitally to the participants along the process chain through digitisation, networking, defined interfaces and data formats in such a way that these can be taken directly from the planning software and evaluated using mathematical methods. For this purpose, comprehensive analysis coordinated between the partners is required. After completion of the development phase, the digital system is to be made available to other companies within the framework of a cloud solution.

First results

With the cloud-enabled web application created for the project, it is already possible to optimize the composition of the melting in terms of costs and shape (share of turnings and massive pieces) using a simplex algorithm. The optimization can be supplemented with further boundary conditions. The screenshot on the left shows the result of a cost optimization from the web application in a shortened view.

The melting process in the furnace of a foundry is modeled with machine learning (ML) to analyze the process-related influencing variables. The graph on the left shows as an example the forecasted required quantity result (with ML) of ferrovanadium (FeV) to produce 1.3343 steel. As input the process data from the project partner Lohmann are used. The ML models will be integrated into the cloud application to enable an overall optimization in terms of metallurgical interactions in the melt and total costs.

Consolidation of competences

The joint project OptiRoDig brings together the main players in the supply chain between the points where metal waste is generated and steel production. These are supplemented by the know-how of university institutes.

The project coordinator is RHM Rohstoffhandels-gesellschaft mbH, a wholly owned subsidiary in the RHM Group, based in Mülheim. As a scrap trading company, RHM specialises in the sector of high-quality steel alloys and related metal alloys with rare elements such as tungsten, chromium, vanadium, cobalt, nickel, titanium, etc.

The smelting works of Friedr. Lohmann GmbH, based in Witten, act as representatives of the “OptiRoDig” network. In their two steelworks, high-speed, tool and special steels are produced as well as highly wear-resistant and heat-resistant castings.

The Institute of Metal Technologies at the University of Duisburg-Essen (UDE) and the University of Applied Sciences Kempten have many years of expertise in the fields of process optimisation, database systems, static evaluation and predictive manufacturing.

The partners RHM and Friedr. Lohmann benefit from the results by optimizing their processes and the application-oriented evaluation of raw materials. The university institutes can test and optimize developed models and algorithms in operational practice. In the second project phase of “OptiRoDig”, the data exchange is then to be made accessible to other companies in the recycling industry as well as the foundry and steel industry.

Funding measure

Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

As part of the FONA Field of action 6:

The circular economy – efficient use of raw materials, avoiding waste.

Project title

OptiRoDig – Optimisation of raw material productivity in the foundry and steel industry from products of the recycling industry by using modern mathematical methods, networking and digitalisation

Project duration

01.07.2019 – 30.06.2022

Funding reference number

033R247

Funding volume of the project

1.319.675 Euro

Internet

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Networking and transfer project “ReSSWInn”

Design

PM-GrafikDesign

Picture credits

Friedr. Lohmann GmbH
Universität Duisberg-Essen
Hochschule für angewandte
Wissenschaften Kempten

Status

March 2021

Cover-Picture: New scrap on a scrap yard.



The project “OptiRoDig” is funded within the funding measure “Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)”.

“ReziProK” is part of the research concept “Resource-efficient Circular Economy” of the Federal Ministry of Education and Research (BMBF) as part of the FONA Field of action 6: “The circular economy – efficient use of raw materials, avoiding waste” and supports projects that develop business models, design concepts or digital technologies for closed product cycles.

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PROJECT PARTNERS

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Universität Duisburg-Essen (U-DE), Institut für Technologien der Metalle
Hochschule für angewandte Wissenschaften Kempten

“PERMA” picks up on the growing social awareness for more sustainability and aims to establish a resource-efficient circular economy in furniture and object construction. New types of product life cycles and manufacturer-independent compatibility guidelines enable sustainable and flexible reuse and further use of products in a value-preserving form. The development of innovative business models creates a platform for re-use, up-, down- and recycling.



PERMA

Platform for efficient resource utilisation in the furniture and furnishings industry



Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

SPONSORED BY THE



Recyclable design

Decreasing raw material volumes are leading to a current change in environmental awareness. On the other hand, the demand for materials in the furniture industry is increasing due to increasing flexibility requirements resulting from rapidly changing forms of office organization such as co-working and open space. In other industries, such as exhibition, trade fair and scenery construction, the useful life of the equipment used is significantly shorter than its actual service life as well. By intervening early in the design and planning processes, products are created whose basic concept serves an increased usage and service life in cycle-oriented business models.

In order to optimise raw material efficiency in terms of holistic reuse and recycling, the “PERMA” project consortium is developing an open product and raw material platform. Based on the three-pillar model for sustainability – economic, ecological and social – innovative business models are being developed. The use of environmentally friendly materials and modularity integrated into the product design as well as cross-manufacturer compatibility open up new types of product life cycles. Parameterized modularity in addition to secondary use of the products and their sub-components, recyclable reuse options through up- and downcycling are first being investigated. Only then a return of raw materials via recycling is considered.

The basis for this is a technically implemented, holistic representation of occurring product structures and life cycles. Within the utilization concept, manufacturing characteristics and criteria are collected, with which reuse parameters are defined. New as well as used furniture and material components of various actors in the furniture and equipment industry can thus be made available for further use via the platform with corresponding parameterisation of their product and quality characteristics.

Parameterized modularity

In addition to a secondary use of the products and their sub-components, recyclable reuse possibilities through up- and downcycling are being investigated. Only finally will the return of raw materials via recycling be considered. The basis for this is a technically implemented, holistic representation of occurring product structures and life cycles.

Within the utilization concept, manufacturing characteristics and criteria are collected, with which reuse parameters are defined. New as well as used furniture and material components of various actors in the furniture and equipment industry can thus be made available for further use via the platform with corresponding parameterisation of their product and quality characteristics.

Open IT platform

Initially, the two manufacturing companies SYSTEM 180 GmbH and kubix GmbH will work together to develop innovative business models. Derived from this, product structures and application requirements will be discussed, which will serve as a basis for the creation of the platform. Furthermore, an evaluation matrix of recyclable product and quality features will be established with the participating scientific institutions, the Eberswalde University of Applied Sciences and the Technical University of Berlin. Finally, corresponding results will decisively determine the structure of the platform, the prototypical installation of which will be carried out by the IT company StoneOne GmbH.

With an appropriate process framework and a methodological toolbox as well as design rules, participating companies will be supported in the resource-efficient design of products throughout the entire product development process. By centralising processes and activities within the platform, the positive resource effects are increased in the form of extended service life and intelligent, cross-sector business models for reuse and further use throughout the entire cycle.

By opening up the platform to various stakeholders – from raw material suppliers to users – a large community can be reached and resource efficiency along the entire furniture and component cycle can be optimally designed. Cross-manufacturer combination options for modular components contribute significantly to increasing flexibility and the overall value proposition for customers.

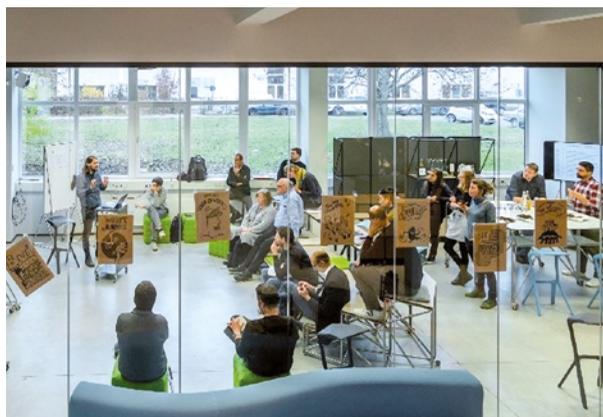
First results

The two manufacturing companies have developed an innovative, sustainable and economically viable business model that forms the basis for exemplary process and function representations of actors on the platform by the universities. Based on these process representations, an agile draft of the specifications for the IT-technical representation of the platform was written.

The actors were assigned roles that define access rights, scope and functionality on the platform. The core function of the platform is a circular solution search of furniture and building groups, which is organised as an economic B2B internal market with corresponding sets of rules.

The platform is to be operated via an independent, non-profit-oriented business model. This business model includes the technical and content-related operation of the platform, as well as the integration of additional players who are not functional participants in the internal market.

In addition, further central and relevant functionalities of the platform are controlled: a knowledge library on the circular economy, certification and evaluation control as well as actor and community management.



PERMA network meeting / October 2019

The project “PERMA” is funded within the funding measure “Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)”.

“ReziProK” is part of the research concept “Resource-efficient Circular Economy” of the Federal Ministry of Education and Research (BMBF) as part of the FONA Field of action 6: “The circular economy – efficient use of raw materials, avoiding waste” and supports projects that develop business models, design concepts or digital technologies for closed product cycles.

Funding measure

Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

As part of the FONA Field of action 6:

The circular economy – efficient use of raw materials, avoiding waste.

Project title

PERMA – Platform for efficient resource utilisation in the furniture and furnishings industry

Project duration

01.08.2019 – 31.07.2022

Funding reference number

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1.604.436 Euro

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Networking and transfer project “ResWInn”

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PM-GrafikDesign

Picture credits

P. 1: StoneOne AG

kubix GmbH

P. 2: System 180 GmbH

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HNE Eberswalde

praxPACK

User-integrated development and testing of practical, resource-efficient reusable packaging solutions in the mail order business



Resource-efficient Circular Economy –
Innovative Product Cycles (ReziProK)

SPONSORED BY THE



Online shopping is growing steadily; an additional boost resulted from the corona pandemic. Online shopping products are mostly packed in disposable packaging, which is disposed of by the end consumer. This system leads to a relevant consumption of resources and corresponding amounts of waste. Practical reusable systems for packaging in online and mail-order trade – as conceived, developed and tested in praxPACK – can make a considerable contribution to reducing the packaging-related consumption of resources and the amount of waste.



Packaging material in online shopping

Online shopping in Germany and Europe has been showing continuous growth for years. Products in online trade are mostly packed in one-way shipping packaging, which is disposed of upon receipt of the goods. This linear packaging system leads to a high consumption of resources and corresponding amounts of waste. Current studies show that private end consumers in Germany produce over 750,000 tonnes of paper, cardboard or paperboard packaging and over 50,000 tonnes of plastic packaging per year. In 2020, there has been further significant growth due to the Corona pandemic. If the trend of steadily increasing resource consumption in this area is to be broken, innovative solutions at logistics system level and adjustments to business models will be required.

Here the “praxPACK” project comes in: The aim of the project is to contribute to the establishment and distribution of reusable systems in online trade in order to achieve a substantial reduction of packaging-related resource consumption – and associated waste quantities – in the medium term. For this purpose, practical reusable concepts in online trade are being developed and tested within the framework of the project under the leadership of the network coordinator Ökopool and comprehensive knowledge is being gained about how the business models of the actors involved in online trade need to be adapted in order to make the use of reusable systems economically viable.

This knowledge is prepared and made available in a systematic and application-oriented manner in order to support further responsible companies from online trade in testing and disseminating the use of reusable systems.

Cooperation laboratory and pilot project

The central element of praxPACK is a cooperation laboratory in which the project partners will develop concrete solution elements for the construction of practice-oriented and self-supporting reusable systems. The intensive exchange of experience and learning processes in the development of possible reusable concepts and necessary business model adaptations will play an important role in this process.

Based on the solution elements and reusable concepts developed jointly by the partners, reusable systems are being tested and further developed in concrete pilot projects at online retailers. These pilot projects will be conducted under the leadership of the three participating online retailers: Tchibo, OTTO and Avocadostore. The implementation of these pilot projects is supported by the expertise of the other partners involved: Cargo Plast, RePack (Plan B) and GVM. The Institute Ökopool is responsible for the coordination of the entire project.

First results

Between August and October 2020, Tchibo, OTTO and Avocadostore carried out a first pilot test in the use of reusable shipping bags in online trade. These three online retailers shipped around 14,000 reusable packaging bags as part of this test. Customer feedback from all three online retailers was overwhelmingly positive. The reusable packaging was consistently perceived as sustainable. Between 74% and 81% of the packaging has been returned by the customers up to now.

The main challenge is the additional cost of reusable systems compared to one-way packaging. It is particularly the return logistics that are a cost driver in this case.



Reusable packaging was tested in practice at Tchibo as well as at OTTO and the Avocadostore.

reziplik.produktkreislauf.de/en

Online toolbox and recommendations for action

The findings from the cooperation are made available via praxpack.de. This is intended to support interested online retailers in initiating and implementing a reusable system.

In addition, recommendations for action in terms of technical and sector policy will be derived. This includes the identification and analysis of existing obstacles for the broad establishment of reusable systems in online trade due to legal and sub-legal framework conditions and established industry standards of logistics service providers, the development of proposed solutions to overcome these obstacles and the derivation and coordination of recommendations. The addressees of these recommendations for action are the responsible departments in Germany and the EU as well as relevant industry committees.

Funding measure

Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

As part of the FONA Field of action 6:

The circular economy – efficient use of raw materials, avoiding waste.

Project title

praxPACK – User-integrated development and testing of practical, resource-efficient reusable packaging solutions in the mail order business

Project duration

01.06.2019 – 31.01.2022

Funding reference number

033R243

Funding volume of the project

760.495 Euro

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Networking and transfer project “ReziWInn”

Design

PM-GrafikDesign

Picture credits

P. 1: Till Zimmermann

Tchibo GmbH

P. 2: Tchibo GmbH

Status

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Cover-Picture: Reusable systems instead of disposable packaging: “praxPACK” develops closed-loop solutions.

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PROJECT PARTNERS

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Cargo Plast GmbH
GVM Gesellschaft für Verpackungsmarktforschung mbH
Otto GmbH & Co KG
Tchibo GmbH

ReLIFE

Adaptive Remanufacturing for Life Cycle Optimization of Capital Goods



Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

SPONSORED BY THE



Against the background of globally increasing resource consumption, the Adaptive Remanufacturing approach in ReLIFE aims at increasing resource efficiency by extending the life cycle of capital goods. Therefore, the application of maintenance measures is optimized in technical, economic and ecological terms. Measures are controlled based on Condition Monitoring to maintain a defined productivity level of the machine.



Project demonstrator: Exhaust air purification system.

Resource-efficient life cycle extension

The research project ReLIFE aims at increasing resource efficiency by extending the life cycle of capital goods. Therefore, the innovative approach of Adaptive Remanufacturing is developed. It describes an adaptive maintenance strategy, which determines the optimal time and scope of maintenance and remanufacturing measures based on sensor evaluations under technical, economic and ecological aspects. In the course of ReLIFE, a prototype application is developed as a demonstrator based on an existing capital good. Furthermore, business models based on Adaptive Remanufacturing are developed enabling companies to generate competitive advantages. Thus, the prerequisites for the successful implementation of the approach in industry are created.

Innovation of Adaptive Remanufacturing

The innovative character of Adaptive Remanufacturing lies in its adaptability in terms of time and scope. Based on the monitored wear conditions of components, preventive maintenance and remanufacturing measures are proposed situation-specifically. The performance assurance of capital goods is the basis for innovative business models ensuring long-term productivity. The agreed minimum performance level of the machine is maintained through purposeful maintenance measures.

Simultaneously, product design guidelines focusing on integrated sensor technology are developed and implemented in a physical demonstrator. On this basis, a decision support model is designed and implemented in a software application to determine the optimal usage of remanufacturing measures. At the same time, business models are developed based on Adaptive Remanufacturing.

First results

In the course of the project, remanufacturing and maintenance measures have been identified, aggregated, and evaluated in a measure catalog. Additionally, a relevance-indicator was developed to determine the remanufacturing relevance of investment good components. Moreover, economic, ecological, and technical indicators influencing the optimal measure selection were determined in this phase of the project. Based on these indicators, a scheme was developed for decision-making on measure application in specific use cases in order to maximize ecological and economic benefits. The scheme will be validated by means of the demonstrator within the project scope.

The remanufacturing-relevant components of the demonstrator were determined based on a detailed product structure analysis to focus research activities. The

technical properties and the driving wear mechanisms were determined for the components with remanufacturing-relevance. Based on the determined remanufacturing-relevance, which includes the detected wear mechanisms, components, which can be monitored economically, were prioritized. Existing sensor technology within the demonstrator can be used to monitor the condition of some of the components. For the remaining components, a sensor concept was developed and transferred to procurement and implementation to upgrade the demonstrator. For all remanufacturing-relevant components, technically applicable remanufacturing and maintenance measures were identified and narrowed down within a preselection.

Based on the preliminary work, the next step is the development of the central decision model for intelligent measure selection and its implementation in a software application. For this purpose, sensor data as well as economic, ecological, and technical indicators will be taken into account.

Furthermore, three innovative remanufacturing-based business models are being developed within the project. These are product service system-oriented models, which differ primarily in their ownership and responsibility structure.

Another success of ReLIFE is the participation in the 27th CIRP LCE Conference on Life Cycle Engineering with two publications on the project results.



Project content: Upgrade of a capital good to a demonstrator.

Consortium from research and industry

The results are jointly developed by the consortium partners. The Laboratory for Machine Tools and Production Engineering (WZL) of the RWTH Aachen University is the consortium leader and mainly responsible for the development of remanufacturing measures and the decision model for the application of these measures. The Chair of International Production Engineering and Management (IPEM) of the University of Siegen focuses on the development of remanufacturing-based business models. Achenbach Buschhütten GmbH & Co. KG is significantly involved in the construction of the demonstrator with integrated sensor technology.

The results of the project can be utilized within research as well as by national, international and in particular small and medium-sized companies in order to raise economic potentials through the proactive life cycle optimization of capital goods.

Funding measure

Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

As part of the FONA Field of action 6:

The circular economy – efficient use of raw materials, avoiding waste.

Project title

ReLIFE – Adaptive Remanufacturing for Life Cycle Optimization of Capital Goods

Project duration

01.07.2019 – 30.06.2022

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937.065 Euro

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Networking and transfer project “ReSSWInn”

Design

PM-GrafikDesign

Picture credits

WZL

Status

March 2021



Cover-Picture: “ReLIFE”: Circular economy by means of sensor evaluation.

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PROJECT PARTNERS

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Achenbach Buschhütten GmbH & Co.KG

RePARE Regeneration of Product and Production Systems through Additive Repair and Refurbishment

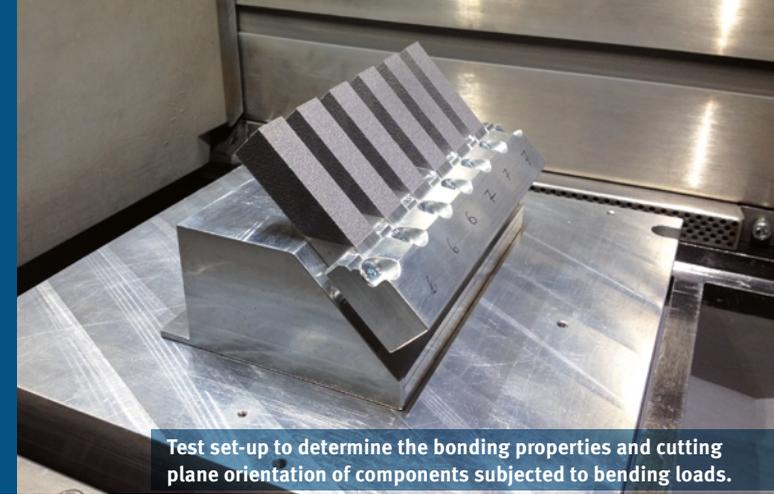


Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

SPONSORED BY THE



In mechanical and plant engineering, the customer-centred improvement of delivery speed and quality is a key objective, whereas resource efficiency has been less of a focus so far. The project “RePARE” aims to complement measures such as preventive maintenance and the high safety stock of spare parts with additive repair procedures, thus enabling the systematic regeneration of spare parts.



Test set-up to determine the bonding properties and cutting plane orientation of components subjected to bending loads.

Additive Repair in Mechanical and Plant Engineering

The competitive pressure in the mechanical and plant engineering industry leads to new strategies to ensure differentiation from global competition. One strategy for enhancing economic and ecological sustainability is to extend the life cycle of machines by converting, replacing or upgrading components. In order to contribute to this, the project is investigating the remanufacturing of partially worn spare parts using additive manufacturing processes such as Selective Laser Beam Melting or Laser Metal Deposition in the sense of additive repair.

With the help of an economic-technical framework, an evaluation is made of which components are suitable for remanufacturing. From a business management point of view, holistic service concepts for the use of additive repair are defined and, by means of parameters, the reparability is evaluated in terms of a rebuild-or-replace decision. The consideration of life cycle assessment extends the view of sustainability.

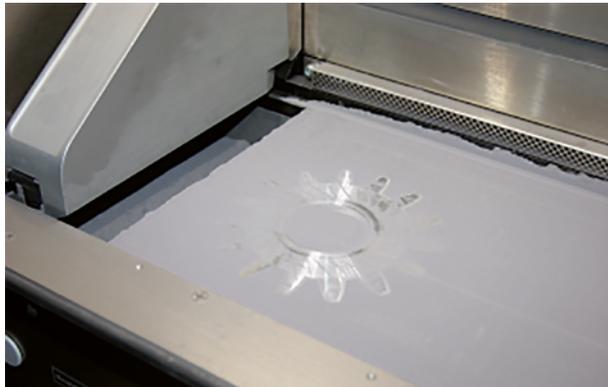
The Potentials

The use of additive manufacturing for the remanufacturing of spare parts is associated with various potentials and challenges, which will be investigated and discussed in the project, also by tests using demonstrator components. On the one hand, the costs incurred by manufacturers, such as spare parts storage and logistics, and customers, such as downtime costs, can be minimized and the life cycle of components extended. On the other hand, there is the challenge of carrying out downstream activities such as installation and removal as well as quality assurance of the spare part with regard to warranty and liability issues. Since the market for additive manufacturing is highly dynamic, the project team also looks beyond the research period in the context of a scenario analysis, for example to anticipate developments in production unit costs.

First results

In the course of the project work so far, potential applications for additive repair and refurbishment have already been identified, even beyond high-priced capital goods, as well as decision variables for the selection of suitable components. Furthermore, a damage classification is used to select suitable repair strategies according to the condition of the component. With the application of Laser Powder Bed Fusion (LPBF) for the repair of demonstrator components, first data for the evaluation of economic and ecological factors could be collected.

For the integration of additive repair into after-sales services, assistance systems were designed to support the assessment of technical feasibility as well as the support of accompanying service activities such as on-site assembly/disassembly.



Building a new geometry onto a conventionally manufactured gear by selective laser beam melting

Consortium and Results

In RePARE, scientists from the German Research Center for Artificial Intelligence (DFKI) are working together with engineers from the Institute for Product Development (IPeG) at Leibniz Universität Hannover. The DFKI team will explore the potential that arises from the business model and the circular economy and provide a summarizing framework by developing a complete system for the systematic integration of additive repair scenarios right through to the service processes. The IPeG investigates different repair strategies for plant engineering components, executes practical tests and subsequently validates the regenerated components. The results are incorporated into an assistance system that supports designers in the design and planning of repair tasks.

From industry, the researchers receive support from DMG Mori Spare Parts GmbH and Windmüller & Hölscher KG. The industrial partners are supporting the project by collecting and classifying wear mechanisms and comparing manufacturing technologies for the recirculation of components. Furthermore, from a practical point of view, questions regarding the type or mechanism of damage, suitable materials and integration into the value chain are of interest. Based on these questions, a quantification of the procedures with regard to processes, life cycle assessment and proportionality can be carried out.

Funding measure

Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

As part of the FONA Field of action 6:

The circular economy – efficient use of raw materials, avoiding waste.

Project title

RePARE – Regeneration of Product and Production Systems through Additive Repair and Refurbishment

Project duration

01.07.2019 – 30.06.2022

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1.338.848 Euro

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Publisher and editorial office

Networking and transfer project “RessWInn”

Design

PM-GrafikDesign

Picture credits

IPeG, Leibniz Universität Hannover

Status

March 2021



Cover-Picture: Repair of an angle lever using Laser Powder Bed Fusion

The project “RePARE” is funded within the funding measure “Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)”.

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PROJECT PARTNERS

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DMG MORI Spare Parts GmbH
Windmüller & Hölscher KG

REPOST

Autoclaved aerated concrete recycling cluster: Development of new options for circular economy



Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

SPONSORED BY THE



REPOST has set itself the goal of creating the basis for a high-quality and economical circular economy of autoclaved aerated concrete (AAC). New and competitive products for masonry constructions are to be created from waste AAC. In addition to direct material recycling, alternative recycling methods – e.g. the production of clinker substitutes – are also being investigated. Ecologically and economically viable business models are being developed on the basis of system analyses.



Powder from post-demolition AAC.

High-quality recycling of AAC

AAC is a building material that has been known and proven for almost 100 years and is also fully recyclable. The recycling of AAC fresh from production, which occurs as cuttings or breakage during production, has been practiced for decades. In contrast, demolished AAC often contains accompanying materials that make high-quality recycling difficult, which is why AAC is usually deposited in landfill after use. Decreasing landfill capacities, legal obligations for the recyclability of products and the protection of primary materials therefore make it essential to find recycling alternatives for this demolition material.

REPOST aims at the reduction of primary raw materials in the production of AAC by recycling AAC at the same or comparable quality level. This concept thus differs from conventional building material recycling. According to statistics, around 90 percent of mineral construction waste was recycled in 2016, but mostly as low-value and one-off down cycling in road construction.

The entire product life cycle at a glance

The REPOST work plan is based on the life cycle of a recycled AAC block and begins with the dismantling and processing of AAC from the existing stock. The central question is which sorting methods are most suitable for obtaining a secondary raw material of the highest possible quality.

The secondary raw material thus obtained is to be used directly as an aggregate for new masonry products. These can be calcium silicate units (CSU) and lightweight concrete blocks or even new AAC blocks.

AAC contains a large proportion of deacidified lime, which was produced with high energy input and high CO₂ emissions. Where recycling within a closed cycle is not possible, thermal conversion into dicalcium silicate, a main component of cement clinker, is being investigated. The aim is to partially replace the primary raw materials cement or lime in the production of AAC with a recycled product that causes lower CO₂ emissions and energy expenditure during its manufacture.

With the involvement of building owners, demolition companies and processing companies, business models for the new recycling options are being developed over the entire life cycle.

First results

At project start, Otto Dörner delivered 25 tons of pre-sorted post-demolition AAC to the Xella granulate plant in Rotenburg/Wümme. After a visual inspection for critical foreign matter the material was subjected to crushing. The resulting AAC-powder was free of pollutants according to LAGA M20, TR Boden, so that from a chemical point of view there were no application restrictions for its utilization.

First application tests to produce belite using the Resynergy process were successfully completed at the KIT-ITC.

Various recipes for the production of new AAC or calcium silicate units using post-demolition AAC were developed at the pilot plant of Xella's R&D-Center. It could be demonstrated that standardized or approval-relevant material parameters can be achieved without any effort up to certain added quantities. In the next step, these results are to be validated by upscaling in selected production plants.

By means of modelling, site-specific (at district level) volumes of post-demolition AAC that would accrue by 2050 were determined by KIT-IIP. Currently, the IIP is working on the techno-economic analysis of all considered recycling options for post-demolition AAC as well as on the modelling of possible circulation systems.



AAC small-scale test specimen after hydrothermal curing

Applied and basic research

The Hamburg-based company Otto Dörner Entsorgung GmbH will focus on the sorting of AAC in various quality grades and will provide the project partners with waste AAC for the development of recycling products.

The chemists from the Institute of Technical Chemistry (ITC) at the Karlsruhe Institute of Technology (KIT) will adapt the process developed and patented there for the conversion of mineral residues to Belit ("Resynergy") for the starting material AAC.

The Institute for Industrial Production (IIP) of KIT will model the new recycling options in a comparative system analysis. Taking into account the informational, economic, and regulatory framework conditions to be complied with, an assessment is made over the entire life cycle.

Project coordination is carried out by Xella Technologie- und Forschungsgesellschaft mbH, the R&D facility of the AAC and CSU manufacturer Xella. In addition, building material prototypes are developed here on a small and large-scale technical scale and finally transferred to production in selected Xella plants.

Funding measure

Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

As part of the FONA Field of action 6:

The circular economy – efficient use of raw materials, avoiding waste.

Project title

REPOST – Autoclaved aerated concrete recycling cluster: Development of new options for circular economy

Project duration

01.06.2019 – 31.05.2022

Funding reference number

033R249A–D

Funding volume of the project

821.836 Euro

Internet

reziprok.produktkreislauf.de

Publisher and editorial office

Networking and transfer project "ResWiInn"

Design

PM-GrafikDesign

Picture credits

Dr. Oliver Kreft

Status

March 2021



Cover-Picture: Visual inspection of post-demolition AAC (25 t) before crushing/milling: Uncritical accompanying materials such as paint, wallpaper residues, mortar/glue, corrosion protection and one (!) dowel.

The project "REPOST" is funded within the funding measure "Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)".

"ReziProK" is part of the research concept "Resource-efficient Circular Economy" of the Federal Ministry of Education and Research (BMBF) as part of the FONA Field of action 6: "The circular economy – efficient use of raw materials, avoiding waste" and supports projects that develop business models, design concepts or digital technologies for closed product cycles.

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Karlsruher Institut für Technologie (KIT), Institut für Technische Chemie (ITC)

ResmaP

Resource efficiency through smart pumps



Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

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ResmaP relies on the innovations of smart pumps of the latest generation in order to save valuable resources through new processes, forms of organization, and exchange and spare parts strategies. Innovative approaches, such as remote maintenance or remote-update capability, are used in a targeted manner to increase the service life of the products on the one hand, and to ensure that replaced pumps and components are recycled at a high level of value preservation.



Heating pumps in the internet of things

Modern smart pumps make it possible to record and transmit valuable data on the condition, e.g. malfunctions, and the conditions of use of the product throughout the life cycle of the pump. This data can be used by service personnel and specialist technicians to simplify fault diagnosis and repair. In addition, this data can provide information for further product development. In ResmaP, the project consortium plans to use these new possibilities specifically to increase resource efficiency.

Whereas previous developments in the field of pump technology have focused mainly on energy efficiency in the utilization phase, ResmaP focuses on the area of material efficiency. For example, the technical possibilities of smart pumps should help to reduce resource consumption by extending the service life and targeted recycling of products and components considerably. To this end, the processes along the distribution chain, especially in maintenance and repair and in the return of products, are to be redesigned. This is intended to make optimum use of the resource efficiency potential inherent in smart pumps.

Closer cooperation

The use of resource efficiency potential through smart pumps requires two things in particular: firstly, precise knowledge of resource consumption over the entire product life cycle of the product and secondly, an increased willingness to cooperate between the actors. The skilled tradesmen and women in particular play a decisive role here. The skilled tradesman is usually the one who installs and maintains the heating pump and also decides when and whether a pump needs to be replaced or whether repair or replacement of certain components is sufficient.

In order to achieve the project objectives, the cooperation between pump manufacturers and skilled tradesmen is to be intensified in future. Other parties involved, such as wholesalers and facility management for larger residential units, are also to be involved accordingly. This requires a profound redesign of the processes and organisational structures between the actors. In order to achieve these goals, the project will test and evaluate new processes and organisational forms in maintenance and repair as well as in the return and dismantling of products and components – starting with a detailed investigation of resource consumption – from raw material extraction to recycling.

First results

Throughout the first half of the project, the team was able to gain valuable insights into the potential of selective circulation of pumps as well as levers for increased resource efficiency throughout the pumps' lifecycle enabled by digitalisation and the introduction of smart products. Existing processes for repair and maintenance of pumps were analysed in detail and adapted to allow for the implementation of remote processes enabled by smart pumps. Preliminary assessments hint at potential savings in both repair and maintenance related travel as well as a reduced overall number of spare parts needed. In parallel the LCA study was advanced by gathering information on products, materials and processes involved and a corresponding model is being developed. Initial findings were presented at the Electronics Goes Green 2020 conference in September with additional publications currently being explored.



A new pump from the lead company WILO SE.

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Expected project results

The aim of the project is a new process of maintenance and repair and the replacement and recirculation of pumps, which has been tested in pilot trials. This new practice, initially tested by service technicians of the Wilo SE company, enables the extensive use of the resource efficiency potentials of smart pumps. In the course of the project, the results will be processed for external actors such as specialist tradesmen in a target-group-oriented manner in order to enable them to act in a resource-efficient manner in the future, which is reflected both in longer product lifetimes and in high-quality closed product cycles.

In order to achieve the project goals, Wilo SE, as a leading pump manufacturer, has joined forces with the Fraunhofer Institute for Material Flow and Logistics IML, whose focus is on recycling management and process design, and the TH Köln University of Applied Sciences with its focus on resource-side evaluation.

Funding measure

Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

As part of the FONA Field of action 6:
The circular economy – efficient use of raw materials, avoiding waste.

Project title

ResmaP – Resource efficiency through smart pumps

Project duration

01.07.2019 – 31.12.2021

Funding reference number

033R233A-C

Funding volume of the project

817.418 Euro

Internet

reziprok.produktkreislauf.de

Publisher and editorial office

Networking and transfer project “ResWInn”

Design

PM-GrafikDesign

Picture credits

Wilo SE

Status

March 2021



The project “ResmaP” is funded within the funding measure “Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)”.

“ReziProK” is part of the research concept “Resource-efficient Circular Economy” of the Federal Ministry of Education and Research (BMBF) as part of the FONA Field of action 6: “The circular economy – efficient use of raw materials, avoiding waste” and supports projects that develop business models, design concepts or digital technologies for closed product cycles.

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PROJECT PARTNERS

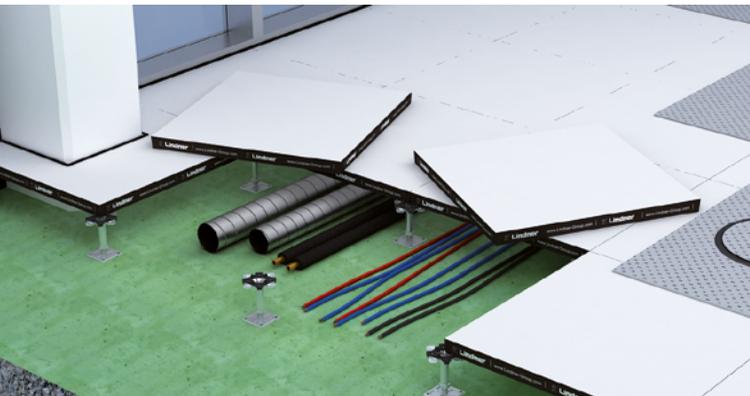
Fraunhofer Institute for Material Flow and Logistics IML, Dortmund
Technische Hochschule Köln, Köln

Commercial premises are converted at relatively short intervals because they are subject to frequent changes of use or changing needs of the tenants. The aim of the RessProKA project is to develop technical and financial solutions to keep the building products used for commercial premises in circulation for as long as possible.



RessProKA

Closing resource-efficient product cycles in the finishing trade through new business models



Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

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Resource-relevant finishing trade

The finishing trade is the most important sector in the construction industry in Germany with a transaction volume of around 136 billion euros and around 1.2 million employees in 252,000 companies. The building products used in this sector have significantly shorter turnaround times compared to carcass construction, usually less than ten years.

RessProKA focuses on the optimisation of the technical cycle and the development and implementation of commercial and legal elements in business models for products which may remain the property of the manufacturers throughout their entire service life. After use, the manufacturers are also responsible for recycling and remanufacturing. RessProKA pursues a systemic approach, which is intended to enable the transfer of the developed models to other construction products in terms of concept and instruments.

Interior as an examination unit

For this purpose, in contrast to previous approaches with individual solutions, the interior is considered as a unit and all elements contained therein such as doors, floors, etc. are included in the investigations. As a result, a large number of different material flows and materials are taken into account. The focus here is on commercial and public building construction. In this area, more standardised construction methods are used, the replacement cycles are significantly shorter and the degree of individualisation is much lower than, for example, in private residential construction. The possibilities offered by digitization – for example, by means of Building Information Modeling (BIM) – for data documentation and for marking for location and tracking are also to be investigated and evaluated. These evaluations will also feed into the development of new approaches.

In addition to a further optimisation of the preliminary work already carried out at the project partner Lindner Group KG with regard to technical aspects such as construction, maintenance, deconstruction and recycling, processing and possible applications of secondary raw materials, the questions of concrete implementation in a business model are the focus of the considerations. Only if the corresponding approaches offer incentives for both, producers and customers, the comprehensive realization of closed circle for these products can be expected.

First results

The market assessment revealed a positive development in office space. Due to the prevailing trend towards working from home, in this regard, no significant change is expected in the future.

In particular, the steady reduction in average lease terms underpins the current project's approach of offering interior business models that support customers during conversion and refurbishment cycles in the interests of resource efficiency.

To develop the business models, a canvas analysis was carried out first. As a result, the material and formal objectives as well as the cost structure of the further business consideration were defined.

An ecological assessment of the business model variants permanently accompanies the development of the models.



Mixed construction waste unsuitable for high-quality recycling

Potential for application

The Lindner Group, Europe's largest manufacturer of interior finishing systems for the main areas of ceilings, floors and walls, as well as a complete service provider in the field of drywall construction, will, together with its research partner IWARU from Münster University of Applied Sciences, develop the technical solution approaches which enable the recycling-compatible deconstruction and reuse of interior design elements. BIFAS, an independent research and consulting institute, is responsible, among other things, for developing models that create commercial and legal incentives to maintain the technical and material possibilities of modular building products over several life cycles.

If possible, these business models are to be generalised to such an extent that transferability to other construction products and other construction sectors is possible. Important support in this respect is also provided by the associated partners involved in the project, such as Schüco, e.g. for the window, external doors or veneer segments, and the Re!source Stiftung e.V., as an independent initiative from business, society, science and politics.

Funding measure

Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

As part of the FONA Field of action 6:

The circular economy – efficient use of raw materials, avoiding waste.

Project title

RessProKA – Closing resource-efficient product cycles in the finishing trade through new business models

Project duration

01.07.2019 – 30.06.2022

Funding reference number

033R250A-C

Funding volume of the project

528.859 Euro

Internet

reziprok.produktkreislauf.de

Publisher and editorial office

Networking and transfer project “RessWInn”

Design

PM-GrafikDesign

Picture credits

P. 1: Lindner Group KG, Arnstorf

P. 2: IWARU, Münster

Status

March 2021



Cover-Picture: The components of this Nortec raised access floor can be almost completely reused or recycled.

The project “RessProKA” is funded within the funding measure “Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)”.

“ReziProK” is part of the research concept “Resource-efficient Circular Economy” of the Federal Ministry of Education and Research (BMBF) as part of the FONA Field of action 6: “The circular economy – efficient use of raw materials, avoiding waste” and supports projects that develop business models, design concepts or digital technologies for closed product cycles.

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PROJECT PARTNERS

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UPZENT



“Upcycling Centre” – A participatory business model to raise awareness and implement a resource-efficient circular economy

Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

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In UpZent the approach of the Upcycling Centre is transferred into a transferable business model and tested at several locations. Suitable forms of organisation are being investigated for this purpose. The aim is to work out a business model for a resource-efficient circular economy around the topic of upcycling in order to establish a socio-economically sustainable structure. The production of upcycling products and the sensitisation of interested stakeholders are to contribute to a resource-efficient circular economy



Circularity at regional level

The project leader, the Institute for Applied Material Flow Management (IfaS), has been operating an upcycling centre since 2016. UpZent is a project for circular economy, qualification and integration, which is being implemented in the district of Neunkirchen (Saarland) and in Herzogenrath. In the project, furniture and products are developed by product designers of K8 gmbH and produced by a social company as part of qualification measures. In the sense of a resource-efficient circular economy, the aim is to establish a sustainable cascade through the conversion and upgrading of commercial waste materials at regional level on a permanent basis and in dialogue with companies, recyclers and consumers.



Economic model

Upcycling implies cycle-oriented and intelligent product designs, choice of raw materials, and production and reuse processes. This in turn requires trans-sectoral cooperation between different actors along the entire product life cycle, from product design and manufacture to use and recycling. The concept of the Upcycling Centre, which has already been developed and tested by IfaS, is based on a sustainable education strategy of the participants and supports their networking. The further development of the Upcycling Centre into a self-supporting business model enables transferability to other regions and can promote the system change towards a circular economy in Germany.

Research questions that are being addressed in this project are:

- Is it possible to jointly use economies of scale and standardisation so that a model can be organised in an economically viable manner?
- Is it possible to influence product design, production or the reuse of materials via an upcycling centre?
- What contribution can this instrument make in terms of the EU objective and taking into account the waste hierarchy in regional as well as decentralised structures?

First results

From the beginning of the project, more than 2,000 products from commercial residues such as waste wood, old textiles or kite material have been produced by the partners AQA gGmbH in Neunkirchen and FAUK e. V. in Herzogenrath. In the course of the project, the network partners continuously developed and optimized the circular product design, the manufacturing process, as well as product quality and security.

In the regional environment of the UpZent locations in Neunkirchen and Herzogenrath, cooperation's with local partner companies have been successfully settled. UpZent currently cooperates with around 20 companies for the acquisition of residual materials.

The goals of this cooperation are the cascading use of residues, as well as the sensitization of the partner companies to a recycling and resource efficiency. This also raises the actors' awareness of sustainable consumption.

UpZent was selected as one of six best practice projects as part of "KreativLandTransfer". Thanks to their outstanding commitment to innovative design and circular economy, the selected projects serve as role models for stakeholders across Germany.

UpZent has currently a successful cooperation with the Service Agency Communities in One World (SKEW) from Engagement Global gGmbH, where the IfaS supports local communities in Saarland in the implementation of the Sustainable Development Goals (SDGs). For this purpose, UpZent stools were made from leftover cardboard and waste wood, which represent the 17 goals for sustainable development.

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Project team from research and companies

The project pursues an inter- and transdisciplinary research approach with high practical relevance. Therefore, in addition to the two university partners, the Trier University of Applied Sciences and the Saar University of Fine Arts, three upcycling centres are to be integrated as practice models and research platforms. Furthermore, the manufacturing industry and the waste management sector will be integrated.

In order to ensure that the project is processed efficiently and effectively, the upcycling centre already established in Neunkirchen and its corporate partners will act as a best practice model. The second project partner is also a non-profit organisation in Herzogenrath in the Aachen region. The third location will be found during the project period.

The project team aims to develop the success factors for transferability. Essentially, these are suitable instruments and standardisation as well as the selection and design of a long-term sustainable business model.

The research results thus enable interested parties to implement innovative and economically viable product cycles or cascade systems and to organize themselves within a network in such a way that economies of scale and synergies can be tapped.

The project "UpZent" is funded within the funding measure "Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)".

"ReziProK" is part of the research concept "Resource-efficient Circular Economy" of the Federal Ministry of Education and Research (BMBF) as part of the FONA Field of action 6: "The circular economy – efficient use of raw materials, avoiding waste" and supports projects that develop business models, design concepts or digital technologies for closed product cycles.

Funding measure

Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

As part of the FONA Field of action 6:

The circular economy – efficient use of raw materials, avoiding waste.

Project title

UpZent – "Upcycling Center" – A participatory business model to raise awareness and implement a resource-efficient circular economy

Project duration

01.09.2019 – 31.08.2022

Funding reference number

033R239A

Funding volume of the project

961.388 Euro

Internet

reziprok.produktkreislauf.de

www.upcycling-zentrum.de

Publisher and editorial office

Networking and transfer project "ReSSWInn"

Design

PM-GrafikDesign

Picture credits

Trier University of Applied Sciences.

Institute for Applied Material Flow

Management (IfaS), UpZent, 2021

Status

March 2021



Cover-Picture: In "UpZent", new products are created from residual materials

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Förderverein Arbeit, Umwelt und Kultur in der Region Aachen e. V.

(FAUK e. V.)

Wear2Share Innovative circular business models in the textile industry



Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

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Federal Ministry
of Education
and Research

FONA

Research for sustainability

Field of action 6:
The circular economy –
efficient use of raw materials,
avoiding waste.

Innovative circular business models in the clothing sector no longer offer clothing for sale, but for temporary rental. This is because small children's clothing or fashionable women's clothing in particular is often not worn for very long. "Wear2Share" investigates whether and how such business models lead to more sustainable consumption, how they can be optimized economically and ecologically, and whether they are suitable for mass consumption in the long term.



Renting instead of buying

Clothing leads to a high direct and indirect consumption of resources due to the large quantities that are consumed. At the same time, the potential for savings is also very high, as on average one in three garments is never worn or is worn less than once in three months. New circular business models could help to avoid such unused purchases and contribute to a much more efficient use of garments. They make clothing available on loan, thus ensuring that unworn garments quickly find a new user. However, not every circular business model automatically leads to improvements in the environmental performance since the savings in resources can be offset by high logistics and cleaning costs.

The aim of the project Wear2Share is to analyze the ecological and economic sustainability potential using two exemplary circular business models and to clarify the question of whether these circular business models really do help to improve the environmental impact of garments. In addition, boundary conditions are identified that influence the environmental assessment of the models. Finally, the project examines potential for optimization in the business model.

Digital potentials

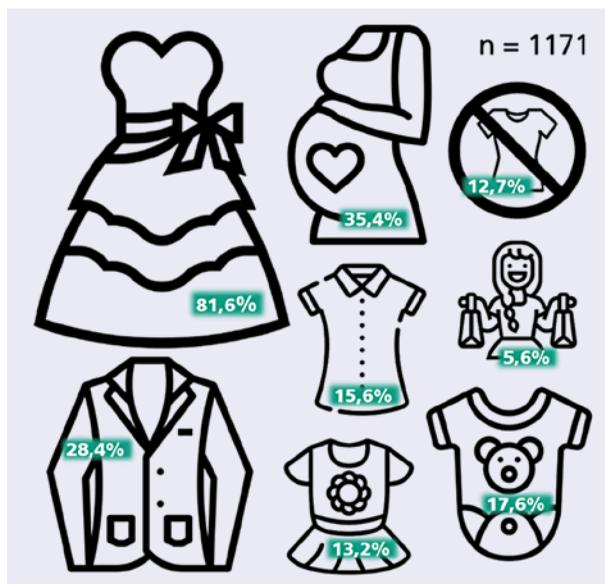
New circular business models become possible with the help of digitalisation. Digital access and the convenient lending process make these business models able to compete with conventional purchasing. To find out how well these new lending models are being accepted, researchers have already conducted consumption studies and representative surveys to determine their market potential as well as consumers' motives for use. The data thus obtained further serves as the basis for the subsequent life cycle assessment. In addition, in-depth interviews with the project partners of Relenda GmbH as well as an analysis of relevant business data provide information about possible optimization potential for the digital business model of rental clothing.

First results

The survey of women aged 20-59, which is representative of Germany, found that around a third (31.8%) of the women surveyed could imagine renting clothing for their own use. The most important reason for renting clothing, according to the survey, is the possibility of not having to buy clothing that is only needed once (76.7%). Another reason for 60.6% of women is to avoid making bad purchases that are hardly ever worn, closely followed by the desire to try out new styles without obligation (60.2%). Slightly more than half (52.6%) think that renting clothes

would be better for the environment or would be happy to have more variety in their own closet (52.6%). Potential savings, however, are not a significant motive for renting clothing, as only 13.7% of the women gave this as a reason.

Two-thirds of women (68.2%) surveyed currently can-not imagine renting clothing. The biggest concern of the respondents (69.5%) is that they could be held liable for possible damage to the rented garments, closely followed by the desire to own garments and not just rent them temporarily (65.5%). At the same time, more than half of the women (55.1%) fear that rented garments could show signs of wear and tear or that renting would become too expensive in the long term (52.8%). Finally, 47.4% of women do not want to wear clothes that strangers have already worn and 37.3% find the concept of the rental system to be impractical.



What type of clothing would you rent? Clothes for special occasions (81.6%); maternity wear (35.4%); business wear (28.4%); everyday wear for women (15.6%) or children of different age groups (0-3 years: 17.6%; 4-12 years: 13.2%; 13-18 years: 5.6%); none of these categories (12.7%).

reziprok.produktkreislauf.de/en

Team of researchers and companies

In the project Wear2Share, researchers at Fraunhofer ISI (Karlsruhe) work together with existing companies in order to shed light on current circular business models operating in the market. Relenda GmbH offered various digital rental models for children's and ladies' wear through the end of 2020. In the project, the company therefore provided its expertise and insights based on real-world experiences as well as data from its own rental platforms. In addition, the manufacturers' perspective is incorporated through the associated participation of bubble.kid berlin kidswear, a manufacturer of durable children's clothing, as well as the expertise of Thekla Wilkening, an expert for circular business models in the textile and clothing industry.

The project provides insights into the sustainability of circular business models and aims to clarify which product groups lend themselves to being transferred to such circular business models. In addition to generating new insights, the project focuses on the strategic transfer of knowledge into practice in order to show companies that are committed to the circular economy which paths exist to sustainable development.

The project „Wear2Share“ is funded within the funding measure „Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)“.

„ReziProK“ is part of the research concept “Resource-efficient Circular Economy” of the Federal Ministry of Education and Research (BMBF) and supports projects that develop business models, design concepts or digital technologies for closed product cycles.

Funding measure

Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

As part of the FONA Field of action 6:
The circular economy – efficient use of raw materials, avoiding waste

Project title

Wear2Share – Innovative circular business models in the textile industry

Project duration

01.07.2019 – 30.06.2022

Funding reference number

033R248

Funding volume of the project

402.154 Euro

Internet

reziprok.produktkreislauf.de

Publisher and editorial office

Networking and transfer project “ResWiInn”

Design

PM-GrafikDesign

Picture credits

Titel: © Relenda GmbH

S. 2: © Pexels

S. 3: Fraunhofer ISI with icons from flaticon.com
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Status

March 2021



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Thekla Wilkening UG

RessWinn

Networking and transfer project
for the BMBF funding measure
„Resource-efficient Circular Economy –
Innovative Product Cycles



SPONSORED BY THE

The networking and transfer project “RessWinn” networks the research teams of the funding measure “Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)” of the Federal Ministry of Education and Research (BMBF), provides them with technical support and supports the transfer of the results into economic practice.



From a linear to a circular economy

Against the background of the ecological consequences of the high consumption of resources and the limited availability of raw materials, it is indispensable to fundamentally transform the hitherto mostly linear economy along the raw material extraction – production – use – disposal chain into largely closed cycles.

The aim of the research projects of the BMBF funding measure “ReziProK” is to contribute to the implementation of a resource-efficient circular economy by closing product cycles. The research results are then to be immediately transferred into economic practice and marketable products in order to strengthen companies in Germany as competitive suppliers of circular economy solutions.

Commonality in the network

The “ReziProK” projects are looking for innovative solutions and concepts in various sectors and subject areas such as the electrical and construction industry, the plastics industry and electromobility. The networking and transfer project “RessWinn” aims to support a lively exchange by networking the individual projects within and outside the funding measure. By identifying cross-relationships, potential is to be fully exploited and synergy effects generated in order to strengthen the projects and support a “thinking-outside-the-box”.

In concrete terms, “RessWinn” supports the establishment of cross-project issues that are discussed in discussion forums and workshops. Target group-specific “ReziProK” events, such as status conferences and parliamentary evenings, contribute to networking within the funding measure and with relevant external actors and national and international research activities. In this way, the research approaches and results are discussed in the funding measure and in the respective value-added chains – with the involvement of further stakeholders from the economy, politics, science organisations, environmental and social interest groups – and the dissemination of results is supported.

RessWInn also offers overarching public relations work, which includes the provision of information materials, the ReziProK internet platform and a presence in social media. This strengthens the visibility of the projects; a joint appearance provides more reach to the public as well as to relevant target groups in business, politics and scientific organisations and involves them in the dialogue with the funding measure.

“RessWInn” also offers the “ReziProK” projects intensive support in transferring the project results into economic practice, if required. If desired, the projects can be supported in evaluating the exploitation potential of their project results and in feeding transferable results into relevant platforms, databases and networks.



Cross-project issues can be discussed together in discussion forms and workshops.

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Partner for networking and exchange

DECHEMA is the competent network for chemical engineering and biotechnology in Germany. As a non-profit professional society, it represents these fields in science, industry, politics and society and promotes the technical-scientific exchange of experts from different disciplines and organizations. DECHEMA contributes its many years of experience in the coordination, networking and public relations work of research and development projects and scientific accompanying projects to other BMBF funding priorities in “RessWInn”.

The company N³ Nachhaltigkeitsberatung Dr. Frieger & Partner complements the competences of DECHEMA with further expertise, practical and project experience, among others in the fields of environmental economics and resource management (private and public sector), sustainability assessment as well as technology and knowledge transfer and networking of stakeholders along value chains.

Funding measure

Resource-efficient Circular Economy – Innovative Product Cycles (ReziProK)

As part of the FONA Field of action 6:
The circular economy – efficient use of raw materials, avoiding waste.

Project title

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