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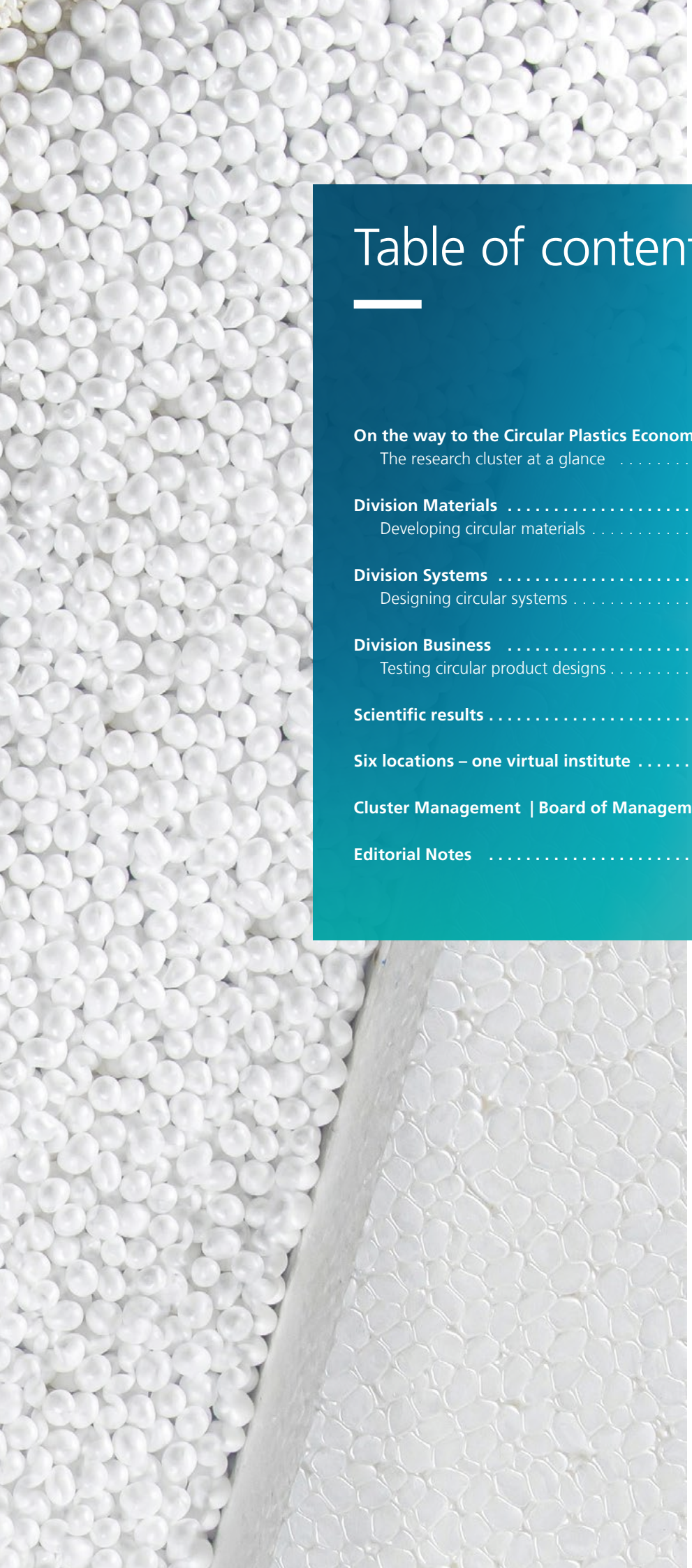
CCPE

Fraunhofer Cluster of Excellence
Circular Plastics Economy CCPE

Circular Plastics Economy

Keeping plastics in the loop

www.ccpe.fraunhofer.de/en.html



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On the way to the Circular Plastics Economy

Plastic is the material of our present and future. It is light, functional and inexpensive. It is used in cars, electronics, cosmetics and furniture, and in almost all areas of medicine. At the same time, however, this polymer all-rounder is regarded as a disposable item and an environmental pollutant. An image that overshadows its enormous potential.

2020, global plastics production was almost 367 million tonnes, of which 55 million were produced in Europe.* The material is especially applied in the packaging industry, the construction industry, the vehicle construction and the electronics industry. And the demand continues to rise.

Inefficient recycling systems: Too much plastic ends up in the environment

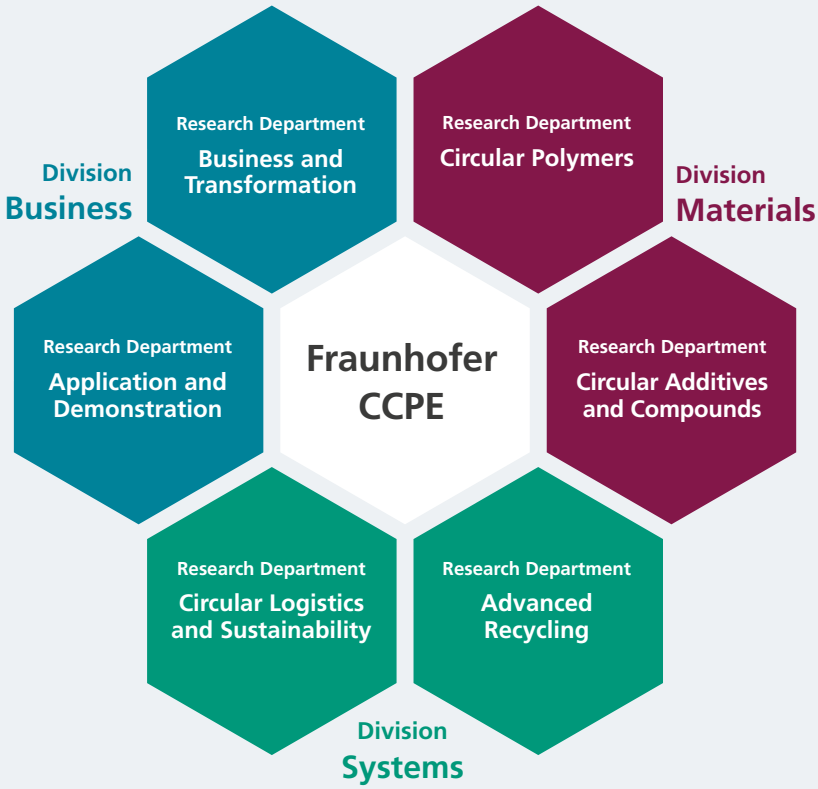
However, globally, we are still trapped in a linear plastics economy worldwide. Plastic waste is often landfilled or ends up as litter in the environment. Recycling systems are inefficient or absent altogether. Few plastic recyclates reach a sufficiently high quality to be processed into new products.

The handling of plastics must change

The solution: Our approach to plastics must change fundamentally. We need to find the path to a Circular Plastics Economy in which fewer fossil resources are extracted, products are used for longer, and end-of-life losses are reduced.

This is where the Fraunhofer Cluster of Excellence Circular Plastics Economy CCPE comes in. Together with partners from industry, six institutes of the Fraunhofer-Gesellschaft are developing system services for a functioning Circular Plastics Economy. How must plastic products be designed so that they do not end up in the environment after use? When does your product become part of the Circular Plastics Economy? And how can plastics that end up in the environment be degraded quickly and without leaving residues?

* https://s.fhg.de/plasticseurope



The cluster is divided into three divisions

The research cluster at a glance

Research and development is networked along the life cycle of plastic products. Tailor-made plastics, optimized systems and successful business models are the results of these research projects.

The transformation from a linear to a Circular Plastics Economy can only succeed with a multi-stakeholder approach. The Fraunhofer Cluster of Excellence Circular Plastics Economy CCPE therefore combines the competencies of six institutes of the Fraunhofer-Gesellschaft and cooperates closely with partners from industry. Together, we work on systemic, technical and social innovations, focusing on the entire life cycle of plastic products.

Who?

Six research institutes have joined forces: the Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT (management), the Fraunhofer Institute for Applied Polymer Research IAP, the Fraunhofer Institute for Chemical Technology ICT, the Fraunhofer Institute for Material Flow and Logistics IML, the Fraunhofer Institute for Process Engineering and Packaging IVV and the Fraunhofer Institute for Structural Durability and System Reliability LBF.

What?

The aim of the Fraunhofer CCPE is to bundle competencies and to provide a central point of contact for the Circular Plastics Economy. Economic developments and social consequences are analyzed and a sustainable change process is designed.

Why?

Currently, more resources are being consumed worldwide than the existing ecosystems can supply. In order to achieve sustainable development, both the management of goods and the lifestyles of society must be fundamentally changed. The research cluster is committed to the United Nations' Sustainable Development Goals (SDGs) – especially goal number 12: "Responsible consumption and production."

How?

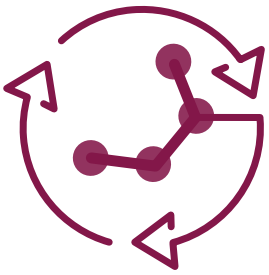
Research and development work is carried out in three divisions, which are oriented to the life cycle of plastic products. Two research departments are assigned to each of these divisions.

Division Materials

Developing circular materials

In the **Division Materials,** plastics from a sustainable mix of resources are processed into functional and durable materials for a closed-loop economy. Polymers and compounds based on circular principles and environmentally compatible additive systems ensure stable recyclates, multiple recycling processes and – if necessary – controlled degradation in the environment.

Division
Materials



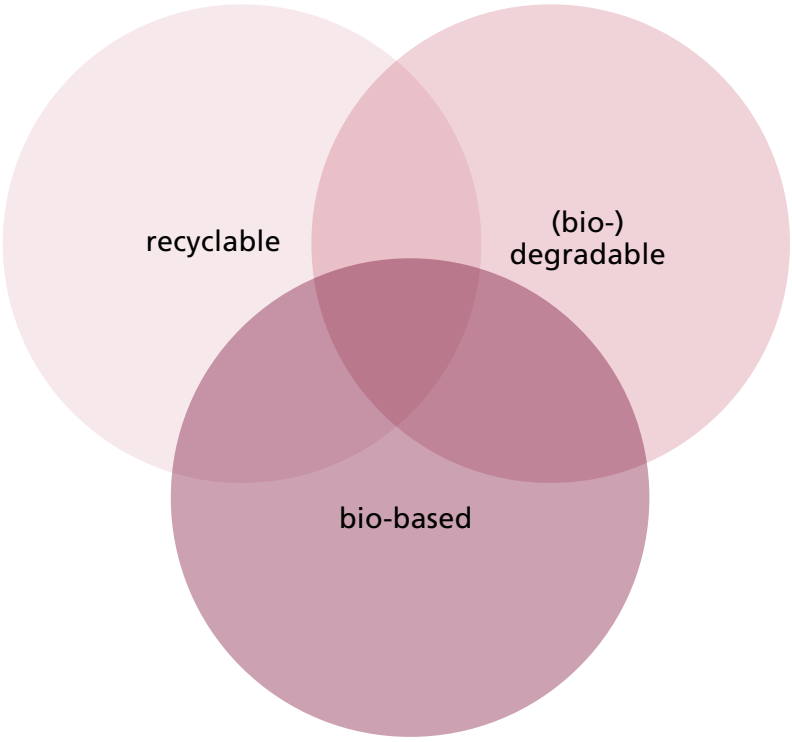
Research Department "Circular Polymers"

At the beginning of the plastics value chain is the polymer, a chemical substance consisting of macromolecules. Synthetic or semi-synthetic polymers are the main components in the production of plastics. We research new polymer syntheses and processing methods to obtain recyclable and degradable materials based on renewable raw materials.

In order to be able to link biobased building blocks into new polymers, we further develop existing synthesis techniques or modify the chain architecture of known polymers accordingly. In addition, we are designing innovative processing technologies in order to be able to develop self-reinforced single-component materials.

A particular focus of research activities is on the aging and degradation behavior of plastics. The various life cycle phases and environmental influences are simulated under realistic conditions with the aid of test rigs. Certain parameters such as temperature, UV light, oxygen and moisture provide important information for controlling the desired degradation behavior.

Division Materials



Your benefit

Increase the circularity of your materials, avoid plastic emissions into the environment and attract new customers.

Contact us

materials@ccpe.fraunhofer.de

Research Department “Circular Additives and Compounds”

We optimize the functionality and service life of conventional and bio-based polymers. Additives play a decisive role here. They are added to the products as additives to ensure gentle and safe processing and to enable long-term properties such as stability. Additives are also used to adjust the properties of plastics to suit specific applications.

We develop tailor-made additives and compositions that enable the polymers to be used for a long time, optimally recycled or biodegraded in a targeted manner. To this end, we investigate what prior damage and impurities can be found in plastic waste resulting from private or commercial use, and how new products can nevertheless be created from it. These types of plastic are referred to as “post-consumer recyclates”.

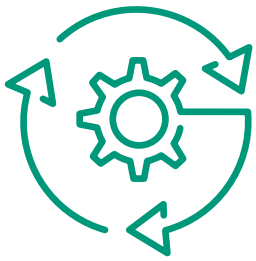
In addition, we are investigating whether and to what extent additive systems made from renewable raw materials can be used. We are developing new bio-based additive systems that allow controlled and, if necessary, time-controlled degradation. We are working on polymers based on fossil raw materials as well as on bio-based polymers, which we are modifying or developing.

Division Systems

Designing circular systems

Efficient collection and transport technologies go hand in hand with new recycling processes. In the **Division Systems,** digitally mapped processes and thus optimal value creation cycles are being created. Intelligent collection, sorting and recycling methods enable plastics to be recovered and used. Digitalization, marking and system analysis enable efficient logistics and the evaluation of product life cycles. In this way, plastic waste becomes "recycled content".

Division
Systems



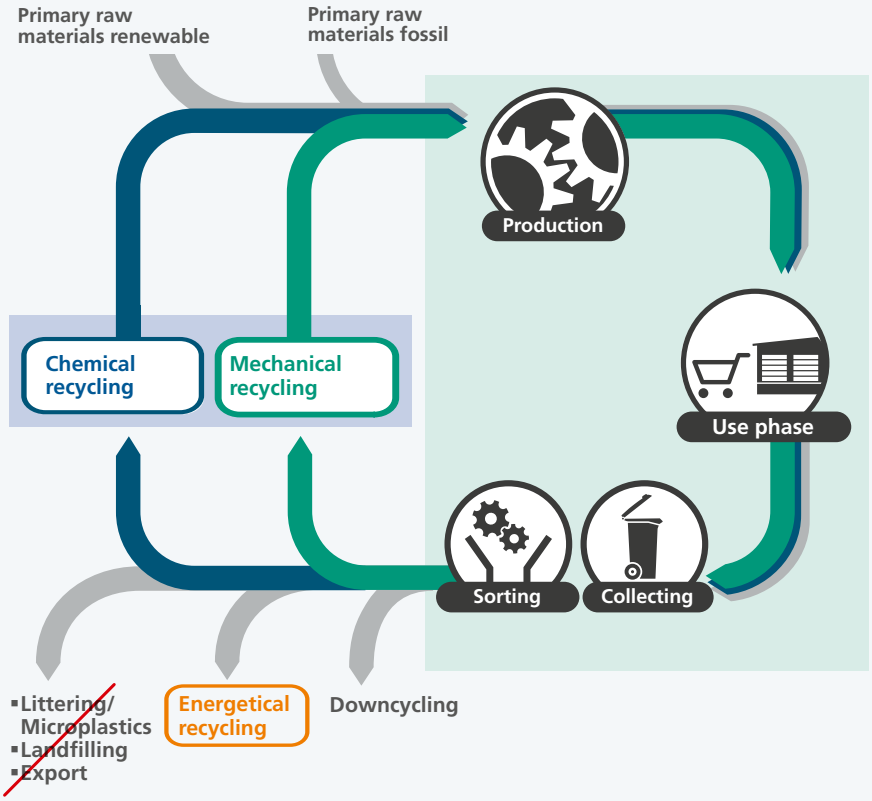
Research Department "Advanced Recycling"

A successful Circular Plastics Economy requires optimized collection and sorting processes upstream of the recycling of valuable materials. Advanced process technologies are used to recover polymers and also monomers, which can be fed into the cycle at the beginning and then further processed into products.

To date we are optimizing the upstream process steps in the recycling of plastics. The aim is to ensure that more suitable material can be returned to production as raw material ("recycled content") during the collection and sorting of plastic waste. We are developing raw and mechanical material processes as well as conceptual approaches. The aim is to recover polymers and monomers from the industry-specific life cycles of plastics that can be immediately processed and used for various applications. For this purpose, chemical recycling processes for conventional and bio-based polymers as well as recycling strategies for bulk plastics such as PS (polystyrene), PET (polyethylene terephthalate) and PU (polyurethane) are being investigated.

We develop conceptual measures for optimized collection and sorting. A holistic approach is particularly important: Our comprehensive analysis therefore takes into account parameters such as eco-efficiency and the cost-benefit ratio. The result is a catalog of measures that takes into account the different sectors and types of plastics and reflects the country-specific development status of waste management.

Division Systems



Research Department “Circular Logistics and Sustainability”

This research department develops innovative processes for efficient logistics. Sustainability assessments and life cycle assessments, taking into account various cycle characteristics, should lead to optimized recycling of plastics. In addition, new assessment methods are to be developed that will indicate the direction of material and product innovations and will allow the circular value chains of plastic flows to be monitored in the futur

In order to be able to efficiently carry out and evaluate the recycling of plastics in the long term, it is necessary to have a complete digital record of the respective recycling status.

With the help of virtual images of plastics and products, for which new methods are being developed in the research cluster, digital transparency is being created as the basis for lifecycle-wide process data management. The concept of the “digital twin” will make it possible to track plastics in the cycle and to evaluate them economically and ecologically. We involve plastics stakeholders from business, science and society in new measures for circular value creation.

Your benefit

Identify circular innovations for your products and increase the proportion of recycled material.

Contact us

systems@ccpe.fraunhofer.de

Division Business

Testing circular product designs

The **Division Business** offers holistic system services for circular plastics across all industries: from assessment tools, product designs and prototypes to recycling, acceptance processes and business models. Material and technology innovations are demonstrated on prototypes and tested in practice. Marketing strategies for circular products will be developed on the basis of a reusable transportbox and a child car seat.

Division
Business

Research Department "Application and Demonstration"

Using two demonstrators, we develop industry-oriented circular product designs. The development is based on the previous circular assessment of the existing products. In addition to high economic efficiency and a long service life, the demonstrators should above all be repair- and recycling-friendly. Their materials should be degradable in the environment, if required.

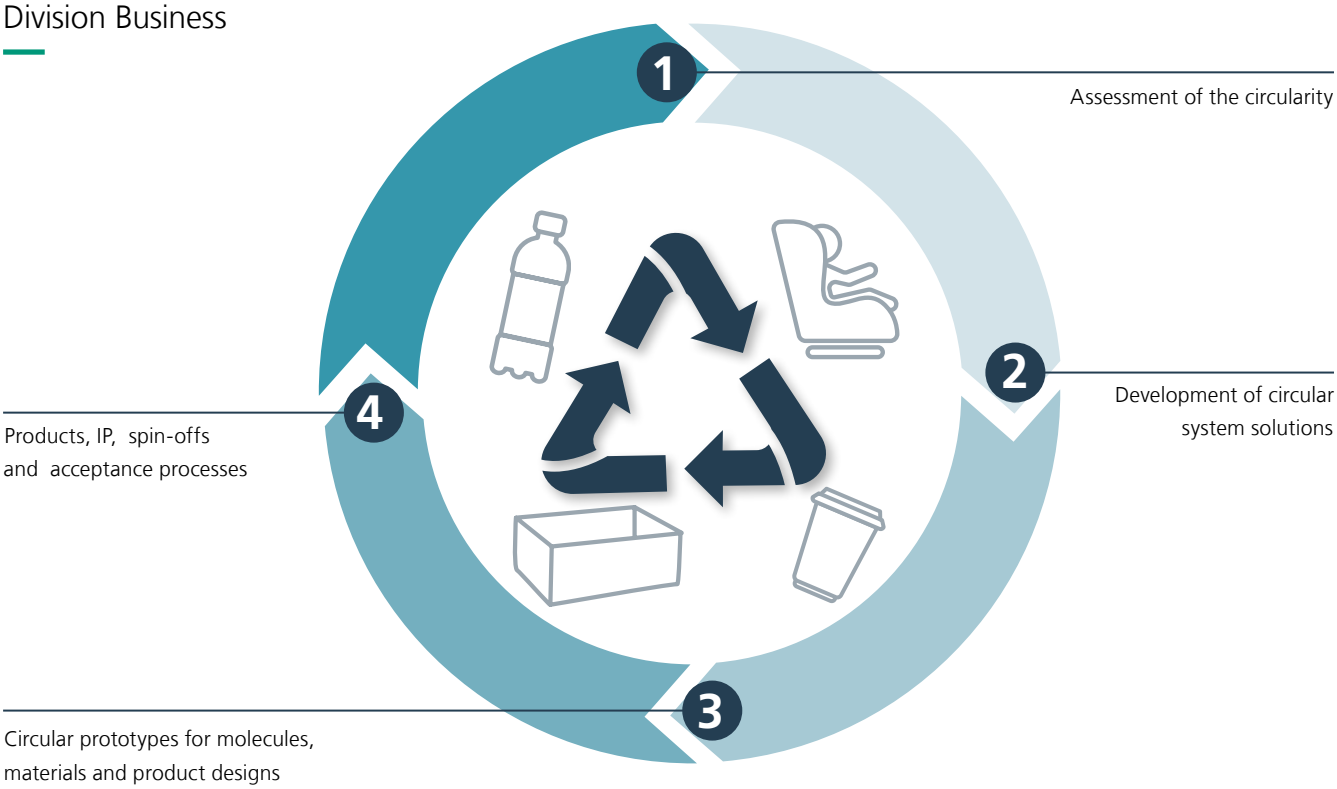
We are combining the newly developed concepts, materials and systems from the Division Materials and the Division Systems into two demonstrators. We have selected demonstrators with great innovation potential that represent a specific market and can be easily transferred to other products.

Demonstrator 1 **reusable transport boxes for online retail**

Demonstrator 2 **child car seat, deputy for other seating systems**

We work together with industry partners to develop the necessary process technologies and possible applications for specific products. The focus is on new processing technologies and the development of new design concepts for recyclable products. Heregy, the properties of durability, reparability and adaptability play an important role.

Division Business



Research Department “Business and Transformation”

The transformation to a successful Circular Plastics Economy will succeed if innovative marketing strategies and new business models are integrated into the overall value network.

For this purpose, the following design tools, for example, are developed and applied:

- Innovative design tools
- Innovation radar
- Modeling circular business models

With this toolbox, the degree of circularity of materials and products is examined at an early stage. The results determine the direction and path of promising material, system and product innovations. They form the starting point for a new innovation cycle.

Your benefit

Find optimal solutions for your target market and benefit from circular product and business models.

Contact us

business@ccpe.fraunhofer.de

Scientific results

The research Cluster Circular Plastics Economy CCPE was launched at the end of 2018. Since then, the scientists have been able to achieve some notable successes – from a test rig for degradation tests in the environment to solutions for material and chemical recycling on a demonstration scale to circular assessment methods. Some of the results at a glance.

Link to the self-check

www.crl.fraunhofer.de

Circular Readiness Level® (CRL®)

Whether products, services or business models – with the help of the Circular Readiness Level® (CRL®), the cluster offers methods and tools to evaluate products and product systems at various levels of detail. The self-check is an easy way to get started: companies can evaluate their products themselves in 15 categories. Among others:

- What about multifunctionality, reparability or dismantlability of a product?
- Does the product consist of secondary, renewable or biodegradable plastics?
- Can the end-of-life product be recycled?

At the end, companies receive an assessment of the Circular Readiness Level® (CRL®) of their measures as well as recommendations for further steps: In life cycle assessments, we compare circular characteristics such as reuse, repair and recycle and quantify the environmental impact of circular strategies.

Extending the service life and recyclability of bio-based plastics

New additives for bio-based plastics such as polylactic acid and polybutylene succinate are being developed in the CCPE laboratory. Their task: to extend the service life and recyclability of the plastics without changing their processing properties. At the same time, the additives are to enable a controlled degradation of plastics in the environment.

> **Wouldn't it be great, if used face masks that may contain viruses or bacteria could be recycled into new masks of like-new quality?"**
>
> **Dr. Peter Dziezok**
> Procter & Gamble Service GmbH

Technical fibers based on polylactic acid (PLA)

CCPE researchers are developing a manufacturing process for PLA-based filament yarns for technical applications using the melt spinning process. By specifically exploiting stereocomplexation, they are achieving an improvement in the thermal properties.

The special feature: Increasing the melting temperature of these fibers allows them to be incorporated into a conventional PLA matrix and to develop innovative, self-reinforced composites that are easier to recycle.

PLA particle foam blowing agent loaded granules (left), pre-expanded particles (center), sintered plate (right).

Chemical recycling of plastics

Composite materials such as CFRP, GFRP, thermosets, resins or residues from the processing of electronic waste and end-of-life vehicles often end up in thermal recycling due to a lack of alternatives. The CCPE researchers want to change this: They are working on a pyrolysis process for the recovery of basic chemicals. This involves depolymerizing glass-fiber-reinforced plastic waste to produce a styrene concentrate that can be polymerized again into polystyrene.

CCPE Innovation Radar

How innovative are products and processes that are intended to help shape a Circular Plastics Economy? The CCPE Innovation Radar provides answers to this question. Based on market research, trend analyses and our own know-how, it is used to classify measures and evaluate market opportunities.

Other results

www.ccpe.fraunhofer.de/en.html

Six locations – one virtual institute

In a word: This is what the players of the cluster say

1 | Darmstadt
The Fraunhofer LBF provides solutions for fatigue strength, system reliability, vibration technology and plastics.

"Mechanical recycling makes a major contribution to mastering the key challenges of our time in a sustainable manner. It has enormous technical and economic potential if we succeed in replacing primary plastics with high-quality recyclates. Tailor-made recyclate additives are the key components for this. This is a key task that the partners in our cluster are tackling."

Prof. Dr.-Ing. Tobias Melz, Director of Fraunhofer LBF | Division Materials/Business

2 | Dortmund
The Fraunhofer IML stands for material flow technology, simulation-based business and system planning, transport systems and resource logistics.

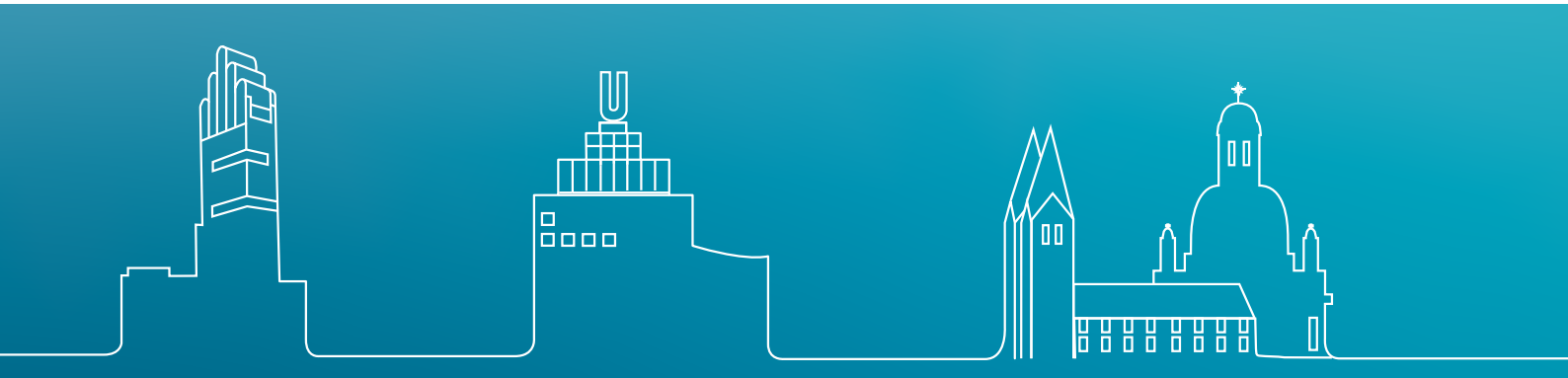
"By bundling competencies in material and product development, recycling technology, digitalization, business development and logistics across institutes, we support the recycling of plastics and create systemic added value for the Circular Plastics Economy."

Prof. Dr.-Ing. Uwe Clausen, Director of Fraunhofer IML | Division Systems

3 | Freising
The Fraunhofer IVV stands for research in the fields of food, packaging, product effects, processing machinery, recycling and the environment.

"Natural resources are becoming scarcer, and at the same time the world's population is growing. On the way to climate neutrality and to relieve the environment, it is necessary to use renewable raw materials industrially and to realize a recycling of technical materials as well as of packaging materials. The transformation to a bioeconomy and circular economy requires our joint action. We have to involve politicians and the population in this process – by guaranteeing quality and safety and by creating acceptance. This is what we are working for as a team in the cluster."

Prof. Dr. Andrea Büttner, Director of Fraunhofer IVV | Division Business



1 | Darmstadt
Mathildenhöhe with wedding tower

2 | Dortmund
Dortmunder U

3 | Sites in Freising, Dresden
Freising Cathedral | Church of Our Lady

"We want to reposition the plastics industry. We want to provide impetus for rethinking the production, use, disposal and recycling of plastics. This is a system-relevant task. That's why, in the Fraunhofer Cluster of Excellence Circular Plastics Economy CCPE, we are relying on a cross-institutional research structure consisting of six partner institutes."

Prof. Dr.-Ing. Eckhard Weidner, Director of Fraunhofer UMSICHT | Head of Fraunhofer CCPE

"The transformation to the circular economy is nothing less than the transformation of the previously established and lived economic logic. The rethinking of products, their use, the handling of products, components or materials, the end-of-life of products and the underlying business model transformations span a broad field of development. We want to shape this transformation together with companies, society and politics."

Dr.-Ing. Manfred Renner, Fraunhofer UMSICHT | Division Business

"Only with a systemic approach, as pursued in the cluster, the future challenges of the plastics processing industry with regard to a circular economy approach can be met. In addition to efforts to develop new, sustainable raw material and material concepts, a rethinking of product design is also necessary to achieve a closed loop of recyclable materials in plastic products."

Prof. Dr.-Ing. Frank Henning, Director of Fraunhofer ICT | Division Systems

"Plastics don't have to be made from the fossil resource petroleum, and they don't have to pollute the environment. Bio-based and/or biodegradable plastics – currently still a niche – will make their contribution in a Circular Plastics Economy. That's what we're working on in the Division Materials."

Prof. Dr. Alexander Böker | Fraunhofer IAP, Director of Fraunhofer IAP | Division Materials

4 | Oberhausen
The Fraunhofer UMSICHT is a pioneer for a sustainable world. With our research in the areas of climate-neutral energy systems, resource-efficient processes and circular products, we make concrete contributions to achieving the 17 Sustainable Development Goals (SDGs) of the United Nations.

5 | Pfinztal
The Fraunhofer ICT is competent in chemical processes, energy systems, explosives technology, new drive systems, plastics technology and composite materials.

6 | Potsdam
The Fraunhofer IAP makes polymers fit for the future and covers the entire field of polymer applications.

4 | Oberhausen
Gasometer

5 | Pfinztal
Fraunhofer ICT / Wind turbine

6 | Potsdam
Sanssouci Palace

Cluster Management

Prof. Dr.-Ing. Eckhard Weidner

Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT | Director
Head of Fraunhofer CCPE
+49 208 8598-1102 | eckhard.weidner@umsicht.fraunhofer.de

Dr.-Ing. Hartmut Pflaum

Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT
Head of Fraunhofer CCPE Office
+49 208 8598-1171 | hartmut.pflaum@umsicht.fraunhofer.de

Julia Kast

Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT
Marketing Officer Fraunhofer CCPE
+49 9661 8155-502 | julia.kast@umsicht.fraunhofer.de

Board of Management

Prof. Dr. Alexander Böker

Fraunhofer Institute for Applied
Polymer Research IAP
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Prof. Dr. Andrea Büttner

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Director | Division Systems

Prof. Dr.-Ing. Tobias Melz

Fraunhofer Institute for Structural Durability and
System Reliability LBF
Director | Division Materials/Business

Dr.-Ing. Manfred Renner

Fraunhofer Institute for Environmental, Safety
and Energy Technology UMSICHT
Division Manager | Division Business

Editorial Notes

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Fraunhofer Cluster of Excellence
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Office of the Cluster
Fraunhofer Institute for
Environmental, Safety and
Energy Technology UMSICHT
Osterfelder Straße 3
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Fraunhofer-Gesellschaft zur
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Forschung e.V.
Hansastrasse 27 c
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Editorial Team
Dr.-Ing. Hartmut Pflaum
Julia Kast
Stefanie Bergel, M.A.

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Silvia Lorenz, Lara Groenenstijn

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We shape your business transformation to the Circular Plastics Economy!

More information

www.ccpe.fraunhofer.de/en.html

s.fhg.de/linkedin-fraunhofer-ccpe