Fraunhofer
IWKS

FRAUNHOFER RESEARCH INSTITUTION FOR MATERIALS RECYCLING AND RESOURCE STRATEGIES IWKS

FROM FOOD WASTE TO BIODEGRADABLE FOOD PACKAGING

Fraunhofer IWKS, Hanau, Picture © hammeskrause architekten bda

Picture Title: (C) Aitiip Centro Technologicó

Fraunhofer
IWKS

Research focus

The Fraunhofer Research Institution for Materials Recycling and Resource Strategies IWKS stands for a responsible use of resources. The aim of the research of Fraunhofer IWKS is to establish an efficient circular economy. Therefore, the scientists work at recovering recycable materials and introducing them into a new product cycle or to substitute valuable materials with sustainable alternatives. Fraunhofer IWKS develops technical and strategic solutions for the efficient use of secondary materials and functional materials.

The researchers are working on current challenges such as bio-based plastic packaging and offer industry solutions for a more sustainable approach.

Let's take a closer look at the organic plastic bag and packaging: It often consists of renewable raw materials such as corn starch which is in competion with food production.

Fraunhofer IWKS deliberately pursues a different approach that does not compete with the food industry. Researcher work with food scraps that can even be used as animal feed afterwards.

Plastics in packaging and in electronic waste

While plastic/polymer waste is high on the media agenda in the packaging sector, comparably less is reported about plastic/polymer fractions in electronic waste. Whether it's cell phones, vacuum cleaners, tablets or televisions that are discarded - more than nine million tons of electronic waste are generated in Europe every year. Although a large proportion of this waste consists of high-quality plastics, it is usually only utilized once. If the electrical appliances are no longer used and disposed of, the plastics hardly ever get back into a production process. Instead, they end in incinerators or kilns of the cement industry and are therefore lost for recycling.

Recycling of plastic is not easy, because plastics are a complex material consisting of several compounds and additives. This often makes recycling and reuse technically complex and costly. Here Fraunhofer IWKS comes in.
With the aim of creating efficient material cycles for the sustainable use of resources along the entire value chain, the researchers at the Fraunhofer IWKS are exploiting new approaches for separating and recovering plastics by type.

Please do not hesitate to contact us.

Yours,
Prof. Dr. Anke Weidenkaff
Executive Director, Fraunhofer IWKS

Fraunhofer IWKS, Alzen Picture: BHBVT, Berlin

BIO-BASED RAW MATERIALS THAT DO NOT COMPETE WITH FOOD PRODUCTION

Bioplastics are often associated with sustainable and environmentally friendly packaging. However, bioplastics are not just bioplastics. And do bioplastics have the potential to replace conventional plastics as sustainable alternatives? Fraunhofer IWKS points out facts and takes a stand.

"In theory, all biodegradable plastic films worldwide could already be coated with extracts from residues of the German food industry alone."*

Dr. Stefan Hanstein, Department Biogenic Systems at Fraunhofer IWKS

*(based on a production capacity of 2.05 million tonnes of new economy bioplastics per year, as of 2018, IfBB Hannover).

Most of the plastics used today are made from fossil raw materials such as crude oil or natural gas (1). Although flexible and versatile, conventional plastics have the disadvantage of consuming non-renewable resources in production and not being (fully) biodegradable. Since plastic has become an essential material in our society, for example in medical technology, which has to meet high requirements, it cannot easily be replaced by other materials. One way of conserving fossil resources and reducing waste is to use plastics based on natural raw materials. These substances can, but do not have to, be biodegradable. There are also plastics that are biodegradable but made from petrochemical raw materials. In order to facilitate differentiation, one often speaks of biobased plastics, i.e. plastics produced from renewable raw materials, and/or biodegradable plastics, i.e. plastics that can be decomposed by microorganisms present in the environment.

The researchers of the Fraunhofer IWKS are convinced that bioplastics can make a considerable contribution to the relief of resources and the environment. However, there are some basic requirements to be met.

This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No 720736

The researchers recommend

- to use alternative bio-based raw materials that do not compete with food production. Only then can bioplastics be used sensibly and sustainably with regard to ecological, economic and social factors (7).
- to support further research approaches such as the consistent use of residues from food production for applications on industrial scale (e.g. from raspberry or apple pomace) (8).
- to further improve the properties of bioplastics according to industry requirements without compromising sustainability (e.g. biobased and biodegradable coatings based on hemicellulose or biogenic adhesion promoters to improve the mechanical properties of sustainable composite materials) (9).
- to create more transparency for consumers through clear labelling on the products, on the one hand in order to open up the possibility of influencing purchasing behavior and on the other hand to guarantee correct disposal.
- biodegradable plastics should be labelled uniformly for automated sorting. Only then, from the point of view of the Fraunhofer IWKS, does it make sense to feed biodegradable plastics into the recycling cycle.
- active involvement of industry and recycling companies through incentives to develop prototypes and implement them at industrial scale (incentives instead of exclusively prohibitions, approach of Design for Circularity).

HyperBioCoat research project

The HyperBioCoat project aims to develop a new bio-based and biodegradable coating for plastic packaging.

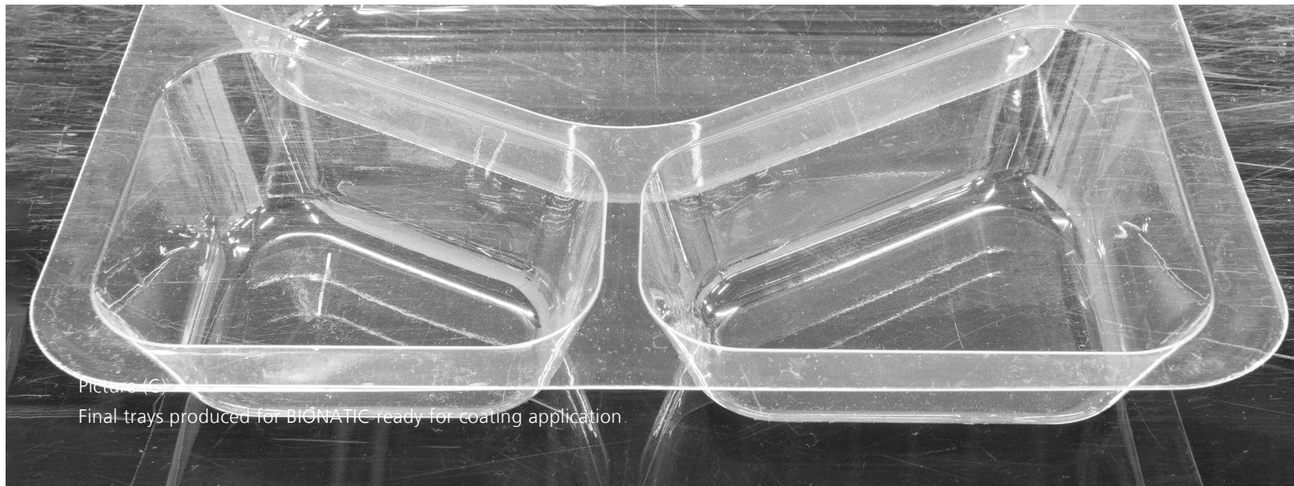
Today, fresh food as well as convenience food is sold in packages. Hygienic conditions, long shelf life and easy availability of these packed products account for our standard of living. However, this convenience contributes to environmental pollution in a significant way, as packaging is mainly achieved by plastic materials in this case.

A European consortium of 12 entities have partnered as part of the HyperBioCoat project, composed by different R&D entities and companies. This project will investigate and develop a new bio-based and biodegradable coating for rigid and flexible plastic packaging.

This coating, applied to bio-based packaging, will improve the barrier properties of bio-based packaging, which actually are not as strong as needed.

This new bio-based coating will increase the product's shelf life and contribute to a reduction of CO2 emissions, as all the precursors needed for lacquer synthesis will be based on renewable materials.

The project, coordinated by the Fraunhofer Institute ISC, has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No 720736.



Picture (C)
Final trays produced for BIONATIC ready for coating application

Compact facility for the intensified extraction of hemicelluloses from fruit residues of the agro-food industry at Fraunhofer Research Institution IWKS. Process yields highly water-soluble biopolymers which can be functionalised in homogeneous systems thereby lowering process costs.

THE PILOT EXTRACTION PLANT

EVER THOUGHT ABOUT PRODUCING OR APPLYING A SUBSTITUTE FOR CELLULOSE AND STARCH ?

FRAUNHOFER IWKS OFFERS

- Intensified extraction process for hemicelluloses (branched ß-glycans) from fruit residues of the agro-food industrie
- Cationic derivatives of these glycans produced in a one-step process
- Applications in barrier coatings (thermosets) on packaging materials

Specification of our extraction pilot plant

The sustainable extraction process comprises five steps: intensified glycan extraction (with pressurised hot water) – removal of insoluble particles from the extract – selective precipitation of glycans with alcohol – separation of precipitated glycans – alcohol recovery.

- Compact skid construction with a size of 3 m x 4 m x 5 m (w/l/h)
- Material of tanks and pipes: stainless steel (1.4404), complying with food grade applications
- ATEX compliance of the whole system
- Peripheral safety systems with sensors and ventilation for preventing explosive atmosphere
- Biomass charge for extractor module up to 5 kg dry mass. Wet material may be added if it can be pumped. Glycan yield with 3 kg dry apple pomace 200 g. For other biomass glycan yield may be up to 1 kg per 3 kg dry mass or higher (e.g. tamarind, guar)
- Volume of extractor 50 L, percolation pump (1.5 kW) maintains flow at 25 L/min for efficient extraction. Sieve plate with 1-mm-holes keeps solids within the extractor.
- Extraction solvents for glycans: pressurised hot water (temperature up to 150 ° C, pressure up to 10 bar, extraction time e.g. 90 min), NaOH (0.5 - 4 M)
- Hot-water extraction mode provides sterile extract
- Extraction solvents for non-carbohydrate com pounds (e.g. polyphenols): ethanol or isopropanol (up to 65 °C).
- Extraction module can be operated under inert conditions (N2) for sensitive glycans
- Solvent heating with flow heater (6 kW). For fast extract cooling heat exchanger (0.28 m^2)
- Easy removal of extraction residues through swinging extractor bottom plate
- Storage tank (150 L) for extraction solvents or cleaning liquids (CIP cleaning)
- Stainless steel filter unit (gap width 30 µm) for removal of particles from the extract
- Filtrate is pumped into 400 L precipitation, reactor with cooling jacket, pH sensor for pH adjustment, stirrer (370 W, 930 rpm), alcohol feed, inspection window, and CIP nozzle
- Stainless steel tank (500 L) for alcohol
- For separation of glycan precipitate double filter unit with bag filters (FiltraLine) with a nominal pore size of 1 µm (e.g. polyester needle felt, Nylon monofilament) operated at a pressure of up to 2 bar. Flow up to 25 L / min
- 350-L-storage tank for remaining aqueous alcohol solution, with CIP nozzle. Alcohol is recovered using a rectification column: capacity 180 L, length 2.90 m, pressure (bar) -1.0/0.5, temperature (°C) -10/111, heater performance 51 kW

(C) Picture
Apple residue after extraction

PLASTIC FROM ELECTRONICAL WASTE

Precious metals in smartphones are an example of how lucrative recycling can be. However, most discarded electrical appliances are made of plastic - and despite the Waste Electrical and Electronic Equipment Ordinance, the EU plastics strategy and the increased entry into the environmental service branch, this material is still predominantly incinerated. The more pure a waste fraction is, the better it is for recycling. With plastics, this is difficult because electronic waste contains many different types of plastic that can hardly be sorted.

"THE PURER A WASTE FRACTION IS, THE BETTER IT IS FOR RECYCLING."

Dr. Katrin Bokelmann, Head of Department Urban Mining at Fraunhofer IWKS

Small display devices such as smartphones and tablets as well as printed circuit boards (PCBs) are very complex material composites that can contain polymers (25-40%), glass (10-40%) and metals, including critical elements such as indium, gallium, germanium, etc.

One of the research projects at Fraunhofer IWKS is about developing an innovative process chain from technologies already developed and reaching an industrial production scale to recover valuable materials and raw materials from such display devices. Because at present, there are no mechanical or chemical processes that could break down such old products into homogeneous components. Recycling therefore takes place in blast furnace processes, which can effectively recover many metals, but not polymers, glass and the low-concentration critical elements.

Today's blast furnace processes focus on the effective recovery of metals, while other valuable materials such as polymers, glass and the low-concentration critical and therefore cost-intensive elements are largely lost.

Recovery of valuable materials and raw materials from displays and PCBs

The DISPLAY project intends to supply a technically and economically convincing solution for a material-oriented disassembly of display appliances and PCBs by combining electrohydraulic fragmentation, spectroscopic sorting and the solvent-based CreaSolv® process.

The individual processes, which are currently on the technology readiness level (TRL) 5 (component and/or breadboard validation in relevant environment) shall be connected and elevated to TRL 7 (system prototype demonstration in an operational environment). The products to be obtained are high-quality flat glass, engineering plastics like ABS or PA and metal concentrates. The latter will be provided to downstream hydrometallurgical and pyrometallurgical recovery processes, This approach will increase the overall material recovery and the economy of the recycling process since a much higher percentage of waste is transferred into and sold as secondary raw materials.

Electrohydraulic fragmentation

The technology is based on shock waves which are generated by pulsed high voltage spark discharges. The shock waves propagate through the surrounding carrier medium and hit the material. The short but very intense mechanical impacts preferably attack weak spots within the material: The fragmentation occurs at macroscopic joinings (clamped, bonded, screwed) or microscopic phase or grain boundaries.

The Fraunhofer IWKS is operating a pilot plant that is accessible to the recycling and raw materials industry for processing of specific materials.

Technical Data

- Operating voltage 30-40 kV
- Integrated EMC and noise protection
- Automated operation via touch screen
- Batch operation with manual exchange of reactor vessels
- Reactor vessels with a nominal diameter of DN 400 and volumes of 29 l or 39 l

Electronic waste contains many different types of plastic

(C) Picture Shutterstock

BEIERSDORF IN COOPERATION WITH FRAUNHOFER DEVELOPED

100% RECYCLED PE BOTTLE

From 2,600 collected PE bottles, which would otherwise have been disposed of as waste, 2,500 new bottles were created.

BEIERSDORF DEVELOPS 100% RECYCLED PE BOTTLE IN COOPERATION WITH FRAUNHOFER

Beiersdorf Commits to Sustainable Packaging
By 2025, Beiersdorf, the skin care company, intends to use 100 percent recyclable, compostable or reusable packaging. At the same time, the Group plans to increase the proportion of recycled plastic packaging in Europe to 25 percent.

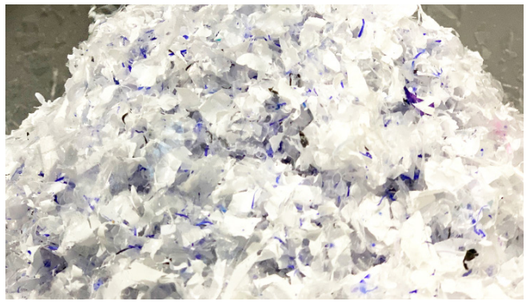
These targets reflect the increased relevance of sustainability as part of the C.A.R.E.+ Group strategy announced by the new CEO Stefan De Loecker in March this year. The voluntary commitment in the area of plastic packaging is ambitious and competitive. The market launch of the first products with recycled packaging content have already been realized this year. Beiersdorf's two new sustainability targets in the area of plastic packaging are based on the principle of recycling management, i.e. a closed system in which packaging materials are recycled and no longer incinerated or disposed of as waste after a single use. In this way, recyclable materials are preserved and the burden on the environment is reduced. Beiersdorf acts in accordance with the four sustainability principles of avoidance, reduction, reuse, and recycling.

This is where Fraunhofer comes in
Beiersdorf employees recently demonstrated in an internal recycling campaign how the circular-flow economy can function. Over a period of six weeks, employees at the Hamburg headquarters and other locations in Germany collected the empty polyethylene (PE) bottles of various Beiersdorf products and returned them to the company.

They were then recycled in collaboration with two Fraunhofer Institutes and reused 100% for the production of a new bottle.

From 2,600 collected PE bottles, which would otherwise have been disposed of as waste, 2,500 new bottles were created which were filled with NIVEA Creme Care shower gel and given to the employees as a symbol of the vision of recycling management. They were then recycled and reused 100% for the production of a new bottle.

Beiersdorf
Fraunhofer IWKS
Fraunhofer IVV



(C) Bilder: Beiersdorf AG

ELEKTRO-HYDRAULIC FRAGMENTATION

FRAGMENTATION - SEPARATION - SORTING

MECHANICAL FRAGMENTATION

Fraunhofer IWKS owns a large number of fragmentation technologies with different types of stress on a laboratory and pilot scale. The material can be coarsely and finely fragmented and homogenized as required. The technologies can be used for different materials: Soft, fibrous, hard and brittle samples in wet and dry condition can be processed. Sorting and sieve analyses according to grain size and shape as well as density are also possible.

- Impact crusher
- Jaw crusher
- Rotor mill
- Cutting mill with cyclone
- Planetary ball mill
- Vibrating tube mill
- Cryogenic mill
- Sieve tower
- Wet separation table
- Optical particle size analysis

ELECTRO-HYDRAULIC FRAGMENTATION (EHF)

A particularly innovative technology for the fragmentation of materials is the so-called electro-hydraulic fragmentation by means of shock wave technology. Here, the material to be shredded is placed in a reactor in a liquid medium (e.g. water). An electrical discharge generates shock waves which propagate in the reactor with the aid of the liquid and thus cause the material to be separated along phase boundaries. These short but violent mechanical shocks attack weak points in the material: The separation takes place at macroscopic joints or at microscopic bounderies. In the Fraunhofer IWKS pilot plant, an EHF system is in operation on a pilot scale.

Here, tests are carried out with your material in the EHF plant and the process parameters are optimised for your material. The test results are evaluated in detail and the starting and final materials physically and chemically analyzed.

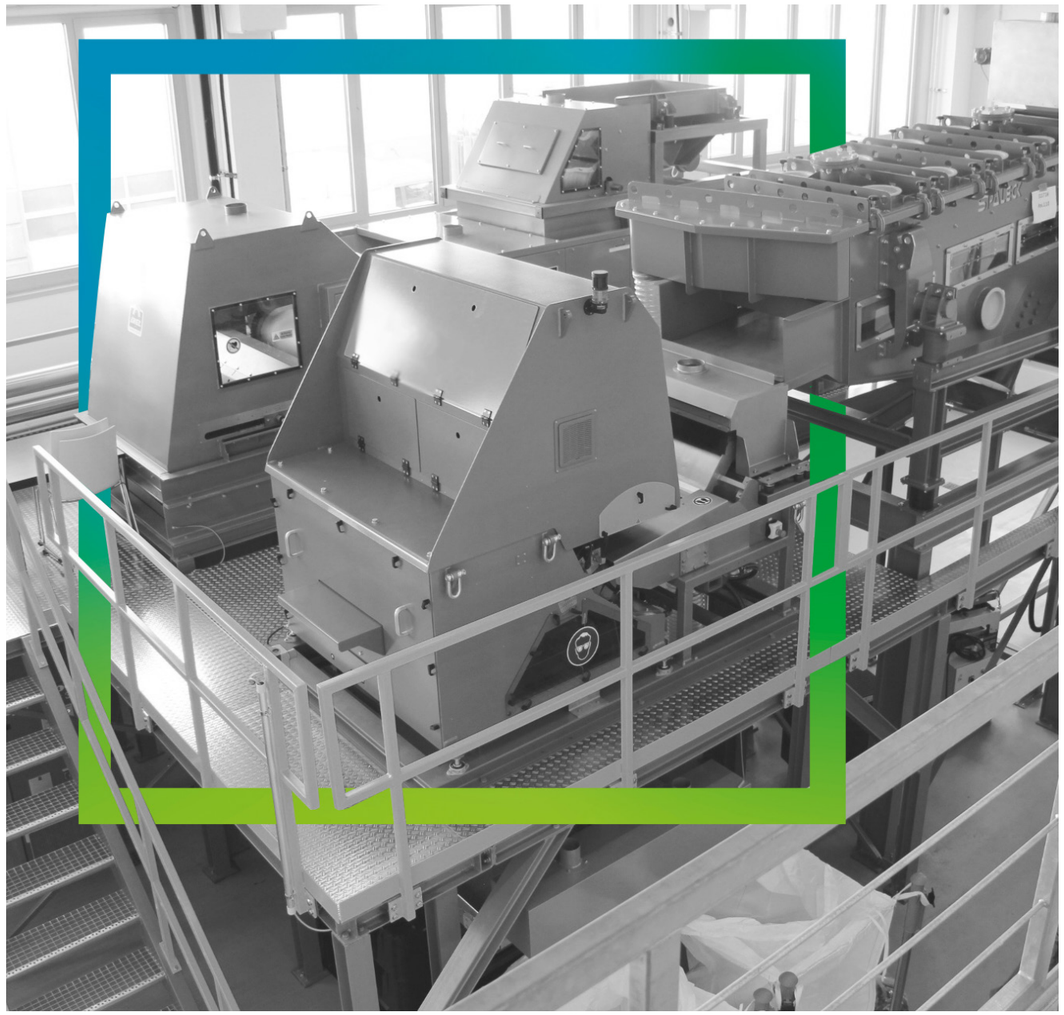
In the end, the respective process is considered to be economical according to customer requirements and can thus be scaled up to industrial standards.

Picture: Fragmentation using shredding

Picture: Selective fragmentation using electrohydraulic fragmentation

MODULAR SORTING PLANT

After the electrhydraulic fragmentation the waste fragments are separated. Now the different materials can be sorted so that as a result, there is a high liberation of materials without excessive comminution. Fraunhofer IWKS develops technical and strategic solutions for the efficient use of secondary materials and functional



Modular sorting plant at Fraunhofer IWKS

The research and development of new technologies for recycling processes of certain recyclable materials, such as rare metals, without which numerous technological products such as mobile phones in their present form would be unthinkable, is increasingly becoming a task for the future of industrial societies. At present, however, only a few efficient recycling processes exist to separate or recover even small concentrations of critical substances. Like recyclable materials, pollutants are often too diluted to be separated economically and in a clean way.
The central element for closing recyclable material cycles is the processing of the corresponding material and the subsequent separation of corresponding recyclable materials.

Technical equipment of Fraunhofer IWKS

Sinter oven

Technology: The modular sorting plant

The Fraunhofer Project Group IWKS has a flexible sorting plant at its disposal which is suitable both for basic investigations of the sortability of material flows as well as for the processing of large quantities. The advantages:

- Fully automated multi-modular system for sensor-based sorting of electric scrap, plastics, etc.
- Flexible process control by linking individual sorting steps
- Individual adaptation to waste streams
- High data availability and connection as well as digital machine networking for high information transparency and HMI communication options (Industry 4.0)

Individual units

- Flip-flow screen (classification in three fractions)
- Magnetic drum separator (recovery of iron)
- Eddy current separator (removal of non-ferrous metals)
- Sensor-based sorting system (any combination of sorting parameters: color, form, NIR spectrum, metal)

Technical data

- Throughput of up to 2.5 t/h (depending on material)
- Particle size of 3 - 50 mm
- NIR spectrum of 1330 - 1900 nm, detection of up to 3 mm
- 2 CCD line scan cameras for form and RGB color recognition, up to 0.375 mm resolution
- Inductive metal detection coil for ferrous and non-ferrous metals

MATERIAL FLOW MANAGEMENT

THE UNIVERSAL LIFECYCLE TOOL

"WASTE IS MERELY RAW MATERIAL IN THE WRONG PLACE."

Dr. Andrea Gassman, Head of Department Material Flow Management

Resources are the key to long-term competitiveness. They must be used **effectively**. This requires a sustainable strategy on costs, environmental impacts, political dependencies and technical requirements. Our material flow management integrates all these criteria. With our holistic evaluation tool, we have developed our **own methodology** that guarantees high flexibility and consistent quality. Future technologies are taken into account and new business models are derived.

With the flexible Universal Lifecycle Tool, we are able to describe any type of product or process in detail and evaluate it according to sustainability criteria of the current scientific standard. With the modules listed, various impact indicators are applied to the modeled processes: recyclability, ecological effects, life cycle costs, material criticality and the influence of CO2 pricing. The structure of the complex model systems and the quantitative determination of impacts are specific and consistent.

This results in technical improvements that optimise the product design in the sense of the circular economy (functional maintenance over several life phases). The complete consideration of the product life cycle also leads to new business models for the development of long-term profitability "

Individual research with us:

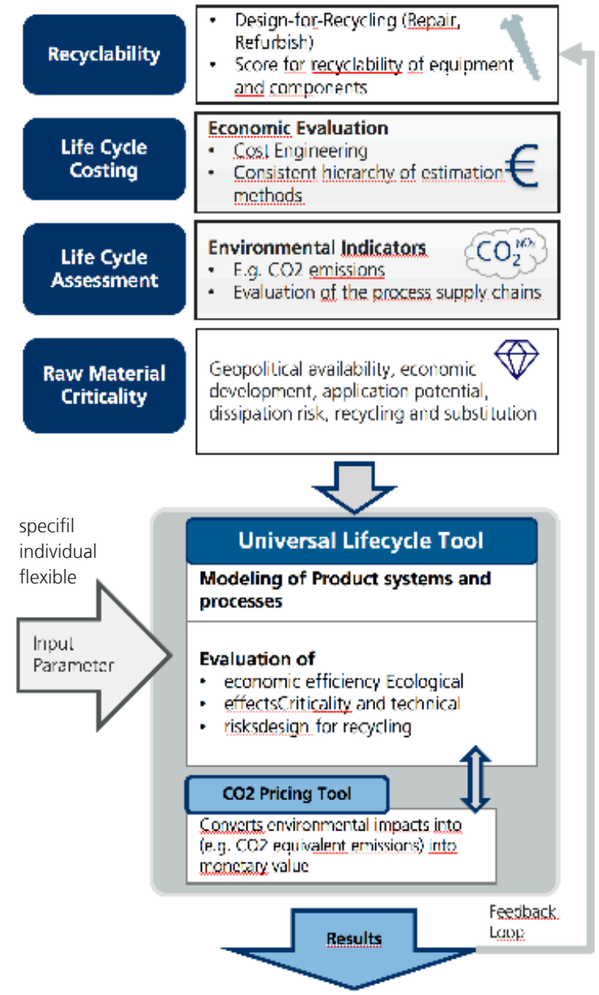
- Supply Chain Management & Hot Spot Analysis
- Optimization of Material Use: Design-for-Reuse & Design-for-Recycling
- Assessment of sustainability & risks of new processes

Businesses benefit from:

- Chemical compounds (packaging, catalysts)
- Facilities and products
- Automotive parts
- Recycling processes
- Business models & infrastructure
- Future technologies

The value we create:

- ensure market shares, costumer and product retention through innovative business models
- ensure newest legislation and specifications already during RnD
- ensure sustainability and *Green products*
- ensure raw materials supply & stable supply chains



HOW CAN WE ASSIST YOU?

Are you an entrepreneur or do you work in the research department of a company?
Would you like to promote your product with the help of research? As an experienced partner for companies and other research institutions, Fraunhofer IWKS offers a range of different opportunities for cooperation in research and development (R&D).

(C) Pixabay

Bilateral cooperation and R&D projects

- Individual tasks
- Short- and long-term contract research
- Direct knowledge transfer through indepth cooperation on site
- Support during implementation in production

Industrial joint projects

- Complementary partners (e.g. users and suppliers)
- Use of the extended pool of methods and competences
- Reliability of exploitation through IP generation

Publicly funded joint projects

- Network of research and industry partners
- Medium and long-term research projects
- Partial financing through public project funds
- Pre-competitive development of application-oriented fundamentals

Industrial working groups

- Joint finding of solutions in a low-competitive field of action
- Long-term projects
- Reduced costs for the individual, as joint financing of the research work is ensured

If you have any questions about concrete cooperation and financing possibilities, please do not hesitate to contact us.

www.iwks.fraunhofer.de/en

Contact us

First name

Last name

Street

Company

Zip Code

City

Your position

Business area

Company size

Telephone

E-Mail

How can we assist you?

I agree with the storage of my data ☐

Signiture

CONTACT

Fraunhofer IWKS
Fraunhofer Research Institution for Materials Recycling and Resource Strategies IWKS

Brentanostraße 2a
63755 Alzenau
Phone: +49 6023 32039-801
Fax: +49 6023 32039-6-801

Aschaffenburger Straße 121
63457 Hanau
Phone: +49 6023 32039-817
Fax: +49 6023 32039-6-817

Mail: info@iwks.fraunhofer.de
www.iwks.fraunhofer.de/en