



Fraunhofer
UMSICHT

FRAUNHOFER INSTITUTE FOR ENVIRONMENTAL, SAFETY, AND ENERGY TECHNOLOGY UMSICHT



**ANNUAL REPORT
2016 | 17**

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, management and the institute's directorate are equally involved in the implementation.

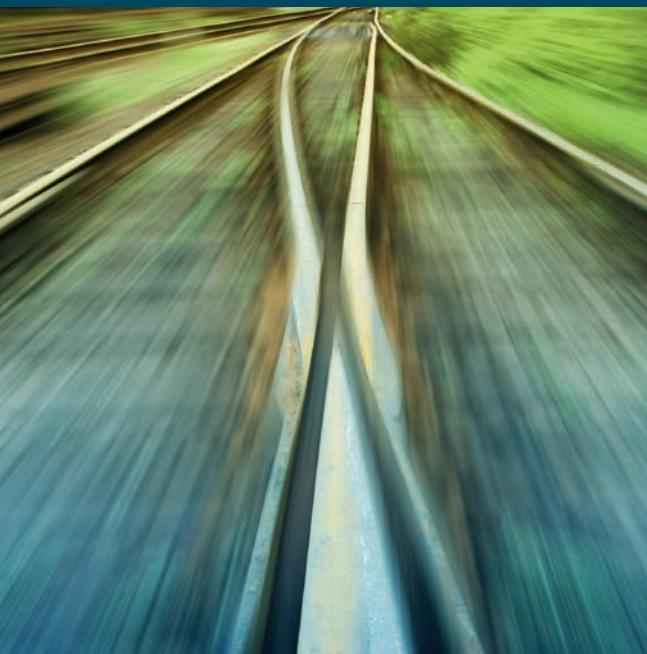
We would like to show all of our interested parties (customers, the public, job applicants) specifically which contribution our R&D products and services make to sustainable development. We want to get in touch with them in order to jointly further these objectives and to improve the quality of life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

MORE ABOUT SUSTAINABILITY
AT FRAUNHOFER UMSICHT

www.umsicht.fraunhofer.de/en/sustainability.html



TABLE OF CONTENTS



EVERYTHING AT A GLANCE.

On 56 pages, we report on our 2016 projects,
the people behind the projects and the prospects.

4 PREFACE

6 INSTITUTE

- 7 Pioneers of a Sustainable Energy and Raw Materials Management
- 8 Facts and Figures
- 10 Organizational Structure

12 STRATEGIC PROJECTS

- 12 Fraunhofer Lighthouse Project "Electricity as a Resource"
- 14 Carbon2Chem® – CO₂ from the Steel Industry
- 14 Closed Carbon Cycle Economy
- 15 Dynaflex High-Performance Center
- 15 Circular Economy/Circular Plastics

16 BUSINESS UNITS

- 16 Our Business Units | Overview
- 18 Business Unit Polymer Materials
 - 19 Service Portfolio
 - 20 Success Story
 - Cleantan® – Revolutionary Leather Tanning Process
- 22 Business Unit Chemistry
 - 23 Service Portfolio
 - 24 Success Story
 - Bio-based Softeners and Tensides
- 26 Business Unit Environment
 - 27 Service Portfolio
 - 28 Success Story
 - From Throw-away Product to Circular Economy
- 30 Business Unit Biomass
 - 31 Service Portfolio
 - 32 Success Story
 - Pilot system for biochar production
- 34 Business Unit Energy
 - 35 Service Portfolio
 - 36 Success Story
 - Rethinking Cogeneration

38 INTERNATIONAL

- 36 International Partnerships with Kuwait, Canada, Chile

40 PEOPLE/ PRIZES AND AWARDS

- 41 Awards
- 42 Fraunhofer-inHaus-Center: Rooms for Visions
- 43 New Forms of Cryotherapy
- 44 Establishing Biochar as Raw Material
- 45 Urban Digital Production

46 NETWORK

- 47 The Fraunhofer-Gesellschaft
- 48 Board of Trustees
- 49 Spin-offs at a Glance
- 50 Research and Teaching/Institutions of Higher Learning
- 51 UMSICHT Research School
- 52 Interdisciplinary Distance Learning Environmental Sciences infernum
- 53 UMSICHT Science Award

54 CONTACT / BIBLIOGRAPHY

- 54 Fraunhofer Publications and Patents
- 54 Schedule 2016 and Services
- 54 Funding Notes
- 55 How to reach us

56 EDITORIAL NOTES

PREFACE



Prof. Dr.-Ing. Eckhard Weidner, Director



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

Dear readers,

2016 was a very eventful year – not just with respect to world affairs, but also for us at Fraunhofer UMSICHT. Last year, we received the go-ahead for multiple large projects towards which we had been working, in part, for several years already. One example of this is the Carbon2Chem® joint project in which 19 project partners from business and science are working on substituting blast furnace gases for crude oil as chemical raw material and, as such, at the same time reduce CO₂ emissions from steel production. A project that is a perfect match for our mission since Fraunhofer UMSICHT regards itself as a pioneer of a sustainable energy and raw materials management. In our research, we deal with energy and materials cycles, and with which solution we have to explore and develop in order to allow for sustainable business practices. Furthermore, we are convinced that the Circular Economy, which we will increasingly focus on, will become more and more of a focal point in the future, e. g. in terms of the topic of plastics.

But let's return from an outlook into the future to the year 2016 and other positive events. Our institute branch in Sulzbach-Rosenberg, which has belonged to Fraunhofer UMSICHT since 2012, was positively evaluated last summer and was finally included in the Fraunhofer-Gesellschaft. With our colleagues in the Upper Palatinate region, the research is also all about cycles and sustainable business practices. As such, e. g., in another large-scale project for the emirate of Kuwait, a sustainable waste management will be created within the next four years subsequent to a comprehensive stocktaking of the current situation.

On the following pages you will find out more about our first experiences in Kuwait and about additional exciting projects from our five business units: Polymer Materials, Chemistry, Environment, Biomass, and Energy.

We wish you an exciting read of our look back onto the year 2016.

Cordial greetings


Eckhard Weidner


Görge Deerberg

INSTITUTE

THE BASIC DATA OF FRAUNHOFER UMSICHT.

Profile, Key Performance Indicators,
Organizational Structure.



PIONEERS OF A SUSTAINABLE ENERGY AND RAW MATERIALS MANAGEMENT

In Germany, the energy system is 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 are convincing.

Fraunhofer UMSICHT is situated in Oberhausen, has an institute branch in Sulzbach-Rosenberg (Bavaria) and a branch office (plastic 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 critical contributions to a resource-saving society and industry. We do everything in our power 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.

TRADEMARKS OF FRAUNHOFER UMSICHT

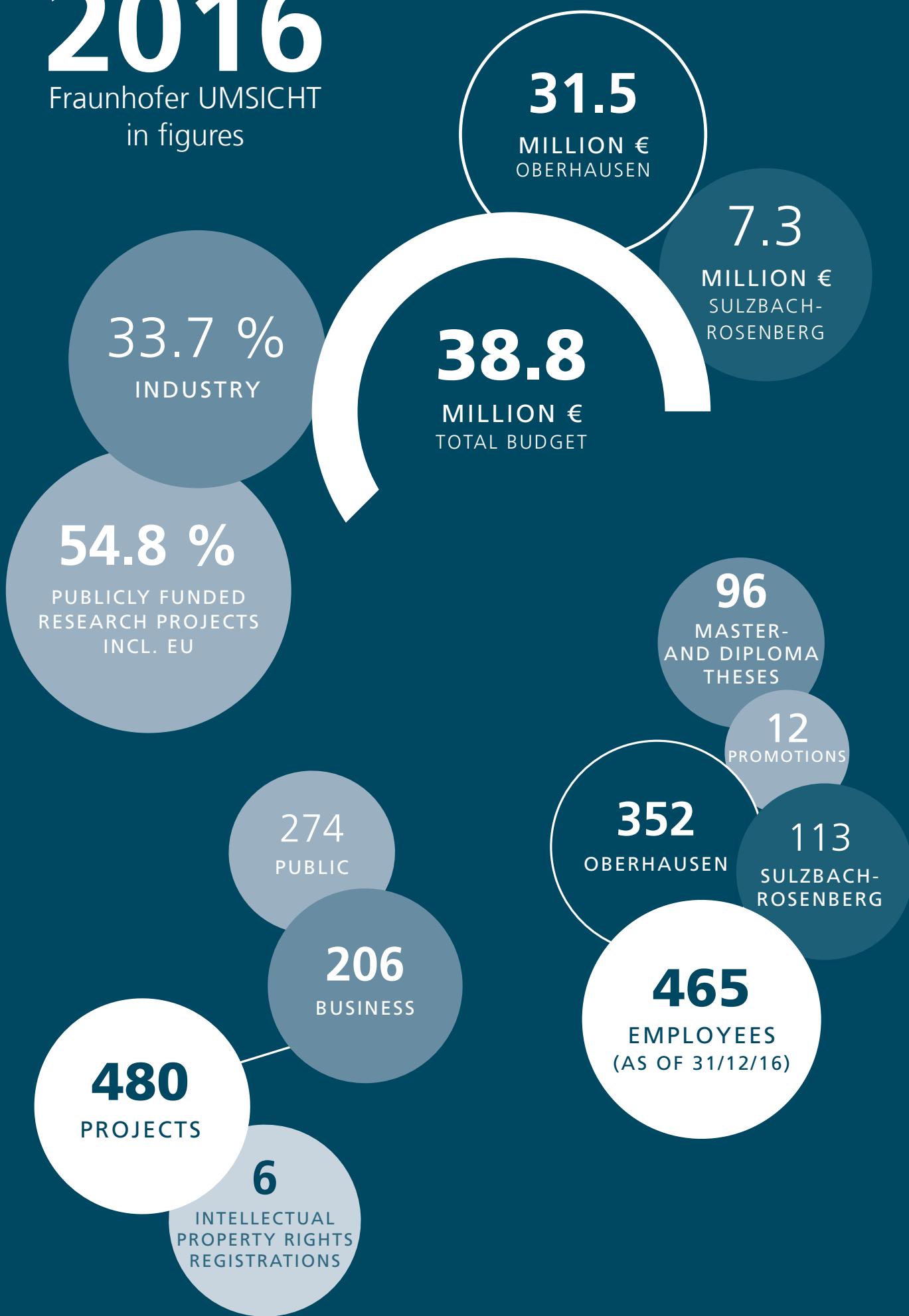
- Expertise in chemical-biological-physical conversion, material development, component development, process technology, product development and product evaluation, energy systems, mathematical and analytical methods
- Creativity, quality and efficiency in idea generation and the implementation in applications 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

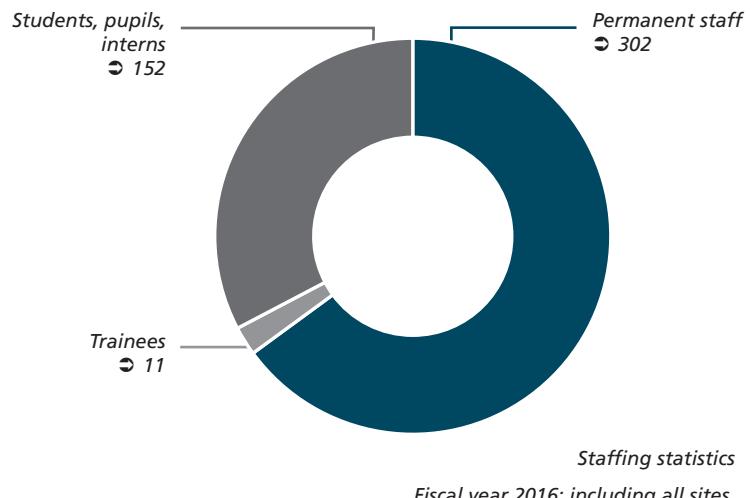
2016

Fraunhofer UMSICHT
in figures



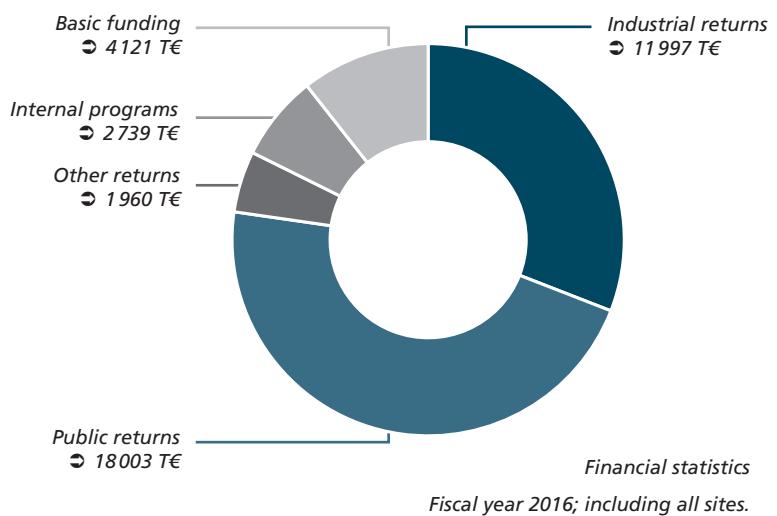
STAFFING STATISTICS 2016

	OB	SURO *
Permanent staff	232	70
Scientific	180	52
Administrative	52	18
Other staff	120	43
Trainees	8	3
Students, pupils, interns	112	40
Total staff	352	113



FINANCIAL STATISTICS 2016

	[in thousand euros]	
	OB	SURO *
Operating budget	28 557	7 046
Other costs	13 837	2 519
Staff costs	14 720	4 527
Investments budget	2 954	264
External project investments	2 588	264
Internal investments	366	0
Total returns	31 511	7 309
Industrial returns	10 309	1 688
Public returns	13 077	4 926
Other returns	1 314	646
Internal programs	2 690	49
Basic funding	4 121	0



ORGANIZATIONAL STRUCTURE

As of October 2016

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 areas 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

Director

Prof. Dr.-Ing. Eckhard Weidner (r.)

eckhard.weidner@umsicht.fraunhofer.de

Deputy Director

Prof. Dr.-Ing. Görge Deerberg (l.)

goerge.deerberg@umsicht.fraunhofer.de

OFFICE

Manuela Rettweiler M.A.

Advisor to the Institute Management

Phone +49 208 8598-1109

Verena Buhle

Assistant to the Institute Management

Phone +49 208 8598-1152



DIVISION ENERGY

Prof. Dr.-Ing. Christian Doetsch

christian.doetsch@umsicht.fraunhofer.de

- Energy Systems Engineering
- Energy Systems
- Chemical Energy Storage
- Thermal Storage and Systems



DIVISION PROCESSES

Prof. Dr.-Ing. Görge Deerberg

goerge.deerberg@umsicht.fraunhofer.de

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



DIVISION PRODUCTS

Prof. Dr.-Ing. Eckhard Weidner

eckhard.weidner@umsicht.fraunhofer.de

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



INSTITUTE BRANCH SULZBACH-ROSENBERG

Prof. Dr. rer. nat. Andreas Hornung

andreas.hornung@umsicht.fraunhofer.de

- Renewable Energy
- Thermal Process Technology
- Recycling Management
- Biological Process Technology

BUSINESS UNITS

further information see pg. 16

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.



Polymer Materials

Dr.-Ing. Manfred Renner

manfred.renner@umsicht.fraunhofer.de



Chemistry

Dr.-Ing. Axel Kraft (l.)

axel.kraft@umsicht.fraunhofer.de

Dr.-Ing. Hartmut Pflaum (r.)

hartmut.pflaum@umsicht.fraunhofer.de



Environment

Dipl.-Ing. Gerold Dimaczek

gerold.dimaczek@umsicht.fraunhofer.de



Biomass

Dipl.-Phys. Thorsten Wack

thorsten.wack@umsicht.fraunhofer.de



Energy

Dr.-Ing. Wilhelm Althaus

wilhelm.althaus@umsicht.fraunhofer.de



INNOVATION MANAGEMENT AND STRAT. PROJECTS

Dr.-Ing. Hartmut Pflaum

hartmut.pflaum@umsicht.fraunhofer.de



DIVISION ORGANIZATION

Andreas Weber

andreas.weber@umsicht.fraunhofer.de

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

STRATEGIC PROJECTS

PIONEERS OF A SUSTAINABLE ENERGY AND RAW MATERIALS MANAGEMENT

A climate-neutral supply with energy and carbon-based raw materials is possible if a fundamental change of the energy and raw materials system takes place that takes into consideration the needs of society and business. The overriding objective is to replace the, to date, mostly linear approach to business with a circular economy.

The new "raw materials" of a circular economy are sustainably provided carbon, renewable, but often fluctuating energy, and products and materials maintained in a cycle.

Here is where Fraunhofer UMSICHT comes into play with its strategic projects that are based on two pillars: Circular Energy Economy, and Circular Product Systems.

FRAUNHOFER LIGHTHOUSE PROJECT "ELECTRICITY AS A RESOURCE"

The energy transition and its concomitant low-CO₂ electricity open up new paths to establish an electricity-driven production. If this electricity flows into electrochemical reactions, basic chemicals for industrial production become accessible for which, to date, most of the time crude oil was consumed. Ten Fraunhofer Institutes, coordinated by Fraunhofer UMSICHT, are developing and optimizing electrochemical processes in the lighthouse project "Electricity as a resource" that use this electricity to manufacture important basic chemicals. These electrochemical processes are classic "enabling technologies" for the system coupling between energy system and chemical production, for which the lighthouse project is creating an on-going technological research and development platform that will be expanded to also include education and training.

Electrochemistry can supplement or replace catalytic thermochemical processes – if their utilization is associated with efficiency or sustainability advantages. A need for research exists in the technical application of electrochemistry for new synthesis paths. It is urgently necessary to develop catalysts and plant technology in order to achieve new process concepts for efficient, modular, and decentralized production facilities.

Two electrochemical synthesis routes

In the lighthouse project, new electrochemical processes are being developed, technically demonstrated, and their integration into the German energy system prepared. Two synthesis routes are being pursued:

Demonstrator 1: Decentralized electromechanical manufacturing of hydrogen peroxide (H₂O₂)

Hydrogen peroxide (H₂O₂) serves as environmentally friendly bleaching agent, e. g. for cellulose in the manufacturing of paper. At present, the industry is producing H₂O₂ via the anthraquinone method. The latter requires large amounts of solvents, energy, and capital in huge plants.

Demonstrator 2: Electrochemical conversion of carbon dioxide (CO₂) into ethene and alcohols

CO₂ is being generated in industrial processes all over the world. It is a sensible carbon source for chemicals and fuels if renewable energy is used for its activation. If this is achieved, electricity, CO₂, and water become the raw materials of a CO₂ refinery. Alcohols are an important group of substances



since they serve as starting material for numerous chemical products. Therefore, the lighthouse project has, as second electrochemical synthesis route, the manufacturing of alcohols (C_1 - C_4 alcohols, C_4 - C_{20} alcohols¹⁾) from CO_2 as its objective.

¹ *The number in the index specifies the number of carbon atoms (chemical sign: "C") contained in the alcohol.*

Cross-cutting research

The development of the demonstrator is being supported by cross-cutting research regarding system optimization:

Electrochemical component development and analytics

Membranes, electrodes, and sophisticated analytics are important elements of electrochemical cells and processes. They are being newly developed for the demonstrators.

Process modeling, simulation, and optimization

Mathematical equations describe mechanisms and interdependencies from the "molecule" level to the "process" level. In the lighthouse project, these equations become a support tool for efficient electrochemical processes.

Systems analysis and sustainability assessment

In this sub-project, energy scenarios are being created that study energy coupling, perform sustainability assessments, and integrate stakeholder interests. Scenarios for the future mix and price of electricity are being derived from trends and developments of the energy system. Jointly with scenarios for the economic system of Germany, they serve as basis for a comparative sustainability assessment that includes an economic process assessment.

Exploitation and business models

"Electricity as a resource" is designed for a long exploitation chain with which brand-supported new offers and business models are introduced to the market. In stage 1, products and services are developed from within the project.

Stage 2 develops innovation interfaces to sectors such as the chemical industry, plant construction, paper, textile, recycling, water via a multi-sector approach which does not yet exist for the area of "electrochemistry". Stage 3 pursues the setup of a Business and Innovation Center (BIC) that brings together science, marketing, and business development in order to design industry-relevant services. The platform serves as a technology center for spin-offs and opens up the Fraunhofer brand world "eSource®".

More Info: s.fhg.de/AHc

Participating Fraunhofer Institutes

Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT, Oberhausen (project coordination)

Fraunhofer Institute for Applied Polymer Research IAP, Potsdam/Golm

Fraunhofer Institute for Chemical Technology ICT, Pfinztal

Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB, Stuttgart

Fraunhofer Institute for Ceramic Technologies and Systems IKTS, Dresden

Fraunhofer Institute for Silicate Research ISC, Würzburg

Fraunhofer Institute for Surface Engineering and Thin Films IST, Braunschweig

Fraunhofer Institute for Industrial Mathematics ITWM, Kaiserslautern

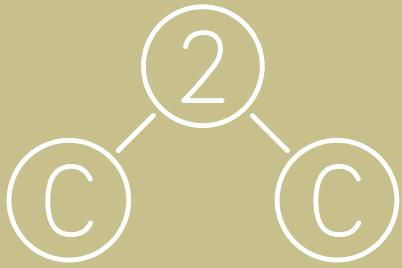
Fraunhofer Institute for Process Engineering and Packaging IVV, Freising (consulting)

Fraunhofer Institute for Wood Research, Wilhelm Klauditz Institute WKI, Braunschweig

CONTACT

Dr.-Ing. Hartmut Pflaum | Business Developer Chemistry |

Phone +49 208 8598-1171 | hartmut.pflaum@umsicht.fraunhofer.de



Carbon2Chem®

CARBON2CHEM® – CO₂ FROM THE STEEL INDUSTRY

At iron and steel works, blast furnace gases that contain significant amounts of carbon-based components are generated in the production process. In the project under the joint coordination of thyssenkrupp AG, Fraunhofer UMSICHT, and the Max Planck Institute for Chemical Energy Conversion in Mülheim an der Ruhr will, jointly with 16 other project partners, develop solutions for the transformation of process gases from steel production into chemical basic materials – in particular the carbon contained therein which, at present, is still being released in large amounts as CO₂. Required for this are technologies for chemical synthesis, e. g. for catalysis with which the gas can be cleaned, conditioned, and transformed into market-ready chemical products or fuels.

To provide such technologies and to integrate them into the context of iron and steel works, those are the essential challenges. For this, Fraunhofer UMSICHT is using methods of systems engineering, e. g. modeling and coupled system simulation in order to develop proposed solutions.

In addition, the institute develops technologies for gas cleaning, for the catalytic manufacturing of methanol and higher alcohols. The project was started in June 2016 with a kick-off event at the Kraftzentrale, a converted power station located in Duisburg Landscape Park. The group project continues until 2020 and is being funded by the German Federal Ministry of Education and Research (BMBF). The consortium has made it its objective to implement the research results as quickly as possible at a large scale in iron and steel works.

More Info (German site): s.fhg.de/hfs



CONTACT

Prof. Dr.-Ing. Görge Deerberg | Project Coordination Carbon2Chem® |
Phone +49 208 8598-1107 | goerge.deerberg@umsicht.fraunhofer.de
Dr.-Ing. Torsten Müller | Business Office Carbon2Chem® |
Phone +49 208 8598-1284 | torsten.mueller@umsicht.fraunhofer.de

CLOSED CARBON CYCLE ECONOMY

Even in the future, industrial societies will be dependent on energy sources and raw materials that are based on carbon. But any carbon atom used eventually will become carbon dioxide. In order to protect the climate and the environment, carbon must be reutilized in a cycle, and all available sources of carbon must be used efficiently – and that across sectors. Because the mobility, heat, and (chemical) raw materials supply sectors have an enormous amount of catching up to do, while in the electricity sector renewable energies are already increasingly being used. For this, expansive new technical as well as societal structures must be established.

At the Ruhr University of Bochum (RUB), the Research Department Closed Carbon Cycle Economy has been founded for this. Approx. 40 actors, Fraunhofer UMSICHT among them, are researching this systemic approach.

Endowment chair

In spring 2017, the German state of North Rhine-Westphalia, the Ruhr University of Bochum, RWE AG, as well as Fraunhofer UMSICHT founded the endowment chair "Carbon Sources and Conversion" at the Research Department Closed Carbon Cycle Economy of the Ruhr University of Bochum. The endowment chair is to contribute process technologies for closing the carbon cycle from domestic, regenerative, and industrial sources. For this transformation technologies as well as products are being developed, and foundations for technical carbon cycles are being explored. This is a challenging task, requiring interdisciplinary and multi-disciplinary expertise.

More Info (German site): s.fhg.de/uQQ

CONTACT

Prof. Dr.-Ing. Christian Doetsch | Division Director Energy |
Phone +49 208 8598-1195 | christian.doetsch@umsicht.fraunhofer.de



DYNAFLEX HIGH PERFORMANCE CENTER

The Fraunhofer High Performance Center deals with the question of how adaptable production systems have to or can be if they are going to be operated, in the future, in a very volatile environment, e. g. with severely fluctuating electricity prices.

With changing customer orders, production volumes, and availability of raw materials, the objective of the partners in the DYNAFLEX High Performance Center is to create the scientific foundations for the optimal, flexible, and efficient use of production systems of the chemical and energy industry, which will increasingly work with volatile "green" electricity and a fluctuating heat supply.

While in the past, continuously operated large-scale plants were particularly well-suited for production, in the future, more work will be carried out with production systems that must be able to produce dynamically, adaptively (i. e., adjustably to changing framework conditions), modularly, and flexibly. For this, the dynamics of technical systems are studied scientifically and application-oriented in order to be able to identify, assess, and increase the flexibility and adaptability of processes and technologies based on this knowledge. As such, the energy and chemical industry are made fit for the future. In the pilot phase, Fraunhofer UMSICHT is working with the universities of the University Alliance Ruhr, Bochum, Dortmund, and Duisburg-Essen on scientific foundations. Jointly with strategic industry partners, these will be transitioned into application. This way, a powerful regional cluster is created.

More Info (German sites): s.fhg.de/ryT or s.fhg.de/SST

CONTACT

Prof. Dr.-Ing. Görge Deerberg | Deputy Director; Division Director Processes |
Phone +49 208 8598-1107 | goerge.deerberg@umsicht.fraunhofer.de

CIRCULAR ECONOMY/CIRCULAR PLASTICS

In its projects, Fraunhofer UMSICHT stands up for the implementation of the concept of a circular economy. We are detailing our understanding of a circular economy, in excerpts, on page 29. One key competence is located in the area of circular plastics.

Study: Circular economy for the chemical industry

Based on the three material flows of tires, rotor blades from wind turbines, and LCD monitors, Fraunhofer UMISCHT has exemplarily studied for the Regional Association North Rhine-Westfalia (NRW) of the German Chemical Industry Association (VCI) where the opportunities and the limits of a circular economy for the chemical industry are located.

(For the article, see p. 28/29)

Consortium study Microplastics/ "Plastic Marine Litter"

Plastics are indispensable for prosperity, health, resource protection, and energy efficiency. But too much plastics waste ends up in ecosystems and food chains.

The amounts of marine litter and microplastics in aquatic biospheres have reached an alarming magnitude and will, in the long term, develop problematically in case of a continuation of the current handling of plastics and plastic waste. Fraunhofer UMSICHT dedicated itself to the topic in a consortium study. Jointly with partners from different areas of business and science, trends are to be pointed out and solution approaches developed. The objective is to understand paths and effects of plastics in ecosystems, and to rethink, respectively the handling of and the conducting of business with plastics.

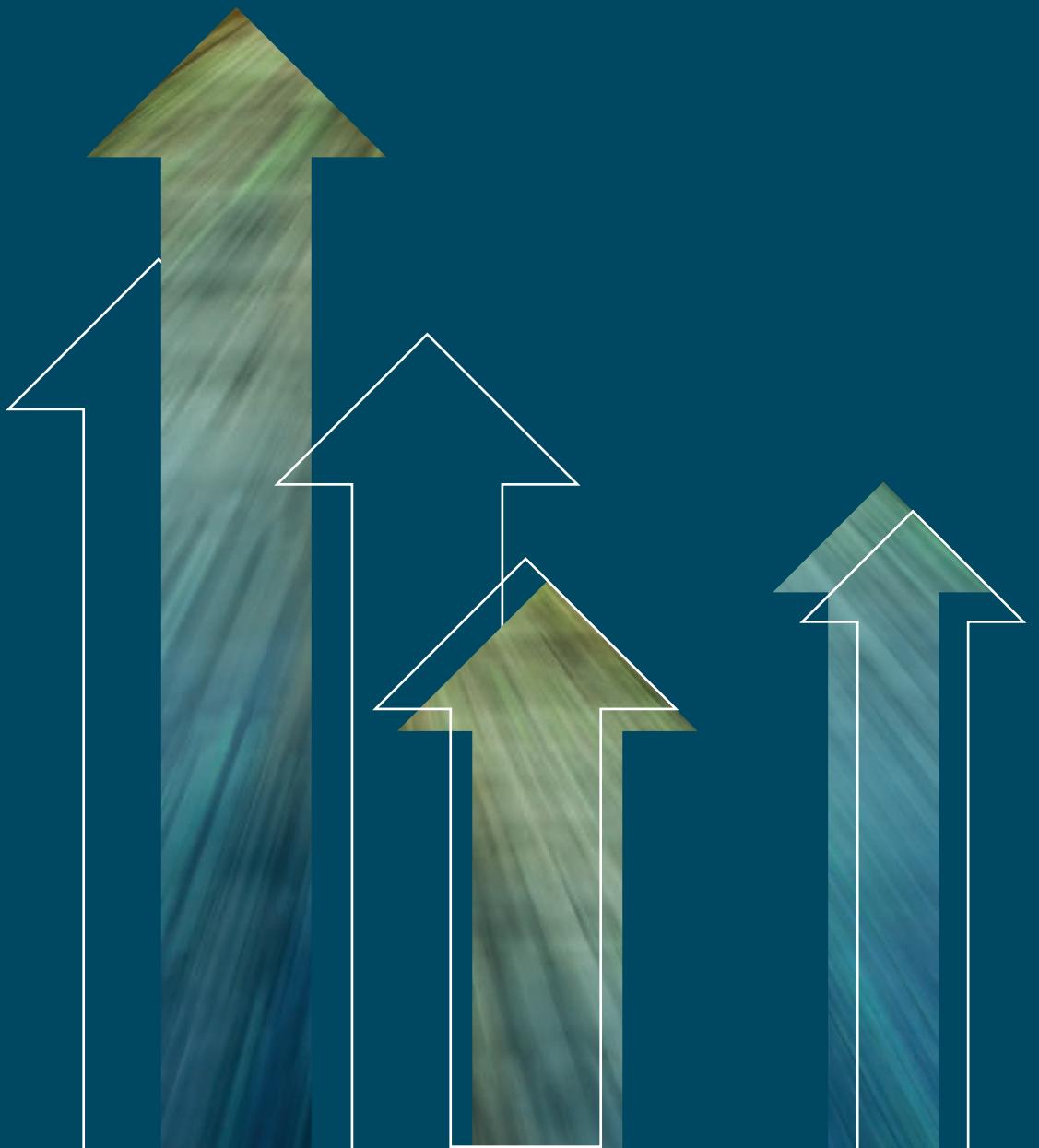
CONTACT

Dipl.-Ing. Jürgen Bertling | Business Developer Environment;
Deputy Head of Sustainability and Resources Management |
Phone +49 208 8598-1168 | juergen.bertling@umsicht.fraunhofer.de

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



U – ENVIRONMENT

- Water, wastewater
- Supply and disposal
- Raw materials
- Infrastructure
- Safety



B – BIOMASS

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



E – ENERGY

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

BUSINESS UNIT POLYMER MATERIALS

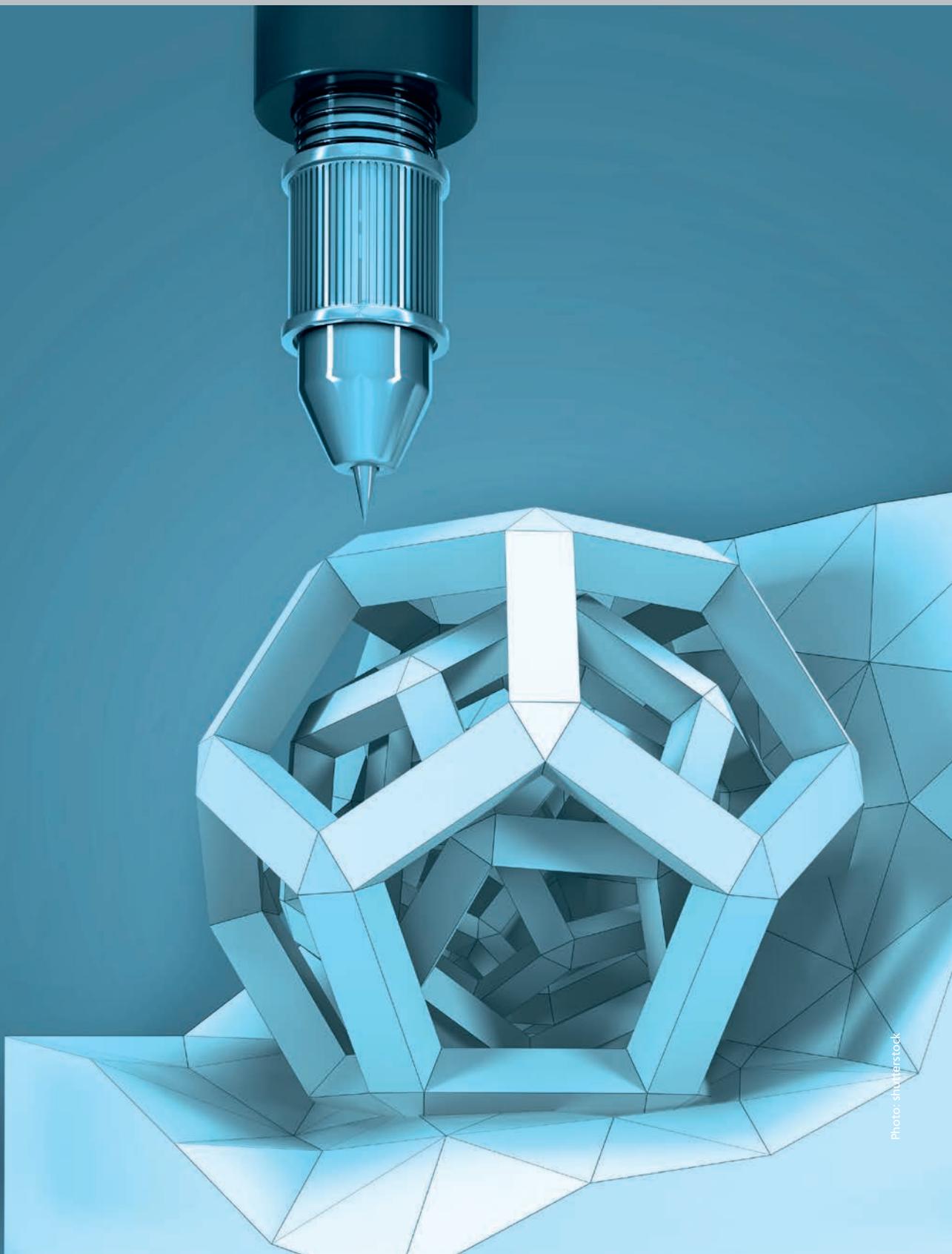


Photo: shutterstock

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

- Materials 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

CONTACT

Dr.-Ing. Manfred Renner | Business Developer Polymer Materials |
Phone +49 208 8598-1411 | manfred.renner@umsicht.fraunhofer.de



CLEANTAN® – REVOLUTIONARY LEATHER TANNING PROCESS

- 1** *Impression from the high pressure technical shop: Wet-blue at center stage (500 kg batch).*
- 2** *High pressure tanning drum, also polymer and wood impregnation. Pre-industrial scale (1700 l volume, max. 300 bar, max. 70 °C).*

In leather tanning, chromium salt serves as a tanning agent. However, 40 percent of these salts end up in the wastewater, and a recycling is subject to extensive process engineering and cost-intensive. With the new CLEANTAN® process, Fraunhofer UMSICHT reduces the chromium-polluted wastewater by more than 95 percent. Another advantage: The tanning process with CLEANTAN® is five times as fast and, especially due to the lower utilization of chromium salt, also significantly more cost-efficient.

Objective: Environmentally friendly tanning of leather

Be it for shoes, bags, or jackets – leather is a popular material. Its manufacturing, i. e., the tanning process, however, is anything but efficient. Because only 60 percent of the chromium salt utilized in this process is bonded in the leather, the remaining 40 percent are emitted via the wastewater. Recovering the salts from the water is extremely costly, because the water contains not only chromium, but also other chemicals as well as fats that are present in the hide. Therefore, there are only very few tanneries worldwide that recycle the chromium salt. The scope is enormous: Of the annually approx. 500,000 tons of chromium salts utilized, approx. 200,000 tons are emitted via the wastewater. To date, there has not been any alternative for significantly replacing or saving chromium tanning agent on a large industrial scale. Therefore, it is the objective of Fraunhofer UMSICHT to develop an environmentally friendly, sustainable, and cost-efficient tanning method.

Result: A 95 percentage reduction of wastewater containing chromium

With the new CLEANTAN® method, Fraunhofer UMSICHT has achieved this. CLEANTAN® reduces the amounts of chromium salt utilized by up to 40 percent. Only as much chromium is being utilized as can be bonded in the hide. But it is not only the amount of chromium salt that is being reduced, there is also less wastewater that is being contaminated with chromium: The chromium wastewater can be reduced by more than 95 percent – as such, hardly any chromium-polluted wastewater occurs. The sulfate load in the wastewater also drops by up to 120,000 tons per year, which corresponds to 60 percent. Another advantage of CLEANTAN®: While the tanning, in the past, took 12 to 15 hours, the process is now already completed in three hours or less.

Environment, methods: Building up of the industrial scale

The main innovation lies in replacing water with compressed carbon dioxide at 30 bar. For this, the researchers of Fraunhofer UMSICHT developed a new, worldwide unique plant and process technology. In a first step, the scientists designed and realized a high pressure system with a



2

volume of 20 liters. From 2011 to 2015, they transferred the results into a pre-industrial scale: At Fraunhofer UMSICHT, they realized a system with a volume of 1700 liters, which made possible a tanning of up to 15 cowhides with a mass of more than 500 kg and a leather surface of more than 100 m². The tannings showed: For all leathers, e.g. calfskin, bullhide, cowhide, and sheepskin, the previously achieved results are transferable to a pre-industrial scale. Furthermore, since the movement of the material was significantly larger here than at the technical shop scale, the quality could be increased significantly once more. At present, the researchers are transferring the technology to an industrial scale – then, implementation of the technology at existing tanneries will be possible without a problem.

Customer benefits: Competitive advantage and improved image

The leather manufacturing industry is faced with increasing pressure to reduce the emissions in the tanning process. With the CLEANTAN® method, the researchers of Fraunhofer

UMSICHT offer companies an effective and economic solution. Since the companies save 40 percent of the tanning agent and 95 percent of the wastewater costs, the system amortizes within 1.5 to 2.5 years. From that point in time on, the method is significantly more cost-effective than the current one – and as such provides for an enormous competitive advantage. The improved image due to the environmentally friendly and sustainable process should also be very huge. As such, CLEANTAN® can become an important component for retaining and strengthening the leather-producing companies in Germany and Europe. Since the prerequisites severely differ depending on company size, site, and product, the researchers of Fraunhofer UMSICHT are developing the return-on-investment calculation confidentially with the respective client.

Market situation: A strong focus on environmental aspects

Worldwide, approx. 2200 square kilometers of leather are being manufactured each year – that's the equivalent of the area of the Saarland region of Germany. A pronounced growth of the leather industry has been noticed first and foremost in Asia and South America. In this, the following applies: Increasingly, central large tanneries are being built. This trend away from small, family-owned companies towards larger tanneries primarily is rooted in environmental aspect. The largest influencing factors on the industry are the requirements of original equipment manufacturers (OEMs), on the one hand, to lower the production costs, and on the other, to reduce emissions. The CLEANTAN® method fulfills both requirements. The emissions are lowered because significantly less chromium tanning agent is needed than in the past. Due to the lower quantities utilized, the production costs also drop drastically; a return-on-investment of the new plant technology is possible in under two years. Therefore, the potential for the CLEANTAN® method is very high, on a national and EU level as well as internationally.

Sustainability:



Approx. 40 percent of the chromium salts utilized for leather tanning are emitted via the wastewater; a recycling is barely possible. The CLEANTAN® method results in a significant drop of these emissions. The reason for this primarily is that significantly less chromium tanning agent is needed. As such, the environment is being significantly unburdened due to the new process. This does not have any impact on the quality of the leather: The leather produced continues to be of identical, high quality. The CLEANTAN® method can be applied worldwide and brings advantages with it: It lowers the production costs and is therefore likely to quickly dominate. Via the application, the emission is lowered drastically; the impact on society as a whole is to be considered to be high.

CONTACT

Dr.-Ing. Manfred Renner | Business Developer Polymer Materials |
Phone +49 208 8598-1411 | manfred.renner@umsicht.fraunhofer.de

BUSINESS UNIT CHEMISTRY



SERVICE PORTFOLIO

We offer process engineering research and development services as well as products and processes including industrial property rights. These help to meet the increasing demands for affordable sustainability and innovation in chemistry, petrochemistry and refinery. Our know-how encompasses 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 biofuels (diesel, kerosene). Biomass, synthesis gas and selected residues constitute the portfolio of raw materials from which we suggest process-specific solutions. Know-how regarding the upstream and downstream processing as well as product formulation round out our expertise. We are points of contact for the whole value added and logistics chains, develop sustainability assessments and strategies. We are glad to 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 incl. consulting regarding the sustainable shift in raw materials
- Optimization of process chains through integration of biotechnological and 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

CONTACT

*Dr.-Ing. Axel Kraft | Business Developer Chemistry |
Phone +49 208 8598-1167 | axel.kraft@umsicht.fraunhofer.de*
*Dr.-Ing. Hartmut Pflaum | Business Developer Chemistry |
Phone +49 208 8598-1171 | hartmut.pflaum@umsicht.fraunhofer.de*



Photo: shutterstock

BIO-BASED PLASTICIZERS AND TENSIDES

1 *Tensides are used as wetting agents, foaming agents, and dispersants. Their use as detergent surfactant, e. g. in dishwashing liquid, is widely known.*

2 *Brittle materials become soft, flexible, or ductile through plasticizers. This makes them easier to process or provides them with certain performance characteristics.*

The trend goes towards bio-based raw materials. But this is not possible in all cases: To date, higher alcohols that serve as the basis for plasticizers in plastics and for tensides in detergents can only be manufactured bio-based from palm oil and coconut oil – a path that is hardly sustainable. Fraunhofer UMSICHT now has developed a process with which higher alcohols can, for the first time, be manufactured from a bio-based source sustainably and economically. Bio-based ethanol serves as the raw material.

Objective: Bio-based plasticizers and tensides

Most plastics require additives to become what they are. In first place here are the plasticizers. Phthalates dominate the plasticizer market. However, they have huge disadvantages: They are carcinogenic, trigger genetic mutations, and affect people's ability to reproduce. The objective of Fraunhofer UMSICHT is to replace the phthalate-based plasticizers with bio-based ones, and to be able to manufacture these additives independent of fossil raw materials. Since higher alcohols serve as starting substance for plasticizers, the core task is the economic manufacturing of bio-based higher alcohols. A similar challenge exists in case of tensides: Here, it is about working with sustainable raw materials of domestic origin.

The result: Increase of the value generation via bio-based alcohols

Ethanol is comparatively cheap; the price per tonne is around EUR 450. For higher alcohols between EUR 1200 and 1800 have to be paid already. The end products, plasticizers and tensides cost between EUR 2000 and 4000 per ton. If the higher alcohols are manufactured on the basis of biomass from ethanol, and if these are utilized as starting material for tensides and plasticizers, the value of the ethanol can be increased approx. up to fivefold. Fraunhofer UMSICHT has developed and patented a process that allows for this jump in value generation. So, Fraunhofer UMSICHT was able, for the first time, to cost-effectively manufacture completely bio-based plasticizers. The process utilizes bio-based ethanol as raw material which the scientists transform into higher alcohols with a special catalyst that is available in large amounts, is stable, and highly efficient. This novel process lowers the CO₂ footprint, utilizes domestic raw materials, preserves jobs, and creates new, highly qualified jobs. Imported palm oil and coconut oil, for which large areas of rain forest are being cleared, are becoming superfluous.

Environment, methods: From sugar to high-quality chemical product

The basis for the bio-based ethanol is sugar, which is fermented. In Europe, the latter originates primarily from grain or sugar beets. The manufacturing based on residues containing cellulose is also steadily gaining in importance. Since the regulation of the sugar market will cease in



Photo: shutterstock

2

September 2017, the sugar price is likely going to drop once more significantly due to cheaper imports. The value generation from manufactured sugar to the high-quality chemical product can be increased manifold with this process.

The process for the manufacturing of higher alcohols is robust and comparatively straight-forward, can be operated even in small quantities decentralized and economically, requires only small investments. With this, the approach of a biorefinery – which sugar factories are already pursuing anyway – is being fine-tuned further and leads to products of ever higher quality.

Customer benefit: Competitive advantages

Europe-wide, there is an ever increasing demand for products that are manufactured from regional and bio-based raw materials. This applies especially in areas where the consumer gets in direct contact with the products – e.g. in case of foodstuffs or consumables such as detergents and cleaning agents. If companies offers innovative solutions here, they can set themselves apart from competitors and that way obtain a

competitive advantage. In a steadily growing market, this is of great importance; in addition, it allows for a comparatively easy entry to the market.

Manufacturing of bio-based tensides

For the manufacturing of bio-based tensides, the researchers manufacture a blend of fatty alcohols which they then transform into tensides with the help of sugars. The fossil-based or non-sustainably manufactured alcohols that are based on vegetable oil are, as such, being replaced by starting materials that are globally available and can be manufactured sustainably. Furthermore, the alcohols manufactured this way do, in part, contain branches that do not occur in fatty alcohols. These change the later properties of the tensides – potentially, these tensides feature better cleaning properties or a wider area of application.

Flexibility of the process

The process developed by Fraunhofer UMSICHT is flexible and enables the users to adapt themselves to the constantly changing markets. For example, ethanol is not the only option as raw material for the higher order alcohols, other alcohols or fermentatively manufacturable raw materials such as butanol, pentanol, isopropanol, or acetone can also be utilized. The possible product portfolio is also wide: Via the developed process, both alcohols for the chemical industry as well as kerosene or diesel of the highest quality can be manufactured. In the past, from a bio-based source this was possible only based on vegetable oils such as rapeseed/canola oil.

Sustainability:



Phthalates, which are found in numerous plastics as plasticizers, are viewed critically due to their negative impacts on health. Not only can the phthalates be replaced via the novel process developed by Fraunhofer UMSICHT, but the fossil starting materials can be bypassed as well. As such, bio-based plasticizers can, for the first time, be manufactured economically. Fossil resources can thus be saved and the CO₂ emission lowered. Even imported vegetable oil – for the manufacturing of which large areas of rain forest are cleared – is no longer necessary.

CONTACT

Dr.-Ing. Andreas Menne | Chemicals and Formulations |

Phone +49 208 8598-1172 | andreas.menne@umsicht.fraunhofer.de

BUSINESS UNIT ENVIRONMENT



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

- Preparation of eco-assessments and sustainability assessments in accordance with DIN EN ISO 14040/14044 for products, processes and services
- 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
- Technological consulting regarding strategic company decisions
- 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

- Customer-tailored safety and hazardous material management software
- Analytics services with problem-oriented assessment and action recommendations
- Economic feasibility studies for processes, methods and products

MARKETS AND INDUSTRIES

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

CONTACT

Dipl.-Ing. Gerold Dimaczek | Business Developer Environment |
Mobile +49 172 8156183 | gerold.dimaczek@umsicht.fraunhofer.de



FROM THROW-AWAY PRODUCT TO CIRCULAR ECONOMY

1 Cover image of the study regarding the circular economy with respect to the chemical industry.

2 Based on the literature research and the institute's own know-how, key questions were developed and discussed in interviews with experts in order to include third-party expertise in the project.

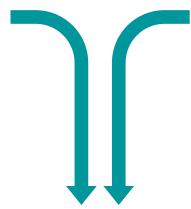
Our "throw-away society" cannot function in the long run. The circular economy approach strives not to put "worn-out" materials to waste but rather put them to use. Based on three products Fraunhofer UMSICHT has researched where the opportunities and limits of such a circular economy are located for the chemical industry.

Objective: To determine the opportunities and risks of the circular economy

The smart phone is already two years old? Time for a new one. The washing machine is broken? Let's quickly buy another one. We have created a throw-away society – an approach that cannot function in the long term with a growing world population and finite reserves of raw materials (even if these will still be available for decades). Therefore, the circular economy is finding more and more approval. The core issue in this: Products and materials are developed in a way that the materials utilized remain in the material cycle even if the product itself no longer is intact. This means: Goods are being repaired and reused as well as continue to be used, materials are being recycled, and products are being designed in such a way that they or their components can continue to be used further without a loss of quality. Wastes, emissions, and dissipative losses are intended to go towards zero, raw material extractions from the environment are to be reduced. Another aspect: In order to maintain the cycle, as little energy as possible should be consumed – and it should only come from renewable resources. In this, the whole system must remain economically expedient and sustainable. But which opportunities does the circular economy offer and which limits does it have?

The result: Opportunities and conflicts of interest to be resolved

In a study, Fraunhofer UMSICHT have investigated these questions for the regional association North Rhine-Westphalia (NRW) of the German Chemical Industry Association (VCI). In this, the focus was on the chemical industry. In order to clearly present the potentials and limits of the circular economy, the researchers investigated three material flows: Tires, rotor blades from wind turbines, and LCD monitors. A huge challenge lies in conflicts of interest: If one product property is optimized, another one may become worse at the same time. If, for example, tires are manufactured in such a way that they are recyclable, this may lead to the vehicle consuming more gasoline, or the tire not adhering as well to the road, or wearing faster. In case of turbines plants, the focus is on the durability and performance of the rotor blades, not on reusability after a period of use of 20 or 30 years. The three material flows investigated differ in composition, lifetime, and recycling options. The most important life cycle phase is the utilization



Current situation, limits, conflicts of interest, and potentials of the circular economy

2



Descriptive and scientifically substantiated

phase. All material flows have potential conflicts of interest in common that affect their potentials for circularity.

Globally, it can be seen that the degree of circularity is still quite small to date: Of the 62 billion tonnes of material that were utilized worldwide 2005, only a mere approx. 6.5 percent ended up in material cycles. Essential for a functioning circular economy is an improvement of the exchange between the actors in order to, for example, establish new business models – one example of this are leasing models. In the implementation of the concept of a circular economy, the current, worldwide economic system is faced with a fundamental transformation process.

Environment, methods: Literature research meets know-how

In the study, the scientists have developed a fact-based foundation

Circular Economy

(Excerpt from the definition of Fraunhofer UMSICHT):

In a circular economy, the materials utilized remain in a material cycle beyond the life cycle of the goods. Wastes, emissions, dissipative losses, and the extraction of raw materials from the environment are therefore to be reduced as much as possible. The reuse and continued use of goods, the recycling of materials and substances are essential, as well as a design of the goods that allows for a recirculation without quality losses and without accumulation of pollutants. The period of utilization of materials is as long as possible, their return into the cycle at the end of their period of utilization is performed as quickly as possible. Materials for which dissipative losses are unavoidable are degradable. The then optimized energy consumption for maintaining the cycle is ideally provided from renewable resources. Substances that cannot be recirculated are utilized energetically.



for the discussion of paths towards an increasingly more circular approach to business and have developed strategic considerations of their own regarding possible designs of these paths. Among other things, these relate to production and product design, consumption, secondary raw materials, plastics and plastic wastes, critical raw materials, and innovation. The basis of the work are comprehensive research of the scientific literature and interviews with experts. Since Fraunhofer UMSICHT, is positioned very broadly, and has an interdisciplinary approach, the researchers can map and assess the whole product and material cycle. Additionally, they possess the technical strategic know-how in the area of the circular economy.

Customer benefits: Basis for strategy development

The study provides for the regional association North Rhine-Westphalia (NRW) of the German Chemical Industry Association (VCI) with a scientific analysis, based on which both the opportunities as well as the challenges and risks of a circular economy that come along with it can be assessed. It is intended to serve as a contribution towards an objective discussion of a circular economy.

Customer voice regarding the project

"A circular economy provides opportunities for the chemical industry as an enabler of solutions. However, in the implementation, conflicts of interests often occur that have to be taken into consideration. Additionally, this will be about the development of economically sensible paths in cooperation with the whole respective value generation chain."

Hans-Jürgen Mittelstaedt, Managing Director, VCI NRW

CONTACT

Dr.-Ing. Markus Hiebel | Head of Department Sustainability and Resources Management | Phone +49 208 8598-1181 | markus.hiebel@umsicht.fraunhofer.de

BUSINESS UNIT BIOMASS



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
- 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

CONTACT

Dipl.-Phys. Thorsten Wack | Business Developer Biomass |

Phone +49 208 8598-1278 | thorsten.wack@umsicht.fraunhofer.de



PILOT SYSTEM FOR BIOCHAR PRODUCTION

- 1 By means of hydro-thermal carbonization, biogenic residues become biochar.
- 2 Corn straw before and after hydro-thermal carbonization.

Fossil fuels are finite, they must be replaced in the long-term. One option for this is biochar which is manufactured from plant matter. To date, however, its manufacturing is very cost-intensive. Fraunhofer UMSICHT now is rendering the manufacturing process become economical.

Objective: Economical substitute for fossil fuels

Fossil fuels are finite. Therefore, new approaches are necessary to manufacture fuels and plastics without fossil starting materials. Here, coal from biomass offers a promising, CO₂-neutral alternative. The biochar is manufactured via hydro-thermal or vapo-thermal carbonization. In hydro-thermal carbonization (HTC), plant matter is carbonized at an elevated temperature in an aqueous environment. In vapo-thermal carbonization (VTC) – a further development of HTC – the vegetable coal is produced in a steam atmosphere. Previously unusable wet biomass, i.e., sludge, green waste, leaves, biowastes, or other residues from agricultural and silvicultural production is suitable as starting material. The drawback: To date, both hydro-thermal and vapo-thermal carbonization have been quite expensive; here, especially the treatment of the process water is a factor. This means that for biochars and potential derived products such as bio-based plastics and biofuels to prevail, economical technologies are needed.

The result: More efficient manufacturing of biochars as basis for plastics and fuels

The researchers at Fraunhofer UMSICHT are developing economical methods to transform biomass into HTC coal. For this, they create a material and energy balance for each and every raw material and develop optimal process engineering solutions for the manufacturing of HTC coal. The objective is to transform raw materials of lower value that, to date, are not combustible, into higher value products – and this in an economical manner. The big advantage: The material is being utilized as it is, it does not need to be processed. Even small plastics particles that erroneously have ended up in the biowaste bin are not a problem. As such, no pretreatment costs are incurred, the energy consumption is low. Additionally, the process scales well – it can be transferred from small systems to systems of any size.

Environment, methods: Pilot system at tonne scale

The researchers have already successfully completed the laboratory tests and are optimizing their technology in a testing plant at the Leppe (NRW) site in the teaching and research project "metabolon". The Leppe site provides an ideal platform for showcasing this technology to



2

manufacturers of HTC units and potential customers under practical condition and to this way make the entry to the market easier. By the end of 2017, the development is to be completed; then, the researchers plan to implement a larger system, jointly with partners.

Customer benefits:

New disposal paths, improved CO₂ balance

The results from the studies regarding reaction kinetics increase the scientific-technical understanding of the process and, as such, let the process become significantly more efficient.

This is of interest to various customers: At companies at which biomass is incurred as a by-product, the process opens up better utilization paths – instead of the costly disposal of the biomass, it can be utilized for profit. The consumers of the biochar, in turn, profit from a better CO₂ balance – be it municipal institutions such as schools or swimming pools that can utilize the coal as an environmentally friendly

substitute for wood pellets, or be it companies that manufacture chemicals and fuels and that utilize coal as starting material. In short: HTC coal provides for a CO₂-neutral replacement of fossil fuels – the sustainability is being improved. The solutions provide for optimal process engineering and for more efficiency and a better economic efficiency.

Fraunhofer UMSICHT, with its expertise, provides advice as needed and analyzes on a case-by-case basis whether it is economical in the respective case to transform biomass into HTC coal. The Institute offers scientific consulting and a reliable data base for strategic decisions.

Further process optimization:

Treatment and minimization of the process water

One cost-intensive step in the HTC and VTC carbonization processes is the treatment of the process water. The latter consists, on the one hand, of reaction water and, on the other, of water that is contained in the biomass. The researchers at Fraunhofer UMSICHT are developing a process with which as much of the process waters as possible can be treated. The crux of the matter in this: They want to return as much water as possible back into the process. This way, the volume of wastewater can be reduced by up to 50 percent. Subsequent to the laboratory tests, the researchers are planning to build a corresponding testing plant at the Leppe site.



Sustainability:

Upon incineration, fossil fuels emit fossil carbon dioxide.

This furthers climate change. The production of biochar can mitigate this situation: By replacing fossil fuels, the technology potentially provides a high greenhouse gas reduction potential. Fraunhofer UMSICHT is developing a process for the ecological and economical treatment of the process water. This opens up value generation options that help the biochar technology to establish itself in the market.

CONTACT

Dipl.-Ing. Josef Robert | Head of Department Process Engineering |
Phone +49 208 8598-1150 | josef.robert@umsicht.fraunhofer.de

BUSINESS UNIT ENERGY



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 system, 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: large-scale 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 for bio energy plants, electricity generation from waste heat, ORC, small steam power plants, innovative chillers

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

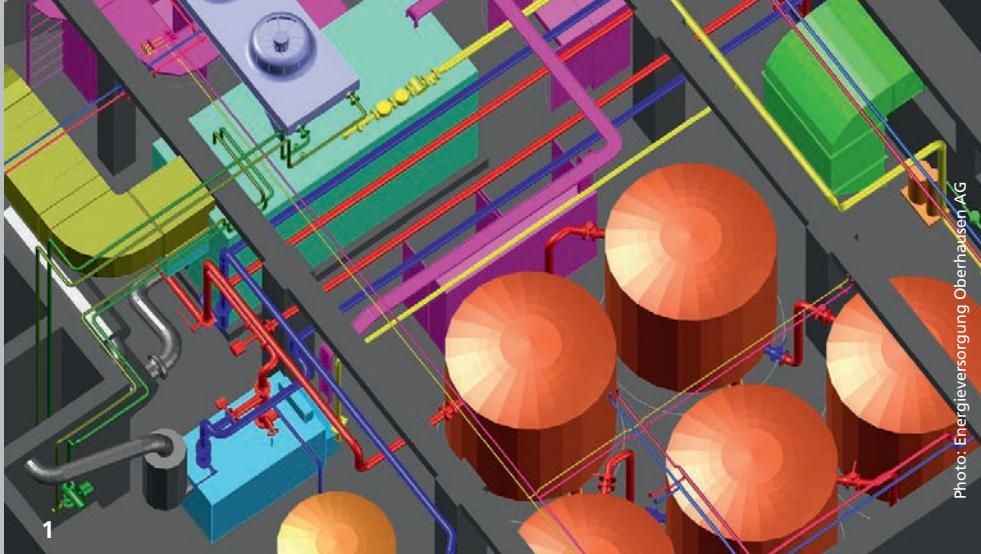
- Energy storage systems, use of storage systems, electricity from waste heat, power-to-X, decentralized bio energy (conversion) processes
- Improving the flexibility of CHP systems, heat demand forecasts
- Management of decentralized energy systems within the network

MARKETS AND SECTORS

- Energy services provider 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

*Dr.-Ing. Wilhelm Althaus | Business Developer Energy |
Phone +49 208 8598-1186 | wilhelm.althaus@umsicht.fraunhofer.de*



RETHINKING COGENERATION!

- 1 System overview of the flex cogeneration system in Barmenholten.**
- 2 Integration of a heat storage of the flex cogeneration system into the boiler room.**

The fluctuating power generation from wind and solar energy poses new challenges for our electrical grid. Fraunhofer UMSICHT combines cogeneration systems with heat storage systems and power-to-heat heat generators and creates an efficient option for compensating for these fluctuations. This way, cogeneration systems can, additionally, be operated more economically also in the future.

Objective: Efficiently compensating for fluctuations – with economical cogeneration systems

When the sun is shining from the cloudless sky or the wind is blowing across the land, solar panels and wind turbines are increasingly providing a significant portion of the electricity we need. This way, effects occur to which the energy markets promptly react – with a drop in the price of electricity. Therefore, some fresh thinking is needed for the setting up of a profitable regenerative energy system. For this, researchers at Fraunhofer UMSICHT see a solution in the flexibilization of cogeneration. The latter generates electricity via motor or turbine: If the wind is calm and clouds are covering the sky, the electricity can be utilized directly. If the electricity prices have hit rock-bottom, the motor remains off and the system falls back on the heat in the heat storage systems for heating purposes. In order for this compensation to succeed, new supply concepts, new methods of operation, and new business models are needed.

The result: Economically competitive cogeneration systems

The researchers of Fraunhofer UMSICHT combines cogeneration systems with heat storage systems and power-to-heat heat generators. The heat storage system decouples the electricity production in cogeneration systems from the heat demand. This means: If the price of electricity is high, the cogeneration system can be switched on – and that even when no heat is needed at the time. Similarly, in case of an oversupply of electricity, the power-to-heat system can draw electricity from the overburdened grid and fill the heat storage system. A mathematical modeling as well as a forecast system are analyzing the weather situation and ensure that the heat storage system is empty in times of high electricity prices and can store the heat generated. This coupling lets the systems respond flexibly to the price development and compensate for bottlenecks in the local grid. If this potential is utilized to its maximum, cogeneration systems can be operated economically also in the future.

Environment, methods: Flexible local heat island in Oberhausen

In the "Flex Cogeneration" project, the researchers of Fraunhofer UMSICHT are currently, jointly with the partners of Energieversorgung Oberhausen AG (evo), converting a local heat network in the Barmenholten neighborhood of Oberhausen. Instead of, as in the past, counting on boilers,



Photo: Energieversorgung Oberhausen AG

a housing development with 150 residential units will be supplied via a combined heat and power plant and a large heat storage system as well as an electric water heater. In this way, the housing development becomes a flexible local heat island: Electricity is produced when it is needed, the heat generated in the process is being stored in sufficient amounts. The cogeneration system is currently in the test phase. The measured data helps Fraunhofer UMSICHT to assess cogeneration system concepts under different market conditions, to study different storage technologies and concepts, and to identify promising sites and favorable framework conditions.

Customer benefit: Combining economy and ecology

Customers are provided with two advantages. For one, energy suppliers can utilize cogeneration economically also in the future. First model calculations have shown: If the dimensions of the cogeneration system as well as the operating method are changed, locations for an energy supply with cogeneration

systems can, in the future, even become economically interesting for sites that do not have a need for heat in the summer. In this, the researchers of Fraunhofer UMSICHT are available to companies with their comprehensive know-how in a supporting role – both for the sizing and design of the systems as well as for the creating of the forecast models. The second advantage: The suppliers as well as the end users of the heat can optimize the heat production with respect to greenhouse gas emissions. After all, the cogeneration systems feature a significantly better energy efficiency than conventional boilers and contribute to a reduction of the carbon emissions.

Changes in the energy market provide opportunities for cogeneration systems

At present, the following applies: Cogeneration systems are considered to be economical primarily when their capacity is being utilized to a high degree. This could change in the future. Then, cogeneration systems operated at maximum capacity may no longer be profitable. However, there is also an opportunity in this: In combination with large heat storage systems, cogeneration systems can optimally and with high efficiency react to the situation on the energy markets. This means they provide a huge advantage in comparison to large power plants. Such systems, however, will only be economical if they generate the electricity during times in which high profits can be achieved on the market – and guarantee the heat generation independent thereof. This is where the researchers of Fraunhofer UMSICHT come into play.

Team

Fraunhofer UMSICHT, in cooperation with Energieversorgung Oberhausen AG (evo), has been researching new supply concepts and operating methods of cogeneration systems since 2015.

CONTACT

Dipl.-Ing. Joachim Krassowski | Group Manager Energy Supply Systems |
Phone +49 208 8598-1162 | joachim.krassowski@umsicht.fraunhofer.de

Sustainability:



The German federal government has made it its object to reduce greenhouse gas emissions from 1990 to 2020 by 40 percent and by 2050 by 80 to 90 percent. The prerequisite for this: We have to move away from fossil and nuclear energy sources, towards renewable energies and the highest energy efficiency. But how are we going to make this happen? Where to put the electricity produced in case of a lot of sunshine? Here, large power plants are not flexible enough. This does, however, not apply to cogeneration: It has the potential to compensate for fluctuations, to significantly reduce the primary energy demand, and to increase the efficiency of the energy supply. Therefore, the German federal government has defined the objective to increase the share of power generation from cogeneration to 25 percent by 2020.

INTERNATIONAL

INTERNATIONAL COOPERATION WITH KUWAIT, CANADA AND CHILE

Fraunhofer UMSICHT works together with partners all over the world. Their common aim: To utilize synergies in technology development and to increase the scientific added value. The strategic cooperations with industry and partners in Kuwait, at the University of Alberta in Edmonton/Canada, and research facilities in Chile are three current examples of international activities.

WASTE MANAGEMENT PLAN FOR KUWAIT

Together with eleven international consortium partners, Fraunhofer UMSICHT in Sulzbach-Rosenberg develops a waste management plan for the Emirate of Kuwait. "For the research site, the project provides for a great opportunity to open up new markets and customers in the Arab region, and to further establish itself internationally", says Dr. Matthias Franke of the project team. The 18 million EURO project with a duration of four years started in early 2017. It pursues the objective to create an information system based on which the environmental situation at any and all landfill sites and treatment systems can be retrieved. The monitoring system is to display exceeded limit values or make the path of the waste visually traceable – and this conveniently via smart phone.

Four project steps

For a comprehensive inventory taking, the team studies the situation in-situ and collects primary data in the Gulf state. Specifically, the scientists want to determine waste volumes and their composition and analyze the paths of the wastes, and the condition and hazard potential of the landfills. All the data is made available to the authorities and public in an interactive geo-information system. From this, a waste management plan for the country will be developed that specifies guidelines for a sustainable waste management for the next 20 years.

RESEARCH PARTNERSHIP WITH CANADA

Food and products – Energy and biomass

Since 2013 already, a strategic research partnership with the University of Alberta, Edmonton, Canada has existed. The objective of the cooperation is to bundle competencies for the joint subject areas of bioindustry (biorefinery and biobattery), electro-chemical energy systems, as well as food and products. The common aim is to generate joint projects and research results that provide great potential for the technology transfer into industry. In 2015, the "Memorandum of Action" prospectively specified the close research partnership and defined the further implementation steps – all the way up to a joint business platform. Last year, two workshops took place in Edmonton, Canada. Experts of the university and of the Fraunhofer-Gesellschaft (Fraunhofer UMSICHT, Fraunhofer IVV, Fraunhofer headquarters) developed concepts for a expansion of the existing cooperation. Participants from industry and politics were also present. "We have developed new project ideas, substantiated potential cooperations, and discussed the selection of potential regional industry partners on-site," says Dr. Anna Grevé, Head of Department Chemical Energy Storage. "In addition to specific joint projects, the research partnership is also intended to contribute towards increasing scientific excellence through, for example, joint publications and regular exchange opportunities of doctoral students or research assistants", she further adds.



Photo: Kuwait Environment Public Authority



Photo: Nelsón Zbinden, UDT

Three current projects

There are three joint projects: The objective of "Biobattery – Decentralized production of fuel from biomass" is to deliver two TCR® systems (Thermo Catalytic Reforming) to Canada. With this technology, it is possible to transform biogenic residues or industrial biomass wastes into oil, gas, or biocrude. In the project "MiDeCO₂ – an innovative CO₂ decontamination technology to ensure food safety of lower water activity food products", the researchers aim at killing off pathogenic micro organisms in food products with low water activity by means of compressed CO₂, and to carry out a holistic product evaluation. The project "Bio-Hipe-Composite: Development of a bio-based high performance composite for the use in automotive applications" aims at the development of bio-based alternatives to petrochemical plastics and mineral fillers that are being utilized in automobiles.

CHILE: SIMILAR STRUCTURES AS IN THE RUHR REGION

In terms of industrialization, Chile is positioned similar to Germany; the country is also undergoing a type of structural change similar to the Ruhr region. There are coal, ore, and copper mines and steel processing – with all the negative impacts on the environment. Another core area is the wood and forest industry. As such, both the material utilization of residual biomasses from the wood processing industry – as raw material source for bio-based plastics – or the energetic utilization – through gasification, incineration, or pyrolysis – are central connecting factors of the cooperation.

First contacts between Fraunhofer UMSICHT and the "Universidad de Concepción (UDeC)" and the associated institute "Unidad de Desarrollo Tecnológico (UDT)" in Coronel, Chile, have already existed since 1992.

Focal point: professional exchange

Two current joint projects started in 2016. In the project "ComCatTar", the team created a comparative study regarding the catalytic removal of tar and ammonia from wood-based synthesis gas. For this, the team in Chile at the UDT manufactures carbon aero gels in order to utilize these as carrier materials for the catalytic gas cleaning. The samples are then examined by the team of UMSICHT in Oberhausen – last, but not least, in a fluidized-bed reactor with real gases. The "Reforming" project deals with nano-structured materials for the catalytic cleaning of biomass-based synthesis gases. "The cooperation with the colleagues in Chile is working very well. Of course, the personal exchange is very important for this. As such, it is a huge advantage that this project is funding one-month and multi-month exchange stays of researchers each year", explains Tim Schulzke of the project team in Oberhausen.

1 On January 8, 2017, the signing of the contract took place in Kuwait.

2 Project manager Tim Schulzke of Fraunhofer UMSICHT at the kick-off of the "ComCatTar" project at the UDT in Chile.

CONTACT

Kuwait: Dr.-Ing. Matthias Franke | Head of Recycling Management | Phone +49 9661 908-438 | matthias.franke@umsicht.fraunhofer.de

Cooperation Canada/University of Alberta:

Prof. Dr.-Ing. Christian Doetsch | Division Director Energy | Phone +49 208 8598-1195 | christian.doetsch@umsicht.fraunhofer.de

Dr.-Ing. Anna Grevé | Head of Department Chemical Energy Storage | Phone +49 208 8598-1271 | anna.greve@umsicht.fraunhofer.de

Chile: Tim Schulzke | Group Manager Thermochemical Processes and Hydrocarbons | Phone +49 208 8598-1155 | tim.schulzke@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.





PRIZES AND AWARDS IN 2016

In 2016, Fraunhofer UMSICHT and its employees received numerous honors and awards for particularly innovative projects or extraordinary scientific performance.

Eckhard Weidner receives Fraunhofer Medal

Prof. Eckhard Weidner, Director of the Institute, received the Fraunhofer Medal and Seal of the Ruhr University of Bochum, pressed into coal, in the context of the colloquium "Innovations with high pressure" on the occasion of his 60th birthday.

Micro steam turbine cleans up at founders' contest

The spin-off of the "Turbonik" team of researchers, which is currently being founded, offers companies with a need for steam a novel micro steam turbine for the resource-friendly production of electricity of their own. For this business idea, the four researchers of Fraunhofer UMSICHT received the 1st prize and the special prize for technology of the start2grow founders' contest initiated by the Office of Economic Development of the city of Dortmund.

Outstanding theses

The UMSICHT Friends and Patrons Group in Oberhausen gave out awards for the theses of the students Lisa Müller and Dennis Emil Tauschnik; Johannes Neidel received an award from the Friend and Patrons Group in Sulzbach-Rosenberg for his bachelor's thesis.

Examiner's honoring

From the Chamber of Industry and Commerce for Essen, Mülheim an der Ruhr, Oberhausen in Essen, Rasit Özgür received the Chamber's Silver Badge of Honor for his 10 years of volunteer service for the economy of the Chamber's district.

1 Eckhard Weidner, Director of the Institute.

2 The "turbonik" team of researchers.

3 The SpeciMold® inline injection molding machine.

tu>startup AWARD for Volterion

The Volterion spin-off scored first place in the founders' initiative tu>startup of the Dortmund Technical University (TU).

More Info (German site): s.fhg.de/volterion-startup-award

i-NOVO award for SpeciMold®

The inline injection molding machine SpeciMold® received the i-NOVO Award at the K 2016 trade fair.

More Info (German site): s.fhg.de/specimold-i-novo-award

Professor-Siegfried-Peter-Prize 2017

Manfred Renner was awarded the Professor-Siegfried-Peter-Prize for his dissertation "Development of a method for the wastewater-free tanning of animal hides under the influence of compressed carbon dioxide" and received the prize which has a value of 1500 euros.

infernun study program receives UNESCO prize

"Education for sustainable development"

The infernum offer for further education of the FernUniversität distance learning university in Hagen and of Fraunhofer UMSICHT received an award from the UNESCO World Program of Action "Education for sustainable development".

More Info (German site): s.fhg.de/infernun-unesco-preis

"Creating a MINT Future": Award for Fraunhofer UMSICHT

The institute branch Sulzbach-Rosenberg received an award for its outstanding measures in the area of "external human resources marketing" and promotion of young MINT talents at the initiative "Creating a MINT Future".



Photo: Fraunhofer-inHaus-Center

FRAUNHOFER-INHAUS-CENTER: ROOMS FOR VISIONS

Located in Duisburg is a special innovation workshop in which the potentials of research institutes and business partners are being bundled. Here, the focus is always on the human beings and their needs. In addition to joint research projects, Fraunhofer UMSICHT has a very special connection to the Fraunhofer-inHaus-Center: Its head, Dr. Nina Kloster, is a former "UMSICHTian".

You have been heading the Fraunhofer-inHaus-Center since January 1, 2016. How did the occupational change go?

I am the successor to Volkmar Keuter who is currently Head of Photonics and Environment at Fraunhofer UMSICHT. Topically, the inHouse is positioned very broadly and focussing on human beings and their needs, which also applies to my work. Especially in the initiation of new projects, I can contribute my experience in the area of health and comfort aspects.

How is the inHouse integrated into the Fraunhofer-Gesellschaft?

It is a department of Fraunhofer IMS with a relatively independent character, and is supported by more than 120 partners from industry and research. From the Fraunhofer-Gesellschaft, currently the ISST and UMSICHT are participating in addition to the IMS. The partners can use the inHouse to develop, test, and showcase products in a lifelike environment. We are, for example, equipped with a hospital laboratory encompassing 350 m², hotel rooms and offices, as well as a residential area equipped with smart technology for people in need of care.

Is flexibility needed here?

Without a question. The 5500 m²-sized house consists of inHouse1 and inHouse2, is a prototype, in which we can remove or move any wall, or install new walls. Things are similar with respect to the technical equipment.

What are inHouse and Fraunhofer UMSICHT working on?

Jointly with Dr. Holger Wack, Deputy Head of Material Systems and High Pressure Technology at Fraunhofer UMSICHT, we are developing greenlining and insulation concepts for our inHouse1 half of the duplex and for the inHouse2. Furthermore, inHouse and Fraunhofer UMSICHT are currently working with additional partners on the group research project "ILIGHTS" which studies the non-visual benefit of a newly developed LED lighting system in the shift operation of the BMW assembly plant in Munich.

Will each and every building feature smart technology in the future?

Similar to what is happening with the apps, Apple, Google and Co. will increasingly mandate to us what type of smart home technology we should be using. However, long-term, I only believe in plug-and-play and wireless solutions. Particularly exciting are technological ideas that adjust themselves adaptively and flexibly to the living circumstance of their inhabitants.

MORE INFO

1 Dr. Nina Kloster and her team are creating a basis for interdisciplinary research and development.

www.inhaus.fraunhofer.de/en



CONTACT

Dr. Nina Kloster | Head of Fraunhofer-inHaus-Center, Duisburg |
Phone +49 203 713967-0 | nina.kloster@ims.fraunhofer.de



1

NEW FORMS OF CRYOTHERAPY

Dr. rer. nat. Stefano Buzzano has been working at Fraunhofer UMSICHT since 2008. The physical chemist knows that the market introduction of products developed in the laboratory often only succeeds through cooperation with users. For the development of a novel cryospray, Buzzano and his colleague Andreas Sengespeick, specialist for formulation engineering, have cooperated with the Sports Medicine Institute Dortmund (SMIDO GmbH) and in this way combined the physicochemical competency of Fraunhofer UMSICHT with medical application engineering know-how.

How did the project in the area of cryotherapy come to be?

In the (sports) medical application of cold, it is advantageous to realize a "soft" influence of coldness between 5 and 15 °C over a period that is as long as possible for 20 to 30 minutes. However, in the dialog with the physicians of SMIDO GmbH, we recognized that conventional products currently do not fulfil these requirements.

What does the solution approach that you developed look like?

In the context of a ZIM project of the Federal Ministry for Economic Affairs and Energy BMWi, in order to react to the deficits, we have, jointly with the SMIDO GmbH, developed a cryospray that is based on a dispersion containing PCM. These so-called phase change materials (PCMs) utilize the enthalpy of reactions such as the melting of ice into water for the storage and release of heat. If this phase change is combined with the cooling evaporation effect of a cryospray, among other things, generated cold stimulus can be extended in the desired form via the occurring freezing and renewed melting of the PCM.

Which advantages does the new product bring with it?

In case of conventional cryosprays, often hypothermia effects and/or frostbite effects can be observed on the skin since these products cool only briefly but particularly intensely. With our solution, for the first time, a functional novel cryospray is available for medical first aid and pain therapy that allows for a long as well as gentle and therapeutically correct cooling.

At the same time, due to the spray function, the product allows the patient unlimited freedom of movement.

What is the cooperation with the partner like?

We have obtained patent protection for the physicochemical foundation of the cryospray. Since this is a medical product, we need the competence of the SMIDO GmbH for the subsequent steps in the value generation chain.

Upon completion of the joint development project, the latter will take over the commercial exploitation of the cryospray, i. e., the contacting of potential manufacturers, the market introduction, as well as sales & distribution. Furthermore, for the future, a joint follow-up project is planned in order to adjust the formulation to the needs of different users such as athletes and medical professionals. As such, our work and that of SMIDO supplement each other optimally.

1 Stefano Buzzano conducts research regarding new forms of cryotherapy.

CONTACT

Dr. rer. nat. Stefano Buzzano | Deputy Head of Biorefinery and Biofuels;
Group Manager Chemicals and Formulations | Phone +49 208 8598-1415 |
stefano.buzzano@umsicht.fraunhofer.de



ESTABLISHING BIOCHAR AS RAW MATERIAL

Fabian Stenzel is Head of Department Biological Process Technologies at Fraunhofer UMSICHT in Sulzbach-Rosenberg and has been working at the institute since 2007. In his department, he is conducting research regarding biochar and its utilization options and applications. His objective is to establish biochar as a raw material. Jointly with his team, he researches the topics of nutrient management as well as water and exhaust air treatment, and works on technical solutions for this.

Which utilization options does biochar offer?

For biochar, there are both energetic as well as material utilization options. It can be utilized as co-fuel in power plants or cement plants. On the other hand, it can be utilized as soil conditioner or as adsorbent. A particularly enticing application in the summer is the utilization as charcoal.

What makes biochar so interesting?

How is it being manufactured?

Interesting, on the one hand, certainly is the history of biochar. Already several hundred to more than a thousand years ago, it was used for soil conditioning in the Amazon Basin as a component of the Terra Preta de Indio and can still be found there, even to date. On the other hand, it is the versatility of the utilization options that come along with this raw material. However, prerequisite is that the coal is manufactured with the correct process in order to ensure the quality. It should feature a stability that is as high as possible and must not contain any pollutants.

At Fraunhofer UMSICHT, we have developed the Thermo-Catalytic Reforming (TCR®), in order to manufacture coals that fulfil these quality requirements. In this process, oil and gas for the production of electricity, heat, and fuel occur additionally as co-generated products. In addition, we very closely work together with the International Biochar Initiative (IBI) which has developed the quality standards for biochars.

Which feed materials are being used for the manufacturing of the biochar?

In principle, any form of biomass is suitable. It provides us with the "green" carbon we need for our biochar. However, we focus on biogenic residues in order not to generate competition for areas for the cultivation of foodstuffs and not to endanger biodiversity through the cultivation of monocultures.

In your opinion, what will the future of biochar look like?

We have found that the topic is met with more and more interest. Initially, the focus was primarily geared towards the soil application. Now, we receive more and more frequently inquiries regarding technical applications. However, in order to provide biochar with the right impetus, quality standards must be established so that the consumer can be certain to receive a clean product.

1 For Fabian Stenzel, the challenge in the utilization of biochar lies in the establishing of a quality assurance.

MORE INFO

s.fhg.de/6p2



CONTACT

Dipl.-Wirt.-Ing. Fabian Stenzel | Head of Biological Process Technologies |
Phone +49 9661 908-432 | fabian.stenzel@umsicht.fraunhofer.de



URBAN DIGITAL PRODUCTION

Sandra Naumann has worked for 16 years at Fraunhofer UMSICHT in the administrative office of the directorate. In 2016, she braved a new start at the institute: Since July 1st, she has been heading the central office of the Science Forum Ruhr (Wissenschaftsforum Ruhr e. V.), a working group of non-university research institutes and coordinates the project "Urban digital production", acquired jointly with Fraunhofer UMSICHT, which brings together various actors regarding the topics of digitalization, transformation, and Industry 4.0.

What are your tasks for the Science Forum?

The Science Forum contributes to the strengthening of the Ruhr metropolis science region with numerous activities. In my role as head of the central office, I coordinate the threads of all organizational flows. Since the focal points of research of the member institutes are broadly positioned, I can, this way, work together with people from the most diverse of disciplines, as is the case, for instance, in the project "Urban digital production".

Why is urban digital production important right now?

The Ruhr region has already undergone a structural change: from the iron and steel region to the science and service landscape. Now, another change is ahead. Due to the digitalization, a large share of future production will take place in and for urban spaces. A tendency towards small, decentralized production sites of a more small to medium-sized enterprise character is to be expected and concomitantly an increasing intertwining of work and personal spaces. This change has to be prepared.

What is the project "Urban digital production" about?

In the context of the changing production structures in the Ruhr region, there are numerous open questions that we would like to answer in the project set up for 18 months. The kick-off was made with an event in December 2016, at which scientists from the Ruhr region discussed work and life in the urban space. Conclusion: A dialog between society and

science is absolutely essential to avoid digitalization losers. Therefore, the objective of the project is the creation of a research and development agenda (R&D agenda) that takes into consideration the effects of the new business practices on companies and society, and points out where there is still a need for research in the area of urban digital production.

What do the next steps in the project look like?

In addition to workshops with members of the Science Forum, in which we work out ideas for the R&D agenda, the focus will be on the dialog regarding the digital change in production: For this, the Science Forum designed a platform for new forms of interaction between companies, politics, science, and citizens, and will, for the first time, be hosting the awarding of the UMSICHT Science Prize 2017 (more regarding the Prize on p. 53).

MORE INFO GERMAN SITE

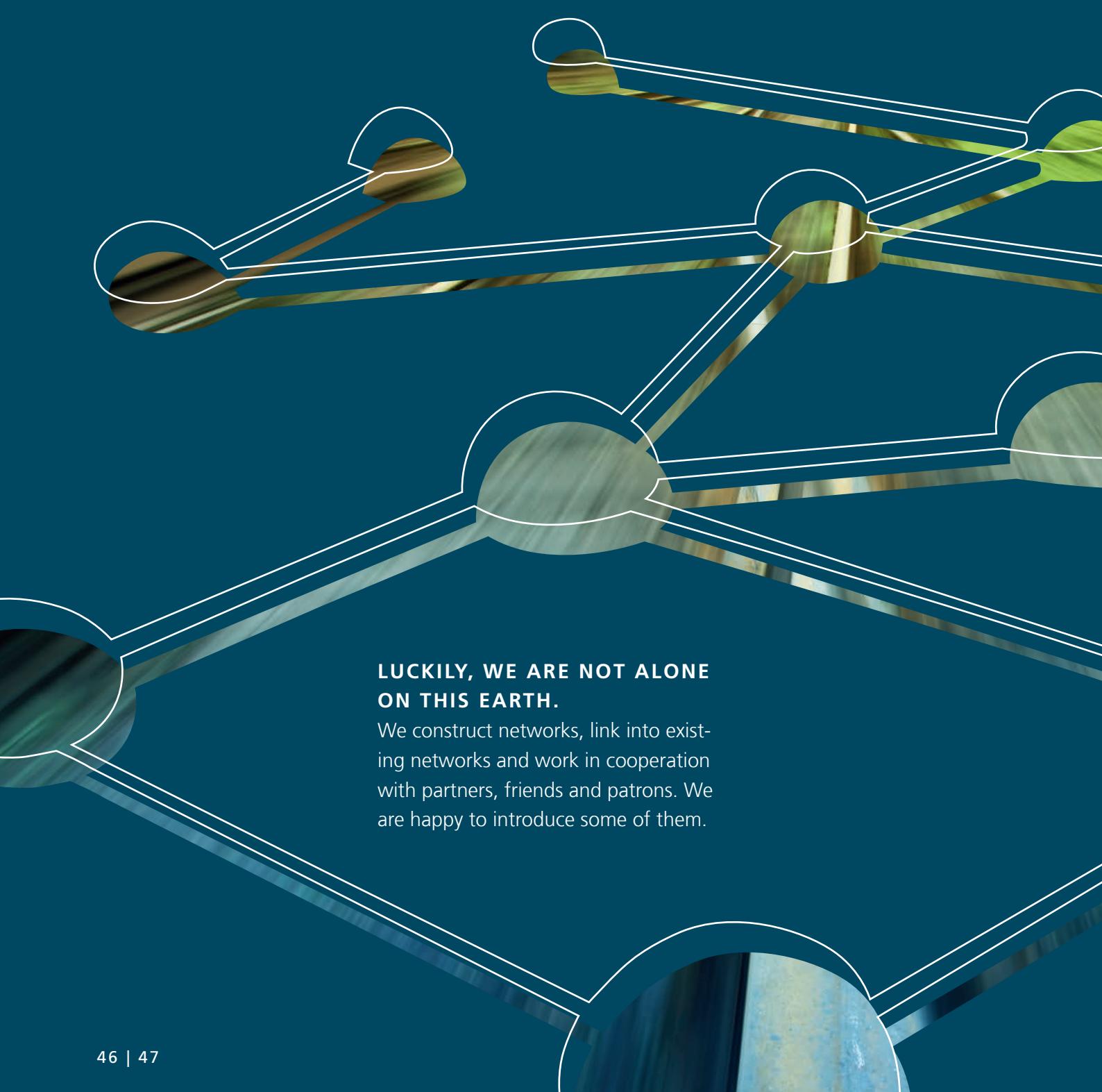
1 Sandra Naumann coordinates
the threads of all organizational
flows of the Science Forum Ruhr.



CONTACT

Sandra Naumann M.A. | Head of the Central Office of Science Forum Ruhr (Wissenschaftsforum Ruhr e. V.) | Phone +49 208 8598-1703 | sandra.naumann@umsicht.fraunhofer.de

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 focus on applied research and key technologies of the future, the Fraunhofer-Gesellschaft plays a prominent role in the European innovation process. Customers are not the only ones to profit from the effect of applied research: with research and development work, the Fraunhofer Institutes contribute to the competitiveness of the region, of Germany, and of Europe. They promote innovations, strengthen the technological performance capability, and ensure the training and continued education of 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 69 institutes and research institutions in Germany,
 - has approx. 24 500 employees, primarily with degrees in natural sciences or engineering,
 - has an annual research budget of 2.1 billion euros, of which 1.9 billion euros are generated in contract research. More than 70 percent of these are derived from contracts with industry and from publicly financed research projects. Almost 30 percent are contributed by the German Federal and Länder 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 January 2017

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](http://www.fraunhofer.de/en/about-fraunhofer.html)



1 *The building of the
Fraunhofer-Gesellschaft (FhG)
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 the institute.

CHAIR

Ernst Gerlach

Chairman of the Board of Trustees

*Association of the municipal RWE-Aktionäre GmbH
(RWE shareholder Ltd.), Managing Director*

Hubert Loick

Deputy Chairman of the Board of Trustees

Loick AG, Managing Director

MEMBERS

Hon. Adv. Prof. (Tsinghua) Dr.-Ing. Reinhold Achatz

thyssenkrupp AG

*Corporate Function Technology, Innovation/Corporate Function
Technology, Innovation & Sustainability*

Burkhard Drescher

BDC Consulting GmbH & Co. KG

Managing Director

Dr.-Ing. habil. Christiane Glasmacher-Remberg

BASF Personal Care and Nutrition GmbH

Head of Research Düsseldorf RCPIOD

Prof. Dr.-Ing. Sabine Grüner-Lempart

Hochschule Weihenstephan, Triesdorf

Senator

Prof. Dr. Andrea Klug

Ostbayerische Technische Hochschule Amberg-Weiden

President

Eckart Lilienthal

Federal Ministry of Education and Research

Department 721 - Policy Issues Sustainability, Climate, Energy

Dr.-Ing. Thomas Mathenia

UMSICHT Friends and Patrons Group

Chairman

Dipl.-Ing. Carmen Michels

FKuR Kunststoff GmbH

Chief Operating Officer

Prof. Dr. Ada Pellert

FernUniversität in Hagen

Rector

MORE INFO

s.fhg.de/umsicht-trustees



1 Competent consulting and
multiplier: UMSICHT Board of Trustees
(Version: November 25, 2016).



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

Greasoline GmbH

Transformation of old fats into blends of hydrocarbons that can be used as fuels, fuel components, and as chemical raw materials.

Gründung: 2011 | contact@greasoline.com | www.greasoline.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, Belgien

Coating for heat insulation and safety applications.

Foundation: 2016 | info@thermallium.com | www.thermallium.com

viteso UG (limited liability)

Service provider for IT solutions with a focus on the development of high quality apps for mobile end devices.

Foundation: 2012 | info@viteso.de | www.viteso.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



Photo: simonthorn/photocase.com

RESEARCH AND TEACHING/ INSTITUTIONS OF HIGHER LEARNING

1 *Applied research requires close ties with science.*

During the 2014/15 winter semester, Fraunhofer UMSICHT sent 24 lecturers to 6 universities and 3 universities of applied sciences, and during the 2015 summer semester it sent 17 lecturers to 3 universities and 2 universities 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

Deputy Director of the institute of Fraunhofer UMSICHT, has been holding 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

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 and a Chair in bioenergy at the University of Birmingham.

Prof. Dr.-Ing. Christian Doetsch

Director of the Energy Division and honorary professor at the Faculty of Mechanical Engineering at the Ruhr University of Bochum for the topics of energy storage and refrigeration engineering.



Photo: shutterstock

1

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 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 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.

CONTACT

Dipl.-Ing. Volker Knappertsbusch | Coordination UMSICHT Research School | Phone +49 208 8598-1232 |
volker.knappertsbusch@umsicht.fraunhofer.de



MORE INFO

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





INTERDISCIPLINARY DISTANCE LEARNING ENVIRONMENTAL SCIENCES

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 2016, infernum additionally received an award from the German UNESCO Commission and from the German Federal Ministry of Education and Research as "Network of the UNESCO World Program of Action for Sustainable Development".

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 "infernun" 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.

infernun 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 in 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

infernun 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 the FernUniversität in Hagen (distance learning University of Hagen) is to further align infernum with the specific needs of the students from the working world.

MORE INFO

www.umweltwissenschaften.de



CONTACT

Dipl.-Ing. Anja Gerstenmeier | Head of Department UMSICHT Academy | Phone +49 208 8598-1111 |
anja.gerstenmeier@umsicht.fraunhofer.de



Photo: Fraunhofer UMSICHT/Ulla Emig

UMSICHT SCIENCE AWARD



In July, the UMSICHT Friends and Patrons Group endowed the UMSICHT Science Award 2016. Dr.-Ing. Saskia Oldenburg received the award in the category Science for her work on the recycling of waste residues. Alexander Stirn was awarded in the category Journalism. He addressed the topic raw materials on the seaground. Since 2010, the award has been endowed to people for a comprehensible communication of topics relevant to society in the fields of environment, safety in processing technology and energy.

AWARD WINNER

Science category:

Dr.-Ing. Saskia Oldenburg

received the award for her dissertation "Development of a concept for the evaluation of the quality of substrates for biogas production using the example of organic residue streams not yet energetically utilized to date". She examined which organic wastes are suitable for biogas production. She found that 2.5 tonnes of horse manure can replace one tonne of corn for power generation. Lawn cuttings and kitchen wastes are also suitable for the process. Through the utilization of residues, the advantages of environmentally friendly energy production would remain, while at the same time, a utilization of wastes that have barely been used to date would take place. Furthermore, she developed a model via which it can be forecast how high the energy content of these wastes is and which problems may occur if biogas is generated from them.

Journalism category:

Alexander Stirn

Below the surface of the sea, a new world of underwater mining has spread out. In his article "Gold ground", published in the Süddeutsche Zeitung newspaper, issue of May 2/3, 2015, journalist Alexander Stirn is describing the consequences and costs of this development, for which he was awarded the UMSICHT Science Award.

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 award winners in the circle of the supporters of the UMSICHT Science Award 2016.*

MORE INFO

www.umsicht-foerderverein.de



CONTACT

Verena Buhle | Administrative Office of the UMSICHT Friends and Patrons Group | Phone +49 208 8598-1152 | verena.buhle@umsicht.fraunhofer.de

CONTACT

BIBLIOGRAPHY

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 **www.publica.fraunhofer.de**, 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.

Information regarding specialized publications
is available from our specialized information service:
fachinformation@umsicht.fraunhofer.de

Information regarding industrial property rights
is available from our industrial property rights officer:
srb@umsicht.fraunhofer.de

SCHEDULE 2017 AND SERVICES

To find current information regarding our events and trade fairs, please visit our homepage on the Internet at:
www.umsicht.fraunhofer.de/de/messen-veranstaltungen.html
(in German only)

FUNDING NOTES

Page 12/13

The project is funded via the lighthouse project initiative of the Fraunhofer-Gesellschaft with the aim of strengthening the business location Germany by quickly turning scientifically original ideas in market-ready products.

08/2015 to 07/2018

Page 15

The pilot phase of the Fraunhofer High Performance Center DYNAFLEX is funded as a joint project with funds of the Fraunhofer-Gesellschaft as well as of the German state of North Rhine-Westphalia under participation of industry partners.

until 12/2019

Page 20/21

BMBF project FKZ 01RI05017

"Sustainability in the economy through application of supercritical fluids"
01/2006 to 12/2008

BMBF project FKZ 01RI0903

"Scale-up of the tanning of leather and impregnation of wood and insulating materials with compressed carbon dioxide"
09/2009 to 08/2012

BMBF project FKZ 033R093

"CO₂ tanning – Resource-efficient utilization of chromium tanning agents through substantial substitution in the tanning process"
08/2012 to 07/2015

Page 24/25

BMEL/FNR project FKZ 22028311 and/or 11NR283

"High-quality material utilization of bioethanol – Manufacturing of higher alcohols and of esters derived therefrom based on renewable resources as well as evaluation of their application"
07/2012 to 07/2015

Page 36/37

BMWi project FKZ 03ET1337

"FlexKWK – Optimized sizing and mode of operation of cogeneration systems in local heat networks for the flexibilization for future electricity markets" – Sub-project: "Optimization of flexible cogeneration systems"
10/2015 to 01/2019



Photo: shutterstock

Page 38/39

BMBF project FKZ 031B0107

"MiDeCO2 - An innovative CO₂-decontamination technology to ensure food safety of low water activity food products"

01/2017 to 12/2019

BMBF project FKZ 031B0275B

"Bio-Hipe-Composite – Development of composite materials, that contain the novel high performance cellulose fibers from Performance BioFilaments"

06/2017 to 05/2019

Project FKZ 20.10-3410.3-01/12

"Biobattery"

01/2012 to 12/2017

BMBF project FKZ 01DN16037

"Reforming – Nano-structured materials for the catalytic cleaning of biomass-based synthesis gases"

11/2016 to 10/2019

BMBF project FKZ 031B0176

"ComCatTar – Comparative study regarding the catalytic removal of tar and ammonia from wood-based synthesis gas"

07/2016 to 04/2019

Page 43

BMW project FKZ KF2084818AK4

"Development of flexible coating systems made of PCM composites for thermoregulation in medicine (ThermoMed)"; Sub-project "Development of PCM-based formulations for coatings of sports tapes and film-forming cryosprays"

05/2015 to 10/2017

Page 45

MIWF project AZ 322-8.05.-126268

"Urban digital production"

05/2016 to 10/2017

HOW TO REACH US

Fraunhofer Institute for Environmental, Safety, and Energy Technology UMSICHT

Osterfelder Strasse 3
46047 Oberhausen
Germany

Phone +49 208 8598-0

Fax +49 208 8598-1290

E-mail info@umsicht.fraunhofer.de

Internet www.umsicht.fraunhofer.de

www.umsicht.fraunhofer.de/en/how-to-reach-us



[How to reach us \(PDF\)](#)

Fraunhofer UMSICHT
Institute branch Sulzbach-Rosenberg
An der Maxhütte 1
92237 Sulzbach-Rosenberg
Germany

Phone +49 9661 908-400

E-mail info-suro@umsicht.fraunhofer.de

Internet www.umsicht-suro.fraunhofer.de

www.umsicht.fraunhofer.de/en/how-to-reach-us-suro



[How to reach us \(PDF\)](#)

Fraunhofer UMSICHT
Willich Branch
Siemensring 79
47877 Willich
Germany

Phone +49 2154 9251-0

Fax +49 2154 9251-61

EDITORIAL NOTES

SELF-PUBLISHER AND PUBLISHER

Fraunhofer Institute for Environmental,
Safety, and Energy Technology
UMSICHT
Osterfelder Strasse 3
46047 Oberhausen, Germany

Phone +49 208 8598-0
Fax +49 208 8598-1290

Internet www.umsicht.fraunhofer.de
E-mail info@umsicht.fraunhofer.de

Fraunhofer UMSICHT is a constituent entity of the Fraunhofer-Gesellschaft, and as such has no separate legal status.
Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V.
Hansastraße 27 c
80686 Munich, Germany

CHAIRMAN

Prof. Dr.-Ing. Reimund Neugebauer, President, Corporate Policy and Research Management
Prof. Dr. Georg Rosenfeld, Technology Marketing and Business Models
Prof. Dr. Alexander Kurz, Human Resources, Legal Affairs and IP Management
Prof. (Univ. Stellenbosch) Dr. Alfred Gossner, Finance, Controlling (incl. Business Administration, Purchasing and Real Estate) and Information Systems

Register court: Amtsgericht (District Court) Munich
Register No. VR 4461
VAT ID No. DE 129515865

EDITORIAL TEAM

Iris Kumpmann (responsible)
Sebastian Hagedorn M. A.
Stephanie Wehr-Zenz M. A.
Dr. Janine van Ackeren

presse@umsicht.fraunhofer.de

REPORTING PERIOD

January 1, 2016 – January 1, 2017

EDITORIAL DEADLINE

April 20, 2017

LAYOUT, TYPESETTING, GRAPHICS

Anja Drnovsek

LEGAL NOTICE

Unless otherwise stated, all rights to text, images and depictions remain property of the publisher. Designations used in this report may be trademarks, the use of which by third parties for their own purposes may infringe on the rights of their owners.

TRANSLATION

Newspeak-Sprachlösungen GmbH & Co. KG,
Düsseldorf/Oberhausen, Germany

ONLINE VERSION OF THE ANNUAL REPORT

www.umsicht.fraunhofer.de/en/media-center/publications/annual-reports.html

FRAUNHOFER UMSICHT IN THE SOCIAL WEB

www.facebook.com/UMSICHT
www.linkedin.com/company/fraunhofer-umsicht
www.youtube.com/fraunhoferumsicht
plus.google.com/+fraunhoferumsicht
www.twitter.com/umsicht

