Fraunhofer
UMSICHT

FRAUNHOFER INSTITUTE FOR ENVIRONMENTAL, SAFETY, AND ENERGY TECHNOLOGY UMSICHT

ANNUAL REPORT 2018|19

A report for you about us,
our products, our services and our
responsibility for the future.

SUSTAINABILITY AS A RECURRING THEME

The subject area of sustainable energy and raw materials management is the focus of our work. Ever since 1990, our founding year, it has been our objective to carry out sustainable research in the areas of environmental, safety, and energy technology. At Fraunhofer UMSICHT, the sustainability strategy was created holistically and is anchored in the institute as a whole. The employees, the management and the institute's directorate are equally involved in the implementation.

We would like to show all of our interested parties (customers, the public, job applicants) specifically which contribution our R&D products and services make to sustainable development. We want to get in touch with them in order to jointly further these objectives and to improve the quality of life of society as a whole.

We are looking forward to receiving your feedback!

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EVERYTHING AT A GLANCE.
On 60 pages, we report on our 2018 projects, the people behind the projects and the prospects.

PREFACE

Prof. Dr.-Ing. Eckhard Weidner | Director

Prof. Dr.-Ing. Görge Deerberg | Deputy Director

Dear readers,

In the preface to last year's annual report, we announced that we would be expanding our circular economy activities in 2018. We have done this very intensively. Undoubtedly, the most significant event was the launch of the Fraunhofer Cluster of Excellence "Circular Plastics Economy". As the coordinator of the cluster, we and four other Fraunhofer Institutes want to use the example of plastics to demonstrate how energy flows and material streams in a recycling chain can be converted into a circular form of economy.

Plastic has also been a central topic in many other projects over the last year. Polymers form the basis of a newly developed wall paint in the "Smartwall" project. They play an important role in an innovative, fully weldable bipolar plate for battery applications. Our consortium study on microplastics, in which we compiled current knowledge on microplastics and macroplastics on behalf of partners from the plastics industry, water management, waste management, and research, met with an enormous response from the media. One of the results was that a very high proportion of the microplastics in the environment comes from tire and road wear particles. The influence of tire and road wear particles on the environment is now being investigated more closely throughout Germany in the joint project "TyreWearMapping".

Other projects that we would like to present to you in more detail in this annual report concerned the development of synthetic fuels for a "green internal combustion engine", the production of molded parts from renewable raw materials, the optimization of turbomachinery with CFD (computational fluid dynamics), and membranes for food technology.

Our large-scale projects focus on cross-industrial networking and the linking of various sectors. While the Fraunhofer High-Performance Center DYNAFLEX® concerns itself with the networking of energy and production, Carbon2Chem® looks at closing carbon cycles. The aim is to use metallurgical gases from steel production – especially carbon dioxide – as a starting material for chemical products. The use of surplus electricity from renewable energy sources for the electrochemical production of base chemicals is at the core of the Fraunhofer lighthouse project "Electricity as a Resource".

As you can see, our range of topics is broad – this annual report can only present a small selection of them to you. Please consider the articles as "appetizers" that will give you an initial insight into our activities, and contact us if you have any ideas for an exciting joint project!

Cordial greetings

Eckhard Weidner

Görge Deerberg

INSTITUTE

THE BASIC DATA OF FRAUNHOFER UMSICHT.
Profile, Key Performance Indicators, Organizational Structure.

Photo: shutterstock

PIONEER FOR A SUSTAINABLE ENERGY AND RAW MATERIALS MANAGEMENT

In Germany, the energy system is being switched to renewable sources. The set climate targets are ambitious. This requires great efforts in the coming years and the cooperation of all social groups. Fraunhofer UMSICHT is a pioneer of a sustainable energy and raw materials management, providing scientific results and transferring them to businesses, society and politics. The dedicated team researches and develops together with partners sustainable products, processes and services that inspire.

Fraunhofer UMSICHT is situated in Oberhausen, has an institute branch in Sulzbach-Rosenberg (Bavaria) and a branch office (plastics technical shop) in Willich. As an institute of the Fraunhofer-Gesellschaft, we are part of a worldwide network and foster international cooperation.

As a pioneer in the energy and raw materials management, we develop innovations that provide crucial contributions to a resource-saving society and industry. We strive to bring knowledge, methods, technologies, products and services in the business units of polymer materials, chemistry, the environment, biomass, and energy all the way up to the application stage. In doing so we focus on the balance of economically successful, socially just, and environmentally compatible developments.

Climate-neutral supply with energy and carbonic raw materials is possible if there is a fundamental change in the energy and raw materials system which takes into account societal and economic needs. The objective is to replace the so far largely linear economy with a circular economy.

The new "raw materials" of the circular economy are sustainably sourced carbon, renewable energy, and recycled products and materials. This is where Fraunhofer UMSICHT comes in with its strategic projects.

Read more about this on page 12.

TRADEMARKS OF FRAUNHOFER UMSICHT

- Expertise in chemical-biological-physical conversion, material development, component development, process technology, product development and product evaluation, energy systems, mathematical and analytical methods
- Creativity, quality and efficiency in idea generation and the implementation in applications and projects
- Market-oriented, long evaluation chains from the idea to the consumer
- Continuous evaluation of the innovations in terms of sustainability
- Contributing to the social discourse on the energy transition and raw materials shift

WHAT WE CAN DO FOR YOU

- Improve products
- Product developments – if necessary up to small series
- Market analysis and innovation consulting
- Introduce new technologies
- Licensing and license acquisitions
- Optimizing processes or organizational forms
- Characterize, examine, and certify

2018
Fraunhofer UMSICHT
in Figures

33,11
MILLION €
OBERHAUSEN

9,10
MILLION €
SULZBACH-
ROSENBERG

42,21
MILLION €
TOTAL BUDGET

26,9 %
INDUSTRY

58,7 %
PUBLICLY FUNDED
RESEARCH PROJECTS
INCL. EU

83
MASTER-
AND DIPLOMA
THESES

12
DOCTORATES

411
OBERHAUSEN

100
SULZBACH-
ROSENBERG

511
EMPLOYEES
(AS OF 31/12/18)

366
PUBLIC

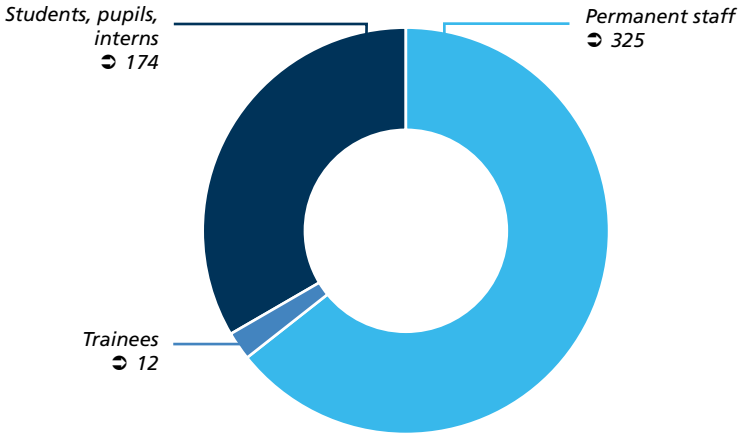
181
BUSINESS

547
PROJECTS

3
INTELLECTUAL
PROPERTY RIGHTS
FILINGS

STAFFING STATISTICS 2018

	OB	SURO *
Permanent staff	254	71
Scientific	190	61
Administrative	64	10
Other staff	157	29
Trainees	10	2
Students, pupils, interns	147	27
Total staff	**411**	**100**



Staffing statistics

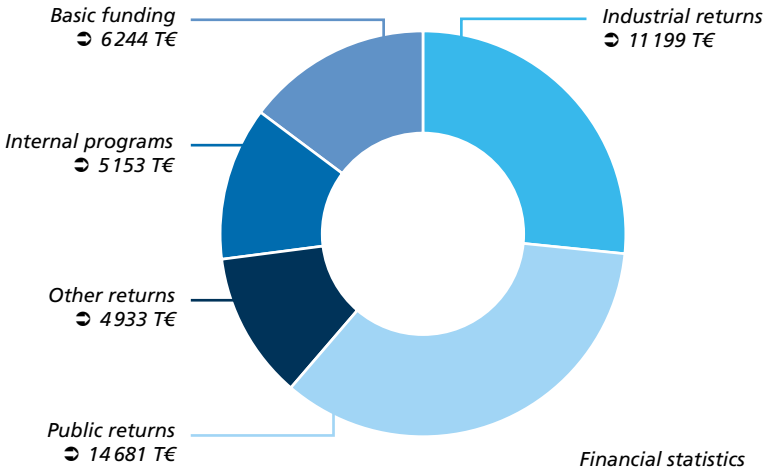
Fiscal year 2018; including all sites.

FINANCIAL STATISTICS 2018

[in thousand euros]

	OB	SURO *
Operating budget	31 327	8606
Other costs	14394	4658
Staff costs	16933	3948
Investments budget	1785	492
External project investments	634	213
Internal investments	1151	279
Total returns	**33112**	**9098**
Industrial returns	9847	1352
Public returns	13112	1569
Other returns	692	4241
Internal programs	4363	790
Basic funding	5099	1145

*OBERHAUSEN/SULZBACH-ROSENBERG



Financial statistics

Fiscal year 2018; including all sites.

ORGANIZATIONAL STRUCTURE

As of January 2019

The organizational structure of Fraunhofer UMSICHT is based on the divisions of Energy, Processes and Products in Oberhausen and the institute branch in Sulzbach-Rosenberg. The divisions with their departments and groups comprise the scientific know-how of the institute by expertise criteria. The division organization unites the technical and administrative departments of the institute.

DIRECTORATE

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- Energy Systems Engineering
- Energy Systems
- Electrochemical Energy Storage
- Chemical Energy Storage
- Think Tank

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- Biorefinery and Biofuels
- Photonics and Environment
- Information Technology
- Process Engineering
- Think Tank

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- Bio-based Plastics
- Material Systems and High Pressure Technology
- Sustainability and Resources Management

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- Energy Technology
- Recycling Management
- Biological Process Technology

BUSINESS UNITS

further information see pg. 18

Five branch-oriented business units complement the organizational structure. They tailor the expertise and research and development competence of the divisions and departments to meet customer needs in the business fields.

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DIVISION ORGANIZATION

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- Administration
- Public Relations
- UMSICHT Academy
- Analytics
- Technics
- Occupational Safety and Environmental Protection
- Information Security
- Library

Photo of the directorate and photos with a gray background: PR photography Köhring, photo branch: Matthias Heyde, further photos: Ilka Drnovsek

STRATEGIC PROJECTS

PIONEERING A SUSTAINABLE ENERGY AND RAW MATERIALS INDUSTRY

A climate-neutral supply of energy and carbon-containing raw materials is possible if there is a fundamental change in the energy and raw materials system that takes account of societal and economic needs. The objective is to replace the so far largely linear economy with a circular economy.

FRAUNHOFER-CLUSTER OF EXCELLENCE "CIRCULAR PLASTICS ECONOMY"

Over 330 million tonnes of plastics are produced worldwide each year. Too much plastic waste ends up in incineration or in the ground and oceans at the end of its life. Governments and authorities around the globe are initiating government measures to combat this development; the EU did so at the beginning of 2018 with its Plastics Strategy. How the plastics economy can become circular is being investigated by the new Fraunhofer Cluster "Circular Plastics Economy".

Plastics economy must become circular

Plastics are indispensable for prosperity, health, resource conservation, and energy efficiency. Their raw material base relies on crude oil but is slowly opening up to biogenic sources. Over half of the plastics collected in Germany are incinerated. A huge amount of uncollected plastic waste is accumulating unchecked in ecosystems around the world, including the oceans. In order to meet the UN goals for sustainable development – including sustainable consumption and production methods and the protection of ecosystems – the previously linear economy must be replaced by a circular economy.

At present, only a small proportion of plastics, which are irreplaceable for resource-efficient products due to their low weight, is recycled. The problem cannot be solved using established recycling methods alone. Instead, the entire value added chain and the interfaces between the actors must be taken into account and designed in a circular manner. This will make a crucial change to the development of molecules, materials, and products, as well as the associated business models.

Giving plastic more value as a material

The Fraunhofer Cluster of Excellence "Circular Plastics Economy" will, for the first time, use plastics as an example to investigate how an entire value added chain can be designed according to the principles of the circular economy. The aim of this holistic approach is to reduce the incineration of plastics and losses in the environment – and to increase the value of plastics as a material. Within a period of around ten years, the consortium aims to develop new circular plastics, additives, and composite materials with optimal recyclability and switchable degradability – from molecules to prototypes and, ultimately, to competitive products. The starting point is always a new type of circular assessment, i.e. a flexible assessment method that allows the gap between a state-of-the-art solution and the desired level of circularity to be determined and bridging solutions designed. This circular assessment combines data-based and standardized tools (e.g. life cycle assessment) with more intuitive tools (e.g. hackathons) to create a new method of product development

The researchers are initially designing a transport box for online retail and a child car seat in line with the principles of circular design. These prototypes are combined with life cycle-wide identification and monitoring techniques.

Consolidated competencies – consolidated research

The aim is to develop system capabilities for the circular plastics economy. System capabilities link interfaces in the value added

Fraunhofer Clusters of Excellence combine the competencies of institutes to investigate relevant topics with scientific excellence. The aim is to establish virtual institutes with international visibility.

chain. What is new here is that science is intertwined with business development right from the start in the cluster in order to provide market-relevant prototypes.
This also includes the CIRCONOMY® brand, under which the consortium of the Fraunhofer Institutes for Environmental, Safety, and Energy Technology UMSICHT, for Applied Polymer Research IAP, for Chemical Technology ICT, for Material Flow and Logistics IML, and for Structural Durability and System Reliability LBF bundles competencies and research for the circular plastics economy. Additional partner institutes support the implementation of the research agenda. Prof. Eckhard Weidner (Fraunhofer UMSICHT) assumes the role of spokesperson.

The cluster was launched in November 2018 with six research departments in three divisions:

Materials division
- Circular Polymers
- Circular Additives and Compounds

Mission: We want to use plastics from a sustainable mix of resources to close material and biological cycles. We use circular principles to do this. Where appropriate, the degradation of plastics in and by nature is intensified. Released carbon dioxide is quickly bound in the material by means of photosynthesis.

Systems division
- Advanced Recycling
- Circular Logistics and Sustainability

Mission: Efficient collection and transport technologies go hand in hand with new material recycling processes to bring more plastics into material cycles. Digitally mapped processes and products enable ecological and economic real-time evaluations in order to design optimal value creation cycles.

Business division
- Application and Demonstration
- Business and Transformation

Mission: Fraunhofer researches and designs circular value added chains and offers new system capabilities for plastics within the circular economy across industry boundaries – from circular design and component layout, recycling, and degradability to prototype design, acceptance processes, and business models.

Circular economy definition
(Excerpt from the definition provided by Fraunhofer UMSICHT):
In a circular economy, the materials utilized remain in a materials cycle beyond the life cycle of goods. Waste, emissions, dissipative losses, and the extraction of raw materials from the environment are therefore to be reduced as far as possible. The reuse and continued use of goods along with the recycling of materials and substances are essential, as well as a design of the goods that allows for recirculation without quality losses and without accumulation of pollutants. The period of utilization for materials is as long as possible, and they are returned to the cycle at the end of their period of utilization as quickly as possible. Materials for which dissipative losses are unavoidable are degradable. The optimized energy consumption for maintaining the cycle is ideally provided from renewable resources. Substances that cannot be recirculated are utilized as energy.

More information: s.fhg.de/A8i, www.cpe.fraunhofer.de

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1

CARBON2CHEM® – CARBON DIOXIDE: FROM STEEL TO CHEMISTRY

German industry is steadily reducing its energy demand and emissions of climate-damaging gases. However, thermodynamic and economic limits are getting closer. A further reduction in energy demand and gas emissions would only be possible for some sectors of industry by creating completely new production routes or imposing production restrictions. The joint project Carbon2Chem® aims to use top gases from the steelmaking process as a valuable raw material source for the chemical industry. Using renewable energy, unavoidable carbon dioxide emissions from the steel industry are to replace fossil raw materials in the chemical industry. As a blueprint, this process coupling should be transferable to other high-emission industrial sectors and thus noticeably reduce the energy consumption of the manufacturing industry and significantly lower emissions of climate-damaging gases.

The road towards a climate-friendly industry can only be followed through collaboration between partners from different industries. One example of such cross-industrial cooperation is the unique alliance of the steel, energy, and chemical industries in the Carbon2Chem® project. Under the joint coordination of Fraunhofer UMSICHT, thyssenkrupp AG, and the Max Planck Institute for Chemical Energy Conversion (MPI CEC), the project develops solutions to convert the top gases from steel production into base chemicals – particularly the carbon contained within it, which is currently still released in large quantities as carbon dioxide.

Technological building blocks

Technologies for chemical syntheses (e.g. catalysis) are required to clean, condition, and convert the gas into marketable chemical products or fuels. Providing such technologies and integrating them into metallurgical plants is therefore one of the major challenges. The project is not looking for one big solution, but for an approach with technology modules that can be connected in a flexible manner.

The consortium in the Carbon2Chem® project comprises a total of 17 partners from science and industry. The interdisciplinary team combines the competencies from the respective working areas in seven sub-projects – each has a clear, technically oriented focus on promising technologies that can be used in future integrated production with a metallurgical plant.

Simulation of the overall system

One central element is the simulation of the planned overall system in order to be able to plan and dimension essential aspects of product selection, process logistics, and process control. At the same time, the simulation enables important conclusions to be drawn regarding the work in the sub-projects. Both the cost-effectiveness and the sustainability of the overall system are evaluated based on the simulation results in the project.

Hydrogen extraction

A further Carbon2Chem® sub-project is investigating how the hydrogen required for the chemical processes can be provided. The focus lies on producing hydrogen by means of water electrolysis using volatile renewable energies. A larger plant in the pilot plant station and several small test benches in the laboratory will be operated to ensure the long-term performance of electrolysis under load changes.

Gas processing and synthesis technologies

The processing of metallurgical gases is of central importance for Carbon2Chem®. A sub-project is therefore working on process concepts that are adapted to the selected synthesis routes and enable the provision of a syngas in the level of quality required for chemical production under dynamic boundary conditions.
In this context, Fraunhofer UMSICHT is developing and testing technologies and system solutions for gas purification and for the catalytic production of methanol, higher alcohols, and oxymethylene ethers – each adapted to the use of processed metallurgical gases.

Photo: Fraunhofer UMSICHT/Birgit Seidel

Technical infrastructure

A central infrastructure exists to support joint research and development. In the project laboratory, which Fraunhofer UMSICHT operates in cooperation with the MPI CEC in Oberhausen, catalyst behavior is investigated using synthetic metallurgical gases. One focus lies on the flexibility potential of the processes in order to make production as dynamic as possible later on.

thyssenkrupp AG built a pilot plant station for Carbon2Chem® near the Duisburg steel mill in order to validate the laboratory results with real metallurgical gases.
How the chemical processes react to real gas compositions under industrial conditions will be demonstrated here in a cross-industrial network. The direct link to the metallurgical plant enables the necessary investigations to be carried out concerning process control under dynamic boundary conditions.

Closing cycles

Cost-effectiveness, climate protection, and sustainability are the main tasks within the Carbon2Chem® project.
The consortium therefore aims to implement the research results as quickly as possible on a large scale in steel mills and comparable industrial locations.
The joint project launched in 2016 runs until 2020 and is funded by the German Federal Ministry of Education and Research (BMBF).

The results of the first two years of Carbon2Chem®

Published in Verlag Wiley-VCH, Chem. Ing. Tech. 2018, 90, No. 10: Carbon2Chem®
Order free of charge: s.fhg.de/pubform

More information:
www.umsicht.fraunhofer.de/carbon-cycle

1 *The Carbon2Chem® laboratory at Fraunhofer UMSICHT in Oberhausen. Research is being conducted into processes for gas purification and the production of methanol and higher alcohols in 500 square meters of laboratory space.*
2 *Those who opened the Carbon2Chem® laboratory together on March 7, 2019 (from left to right): Ralf Güldenzopf (City of Oberhausen), Dr. Markus Oles (thyssenkrupp AG, Project Coordination), Dr. Holger Ruland (Max Planck Institute for Chemical Energy Conversion), MinDir Volker Rieke (German Federal Ministry of Education and Research), Prof. Görge Deerberg (Fraunhofer UMSICHT, Project Coordination), Dr. Raoul Klingner (Fraunhofer-Gesellschaft), Prof. Eckhard Weidner (Director of Fraunhofer UMSICHT).*

SPONSORED BY THE
Federal Ministry of Education and Research

Carbon2Chem®

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HIGH-PERFORMANCE CENTER DYNAFLEX®
FLEXIBLE SOLUTIONS FOR THE ENERGY TRANSITION AND RAW MATERIALS SHIFT

Technologies to increase efficiency and reduce CO_2 emissions are increasingly becoming the focus of the business activities and strategies of German companies. They need to maintain their competitive position despite increasing pressure from stricter requirements from European climate protection measures. Sustainable and environmentally friendly value creation presents major challenges for industry and SMEs but will also be a competitive advantage in the future. Implementation in the regions requires a joint approach in cross-industrial networks. Not only are new technologies and more efficient processes required here but the importance of value added chains that operate beyond the existing sector and industry boundaries is also increasing. This is necessary because many processes in companies have already been optimized to the limits of what is technically feasible. Cross-sector approaches in regional alliances are offering new opportunities in order to nevertheless achieve the specified requirements with regard to climate protection.

Networking platform

The High-Performance Center DYNAFLEX® particularly assists SMEs and start-ups by bundling competencies for sector coupling in the energy and materials industry in the knowledge metropolis Ruhr. The areas considered are process and power engineering, carbon cycles, sustainability, digitalization, chemical and physical basic principles, and dynamic development methods.
Together with the universities in the University Alliance Ruhr (UA Ruhr) in North Rhine-Westphalia, Fraunhofer UMSICHT creates structures and fundamental research results to establish a digital networking platform for basic and applied research throughout entire value added chains. Goals are application and demonstration projects.

The High-Performance Center DYNAFLEX® develops technological solutions and system proposals as well as operating and business models using modeling and simulation. These are jointly implemented and demonstrated by means of experiments in the laboratory and the pilot plant station.
Together with business partners, a long-term cluster is being created that positions itself nationally and internationally and contributes to research initiatives. As part of this, adaptable solutions are being developed at the interface of the energy and materials industries, allowing cross-sectoral economic ecosystems to form that are stable and successful even in an increasingly dynamic environment and in volatile markets.

Positively evaluated

With the High-Performance Center DYNAFLEX®, the fundamental technical and structural requirements are created in the pilot phase. Numerous transfer projects, including three larger demonstration projects ("Cross-industrial symbiosis Bad Langensalza", "Phytopark", and "CHP systems"), have already been initiated or conducted in close cooperation with industry. Application projects with economic partners are set to be implemented and accompanying research projects applied for as part of the further development (from 2020).
The High-Performance Center DYNAFLEX® was positively evaluated in March 2019, allowing efforts towards stabilization to take place.

More information:
www.dynaflex.de, s.fhg.de/fLw

CONTACT

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FRAUNHOFER LIGHTHOUSE PROJECT "ELECTRICITY AS A RESOURCE"

The new "raw materials" for a circular carbon economy are sustainably sourced carbon, renewable energy, and recycled products and materials. The Fraunhofer lighthouse project "Electricity as a Resource" translates this idea into technology and is set to be implemented in 2019.

The energy transition and the low CO_2 electricity that comes with it can be used for electrochemical reactions in order to produce base chemicals with lower greenhouse gas emissions than their fossil fuel counterparts. Ten Fraunhofer Institutes, coordinated by Fraunhofer UMSICHT, developed electrochemical processes for precisely this purpose within the lighthouse project "Electricity as a Resource" from 2015 to 2018 and are now marketing them under the brand name eSource®.

Two electrochemical synthesis routes implemented

- The decentralized electrochemical production of hydrogen peroxide (H_2O_2): H_2O_2 is considered an environmentally friendly bleaching, hygienization, and desulfurization agent. Industry currently produces H_2O_2 in large plants that require considerable amounts of solvents, energy, and capital.
- Electrochemical conversion of carbon dioxide (CO_2) to ethene and alcohols: CO_2 is a useful source of carbon for chemicals and fuels when renewable energy is used to activate it. If this is successful, electricity, CO_2, and water will become raw materials for a CO_2 refinery.

The results

Four different electrochemical processes were newly developed and demonstrated in experiments. A brand new membrane for divided electrochemical cells was developed: It has high conductivities, contains very small amounts of fluorine, and can be produced economically. A new Aspen tool and software to support decision-making in current-controlled processes are ready for use. A digital carbon dioxide register shows where in Germany CO_2 is produced in what quantity and quality.

Sets of indicators to assess sustainability provide directional certainty for technical processes in early technology maturity levels. According to these, the eSource® demonstrators perform better than conventional reference processes in many impact categories. The results underwent practical testing in stakeholder dialogues with industry and at the international trade fair ACHEMA 2018.

Application with the eSource® platform

Sector coupling is expected to gain a boost. If actions recommended by the "Growth, Structural Change and Employment" Commission (www.kommission-wsb.de) are implemented in 2019, for example, in terms of a "green hydrogen economy" and power-to-X centers, then there is an acute demand on the market for experts for sector coupling and its new resources electricity and CO_2. As an early expert in sector coupling, Fraunhofer brings together its competencies bundled in the lighthouse project in a brand-supported platform for innovations in electrochemistry. eSource® will serve as an innovation platform and meeting place for users and developers in electrochemistry from mid-2019.

More information:
s.fhg.de/iHi, www.esource.fraunhofer.de

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BUSINESS UNITS

OUTSTANDING RESEARCH SERVICES.
Five business units meet the interdisciplinary needs of selected industry sectors.

OUR BUSINESS UNITS

Offer outstanding research services – in addition to outstanding performance, the declared goal of Fraunhofer UMSICHT requires a view of the big picture. Only then it is possible to assess topics, to provide individual solutions and to perform industry-oriented development. For a comprehensive understanding of markets and customer requirements in selected industry sectors, the departments of the institute's divisions are brought together to form five business units. This allows us to utilize resources more efficiently and to increase our productivity for the benefit of our customers.

P – POLYMER MATERIALS

- Bio-based plastics
- Plastics processing
- Leather/consumer goods
- Additive manufacturing

C – CHEMISTRY

- Petrochemistry
- Refineries
- Catalytic processes
- Biotechnology
- Cross-energy technologies

E – ENVIRONMENT

- Circular economy, ecodesign, and recycling
- Life cycle analyses
- Water, wastewater
- Urban farming
- Citizen science, co-creation

B – BIOMASS

- Bioenergy
- Waste materials
- Nutrients and nutrient recovery
- Agricultural technology

E – ENERGY

- Decentralized energy production and energy use
- Energy efficiency
- Energy storage
- Energy Systems

BUSINESS UNIT
POLYMER MATERIALS

Photo: shutterstock

SERVICE PORTFOLIO

For decades, Fraunhofer UMSICHT has been a strong partner to small and medium-sized enterprises all the way up to large-scale industry in the areas of the development and processing of plastics. Our specialties include the development of materials of bio-based plastics and recyclate-based plastics. We are representative of product and process developments, simulation, production scale-up and additive manufacturing of plastics. In the area of consumer products, we have proven expertise in high pressure technology and coating technology. As an application-oriented development partner, we also transfer our material, process, and product innovations to the construction and leather industries.

RESEARCH AND DEVELOPMENT SERVICES

- Material development (focus on bio-based plastics)
- Product and process development, manufacturing processes
- Product design, CAD design, and sample production
- Surface modification and surface structuring
- Foaming of plastics
- Component and system development
- Coating development
- Studies and consultation
- Multiphysics simulations of components and products
- Technical and economic feasibility studies
- Sustainability assessments
- Analytics, chemistry, biology, environmental analysis
- Determination of the biodegradability of materials and products

MARKETS AND INDUSTRIES

- Plastics and plastics processing industry
- Manufacturers of household articles, consumer care and clothing
- Leather and leather processing industry
- Manufacturers and users of additive manufacturing/ 3D printing
- Construction industry

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IMPROVING FAÇADE PAINTS USING HYDROGELS

1 *Test specimen with the façade paint in white and red.*
2 *Hydrogel as a bulking agent to optimize water management.*

Façade paints are crucially important as the outermost layer of house walls. In order to prevent the growth of algae and mold and to prevent structural damage, façade paints need to be impervious to rain, yet allow the diffusion of moisture from internal rooms. To combine these seemingly contradictory properties in a new material, Fraunhofer UMSICHT developed a switchable bulking agent that is used in an intelligent façade paint.

The objective: Balanced water management on façades

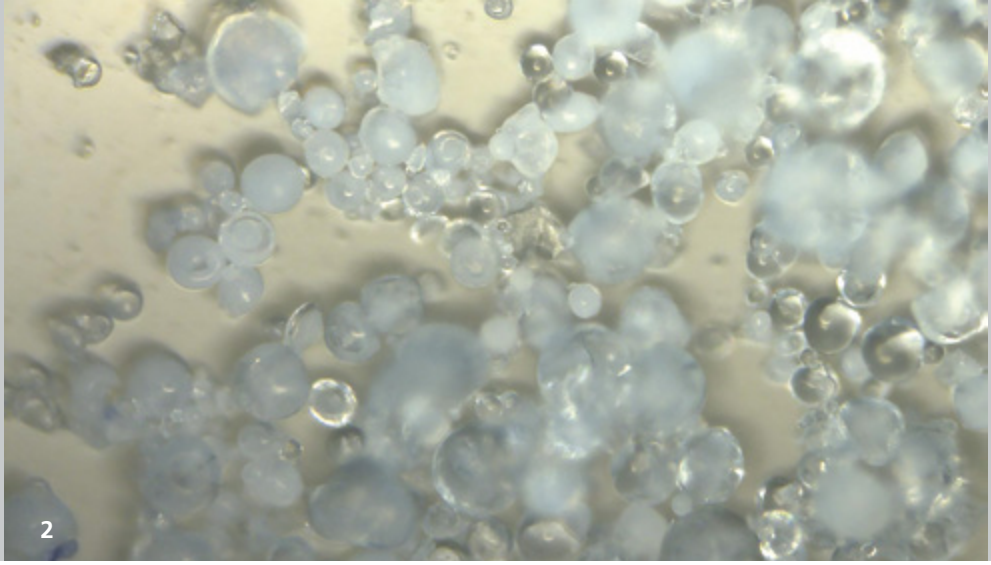
In a two-year research project funded by the German Federal Ministry for Economic Affairs and Energy, Fraunhofer UMSICHT and PROCERAM were able to develop a façade paint that combines the conflicting structural requirements. The new development enables a façade surface to be created that is completely open to diffusion while also possessing water-repellent properties. It has already been tested on house walls and shows promising results. Further development to market maturity is currently in preparation with the project partner PROCERAM. Plant planning and upscaling tests are being accompanied by Fraunhofer UMSICHT.

The result: New product with switchable bulking agent

The façade paint contains a porous, permeable bulking agent combined with a superabsorbent polymer (hydrogel). When it comes into contact with water, this polymer swells and closes the inner pores so that the bulking agent prevents any further water from passing through. After drying, the pores are reopened; air and water vapor can diffuse through them. The examination of the material characteristics shows that using porous bulking agents loaded with hydrogels has led to a significant functional improvement.

Environment, methods: From laboratory to pilot plant station

The development of the paint mainly took place in the pilot plant stations at Fraunhofer UMSICHT. Various hydrogels and paint formulations were developed there. These were then examined with regard to their behavior vis-à-vis water. The sd values (water-vapor diffusion-equivalent air layer thickness) and w values (water absorption coefficient) were determined here on the basis of DIN EN ISO 7783 and DIN EN ISO 1062 and the re-drying behavior was investigated. The functionalized acrylate dispersion façade paint with a filling level between 25 and 40% by volume proved to be particularly suitable. Upscaling was tested on various mixing systems, the paint formulations were improved, and their implementation significantly simplified. Sample productions were successfully implemented by PROCERAM on a 10,000-liter scale.



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Customer benefit: Marketable product

Starting with initial laboratory tests with bulking agents and various formulations, Fraunhofer UMSICHT has driven forward and accompanied the development of the new façade paint to market maturity by means of upscaling tests.

The functionalized façade paint enables active moisture management that keeps the façade dry. Thanks to this outstanding property, the new façade paint has great potential and is set to be tested for further applications. In particular, current research is focusing on reducing the growth of microorganisms on the façade. Initial results indicate that it is possible to use the product in thermal insulation composite systems, which would mean that biocides would no longer need to be added to façade paints in the future.

New façade paint: Very good test results

Moisture management in façade paints is determined using two parameters relating to building physics: The water absorption coefficient (w value) describes the water absorption in classes, and the water vapor diffusion resistance factor (μ value) represents the diffusivity of water vapor through a material.

The combination of low water absorption and good diffusivity would be ideal to maintain a dry wall. In analyses according to DIN methods, the functionalized acrylate dispersion façade paint shows significantly lower water absorption than comparable products. Diffusivity also lies within the optimal range. This is due to the ideally dosed, superabsorbent acrylate-based bulking agent. Long-term weathering over 12 months showed no functional losses.

SUSTAINABLE

Sustainability:

The intelligent water management of the façade paint extends the service life of walls, as the growth of algae and mold is reduced, thus minimizing the resulting damage to buildings. If it should become apparent that the paints can also be used for composite thermal insulation systems in the future, there may be no need to use additives that contain biocides.

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BUSINESS UNIT
CHEMISTRY

Photo: shutterstock

SERVICE PORTFOLIO

We offer process engineering research and development services as well as products and processes including industrial property rights. We provide solutions for the increasing demands for affordable sustainability and innovation in chemistry, petro-chemistry and refinery. We have our own know-how in the areas of fine and specialty chemicals (organic acids, peptides, sugars, tensides), polymers (monomer syntheses, polymerization, polycondensation) as well as chemical mass products (alcohols, naphtha) and fuels (diesel, kerosene). Biomass, synthesis gas, and selected residues constitute the portfolio of raw materials from which we suggest process-specific solutions. Upstream and downstream processing as well as product formulations round out our expertise. We are points of contact for the whole value added and logistics chains, develop specific sustainability assessments and strategies and bundle internal and external competences to fit the customer's project.

RESEARCH AND DEVELOPMENT SERVICES

- Synthesis routes from fossil and biogenic raw materials and residues including consulting regarding the sustainable shift in raw materials
- Optimization of process chains through integration of biotechnological and (thermo-/electro-)chemical-catalytic process steps
- Development and optimization of scalable processes including upstream and downstream processing
- Product development and formulation as well as production scale-up
- Development and screening of catalysts all the way up to kg scale
- Optimization of bioconversion steps with conversion of material by microorganisms, enzymes, or enzyme systems
- Development, sizing, operation, provision as well as optimizations of laboratory and technical shop systems with capacities of up to 20 kg product per week
- Analytics service: analyses in accordance with standard processes, special analytics, development of methods
- Technological consulting: sustainability assessments, economic feasibility analyses, concept studies all the way to basic engineering, studies regarding the potential of utilizing alternative raw materials and residues, topic and trend scouting, strategic concepts for action, innovation road-maps

MARKETS AND INDUSTRIES

- Chemical industry
- Biotechnology
- Process engineering plant construction

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ADVANCED ALTERNATIVE FUELS

1 *Rally legend Walter Röhrl tests TCR® fuel.*

2 *Sustainable fuel for mass-production vehicles – gasoline and diesel engines.*

Despite the discussions surrounding emissions and growing electromobility, internal combustion engines will continue to make an important contribution to our mobility in the future. There are no foreseeable alternatives to liquid energy sources, especially in the fields of shipping and aviation, and in heavy goods and long-distance transport. High-quality, standard-compliant fuels with high energy density will therefore continue to be indispensable in the future.

The objective: Sample production of advanced alternative fuels

The lighthouse project "Internal Combustion Engines for the Mobility of the Future" demonstrates the sustainable and economical production of high-quality advanced fuels using two processes developed by Fraunhofer UMSICHT. The raw materials used in the TCR® (thermo-catalytic reforming) process are residues such as sewage sludge and fermentation residues, while those used in the alcohols-to-fuels (A2F) process are the alcohols ethanol and methanol as well as acetone and isopropanol. Within the "Leitprojekt", around 50 liters of diesel and gasoline are produced from each process. The quality of the fuels is validated by means of engine tests and analyses.

The result: Validation of fuel quality by means of engine tests

The fuels produced are of the same quality as fossil fuels – in some cases, they are even better. In contrast to alternatives such as ethanol and biodiesel, they can be mixed with fossil fuels without any restrictions. The quality of the fuels is so good that, with the right selection of raw materials, not only CO_2 emissions but even NO_x and soot emissions can be reduced – without having to change the engine or the fuel supply chain. This is demonstrated on an engine test bench at the Fraunhofer Institute for Chemical Technology ICT. What's more, the Fraunhofer researchers are currently assessing the potential for reducing greenhouse gases using the processes and comparing this potential to alternative processes and fossil fuels.

Environment, methods: Demonstration plants

The innovative fuels are produced by two demonstration plants (capacity: 5 – 50 liters of fuel per day and plant). Various processes for material separation, e.g. distillation or membrane separation, are used to achieve further purification. The production of fuels is integrated into the "Leitprojekt", which is fundamentally concerned with the further development of internal combustion engines. Fraunhofer UMSICHT, Fraunhofer ICT, and the Fraunhofer Institute for Solar Energy Systems ISE are working together on the project under the direction of the Fraunhofer Institute for Optronics, System Technologies, and Image Exploitation IOSB.

2

Further technological approaches in the "Leitprojekt" include machine learning, lean-burning processes, and processes to reduce emissions and utilize residual heat.

Alcohol-to-fuels (A2F) process

With the alcohols-to-fuels process, simple raw materials that are available in large quantities, such as bioethanol and methanol, can be used to produce high-quality fuels. The components alone have a comparatively low energy density, dissolve in water, and may therefore only be added to gasoline in small quantities. If these raw materials are used in the A2F process, intermediates are created that can be mixed with diesel or even jet fuel following a hydrogenation step and are not subject to any limits.

TCR® process

With the patented TCR® technology, biogenic residues can be converted into the products oil, gas, and carbonate. The TCR® oil corresponds to the properties of fossil crude oil and can therefore be upgraded to the quality of standard fuel by means of a hydrogenation process.

What's more, high-quality syngas is produced, which can be used for engine applications or as a green hydrogen source in a proportion of up to 50% by volume. The carbonate produced is suitable as a nutrient carrier or can be used energetically as a fuel with a high calorific value in simple and robust fixed-bed gasifiers.

Customer benefit: Reducing emissions – improving quality

The pressure to reduce CO_2 emissions as well as NO_x and particulate emissions from engines is growing steadily. Vehicle manufacturers are obliged to limit the CO_2 emissions of their fleets. At the same time, exhaust gas treatment is becoming more expensive, resulting in rising costs and an increase in fuel consumption. While the requirements for CO_2 emissions are becoming stricter, there are also legal requirements to only use sustainable raw materials for alternative fuels. This limits the quantity of raw materials available. Most processes only provide comparatively simple compounds such as ethanol or methanol, which largely rules out their use in diesel vehicles or in aviation. Fuel manufacturers must therefore find alternatives in order to use sustainable raw materials and produce high-quality fuels from them to meet growing blending quotas while also limiting costs.

The processes developed at Fraunhofer UMSICHT make it possible to successfully accomplish this balancing act.

SUSTAINABLE

Sustainability:

The processes developed in the lighthouse project contribute to climate protection as they are able to use biogenic raw materials. During combustion, these raw materials only release the CO_2 that they have bound during growth.

At the same time, the high quality of the fuels can reduce airborne pollutants such as nitrogen oxides and soot, thus improving air quality in inner cities, for example.

The fuels are already opening up options for action in terms of transport, where alternatives are lacking, e.g. in air traffic.

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BUSINESS UNIT
ENVIRONMENT

Photo: shutterstock

SERVICE PORTFOLIO

Our service portfolio includes consulting, applied studies, innovative technology development up to pilot plant scale as well as support of the technical implementation at industrial scale. We provide clear communication paths with a central contact person who looks across our business units for the ideal solution for the customers' demands and who supports the joint realization. We deliver basics for strategic decisions; we improve competitiveness through optimization of energy flows, raw material flows, and waste streams, through sustainability assessments and through optimization of processes and plants. We as a reliable and strong partner for our customers are willing to establish long-term business partnerships.

RESEARCH AND DEVELOPMENT SERVICES

- Sustainability and resource strategies for business and politics
- Analysis of complex energy and raw materials supply systems (systems analysis) in order to support business policy/ political decisions
- State-specific, industry-specific and company-specific strategies and concepts for the supply with primary and secondary raw materials
- Concepts, processes, and products for
  - Recycling, utilization of residues
  - Recovery and generation of reusable materials and critical raw materials
  - Removal of pollutants and recovery of reusable materials from (waste) water
  - Removal of pollutants from waste gases
- Development, engineering, erection, and operation of plants and technologies for recycling, (waste) water treatment, and reduction of emissions at various orders of scale (testing plants, demonstration plants, industrial scale implementation)
- Scientific-technical support in the implementation of new technologies in practice
- Economic feasibility studies for processes, methods, and products
- Preparation of eco-assessments and sustainability assessments in accordance with DIN EN ISO 14040/14044 for products, processes and services
- Customer-tailored safety and hazardous material management software
- Analytics services with problem-oriented assessment and action recommendations
- Stakeholder and dialog processes

MARKETS AND INDUSTRIES

- The Public sector
- Industrial facility management
- Manufacturing industry and plant construction
- Waste disposal, circular economy, and recycling
- Raw materials industry
- Energy supply (incl. the supply of heat and cold)
- Water supply and waste water disposal
- Engineering and planning offices

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CONSORTIUM STUDY AS A TRAIL-BLAZER FOR FOLLOW-UP PROJECTS

1 *Micro- and macroplastics, collected on the French Atlantic coast.*

2 *Plastic waste by the side of the road, collected as part of the "Super-Sauber-Oberhausen" (Super-Clean Oberhausen) campaign.*

Over 400 scientific publications on microplastics were published in 2018 alone. Since then, a significant discussion on microplastics, plastic emissions, and plastics has been taking place in society and politics. In order to gain an overview of the complex topic of microplastics, the state of knowledge was collaboratively researched by Fraunhofer UMSICHT on behalf of eleven partners in a consortium study in 2016. On the basis of this initial study and the expertise resulting from it, Fraunhofer UMSICHT will continue to work on the topic of microplastics in various projects. Alongside its technical expertise, Fraunhofer UMSICHT has used microplastics activities to create a large network in which scientific institutions, NGOs, and special-purpose associations are represented alongside companies.

The objective: Consortium study on microplastics as the basis for the state of knowledge

The state of knowledge on microplastics and macroplastics was compiled and evaluated over a period of one year on behalf of a consortium consisting of eleven representatives from research, waste management, urban water management, and the plastics and consumer goods industries. During this, causes, quantities, and effects from existing literature were analyzed, data gaps identified, and solutions developed. It was thus possible to acquire further projects following the consortium study in order to deepen the findings on concrete sources of microplastics and to develop technical solutions.

The result: Follow-up projects on various topics

Inspired by the social debate, the role of microplastics and synthetic polymers in cosmetic products, detergents, and cleaning agents was investigated in a literature study commissioned by the nature conservation organization NABU e.V. The "PlastikBudget" project, funded by the German Federal Ministry of Education and Research (BMBF), looks at the creation of a plastic emissions budget and a new method for assessing the environmental impacts of plastics in environmental auditing. The "TyreWearMapping" project is investigating abrasion from car tires in Germany as well as modeling and presenting the spreading of these particles in the environment. Extensive mobility, geo and weather data from the German Federal Ministry of Transport and Digital Infrastructure (BMVI) are used for this purpose. The "FibrEx" project concerns a technical solution to reduce microplastics emissions. An innovative filter mechanism is set to be developed for washing machines that selectively retains worn textile fibers. The NRW project "iMulch" focuses on what is known as plastic mulch. Specifically, it involves developing methods to identify and quantify microplastics in soils and their effects on soil ecosystems. It has also been possible to acquire smaller projects. For instance, WWF Germany commissioned

2

Fraunhofer UMSICHT with a study and survey on the infrastructure and logistics of fishing equipment recovered from the sea as part of the "MARELITT Baltic" project.

Environment, methods: Data analysis, environmental distribution, possible solutions

Various methods are used within the projects. Eco-balancing software and geographic information systems (GIS) are used for map-based visualization. Water and soil samples are processed in the chemical and physical laboratory. Existing test benches were used and further developed to investigate filter materials for washing machines. New test benches, including a soil test bench and a laboratory sewage treatment plant, will be set up for ongoing projects.

Customer benefit: Wide-ranging expertise

Employees from the departments Sustainability and Resource Management, Photonics and Environment, and Bio-based Plastics have been concerned with the problems of microplastics and macroplastics in the environment since 2014. This has enabled experience and expertise from different fields to be brought together in order to consider the topic from a variety of perspectives and to build up a broad range of expertise. This expertise is available to customers in other projects. The service includes modeling and estimating quantities and distribution, evaluating the effects, and developing alternative materials or retention technologies. Alongside its technical expertise, Fraunhofer UMSICHT has used microplastics activities to create a large network in which scientific institutions, NGOs, and special-purpose associations are represented alongside companies.

Tire and road wear particles as a source of emissions for microplastics

Around 1100 grams of microplastics per person are released into the environment due to tire and road wear particles in Germany each year, making this the largest source of emissions. There is not yet any specific data on release, distribution, and dispersion in air and water. Closing these gaps in knowledge is the task of the "TyreWearMapping" project. To achieve this, mobility, geo, and weather data will be modeled and combined with experimental data from two river basins in order to visualize distribution routes for Germany. The results will be used to assist decision-making, e.g. with regard to targeted infrastructure measures at hotspots for tire and road wear particles.

SUSTAINABLE

Sustainability:

During the consortium study, knowledge was compiled concerning pollution quantities and pollution paths, which helps to develop efficient strategies and measures to reduce microplastic emissions accordingly. Sustainable solutions are also being developed in the various follow-up projects together with stakeholders. People and the environment are thus protected.

CONTACT

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BUSINESS UNIT
BIOMASS

Photo: shutterstock

SERVICE PORTFOLIO

Provision of bioenergy and biogas, utilization of residues, nutrient management and recovery as well as decentralized production and marketing of bio-based conversion products (biochar, synthesis gas, and pyrolysis condensate) are among our focal points. We develop and optimize thermochemical and biological conversion and distribution processes and the corresponding plant technology. With the objective to recover nutrients from municipal and industrial process chains and the conversion processes, we develop concepts and methods for nutrient management in biomass management. In this, we take into consideration raw materials potentials as well as logistic issues and integrate the technologies developed into established or novel value added chains.

RESEARCH AND DEVELOPMENT SERVICES

- Concept and system development for the provision of raw materials and energy from biogenic raw materials and residues, including process development, component development, and plant development – even by means of storable, carbon-rich intermediate products
- Concepts, construction, operation, and optimization of laboratory systems, technical shop systems and demonstration plants, including trace gas analytics
- Development of methods for reduction of emissions, flue gas purification
- Catalyst and bioprocess development
- Digitization technologies for the agricultural sector
- Development of concepts and technical systems for nutrient management and for nutrient recovery (e. g. nitrate, phosphate) including (sustainability) assessments; treatment of fermentation residues
- Strategy development and techno consulting

MARKETS AND INDUSTRIES

- Agriculture
- Energy supply (focus: bioenergy)
- Water supply
- Treatment/elimination of non-hazardous waste (focus: bioenergy)
- Agricultural engineering/agricultural machine construction

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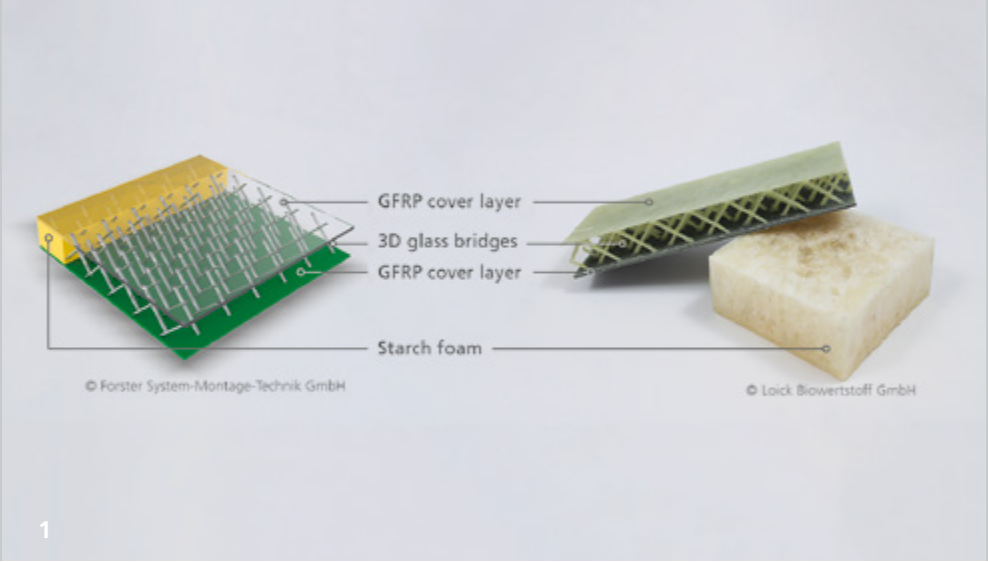

1

STARCH-BASED PARTICLE FOAM MATERIAL

1 *In the "LeichtbauStärke" project, two parallel cover layers made from glass fiber-reinforced plastic (GFRP) are joined together by three-dimensionally arranged strips of glass fibers. A starch-based foam is inserted into the core space, which is dissolved out again once the plastic resin has been applied and cured.*

2 *The starch-based foam can be produced using a conventional industrial process in a heated press.*

A large proportion of the materials used in the packaging industry consists of fossil plastics. Mostly non-biodegradable particle foams made from polystyrene or polypropylene are used to protect products. Based on the renewable raw material starch, Fraunhofer UMSICHT has developed biodegradable foamed molded parts that are lightweight, dimensionally stable, and versatile.

The objective: Biodegradable alternatives for foamed molded parts

An innovative starch foam was developed as an efficient and environmentally friendly alternative to fossil plastics within a collaborative research project. This material forms the basis for two further projects for the packaging industry and for the production of lightweight structures. The different project-specific requirements on the properties of the biodegradable particle foam material pose a particular challenge for Fraunhofer UMSICHT. The researchers address this challenge by constantly optimizing the composition of the starch material in the laboratory.

The result: Use as a water-soluble spacer and product-specific foam cover

In the "LeichtbauStärke" project, the foam is used to produce a lightweight construction. The water solubility of starch foams enables them to be used as temporary spacers that can easily be washed out during the production of lightweight panels, e.g. for trucks or rail vehicles.
The research project "BioFoamPrint" is concerned with developing product-specific foam covers to safely package art and cultural objects. Using a special 3D printing process, a team of industrial and research partners is developing an environmentally friendly packaging solution that can make it possible to dispense with grouped packaging and filling material.

Environment, methods: Ten years of experience in customizing foamed bioplastics

In the field of bio-based plastics, foamed products represent a resource-saving and cost-reducing alternative thanks to their reduced use of materials. For over a decade, the Bio-based Plastics department at Fraunhofer UMSICHT has been continuously expanding its expertise in the (further) development of dimensionally stable starch foams. Research has been conducted into customized foamed bio-based plastics for a wide range of industrial requirements throughout this time. Available bio-based plastics such as poly(lactic acid), cellulose derivatives, and starch are used to produce particle and extrusion foams.
The parameters of raw material availability, market opportunities, sustainability, and cost-effectiveness are taken into account when optimizing materials.

Customer benefit: Efficient, stable and lightweight – starch foam for a wide range of applications

When used as a filling material or auxiliary material in the packaging industry, the lightweight starch foam generally has a positive effect on transport costs, which are based not only on the size of a consignment but also on its weight. Compared to materials made from fossil plastics, non-renewable resources are conserved. Like foams made from standard plastics, starch foams can be reused several times. Lost foam particles from starch material quickly degrade in the environment.

When used as a product-specific, custom-fit packaging solution, there is no need for grouped packaging or filling material. This saves costs and material.

When used to aid assembly in lightweight constructions, the foam can be rinsed out after use. PU foam has been used for this so far, but it cannot be washed out and remains in the product. Thanks to the lower weight of the panels without a foam core, fuel is saved when they are transported by truck or rail vehicles. They are used, for instance, to create partition walls or floors. In addition, the starch foam has another advantage: After it has been washed out, free passages are left within the panels where cables can be laid, for example.

Successful collaboration

The projects were conducted in close cooperation with Loick Biowertstoff GmbH.

The joint project "Particle Foam Material Based on Starch-Containing Raw Materials" laid the foundation for the two follow-up projects. For funding information and project partners, see Appendix p. 57.

Fraunhofer UMSICHT is developing foam molded parts based on starch, a renewable raw material, from the laboratory to the production stage. Particle expansion and the production of molded parts take place in a closed system using a heated press. After melting, the starch particles expand when the press is opened and are removed as a molded part after cooling. The result: foam sheets with low material densities and adjustable elasticities. The highlight: application-related material and process development. Depending on the application and property profile, the researchers determine the necessary constants such as filling quantity, temperature, and time and add the required additives to the raw materials. This allows Fraunhofer UMSICHT to adapt starch-based particle foam materials to various applications.

SUSTAINABLE

Sustainability:

Biodegradable particle foam materials based on starch-containing raw materials are an environmentally friendly alternative to petroleum-based and non-degradable synthetic foams used so far in the packaging industry. The starch molded parts also facilitate completely new, sustainable cycles. If the starch foam is used, for example, as a spacer in lightweight structures and rinsed out after use, the resulting starch mixture can be used as a substrate for biogas plants.

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BUSINESS UNIT
ENERGY

Photo: shutterstock

SERVICE PORTFOLIO

The new energy system is formed by the increased use of renewable and decentralized sources of energy in the energy supply networks as well as increased use of storage systems, smart technologies and services. We are researching efficient solutions for the energy supply of the future. We specialize in applied research, application-oriented technical development and pilot projects using innovative energy technologies. We support companies on technical and systems analysis matters in municipal, regional, and industrial supply systems (e. g. combined energy generation, cross energy technologies, operation of energy storage systems). With a pragmatic view of what is technically, economically, and organizationally feasible, we take an active role in shaping the necessary changes in the energy sector.

RESEARCH AND DEVELOPMENT SERVICES

Energy system analysis and design

- In municipal, regional, and industrial structures: energy concepts, optimization, implementation of energy storage systems, implementation of cross energy technologies, modelling of energy load balancing technologies
- Optimized sizing and mode of operation of energy generation and storage systems in future electricity markets
- Municipal storage systems, energy-efficient municipal buildings, energy load balancing requirements, residual loads (analysis and optimization) in complex energy supply systems (e. g. hospitals)

Technical development

- Thermal, electrical, and chemical energy storage technologies: redox flow-batteries, compressed air energy storage systems, phase change materials and slurries
- Cross-energy technologies: power-to-gas, power-to-chemicals, catalytic- and bioelectric processes
- Customer-specific, innovative, large-scale, flexible, weldable bipolar plates
- Performance tests of battery systems up to 120 kW_{el}
- Pilot plant construction, electricity generation from waste heat, combined energy generation, innovative chillers
- New turbomachinery, small steam turbines, turbomachinery test bench

Studies, consulting

- Strategy and scenario development, meta studies
- Conception, customer-specific calculation, economic feasibility studies, design, planning and integration of energy systems and/or preparation and assessment of technical concepts
- Energy storage systems, use of storage systems, electricity from waste heat, power-to-X, decentralized bio energy (conversion) processes
- Improving the flexibility of CHP systems, heat demand forecasts
- Management of decentralized energy systems within the network
- New resources in steam and compressed air networks

MARKETS AND SECTORS

- Energy services providers for electricity, gas, heating and cooling, compressed air
- Municipal or regional corporations
- Operators of decentralized energy systems, coupled energy production plants, and energy storage systems
- Industrial customers with high energy demands/energy balancing demands
- Raw materials industry and processing industry (e. g. chemicals, steel, cement, paper, food)
- Developers, plant construction, project developers, and suppliers of innovative energy technology
- Users of new analysis and planning tools

CONTACT

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1

NEW ALGORITHM ACHIEVES OPTIMUM BLADE DESIGN

1 *The newly developed algorithm can, among other things, be used in the future for the micro steam turbine installed in the combined heat and power plant of Oberhausen-based energy supplier evo.*

2 *The algorithm couples CFD and optimization methods and automatically generates the optimal geometry.*

In order for the energy sector to be able to react flexibly to changes in the energy transition, innovation cycles must be shortened. New technological tools are needed to enable adaptive development and production so as to minimize the time from product development to market placement. Fraunhofer UMSICHT has developed a tool that automatically and efficiently optimizes turbomachinery.

The objective: Time and cost efficiency in turbomachinery blade design

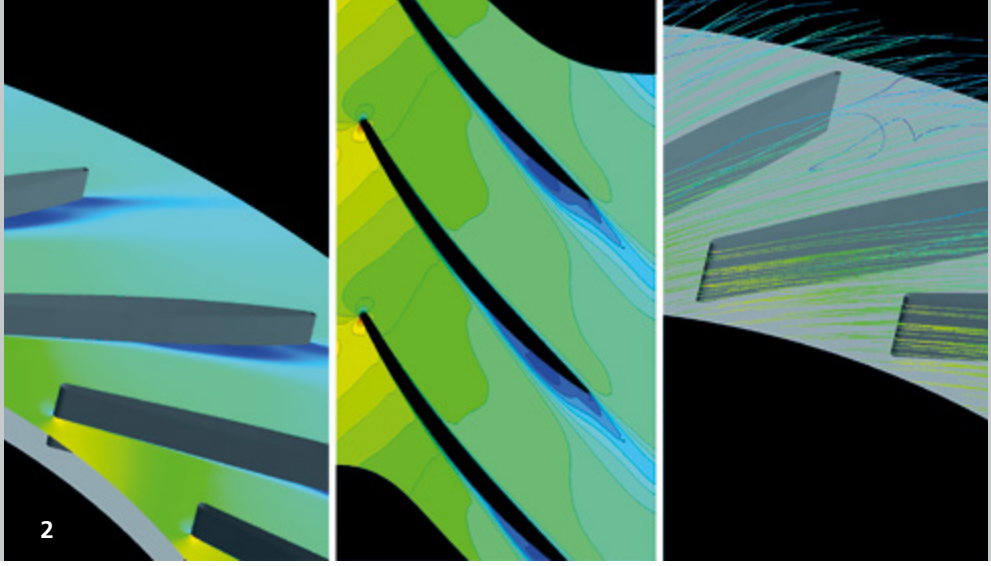
The energy transition has created highly dynamic markets that are changing the energy industry at an ever faster pace and are constantly requiring new products and services. The development of innovative technologies with a short "time to market" represents a great challenge. Fraunhofer UMSICHT has developed an adaptable tool that automatically optimizes the blade geometries of turbomachinery, particularly steam turbines and air compressors, thus offering innovations with lower development costs in a shorter time.

The result: Newly developed algorithm automatically generates the optimum geometry

Companies often operate steam turbines and air compressors at partial load. A clever design of the blade wheels can increase efficiency both at the nominal operating point and in the partial-load range so that more useful energy is generated with fewer resources. Fraunhofer UMSICHT provides an automatic solution especially for the development of micro steam turbines and turbo compressors: The newly developed tool couples computationally intensive CFD (computational fluid dynamics) methods with optimization methods and performs them on the computer cluster to quickly generate results. This allows the best possible blade design to be generated automatically and to react flexibly to changes in the market.

Environment, methods: Increasing efficiency for steam turbines and turbo compressors

The design and optimization of steam turbines and turbo compressors are usually based on empirical values, with the 3D computational fluid dynamics (CFD) supplementing the optimization where necessary. The researchers developed this innovative algorithm, which places CFD simulation at the center of design and optimization in order to obtain the best possible design while also shortening the "time to market". The algorithm, which can be flexibly adjusted to suit the needs of the application, is intended to be used in the future, among other things, in the micro steam turbine installed in the combined heat and power plant of the Oberhausen-based energy supplier evo in order to further increase efficiency and, if necessary, also improve partial load capacity.



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Customer benefit: Quicker reactions, faster placement on the market

The tool is primarily aimed at developers and manufacturers of small turbomachinery. With the automatic optimization tool, Fraunhofer UMSICHT is offering a service that saves the industry both time and money in product development and redesigning. Based on the respective company-specific design, the tool calculates an optimum blade geometry and thus enables efficiency and partial load behavior to be improved for micro steam turbines and turbo compressors. By outsourcing individual elements in the design development and using new IT methods, the development process is accelerated and leads to more efficient results. Considerable potential savings can be achieved. Turbomachinery manufacturers will thus be able to react more flexibly and, above all, more quickly to changing boundary conditions in the future, modify the product accordingly, and place it on the market more quickly.

Dynamic, adaptive, and flexible together

The tool was developed under the umbrella of the Fraunhofer High-Performance Center DYNAFLEX®, a platform for process dynamics and adaptivity in the energy transition and raw materials shift that transfers basic research results to industry and teaching. The aim is to be able to plan coordinated, adaptable, flexible, and modular production systems. Together with the Universities of Bochum, Duisburg-Essen, and Dortmund, as well as various industrial partners, Fraunhofer UMSICHT, as the coordinator, investigates the dynamics of technical systems in a scientific and application-oriented manner. The aim is to improve the future overall system and predict the effects of fluctuations on production and energy supply.

Increasing numbers of smaller turbomachinery are being used for decentralized or mobile applications in the fields of industry and mobility. They decentralize the energy supply as turbochargers or small turbines, or drive forward sector coupling as heat pump compressors.

The Energy Systems Engineering department at Fraunhofer UMSICHT has been optimizing and expanding its expertise in small, high-speed turbomachinery for vaporous and gaseous fluids for many years. The researchers are providing support with regard to profitability analysis as well as design and geometry optimization using CFD simulation. They develop small turbomachinery and test it on the institute's own test bench, build prototypes, commission pilot plants, maintain them, and carry out field tests.

Sustainability:

SUSTAINABLE

The newly developed algorithm allows the respective blade design of steam turbines and other turbomachinery to be optimized and continuously improved both at the design point and in the partial-load range. Increased efficiency offers the optimized utilization of available resources.

CONTACT

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INTERNATIONAL

INTERNATIONAL ACTIVITIES IN SOUTH AND NORTH AMERICA, AFRICA, AND THE NEAR EAST

Fraunhofer UMSICHT cooperates with partners worldwide as part of academic collaborations and international projects. Projects in Kuwait, Chile, and Tunisia, and collaboration with the Universities of Bologna, Birmingham, and Alberta are examples of these international activities.

PARTNERSHIP WITH THE UNIVERSITY OF BOLOGNA

A framework agreement between the Fraunhofer-Gesellschaft and the University of Bologna has been in existence since 2013 and establishes the cooperation between the Sulzbach-Rosenberg Institute Branch of Fraunhofer UMSICHT and the Center for Research in Environmental Sciences and Industrial Research on Energy and Environment at the University of Bologna.

Based on this established cooperation, the possibilities of a Fraunhofer "Project Center for Waste Valorization and Future Energy Supply" on the Ravenna Campus of the University of Bologna in Marina di Ravenna are now being assessed. The next step in this will be to develop a joint business model, which will form the basis for further negotiations. The competencies of both institutions in research and pilot plant development fit excellently into the highly industrialized Emilia-Romagna region (chemistry and energy). The Project Center could serve as a demonstration environment for new disposal technologies in the context of recycling management and for green economy approaches.

TCR® plant for Bologna

A laboratory system for thermo-catalytic reforming (TCR®) was delivered to the University of Bologna as part of the cooperation. The system with a throughput of 2 kilograms per hour was put into operation in the pilot plant station by Fraunhofer UMSICHT and the staff of the University of Bologna received intensive training on the system. Since laboratory systems are already in operation at universities in Switzerland, the United Kingdom, and Canada, this represents a further successful distribution of the TCR® technology.

PARTNERSHIP WITH THE UNIVERSITY OF ALBERTA

Fraunhofer UMSICHT has been working within a strategic research partnership with the University of Alberta, Edmonton, Canada since 2013. The official go-ahead was given for the establishment of a joint technology platform in 2017. Both institutions are conducting research in the fields of bioindustry (biorefinery and biobattery), electrochemical energy systems, and food and products, and want to pool their expertise and generate research results through a partnership.

TCR® plant for Canada

At the end of 2018, a TCR® testing plant was finally delivered to the University of Alberta. This was preceded by a one-week visit by Canadian scientists to Sulzbach-Rosenberg to familiarize themselves with the plant. The TCR® system is preconfigured for access and monitoring via the Internet so that parameterization and results of scientific experiments can be exchanged between Fraunhofer UMSICHT and Alberta.

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MOBILE BIOMASS CONVERSION PLANT FOR CHILE

For the German-Chilean research project "Semi-Mobile Bioenergy from Agricultural and Forestry Biomass Residues in Chile and Beyond" – "SeMoBioEnergy" for short – funded by the German Federal Ministry of Education and Research (BMBF), a system developed by Fraunhofer UMSICHT was delivered to the project partner in South America.

The "SeMoBioEnergy" project aims to develop practical concepts for regional bioenergy chains using residues from agriculture and forestry. The central idea is to use residues from agriculture more efficiently to produce energy, to increase local value creation, and reduce Chile's dependence on energy imports. Various utilization concepts are being investigated as part of the project, including a thermochemical conversion process developed by Fraunhofer UMSICHT. The plant developed for this purpose was commissioned at the Sulzbach-Rosenberg site and shipped to Chile as part of the project.

WASTE MANAGEMENT PLAN FOR KUWAIT

The Sulzbach-Rosenberg Institute Branch of Fraunhofer UMSICHT has been working on a large-scale waste management plan for the emirate of Kuwait since 2017. Among other things, a progressive monitoring and information system is being developed within this, which is set to provide online information on waste quantities, transports, and landfill sites as well as compliance with limit values. This project is regarded as a showcase project for the circular economy in the Gulf region.

MODEL REGION FOR WASTE MANAGEMENT IN TUNISIA

The Tunisian government plans to improve waste management in the country. In addition to the positive effects on health, the environment, and tourism, the country hopes to create new jobs directly in the waste disposal and recycling industry. This project in Northern Africa addresses a problem that affects many African states: the uncontrolled dumping of waste, some of which is heavily polluted, such as waste electrical and electronic appliances. During the project, a concept was developed for a recycling center in which various valuable waste materials, such as waste electrical and electronic equipment (WEEE), can be collected and recycled.

1 *Loading of a pilot plant in Sulzbach-Rosenberg for Chile within the "SeMoBioEnergy" project.*

2 *The team from the University of Alberta receives a TCR® laboratory system for Canada in Sulzbach-Rosenberg.*

CONTACT

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Bologna: *Samir Binder | Deputy Director Institute Branch Sulzbach-Rosenberg | Phone +49 9661 908-402 | samir.binder@umsicht.fraunhofer.de*

Canada/Birmingham: *Prof. Dr. rer. nat. Andreas Hornung | Head of the Sulzbach-Rosenberg Institute Branch | Phone +49 9661 908-403 | andreas.hornung@umsicht.fraunhofer.de*

Chile: *Dr. Nils Jäger | Renewable Energy Department at the Sulzbach-Rosenberg Institute Branch | Phone +49 9661 908-448 | nils.jaeger@umsicht.fraunhofer.de*

PEOPLE
PRIZES AND AWARDS

RESEARCH INVOLVES LOTS OF PEOPLE.

Behind our work there are people; we would like to introduce some of them to you, since without them we would be nothing.

1 © Energieversorgung Oberhausen AG


2 © Fraunhofer/Marc Müller

PRIZES AND AWARDS IN 2018

Imagine Chemistry 2018
Dr.-Ing. Axel Kraft and Martin Peters, from the Biorefinery and Biofuels Department, were honored for their research on a "catalytic process to produce alcohols from more sustainable raw materials" as part of the Imagine Chemistry Competition by AkzoNobel Specialty Chemicals.

Energie Start-up Bayern 2018 and KlimaExpo.NRW
TURBONIK GmbH won first place in the Energie Start-up Bayern 2018 competition with its innovative micro steam turbine. KlimaExpo.NRW also recognized the potential of the development and included the spin-off of Fraunhofer UMSICHT in its nationwide exhibition.

Honorary plaque for Dr.-Ing. Stephan Kabasci
Dr.-Ing. Stephan Kabasci, Head of the Bio-based Plastics Department, was honored for his outstanding voluntary commitment to the establishment and long-term management of the VDI Technical Division Biotechnology as part of the 2018 Annual Advisory Board Meeting of the VDI Society Technologies of Life Sciences.

Honoring the Best
Nils Hohmann was awarded by the Fraunhofer-Gesellschaft for his bachelor thesis at the event "Honoring the Best". Hohmann's work concerned the redesigning of a belt dryer.

Steel Innovation Award 2018
Fraunhofer UMSICHT and TURBONIK GmbH were jointly honored with the Steel Innovation Award 2018. They took first place in the Products category – out of 561 submitted applications – with their project "Highly Efficient and Oil-Free Micro Steam Turbine made from Stainless Steel for Own Power Generation".
More information: s.fhg.de/3bY

Netzwerk Zenit e.V. presents innovation award
Together with Fraunhofer UMSICHT, Cornelsen Umwelttechnik GmbH developed an innovative technology to efficiently clean waters polluted with PFCs while saving resources. This has earned it the innovation award from Netzwerk Zenit e.V.

Innovators under 35
Dr.-Ing. Peter Hense is one of the "ten best innovators under 35" in Germany. He was awarded the young talent award by the magazine Technology Review thanks to his concept "Electronic Waste as a Source of Resources".

Moonshot vision: Two winners
There were two winners from Fraunhofer UMSICHT at the competition as part of the Fraunhofer Symposium "Netzwert 2019". Leandra Hamann impressed with her idea for a biomimetic filter to reduce microplastics. Katharina Reh won over the jury with her vision of cleaner oceans and the "SeaCycle" approach.

100th Greentech.Ruhr partner company
Greentech.Ruhr welcomed its 100th partner company with Volterion GmbH. With its unique redox-flow batteries, the spin-off from Fraunhofer UMSICHT is one of the lighthouse companies in the region that is now also benefitting from the network's services.

1 *Fraunhofer UMSICHT and TURBONIK GmbH are pleased to have been included in KlimaExpo.NRW.*
2 *Leandra Hamann with Fraunhofer President Prof. Reimund Neugebauer.*

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THE RENAISSANCE OF THE EDISON ACCUMULATOR

Juliane Perl studied nanoengineering with a specialism in nanoprocess technology at the University of Duisburg-Essen. As part of her PhD position at Fraunhofer UMSICHT, she is involved in the KOBIBATT project and is researching a battery system with higher energy density, greater safety, and lower costs.

What is your current research focus?
I am looking at what is known as the Edison accumulator, a nickel-iron battery developed by Waldemar Jungner and commercialized by Thomas Edison at the start of the 20th century. The special feature of this battery technology lies in the simplicity and robustness of the electrode materials as well as their low toxicity, high safety, and exceptionally long service life. The Edison battery was already used in electric vehicles around 1900 but has gradually been replaced by more modern battery technologies such as nickel-cadmium and nickel-metal hydride. Today, nickel-iron batteries are only produced in small quantities and are occasionally used as stationary energy storage devices for photovoltaic systems in remote regions.

How do you intend to tap into the potential of this battery technology?
Using our thin bipolar films, we are giving the Edison accumulator a bipolar structure and producing a compact, fully welded nickel-iron battery stack. One challenge in stack construction is gas evolution in the battery system during charging and discharging. As part of my doctoral thesis, I therefore look at the mechanisms that lead to gas development at the iron electrode. Using modern characterization methods, I will isolate the mechanisms responsible for gas evolution and derive an idealized iron electrode based on them. Our stack construction method not only increases the energy density of the battery but also makes the battery maintenance-free, making the Edison accumulator attractive for various stationary applications once again.

What distinguishes the work at Fraunhofer UMSICHT?
Quite clearly: the many freedoms and the high degree of flexibility that I have in terms of research! Thanks to the very well-equipped laboratories and pilot plant stations at the Oberhausen site and the proximity to universities and higher education institutions in the surrounding area, hardly any wishes remain unfulfilled.

What are your goals for 2019?
Together with my colleagues, we want to produce the first fully welded nickel-iron battery stack with a bipolar structure by the end of the year. I'm particularly looking forward to that. My personal goals for this year are the release of my first publication on iron electrodes in the context of alkaline battery systems and, of course, the further development of my doctoral thesis project.

1 *Juliane Perl is currently participating in the Fraunhofer funding program "TALENTA start" in order to expand her expertise in the field of project management alongside her doctorate.*

CONTACT

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DEVELOPMENT AND OPTIMIZATION OF A NEW ULTRASOUND PROCESS

Sewage sludge contains many important recyclable materials that have not yet been optimally utilized. In order to recover phosphorus and other components from the sludge, the BMBF's joint project UltraSep involves testing and optimizing an innovative ultrasonic process. Lukas Rüller is undertaking his doctorate on the ultrasonic treatment of biomass in the Process Engineering department at Fraunhofer UMSICHT and is involved in developing and optimizing the new process.

What are you responsible for in the UltraSep project and who else is involved in the project?
Together with our project partners, AQUATTRO GmbH and Wupperverbandgesellschaft für integrale Wasserwirtschaft mbH (WiW), there are plans to construct a pilot plant that implements an innovative ultrasound process. It will be operated at a sewage treatment plant in order to gradually optimize the process on a larger scale and under real conditions. Within this project, I am involved in tasks ranging from design to the commissioning of the pilot plant. When the plant runs at the sewage treatment plant, I will scientifically supervise the operation and optimize the plant with regard to the relevant process parameters such as temperature, ultrasound power, and flow rate.

What distinguishes the new ultrasonic process from other sewage sludge recycling processes?
The ultrasound technology used is both innovative and the main component of the process. A significantly higher power input greatly increases cavitation, the formation and implosion of microbubbles, in the medium. Due to the implosion effects, the sewage sludge can be almost completely decomposed and then mechanically separated. The results of this separation are cellulose-rich fibers, nutrient-rich gel, and an easily fermentable liquid with nitrogen and phosphorus compounds, the preparation of which enables further recycling.

What will the recovered phosphorus be used for?
Phosphorus can be separated from the liquid phase by precipitation and recovered as magnesium ammonium phosphate. This compound can be used, for example, in fertilizer production.

Is the process already being used in practice?
We would like to demonstrate that the ultrasound process can be technically implemented on a pilot scale at a municipal sewage treatment plant and that a holistic recycling strategy can be realized for the resulting material flows such as phosphorus. If these projects are successful, it will be possible to derive further steps for implementation. For example, the process must be considered and evaluated from an economic viewpoint. It should also be assessed for which sewage treatment plants the process can be used particularly effectively.

1 *Lukas Rüller is working on a new process to improve the recovery of recyclable materials.*

CONTACT

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FROM SENSOR TO BUSINESS MODEL

Samir Binder is responsible for developing a framework for decentralized power engineering and process engineering plants at the Fraunhofer UMSICHT Sulzbach-Rosenberg Institute Branch. Together with his team, he is establishing a real, fully digital test environment, a "Living Lab", in the new pilot plant station. Modules and components from the institute's own development, as well as from industrial partners, can be tested here under real conditions.

How digital is energy plant construction today?
The degree of digitalization in our user areas, i.e. renewable energy, environmental engineering, and process engineering, the circular economy and recycling, is rather low – at least in comparison to general piece goods-based industries such as mechanical engineering and logistics. Every process engineering plant today already has a functioning basic automation system and a control system for process control. However, only large-scale industry and power stations go beyond classic control engineering.

And why will that not be enough in the future?
Because complexity is increasing! If we want to exploit the potential of a decentralized, smaller-scale energy and raw material supply, the plants must be able to react to their environment, i.e. convert electricity into storable energy sources, for example, when a surplus of renewable electricity is available. However, they can only do this if they are operated in a coordinated manner. When there is a large number of small decentralized systems with numerous interaction and feed-in points, this can no longer be handled in the conventional way. For smart solutions, we therefore need digitalization – not as an option but as a must-have.

Where are the difficulties?
We have talked to many industry representatives and understood that digitalization is not primarily a technical challenge but rather an entrepreneurial, organizational task. Traditionally separate specialist departments suddenly have to work together very intensively to create added value for the company. This sounds feasible in theory but it is often virtually impossible in practice.

What is the solution in Sulzbach-Rosenberg?
We offer users a fully digital test environment. Industrial companies can physically place their equipment in our pilot plant station and then digitally upgrade it with our help. This ranges from the digitalization of a specific systems technology to the cloud connection, data engineering, and testing with virtual consumers or components from other manufacturers. Co-operating with our experts opens up new opportunities – from optimization to a digital business model.

1 *Samir Binder, a graduate aerospace engineer, heads the digitalization project at the Sulzbach-Rosenberg Institute Branch.*

CONTACT

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ELECTRONIC WASTE AS A SOURCE OF RESOURCES

Dr. Peter Hense from Fraunhofer UMSICHT in Sulzbach-Rosenberg has prepared the concept of "Electronic Waste as a Source of Resources" in his doctoral thesis entitled "Development and Optimization of a Thermochemical Process for Recycling Waste Electrical and Electronic Equipment". The results of his doctorate enabled the iCycle® technology to be developed, which could make the recycling of electrical and electronic scrap much more lucrative and has also triggered great demand from all around the world.

What happens to electronic waste today?
Recycling companies dismantle the equipment and shred the leftovers into pieces measuring 20 to 70 millimeters in size. This mainly concerns IT equipment and small household appliances such as vacuum cleaners and toasters. Iron, copper, and aluminum are separated from the granulate, as are a limited number of plastics. However, this process leaves around 20 to 25 percent of residue, most of which goes to waste incineration plants. Materials that are heavily contaminated with pollutants are dumped underground. In parts of Southern and Eastern Europe, a large quantity of these materials unfortunately still end up in landfill sites. There are also uncontrolled dumping sites in Africa, such as in Ghana.

Have you found a way to recycle the residue?
Yes, using our iCycle® process, we obtain a metal concentrate from the shredder residues that contains, for example, gold, platinum, silver, and copper. High-tech metals such as tantalum and indium can also be recovered. The plastic from the composite materials is converted into fuels, i.e. gas or diesel-like oil. We burn the gas to supply the process with energy. We can use the oil in engines to generate electrical energy and further heat.

How does the process work?
The core element is a pyrolysis reactor. This works with a patented heat exchanger, which heats the shredder residues to about 650 °C in a controlled process with the exclusion of oxygen. Thanks to the newly developed temperature control system, we are able to bring the pollutant concentrations below the legal limit values, in some cases even below the detection limit.

Is the process economical?
The iCycle® process is already worthwhile with throughputs of approx. 70 kilograms per hour. Incinerating the shredder residues currently costs around 140 to 180 euros per tonne. Our process allows the recycler to obtain a metal concentrate that he can sell to copper smelters for 800 to 2600 euros per tonne.

1 *Dr. Peter Hense laid the foundations for the iCycle® technology with his doctoral thesis.*

CONTACT

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NETWORK

LUCKILY, WE ARE NOT ALONE ON THIS EARTH.

We construct networks, link into existing networks, and work in cooperation with partners, friends and patrons. We are happy to introduce some of them.

THE FRAUNHOFER-GESELLSCHAFT

With its clearly defined mission of application-oriented research and its focus on key technologies of relevance to the future, the Fraunhofer-Gesellschaft plays a prominent role in the German and European innovation process. Applied research has a knock-on effect that extends beyond the direct benefits perceived by the customer: Through their research and development work, the Fraunhofer Institutes help to reinforce the competitive strength of the economy in their local region, and throughout Germany and Europe. They do so by promoting innovation, strengthening the technological base, improving the acceptance of new technologies, and helping to train the urgently needed future generation of scientists and engineers.

FACTS AND FIGURES AT A GLANCE*

Research of practical utility is the central task of the Fraunhofer-Gesellschaft which was founded in 1949. Fraunhofer …

- conducts application-oriented research for the benefit of the economy and to the advantage of society,
- currently maintains 72 institutes and research institutions in Germany,
- has approx. 26,600 employees, primarily with degrees in natural sciences or engineering,
- generates an annual research budget of 2.6 billion euros, of which nearly 2.2 billion euros are generated in contract research. About 70 percent of these are derived from contracts with industry and from publicly financed research projects. Around 30 percent are contributed by the German Federal and State Governments in the form of base funding, enabling the institutes to work ahead on solutions to problems that will not become acutely relevant to industry and society for another five or ten years.

- Our contractual partners and clients are: industry companies, service providers as well as the public sector.

**As of February 2019*

FRAUNHOFER INTERNATIONAL

International cooperations with excellent research partners and innovative companies worldwide ensure direct access to the most important current and future areas of science and economy.

FRAUNHOFER AS EMPLOYER

As an employer, the Fraunhofer-Gesellschaft offers its staff the opportunity to develop professional and personal skills that will allow them to take up positions of responsibility within their institute, at universities, in industry, and in society.

Students who choose to work on projects at the Fraunhofer Institutes have excellent prospects of starting and developing a career at companies due to the practical training and experience they have acquired.

MORE INFO

www.fraunhofer.de/en/about-fraunhofer.html

1 *The building of the Fraunhofer-Gesellschaft in Munich.*

BOARD OF TRUSTEES

Since December 2002, a Board of Trustees with members from science, industry, politics, and administration has been providing advice to Fraunhofer UMSICHT.

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Chairman of the Board of Trustees
Loick AG, Managing Director

Prof. Dr. Ada Pellert
Deputy Chairwoman of the Board of Trustees
FernUniversität in Hagen, Rector

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Chair of Thermodynamics

1 *Offers competent consulting and acts as multiplier: UMSICHT Board of Trustees (As of: November 18, 2018).*

MORE INFO
s.fhg.de/board-of-trustees

SPIN-OFFS AT A GLANCE

The goal of the Fraunhofer-Gesellschaft is to develop innovative technologies which lead to market-ready products. One way to put a development into application and to market the technologies developed at the institute is to establish a spin-off. In addition to a good business concept, areas including financing, investment, and business management have to be implemented successfully as well.

A-TEC Anlagentechnik GmbH
Expert in mine gas utilization and the suctioning off of gas
Foundation: 1998 | *ba@atec.de* | ***www.atec.de***

Catfish Solutions GmbH
Manufacturer-neutral and industry-independent IT consulting company
Foundation: 2011 | *info@catfishsolutions.com* | ***www.catfishsolutions.com***

Datapool Engineering GmbH
Software solutions for process engineering and safety technology
Foundation: 2001 | *info@datapool-engineering.com* | ***www.dp-e.de***

FKuR Kunststoff GmbH
Development and sales & distribution of a broad range of bio-based plastics
Foundation: 2003 | *info@fkur.com* | ***www.fkur.com***

Ruhr Compounds GmbH
Processing of rubber residues into high quality plastics
Foundation: 2011 | *info@ruhr-compounds.de* | ***www.ruhr-compounds.de***

Susteen Technologies GmbH
Conversion of biomass residues through thermo-catalytic reforming into high quality energy sources
Foundation: 2014 | *info@susteen.de* | ***www.susteen.de***

Thermallium SPRL, Mons, Belgium
Coating for heat insulation and safety applications
Foundation: 2016 | *info@thermallium.com* | ***www.thermallium.com***

Turbonik GmbH
High-efficient and oil-free micro steam turbines for power generation from process steam
Foundation: 2017 | *info@turbonik.de* | ***www.turbonik.de***

Volterion GmbH
Energy storage for private homes
Foundation: 2015 | *info@volterion.com* | ***www.volterion.com***

VSM Solar Private Limited
Development, production, installation of solar-powered air conditioners, refrigerators, and walk-in coolers in India, Sri Lanka, Bangladesh
Foundation: 2011 | *info@vsmsolar.com* | ***www.vsmsolar.com***

Wagro Systemdichtungen GmbH
Development and production of sealing systems based on substances capable of swelling for civil engineering and pipeline construction
Foundation: 1999 | *info@wagro-systemdichtungen.de* | ***www.wagro-systemdichtungen.de***

RESEARCH AND TEACHING/ INSTITUTIONS OF HIGHER LEARNING

1 *Applied research requires close ties with science. During the 2017/18 winter semester, Fraunhofer UMSICHT sent 18 lecturers to 5 universities and 4 universities of applied sciences, and during the 2018 summer semester it sent 16 lecturers to 5 universities and 1 university of applied sciences.*

The research and development market is fast-paced. As an institute that, with its application and market-oriented services and products, is acting at the intersection of research at the university and industrial practices and products, we particularly rely on strategic partnerships with institutions of higher learning in Germany and Europe. There is an active exchange between institutions of higher learning, students, and Fraunhofer UMSICHT. In addition to joint projects, many employees teach at universities or universities of applied sciences in the region.

RESEARCH AND TEACHING

Prof. Dr.-Ing. Eckhard Weidner
Manages both Fraunhofer UMSICHT and the Chair of Process Technology at the Ruhr University Bochum, where he also teaches. This provides the institute with a direct connection to the university and strengthens the scientific network of both research facilities.

Prof. Dr.-Ing. Görge Deerberg
Is Deputy Director of the institute of Fraunhofer UMSICHT, and holds the adjunct professorship "Environmental and Process Technology" at the Faculty of Mechanical Engineering of the Ruhr University of Bochum. He is also the scientific director for the infernum distance learning course, jointly offered by the FernUniversität in Hagen (distance learning University of Hagen) and Fraunhofer UMSICHT under the umbrella of the Fraunhofer Academy.

Prof. Dr. rer. nat. Andreas Hornung
The Director of the Institute Branch in Sulzbach-Rosenberg founded the European Bioenergy Research Institute EBRI at Aston University in Birmingham. He holds a position as Professor of High Temperature Process Technology at the Friedrich Alexander University Erlangen-Nuremberg, as Associate Professor at the University of Bologna, and a Chair in Bioenergy at the University of Birmingham.

Prof. Dr.-Ing. Christian Doetsch
The Director of the Energy Division is honorary professor at the Faculty of Mechanical Engineering at the Ruhr University of Bochum for the topics of energy storage and refrigeration engineering. In addition, he is Member of the Board of the Research Department "Closed Carbon Cycle Economy" at the Ruhr University of Bochum.

MORE INFO
s.fhg.de/umsicht-directorate

PAVING THE WAY TO THE DOCTORATE: UMSICHT RESEARCH SCHOOL

The UMSICHT Research School is a supporting offer for doctoral candidates of the institute and was launched in November 2016. The objective is to make doctorates possible within 3 to 4 years and to create uniform framework conditions. Through training plans with individually coordinated continuing education offers, the necessary and helpful competencies for the doctorate and for a career with Fraunhofer UMSICHT are to be acquired.

1 *The UMSICHT Research School helps doctoral candidates to work targetedly on the doctorate.*

SUPERVISION

The supervising professors as well as the supervisors/mentors at the institute agree, in the context of a supervision/mentoring agreement, to regular meetings with the doctoral candidates regarding the progress of the work and in adherence to the time and work schedule.

QUALIFICATION

Through doctorate coaching and special continuing education offers tailored to the needs of the doctoral candidates, their competencies are developed further – commensurate with the requirements. These offers constitute a qualified foundation for the time after the dissertation – at or outside of Fraunhofer UMSICHT. Furthermore, the doctoral candidates are offered colloquia and regular information meetings.

NETWORKING

With an internal website specifically created for the doctoral candidates, Fraunhofer UMSICHT promotes the exchange among them. The networking with the other scientists and employees of the institute as well as with other Fraunhofer Institutes and a variety of external research institutions furthermore supports a broad integration of the doctoral candidates into the national and international science community.

UMSICHT
Research School

MORE INFO

www.umsicht.fraunhofer.de/en/jobs-career/promotion.html

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Photo: Fraunhofer UMSICHT/Ilka Drnovsek

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INTERDISCIPLINARY DISTANCE LEARNING ENVIRONMENTAL SCIENCES

The successful and scientifically-substantiated solution of complex challenges in the fields of environment and sustainability presupposes interdisciplinary thinking and approaches. The interdisciplinary distance learning program in environmental sciences infernum transmits the knowledge necessary for this purpose and builds fluency in the "languages" of various disciplines. infernum is distinguished by its interdisciplinary curriculum, professional breadth, and organizational flexibility; it is unique in the landscape of German university further education programs.

infernum combines the aspects of economic performance, social responsibility, and ecological compatibility and this way provides the students with a qualified further education in the spirit of an education about sustainable development.
Since 2000, infernum – as a distance learning program – allows students to work independently and in a structured way, to obtain scientific further education parallel to job and family, and to improve their chances in the job market. Individual teaching programs can be compiled from (inter)disciplinary modules and the course of studies can be started at any time.

THE FOLLOWING DEGREES CAN BE OBTAINED:

- Master of Science (M.Sc.)
- University Certificate of Environmental Sciences
- Certificates for individual modules
- University Certificate Environment Manager

infernum is a joint offer of the FernUniversität in Hagen (distance learning university) and Fraunhofer UMSICHT under the auspices of the Fraunhofer Academy.

Extensive further development of the blended learning concept and the course curriculum will take place within the framework of the joint project "mint.online", which is funded by the BMBF (Federal Ministry of Education and Research) from 2011 to 2017. The goal shared by Fraunhofer UMSICHT and the FernUniversität in Hagen is to further align infernum with the specific needs of the students from the working world.

1 The distance-learning program pursues the right path with its novel orientation and this is not the least of the reasons why it is allowed to call itself "Place of Progress 2014". The title is an award by the Ministry for Innovation, Science, Research and Technology of the German State of North Rhine-Westphalia (NRW) for guiding intellectual forces from NRW that combine economy, ecology, and social issues. In 2018, infernum received yet again rewards from the German UNESCO commission and the Federal Ministry of Education and Research as "Official Project" of the "UN Decade of Education for Sustainable Development".

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UMSICHT SCIENCE AWARD

UMSICHT FÖRDERVEREIN
Verein zur Förderung der Umwelt-, Sicherheits- und Energietechnik e.V.

The Fraunhofer UMSICHT Friends and Patrons Group awarded the UMSICHT Science Award once again in 2018. Dr. Stefan Kippelt won in the Science category with his doctoral thesis on decentralized flexibility options for the sustainable energy sector. A team led by Christian Baars was awarded in the Journalism category for the TV documentary about deadly super pathogens from pharmaceutical factories. The award has been honoring people for their comprehensible communication of socially relevant topics in the fields of environmental engineering, process engineering, and renewable energy since 2010.

AWARD WINNERS

Science category:
Dr. Stefan Kippelt
looks at the topic of "Decentralized Flexibility Options and Their Contribution to Balancing the Fluctuating Power Generation of Renewable Energies" in his doctoral thesis. He points out that increasing sector coupling and digitalization offer an opportunity to develop new flexibility resources. As part of his work, Dr. Kippelt has developed a tool that simulates the usable flexibility. With the aid of a model, he presents the energy system in 2035 and demonstrates the contribution that decentralized flexibility options can make. The scenario shows that these have a storage efficiency of over 99 percent compared to other storage technologies. A further result: the minimal influence on the future expansion requirements of the German distribution networks.

Journalism category:
Christian Baars
has been working with an interdisciplinary team to investigate the suspicion that pharmaceutical companies illegally dispose of large quantities of antibiotics. Together, they investigated the areas around factories in the Indian city of Hyderabad and discovered that bacteria in the polluted waters there develop defense mechanisms against antibiotics and become resistant. The NDR documentary "Der unsichtbare Feind – Tödliche Supererreger aus Pharmafabriken" (The Invisible Enemy – Deadly Super Pathogens from Pharmaceutical Factories) presents the research results in an impressive way.

UMSICHT FRIENDS AND PATRONS MEMBERSHIP

The "Verein zur Förderung der Umwelt-, Sicherheits- und Energietechnik e. V." (UMSICHT Friends and Patrons) is an essential element of a lively and powerful environment of Fraunhofer UMSICHT.

The members of this group support the institute in the realization of research and development ideas regarding environmental, safety, and energy technology. Furthermore, the group participates in the organization of congresses and seminars, funds promising young scientists and guest scientists, and each year awards the UMSICHT Science Award. **Become a member or a sponsor of the prize yourself, too. Talk to us.**

1 *The 2018 winners with the board members of the UMSICHT Friends and Patrons Group.*

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BIBLIOGRAPHY
FUNDING INFORMATION

FRAUNHOFER SPECIALIZED PUBLICATIONS AND PATENTS

The publications and patents that result from the research activity of the Fraunhofer Institutes are documented in the "Fraunhofer-Publica" database.

At **publica.fraunhofer.de/en**, you can find pointers to papers, conference presentations and proceedings as well as research reports, studies, publications of institutes of higher learning, and patents and/or registered designs. Documents available electronically can be retrieved directly from the database in full text.

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(in German only)

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FUNDING INFORMATION

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The pilot phase of the Fraunhofer High-Performance Center DYNAFLEX® is a joint project funded by the Fraunhofer-Gesellschaft and the state of North Rhine-Westphalia with the participation of industrial partners.

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The "PlastikBudget" project is funded by the German Federal Ministry of Education and Research (BMBF) via the Project Management Agency DLR under the funding code FKZ 01UP1702A.

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The "Geisternetze" project was conducted as a subcontract from WWF Germany as part of the "MARELITT Baltic" project.

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- the "Particle Foam Material Based on Sustainable Raw Materials/ Starch Particle Foam" project, funding code FKZ 22011612 *(Consortium: Fraunhofer UMSICHT, Storopack Deutschland GmbH + Co. KG, Institut für Lebensmittel- und Umweltforschung e. V.)*

- the "LeichtbauStärke" project, funding code FKZ 22021617 *(Consortium: Fraunhofer UMSICHT, Forster System-Montage-Technik GmbH)*

- the "BioFoamPrint" project, funding code FKZ 22018916 *(Consortium: Fraunhofer UMSICHT as a subcontractor of Loick Biowertstoff GmbH, TU Dortmund University, Institut für Verpackungstechnik (IfV) des VVL e. V., DataPool engineering GmbH)*

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We are looking forward to getting into contact with you! If you have any questions, suggestions, and ideas for projects do not hesitate to contact us. You can reach us in many ways.

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