

# Annual Report 2010/11

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

# <sup>1</sup> Content

On 130 pages we are reporting on our year 2010, our projects, the people behind the projects and the plans for 2011.

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# PREFACE

Dear readers,

2010 was an important year for UMSICHT: we celebrated 20 years of crisp and fresh ideas! The visual motive of a crisp green apple led us through the past year and stood for creativity, freshness and "green thinking".

We believe that we may be allowed to be just a bit proud of what we have achieved in two decades. Everything started in 1990 with a few employees in the rooms of a power plant in Oberhausen, Germany. We were integrated into the Fraunhofer-Gesellschaft in 1998 – a bit later than planned, but therefore with more vigorous support by both the state of North Rhine-Westphalia and the headquarters of the Fraunhofer-Gesellschaft in Munich, Germany.

And there was another birthday that had to be celebrated in 2010: the Interdisciplinary distance learning program for environmental sciences, *infernium*, is now 10 years old. Together with the FernUniversität in Hagen (distance learning university), Fraunhofer UMSICHT offers by now more than 550 students the first accredited Master's study program of distance learning in the area of environmental sciences in Germany.

Of course, we are not only looking backwards, we mainly look forward: sustainability, efficiency and the utilization of resources are what we hold very dear. We are, for example, coordinating the Fraunhofer subject of the future of "Energy Storage". We are making one of the largest testing laboratories for redox flow batteries in Europe operational and use it to have energy from natural resources that can be stored, that is predictable and reliable.

Innovative and creative thinking is what drives our employees and many people in the Ruhr region. In 2010, the Ruhr region was Cultural Capital 2010 and demonstrated to Germany and Europe how the largest industrial expanse of the continent became the symbol for change. One example for this is that Oberhausen, with Fraunhofer UMSICHT, is one of the 365 sites in the



*Left image: Prof. Dr.-Ing. Eckhard Weidner, Director of the institute*

*Right image: Prof. Dr.-Ing. Görgo Deerberg, Deputy Director of the institute*

Land of Ideas. The landmark initiative "Germany – Land of Ideas" is awarding the 2011 award to the research project "Smell-induced recognition of critical tears".

In the advertising campaign of the landmark initiative you will, in the course of the year, be able to find out what is hiding behind that.

The first awarding of the UMSICHT Science Award, which was donated by the UMSICHT Circle of Friends and Patrons within the scope of our birthday celebration, was a particular highlight. It will be awarded again in 2011 in the areas of science and journalism, to promote innovative actions and thinking as well as the cooperation of research and industry that is close to the market.

Creative, multi-faceted, self-sustaining, innovative: we at Fraunhofer UMSICHT want to be like that. This would not be possible without the expertise and the enthusiasm of our employees, which is why we want to thank them here very, very much for their committed team efforts.

We would also like to thank our friends and patrons, customers and research partners for their ideas and for their trust in realizing those ideas jointly with us.

And to you, dear reader, our thanks for your interest in Fraunhofer UMSICHT, and we hope you enjoy discovering our many facets.

Glück auf – good luck!

Kind regards

Eckhard Weidner

Görgo Deerberg

*Fraunhofer UMSICHT develops applied and manufacturing-related process engineering. As a pioneer for technical innovations in the areas of environment, materials science, process technology and energy technology, we want to encourage sustainable business practices and environmentally friendly technologies to improve the quality of life for people and to support the innovative capabilities of the domestic economy.*

# <sup>2</sup>General

The basic data of Fraunhofer UMSICHT.  
Profile, Fields of Activity, Key Performance  
Indicators.

Fraunhofer UMSICHT – guaranteed crisp ideas since 1990. Our employees offer you:

Technology that pays!



Sustainable economic development

Applied engineering technologies

Environmentally friendly technologies

Innovative approaches

## FRAUNHOFER UMSICHT

### FRAUNHOFER INSTITUTE FOR ENVIRONMENTAL, SAFETY AND ENERGY TECHNOLOGY

#### PROFILE OF THE INSTITUTE

Fraunhofer UMSICHT develops applied and manufacturing-related process engineering. As a pioneer for technical innovations in the fields of environmental, materials science, process engineering and energy technology, Fraunhofer UMSICHT wants to encourage sustainable economic development and environmentally friendly technologies as well as innovative behavior to improve the quality of life for people and to support the innovation capacity of the national economy.

Where technology is concerned, the institute is positioning itself in the research landscape with four key areas.

The four key areas

- “Biorefinery – Products from Renewable Resources”,
- “matfunc – Particles, Materials and Membranes with Functionality”,
- “Modular Energy Technologies – Flexible Solutions for Sustainable Energy Systems”,
- “Information Networks for Process Engineering and Energy Technology – Utilizing Dispersed Knowledge in Value Added Chains”

are to be understood as scientific pulse generators across business units. They are designed to adapt the profile of the institute to the rhythm of the economic and societal change and focus on promising new lines of research.

Eight specialized business units represent the precisely tailored combination of products and R&D services responding to today's challenges of the market segments addressed. Modern project management methods are used to successfully realize innovation projects. The key research areas are thus continuously adapted to changing demands in a “bottom up” way.

Together with industrial and public customers, the institute develops and researches new technologies and transfers them into industrial applications and marketable products. No matter whether the customer is a small or medium-sized enterprise, a major enterprise or a public institution, UMSICHT can guarantee a one-stop-shop service: starting from the project idea over proposal procedures to the development and market introduction, Fraunhofer UMSICHT offers its clients R&D expertise and thus provides them with competitive benefits and opens up international markets for them.

As a member of the Fraunhofer-Gesellschaft, the institute follows the tradition of applied, market-oriented research and development. Since its founding in 1990, Fraunhofer UMSICHT has been engaged in the structural change of the city and the region, acting as a catalyst for science and economy. This has been done through technology transfer, spin-offs and the set-up of R&D networks. The institute's international activities presently focus on European countries.

# ORGANIZATIONAL CHART

## Directorate

Director: **Prof. Dr.-Ing. Eckhard Weidner**

Deputy Director: **Prof. Dr.-Ing. Göрге Deerberg**

## Business Units

### Renewable Resources

**Dr.-Ing. Stephan Kabasci**

Deputy:  
Dipl.-Ing. Thomas Wodke

- Bioengineering
- Chemical Conversion
- Bio-based Plastics

### Process Technology

**Prof. Dr.-Ing. Göрге Deerberg**

Deputy: Dipl.-Ing. Josef Robert /  
Dr. rer. nat. Stefano Bruzzano

- Downstream Processing
- Water- and Wastewater Technology
- Multiphase Reaction Technology

### Biofuels

**Dr.-Ing. Axel Kraft**

Deputy:  
N. N.

- Catalytic Processes
- Refinery Concepts
- Biofuel Processes

### Materials and Interaction

**Dipl.-Ing. Jürgen Bertling**

Deputy: Dr. rer. nat. Holger Wack /  
Dipl.-Ing. Marcus Rechberger

- Material and Product Design
- Processing Technology
- Biomimetics and Haptics

### Information Technology in Process Engineering

**Dipl.-Phys. Thorsten Wack**

Deputy:  
Dipl.-Ing. Andreas Schröder

- Information and Knowledge Management
- Environmental and Safety Law
- Server Based Computing

### Energy and Recycling Materials

**Dr. rer. nat. Thomas Marzi**

Deputy:  
Dr.-Ing. Barbara Zeidler-Fandrich

- Biogenous and Chemical Energy Media
- Recycling Technologies
- Thermochemical Storage

### Energy Efficiency Technologies

**Dr.-Ing. Christian Dötsch**

Deputy: Dr.-Ing. Wilhelm Althaus /  
Dipl.-Ing. Carsten Beier

- Electrical Energy Storage
- Polygeneration, Thermal Chiller
- Optimization of Energy Systems

### Resources Management

**Dr.-Ing. Hartmut Pflaum**

Deputy:  
Dr.-Ing. Markus Hiebel (MSC)

- Material Flow Management, Eco-Assessment
- Sustainability Management
- Innovation Processes

## INFRASTRUCTURE

### Administration

**Dipl.-Betw. Andreas Weber**

Deputy:  
Dipl.-Region.-Wiss. Nina Junen

- Finances, Controlling, Contracts
- Human Resources Development

### Public Relations

**Dipl.-Chem. Iris Kumpmann**

- Media and Public Relations
- Event Management
- Media Design for Digital and Print

### Library

**Dipl.-Bibl. Kerstin Hölscher**

- Information Services
- Publication Support
- Archive

### Central Technical Services

**Dipl.-Ing. Richard Sprick**

Deputy:  
Dipl.-Ing. Joachim Hillers

- Facility Management
- Pilot Plant Stations and Workshops
- Construction, CAD

### IT Management

**Dipl.-Ing. Andreas Schröder**

Deputy:  
Dipl.-Inform. Christian Knemann

- Usersupport
- Server and Network Management
- Data Lifecycle Management

### Innovation Management/ Industrial Property Rights

**Dr.-Ing. Hartmut Pflaum**

- R&D-Strategies
- Industrial Property Rights, Licensing
- International Projects, EU

### Chemical Laboratory

**Dr.-Ing. Edda Möhle**

Deputy:  
Dr. rer. nat. Anna Fastabend

- Anorganic Analysis
- Organic Analysis
- Development of Methods

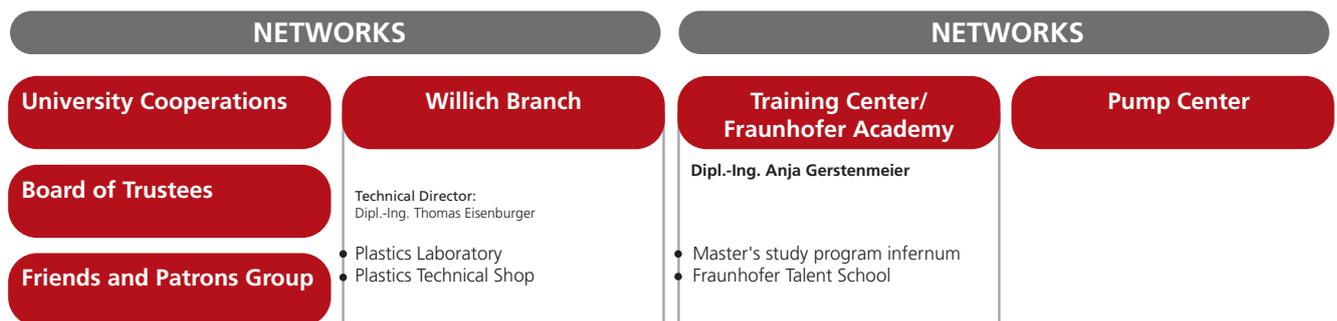
### Occupational Safety and Environmental Protection

**Dr.-Ing. Ulrich Seifert**

Deputy:  
Dipl.-Ing. Jürgen Stein

- Consulting and Coordination
- Safety Analysis and Checks
- Approval Procedures

# NETWORKS



## Willich Branch

At the Willich site, Fraunhofer UMSICHT offers comprehensive services in the areas of compounding and materials development, always customer-oriented and product-oriented. Biodegradable plastics, polymers from renewable resources, nanocomposites and recyclable plastics are being developed systematically and manufactured in pilot series and small batches. Process optimization, analytics and test engineering round out the portfolio of the Willich Branch.

## Training Center/Fraunhofer Academy

We select qualified specialists and leaders with the objective to strengthen the innovative power of Germany. The interdisciplinary distance learning program for environmental sciences infernum, the "Official Project of the United Nations Decade of Education for Sustainable Development, 2005-2014", imparts environmental expertise from more than 10 disciplines and qualifies its students, who are enrolled in the program parallel to their job, to think and act in interdisciplinary ways. The accredited Master's study program infernum is offered in cooperation with the FernUniversität in Hagen (distance learning university) and is part of the Fraunhofer Academy.

"[www.academy.fraunhofer.de](http://www.academy.fraunhofer.de)" or "[www.umweltwissenschaften.de](http://www.umweltwissenschaften.de)"

## Cooperation with universities

As an institute that, with its applications and market-oriented services, is acting at the intersection of research at the university and industrial practices and products, we are relying on strategic partnerships with universities and colleges in Germany and Europe. This is how we incorporate basic research into our projects.

## Competence Center for Hydraulic Turbomachinery "Pump Center" Bochum

The first center of excellence for hydraulic turbomachines in Germany, supported by the Faculty of Mechanical Engineering of the Ruhr University Bochum and Fraunhofer UMSICHT, networks and bundles expertise from the fields of process engineering and energy technology, materials science, manufacturing technology, electrical drive engineering, water management, measurement and control technology and computer science. The objective is to establish the subject of hydraulic turbomachines as an attractive focal point of study in mechanical engineering and to support the market in the future with highly qualified people.

## Circle of Friends and Patrons/Board of Trustees

More info: chapter "Network" (pages 111/113)

# FACTS AND FIGURES

## Staff at Fraunhofer UMSICHT

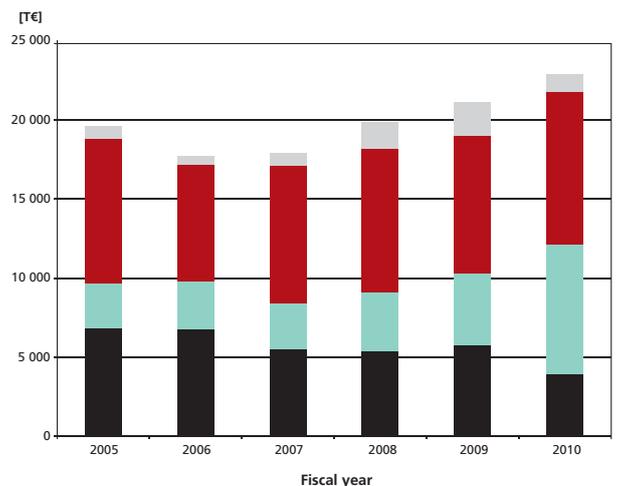
	Numbers
<b>Permanent staff</b>	<b>187</b>
Staff in scientific business units	133
Staff in infrastructure departments	54
Other staff	131
Trainees	17
Students (diploma, master, bachelor)	14
Student assistants and research assistants	79
Interns and persons in civilian service	21
<b>Total staff</b>	<b>318</b>

## Expenditures and Returns 2010

	(in Mio. €)
<b>Operational budget</b>	<b>22.9</b>
Staff costs	10.8
Other costs	12.1
Investments	3.2

## Returns Operational Budget 2010

	(in Mio. €)
Basic funding	3.9
Public returns	8.2
Industrial returns	9.7
Others	1.1
<b>Total Returns</b>	<b>22.9</b>



Basic funding
  Industrial returns  
 Public returns
  Other returns (EU)



## TRAINING CENTER FRAUNHOFER ACADEMY

### Master's study program infernum

The pace of innovation is high, the business environment is changing constantly and globalization creates increasing competitive pressure from abroad. Very often, those who want to successfully face the challenges find that the conventional specialized studies or a traditional professional education/training are no longer sufficient in themselves. Today, life-long continued education is a must. We select qualified specialists and leaders with the objective to strengthen the innovative power of Germany.

On October 30, 2010 we were able to celebrate the 10<sup>th</sup> anniversary of the interdisciplinary distance learning course for environmental sciences infernum ([www.umweltwissenschaften.de](http://www.umweltwissenschaften.de)). The Master's study program, which is being offered jointly by Fraunhofer UMSICHT and the FernUniversität Hagen, started in November of 2000 with 43 students. Meanwhile, more than 550 students have registered. This number speaks for the success of this course of studies, which offers future-oriented continued education in the areas of environment and sustainability.

In parallel to working, infernum provides occupational knowledge about the environment that is gleaned from more than ten expert areas and enables the students to think and act in an interdisciplinary manner. People working in business, associations, science and administration, the self-employed and qualified newcomers to the environmental area obtain current specialized knowledge and interdisciplinary expertise. infernum thus sets the knowledge foundation for the integration of the ecological, economic and social aspects of sustainability. The Master's study program fosters networked

thinking and promotes creativity and the capacity to innovate. Graduates are qualified to realize sustainable solution approaches to complex, scientific environmental tasks in companies and in society and to act as promoters with managerial responsibility and strategic vision.

As a distance learning program infernum supports its participants to work independently and in a structured way and in acquiring specific knowledge. The information is imparted by manageable learning modules in the form of printed course material (Studienbriefe) as well as via internet-supported units. Classroom seminars and excursions supplement the teaching program with current research results, and practical examples complete the program and intensify the contact between the participants and the supervising scientists.

After the successful completion of the accredited program, graduates are awarded a Master of Science (M.Sc.) degree.

In 2005, the study course received recognition as the "Official Project of the United Nations Decade of Education for Sustainable Development, 2005-2014".

The Fraunhofer Academy bundles the continuing education offers of the Fraunhofer-Gesellschaft under one roof and offers excellent continuing education opportunities to scientists and managers. The latest findings from R&D are immediately reflected in the teaching content. This guarantees a unique transfer of knowledge from Fraunhofer research to companies.



## Fraunhofer Talent School

The talents of today are the scientists of tomorrow. It is an important basis for our innovations to get into contact with creative, team-oriented and highly motivated young people today.

Since 2009, Fraunhofer UMSICHT has been participating in the Fraunhofer Talent School ([www.fraunhofer.de/talent-school](http://www.fraunhofer.de/talent-school)). The Talent School is a program for talented and technically interested teenagers from high school. In three-day workshops all students work committedly on interesting scientific topics, such as "Biomimetics", "Energy Supply of the Future" and "Biofuels". The workshops are complemented by an additional program offering interesting insights into the researchers' day-to-day work, as well as into international scientific life.

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## Training Center/Fraunhofer Academy

"With the help of the interdisciplinary work I have learned to look at problems from very different perspectives – of course, this principle can be transferred to other areas of life. Furthermore, the distance learning course advances self-discipline and working continuously. I have also left behind old thought patterns and existing knowledge and have dared to venture into new areas. This way I have looked beyond the rim of the teacup more than once".

*Sonja Hage, Volkswagen AG, Wolfsburg*

*(Graduate of the study course infernum)*

"I have never before learned so much in just three days."

*Participant of the Talent School 2009 in Oberhausen*

# <sup>3</sup> Business Units

This is what we do for you.

Main topics,  
competencies,  
service for research and development  
as well as project examples

## Our eight business units

# RENEWABLE RESOURCES

Inspired by nature.



## Main topics

- Bioengineering
- Chemical Conversion
- Bio-based Plastics

**Information/Administrative office**  
+49 208 8598-1227

## Industries and target groups

- Agriculture
- Energy suppliers
- Recycling and waste management industry
- Chemical and plastics processing industry
- Food industry
- Packaging industry
- Automotive and automotive supplier industry

The foremost objectives of sustainable development are to reduce environmental pollution and to protect fossil resources. These objectives can be achieved by using renewable raw materials. Only those who understand and protect nature can sustainably use it!

## Our competencies

We develop and optimize technical processes for producing materials and for generating energy from renewable raw materials and biogenous residues. Our strengths lie in the application of biotechnological processes and chemical conversion steps as well as in plastics technology.

The focus of our work is on environmentally friendly generation of power, heat and cold, the sustainable production of platform chemicals as well as the development of novel bio-based materials and products. At our laboratory and technical shop systems, the scale-up from first test samples of new materials to small scale industrial production can be worked out and realized.

## Our R&D service

- Optimization of and scientific consulting for biogas plants
- Development and optimization of biotechnological processes, downstream processing
- Research of new chemical synthesis pathways and production of new polycondensates
- Development of bio-based materials and products
- Pilot and small scale production of bio-based polymers and compounds
- Laboratory analysis of polymeric materials
- Certified testing of biodegradability of substances, materials and residues
- Market and feasibility studies, technology assessments

# 3 questions for

**Dr. Stephan Kabasci**

(Business Unit Manager)



**1** Which of the crisp ideas of your team are you particularly proud of?

**1** Last year we developed a bio-based plastic material suitable for the production of foamed packaging trays for warm meals. The material is based on renewable raw materials and is biodegradable so that it can, for example, be composted together with the leavings of a meal. Our industry partners are thrilled. At present we are still jointly optimizing the production process so that the material and the packaging can enter the market soon.

**2** What is becoming more important from the customer's/industry's point of view?

**2** The sustainability of novel processes and products is increasingly being questioned. It is, for example, not enough to simply state "electricity from biogas is sustainable", but this must be backed up by sound carbon footprint or life cycle assessment calculations, too. To stick with the example of biogas production: here, the processes must be optimized in such a way that no climate damaging methane emissions are released at all. Of course, we will continue to work on these issues in future.

**3** What are you hoping for in 2011?

**3** In the next three years we will be cooperating with German and Indonesian research partners and industry companies in an interesting international project. It is about the holistic sustainable utilization of biomass for the production of fuels and chemicals as well as for power generation. I would be quite happy if this project for the development of a biorefinery had a good start.



## EFFICIENT PURIFICATION OF SUCCINIC ACID

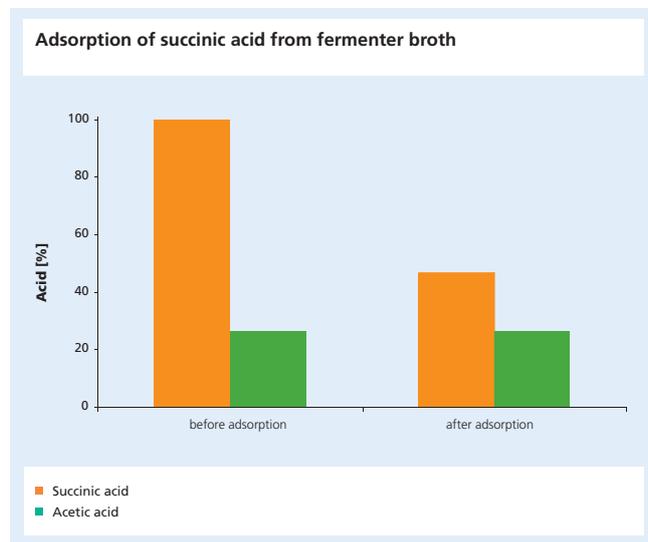
Fraunhofer UMSICHT develops an efficient method for the purification of succinic acid. This fermentation product can be used as an intermediate for further processes, e. g. for manufacturing bio-based plastics, paint or food additives. The novel process for the extraction of succinic acid from fermentation broths utilizes inorganic ion exchangers.

The market for bio-based plastics from renewable raw materials shows promising growth: according to a market study by Ceresana Research<sup>1</sup> from 2009, the consumption of biodegradable plastics based on starch, sugar and cellulose has increased by 600 percent in the past eight years. Succinic acid is an intermediate that can be further processed into plastics such as polyesters or polyamides. In contrast to the chemical production of succinic acid from crude oil, the manufacturing by means of white biotechnology represents an environmentally and resource-friendly alternative. Succinic acid can, for example, be produced through fermentation of carbohydrates such as starch and sugar.

The development of the biotechnology process at Fraunhofer UMSICHT already started in 2006. The researchers optimized the fermentation using the micro-organism *Anaerobiospirillum succiniciproducens*. To further utilize the succinic acid and to develop chemical derivatives, it must be extracted from the fermentation broth. So far, methods for this process included for example electrodialysis, precipitation or chromatography. To date, all these processes are hardly economical, since the extraction generates high costs for energy, chemicals or waste disposal.

### Huge biotechnological manufacturing potential

The process, newly developed by Fraunhofer UMSICHT, uses, for the first time, inorganic ion exchangers for the adsorption of succinic acid. The minerals used have an amphoteric character and thus the characteristic of binding both cations and anions. The tests conducted on lab scale provided very good product yields with various carboxylic acids and carboxylic acid mixtures. With the new process for extracting succinic acid, a first milestone has been achieved; in the next step, processes will be further optimized and binding capacities improved. The process is also suitable for the adsorption of acetic acid or lactic acid. Succinic acid is a platform chemical with an annual demand of currently 15,000 tons and a market value of six to nine euros per kilogram. It has a particularly high biotechnological manufacturing potential and can be used as the basis for a product family tree for numerous chemical derivatives. In a





list of the Department of Energy in the USA, succinic acid is among the twelve biorefinery technology products with the highest potential.

<sup>1</sup> Market study of bio-based plastics. Ceresana Research 2009

I. Bechthold, K. Bretz, S. Kabasci, R. Kopitzky, A. Springer: Succinic Acid: A New Platform Chemical for Biobased Polymers from Renewable Resources, in: Chemical Engineering & Technology, 2008, 31 (5), p. 647–654; doi:10.1002/ceat.200800063.

**Left image:** First lab scale tests with the new extraction process for biotechnologically manufactured succinic acid were successful. Now, the processes need to be further optimized.

**Right image:** Succinic acid powders in comparison: on the left, biotechnologically manufactured after the first isolation step from the fermenter broth; on the right, chemically synthesized succinic acid.

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## White biotechnology

Industrial biotechnology – also called “white biotechnology” – is the targeted utilization of modern biotechnology for the sustainable manufacturing and processing of chemicals, materials and fuels. Through the use of enzymes and micro-organisms, traditional chemical production processes can be replaced by biotechnological processes, and intermediate chemicals and fine chemicals, biopolymers and environmentally friendly biofuels can be manufactured from renewable raw materials. The “white” (industrial) biotechnology is thus considered the third wave of biotechnology, after the “red” (medical) and the “green” (agricultural) one. (Source: BMBF)

# ADHESIVES MADE OF RENEWABLE RESOURCES

There are several examples in nature: shells that attach themselves to rocks via adhesives, or adhesive droplets with which plants catch insects. In industry, adhesives to date are, for the most part, produced from crude oil. Fraunhofer UMSICHT, with partners from industry and universities, is developing new adhesive formulations based on renewable resources to develop sustainable and efficient alternatives for adhesives production.

Wooden parts or metals can be joined with it, it is part of the Airbus A 380 as well as of various articles of clothing and of sticky notes: the connecting element is an adhesive. Both in day-to-day life and in industry, the use of adhesives is an important joining technology. 820,000 tons of adhesives were manufactured across Germany in 2010, a 5.7 percent increase from the previous year – especially for vehicle manufacturing and for the electronics industry<sup>1</sup>. Due to resources becoming ever scarcer, adhesives based on crude oil as the raw material are cost intensive and not sustainable. Therefore, industry is striving to increase the share of bio-based adhesives. Fraunhofer UMSICHT, jointly with partners from industry and universities, is developing new adhesive formulations.

An adhesive is a non-metallic substance that joins two materials by surface bonding (adhesion) such that the connection that is obtained features a sufficient inner strength (cohesion). There are adhesives that cure physically and such that cure through chemical reaction. The impact of an adhesive's individual components on its properties follows complex connections. In two projects, Fraunhofer UMSICHT is developing completely new adhesive formulations in which bio-based backbone polymers and additives are used.

<sup>1</sup>(Source: Adhesives Industry Association (Industrieverband Klebstoffe))

## Pressure-sensitive adhesive based on polylactic acid

The manufacturing of a pressure-sensitive adhesive for industrial applications is the objective of a project of Fraunhofer UMSICHT in cooperation with the Fachhochschule Gelsenkirchen, University of Applied Sciences and the companies Jowat, Logo tape and Novamelt. Pressure-sensitive adhesives are for instance used in adhesive bandages, self-adhesive labels or adhesive tapes. Important requirements that have to be taken into consideration in the development: the adhesive must be removable residue-free, and the strength of the adhesive force must be adjusted exactly to its intended use. Fraunhofer UMSICHT is responsible for the development of the primary polymeric ingredient based on polylactic acid that can be manufactured from renewable resources such as starch or sugar. Polylactic acid provides numerous advantages: it features inherent sticky properties, lactic acid is produced on an industrial scale, and the costs are in the same ballpark as the prices of fossil-based polymeric ingredients. Since the characteristics of polylactic acid are completely different from those of polymers used to date, the first objective is to develop a completely new model formulation. This project is sponsored by the German Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) through the German Fachagentur Nachwachsende Rohstoffe (FNR, Agency for Renewable Resources).



*Image: In adhesive tapes, the adhesive based on polylactic acid is intended for use. For this, the researchers initially are developing a novel model formulation.*

### Food packaging with compostable films

A lot of products must be protected against dirt, wear, humidity and chemicals for a long period of time. This is possible using cardboard packaging with film lamination. Here, printed packaging and print articles made of paper are coated, on one or both sides, with a transparent, glossy, matte or embossed plastic film, such as in food packaging, presentation binders or catalogs. In a joint research project Fraunhofer UMSICHT, together with the companies Achilles Papierveredelung Bielefeld, Jowat and Deckert Management Consultants, is developing novel adhesive systems which both conform to the high quality requirements of laminated articles and are compostable. In this application, predominantly water-based dispersion adhesives are used.

Except for products in which natural rubber is used, at present no other adhesives based on renewable resources exist. Also amiss are fully compostable laminated packaging articles. Due to the combination of the project partners' comprehensive experience and innovative power, both projects have a great potential to develop novel products. This way, a sustainable use of renewable raw materials can be achieved in the manufacturing of adhesives.

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### Polymeric ingredients and dispersion adhesives

Polymers are substances that consist of linear, branched or meshed molecule chains which again consist of many individual molecules (monomers). Polymeric ingredients are the basis of an adhesive formulation. They provide adhesives with the necessary inner strength (cohesion).

In dispersion adhesives, the adhesive components are very finely distributed in water: dispersed. They are applied on one side and must be joined while still wet. Strength is only achieved once the water has been absorbed by the material and/or evaporated into the air.

# BIOPLASTICS FOR BEVERAGE CARTONS

Packaged in paper, cardboard and paperboard packaging (PPK), many products are well protected against mechanical damage, dirt and sunlight. Moist and fatty food, however, soften the packaging. Therefore, those must be coated with a plastic or metal film. This protects both the packaging and the content. Fraunhofer UMSICHT, in cooperation with partners from industry, is developing biopolymer blends based on renewable resources in the area of paper and cardboard coating.

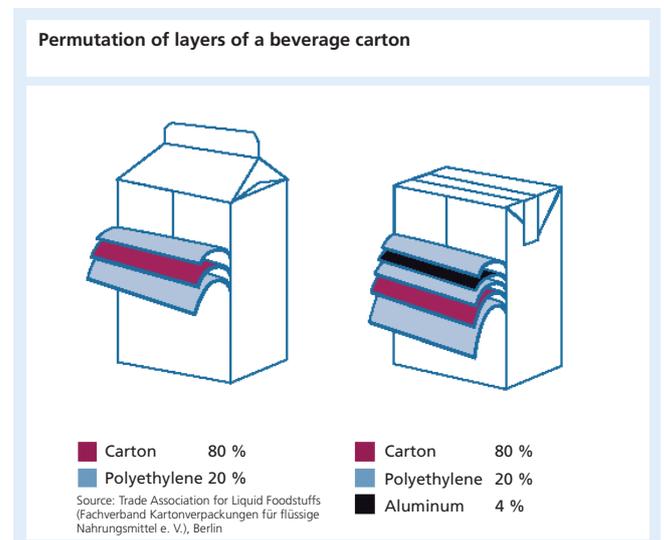
When grabbing a milk or juice pack from the refrigerator, its packaging does not receive any attention most of the time. But it is worth taking a look, since beverage cartons are high-tech materials. Even though a one liter beverage carton only makes up three percent of the gross weight, the demands it is faced with are pretty steep. It is designed to optimally protect food and aroma, guarantee a long shelf life and be sturdy. Quite often, this is beyond the capabilities of packages made from a single material. Therefore, different materials are combined into a multilayer composite: cardboard takes care of sturdiness, a plastic film seals the package tightly, and an aluminum foil prevents light and oxygen from affecting the goods inside.<sup>1</sup>

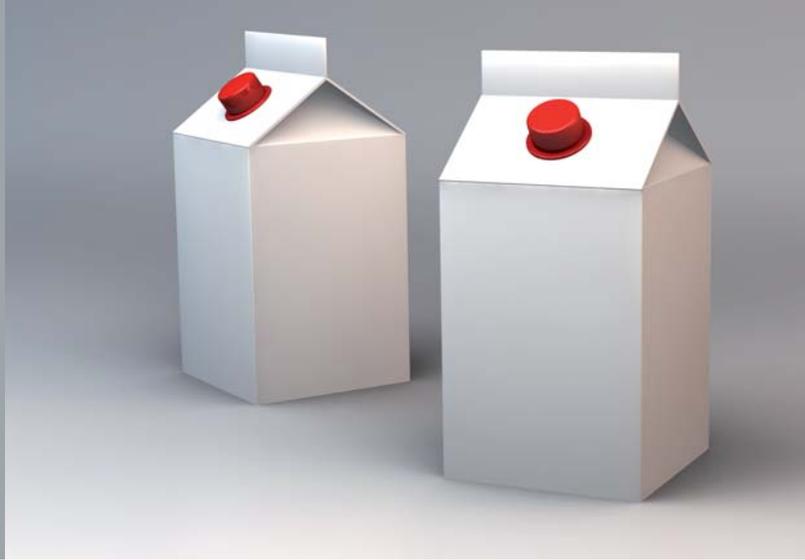
The carton itself constitutes the largest share of the packaging. It consists of paper, cardboard or paperboard. These are manufactured from wood, a renewable resource. Another 20 percent are plastics. They can be processed in an extruder and be applied from the melt as a thin film onto both sides of the carton – the so-called coextrusion process. Or the plastics might already be available as a film which is glued onto the carton – the so-called lamination process. In case of special requirements, an aluminum foil is added to act as a gas barrier. At present, the plastics films for this composite packaging are made of polyethylene (PE) which is manufactured from crude oil. Fraunhofer UMSICHT together with Fraunhofer IVV is developing a plastic blend based on renewable resources for application in beverage cartons as well as a manufacturing process for laminated PPK composites. The

substitution potential of such bio-based plastics would be high: in Germany alone, approx. 44,000 tons of coating polymers are needed each year.

## The expectations in the development of biofilm are high

The mechanical and barrier requirements of fossil-based coatings cannot be met by currently existing bio-based plastics. In addition, for the manufacturing of PPK composite packaging the bio-based materials must be processed on existing machinery. Therefore, this research project aims at adjusting the necessary properties by mixing (compounding, blending)





of commercially available bio-based plastics. At first, potential plastics blends (compounds) are tested for their mixability and barrier properties. For this, sample blends are manufactured on existing test systems (laboratory kneading machine, laboratory rolling mill and laboratory extruder) at Fraunhofer UMSICHT and analyzed for their properties. Subsequently, larger sample batches are produced and the processing of the material is tested at Fraunhofer IVV on a pilot-scale coating machine at close to industry coating speeds.

The project is managed by the Industry Association for Food Technology and Packaging and due to its pioneering significance for the use of renewable resources and materials obtained from them, it is funded by the German Federal Ministry of Economics, through the German Federation of Industrial Research Associations.

<sup>1</sup>Source: Fachverband Kartonverpackungen für flüssige Nahrungsmittel e. V. (Trade Association for Liquid Food Packagings)

*Image: Beverage cartons with bio-based plastics for more sustainability in the packaging industry.*

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**The term “bio-based plastics” is used for different groups of materials:**

1. In case of plastics manufactured from renewable resources, the “bio” prefix stands for the origin of the raw materials and separates bio-based plastics from conventional plastics based on crude oil.
2. In case of biodegradable plastics, the “bio” prefix describes the properties of the material and illustrates that decomposition by micro-organisms can take place. Biodegradable plastics are available either based on renewable resources or on crude oil.
3. In case of biocompatible medical products or products that can be absorbed by the human or animal body, the “bio” prefix expresses the use of plastics in a living organism.

In this article, the term bio-based plastics is used for plastics made from renewable resources.

# MEASURING THE BIOLOGICAL ACTIVITY OF BACTERIA IN BIOGAS PLANTS

The biological activity of bacteria in biogas plants is determined by their metabolism. The better bacteria are turning organic matter into biogas, the higher the biogas production rate is going to be. But, at present, the biological activity in biogas plants still is an unknown. Fraunhofer UMSICHT is developing a test that measures the metabolic activity of the bacteria in the fermenter and thus helps to operate biogas plants more efficiently.

There are approx. 6,000 biogas plants in Germany. Most of them are located at agricultural establishments and work reliably. But many systems have more potential and could operate better.

To achieve the most from the fermentation process, the bacteria have to feel well in the fermenter broth. Only then their metabolism will kick into high gear, their biological activity will be high, and consequently also the biogas yield and quality. If nutrients are missing or other parameters in the fermenter are not optimal, the biological activity of the bacteria drops leading to a reduced gas production. It is necessary to know what is happening in the fermenter in order to be able to operate a biogas plant optimally. But at most plants only a few parameters are measured, such as the pH value and gas quality. Quite often, even information about the methane or carbon dioxide levels in the gas is missing. Mostly, the operators control their plants based on experience.

In the past, it was not possible to measure the metabolic activity of bacteria in biogas plants. Fraunhofer UMSICHT in Oberhausen, Germany, in cooperation with the University of Rostock and the University for Applied Science and Arts (HAWK) Göttingen, has developed a method for turning the unknown biological activity of bacteria into a known quantity. Even better: the test system reveals nutritional deficiencies in the fermenter broth. If trace elements such as cobalt, molybdenum or nickel are lacking, the metabolism of the bacteria suffers, the biological activity drops. If the plant operator knows which elements are missing and in which quantities, he can control the operation of his fermenter

through targeted supply.

Up to now, the fermenter has been mostly regarded as a black box. Inside of it the conversion of organic matter into biogas takes place in a complex food chain in which different bacteria participate. The methanogenic bacteria that generate the biogas are all the way at its end. Only very little is known about the activity of the various groups of bacteria. It is, for instance, known that particularly in plants that do not use liquid manure, a certain nutrient deficiency can occur and that cobalt, nickel and molybdenum can become deficiency factors. But information about the nutrient concentrations required by bacteria for optimal metabolism is barely described in literature.

## The ORGA test's method of measuring

The activity test (ORGA test), named after the project partners' locations, Oberhausen, Rostock and Göttingen, assists in describing and recording the biological activity in a biogas fermenter. The ORGA test is based on a commercial biogas measuring system for assessing gas production in fermentation tests. To conduct the test, one has to retrieve samples from the fermenter broth, feed them into the test system and feed the suspensions with defined amounts of different model substrates. Then, the conversion rate of the substrates into biogas is recorded.

In parallel, comprehensive analyses were conducted to be able to determine the amount of macronutrients such as nitrogen, phos-



*Image: Determining the gas production in fermentation tests*

phorus and sulfur as well as micro-nutrients such as cobalt, molybdenum and nickel in the fermenter broth. Tests were conducted at more than 35 biogas plants in several German regions. In addition to the classic fermenter broths from agricultural biogas plants, using corn silage together with liquid manure, fermenter broths from monosystems that only use corn silage were tested. The challenge is to find the dependencies of the various biological activities from the respective nutrient concentrations since no simple correlation between activity and nutrient levels could be determined.

All in all, the ORGA test contributes to operating biogas plants more efficiently.

The project is sponsored from the German Federal Ministry of Economics through the German Federation of Industrial Research Associations.

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### **Model substrates**

In the development of the ORGA test for measuring the activity of the anaerobic microbial food chain in biogas fermenters, three model substrates could be identified. Corn silage was used as standard. It is among the biomass very frequently used in biogas plants and best reflects reality. Starch was used as an easy-to-process model substrate. Just like corn silage, starch passes through the whole food chain to be decomposed, however, it is much better defined since it consists only of a single component. As an essential innovation of the project, acetic acid was used for the first time as a substrate as part of the test series. Acetic acid is only decomposed by the methanogenic bacteria at the end of the food chain which allows for the specific determination of their activity.

# PROCESS TECHNOLOGY

Our theory is practice.



## Main topics

- Downstream Processing
- Water and Wastewater Technology
- Multiphase Reaction Technology

## Information/Administrative office

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## Industries and target groups

- Food industry
- Metal processing industry
- Pharmaceutical industry
- Chemical industry
- Agriculture
- Biotechnology
- Environmental technology
- Water/wastewater technology

The sub-disciplines of production technology are becoming more and more interlinked. The call for integrated technologies and processes that solve not just one but various tasks at the same time is being voiced both for technical and economic reasons. Efficient overall processes are gaining importance in the context of the use of renewable resources at biorefineries and in white biotechnology in particular.

## Our competencies

We develop and realize system solutions for process technology based on demonstration plants at the laboratory and the technical shop as well as with the help of model-based simulation software. In this, we are looking at the process chain as a whole: from the process idea to the commercial process and from the raw material to the utilization of residues after the product has been used.

Our strengths are in membrane, separation and reaction as well as pipeline technology. Our expertise ranges from water cycle completion, wastewater treatment, recovery of materials from process flows and thermal process engineering to in-depth expertise in the areas of multiphase systems and the downstream processing for white biotechnology and biorefineries.

## Our R&D service

- Development of microsieve and membrane processes
- Process development for white biotechnology and biorefineries
- Process design for downstream processing
- Extraction of phyto-materials
- Water, wastewater and pipeline technology
- Reaction calorimetry
- Analysis, development and optimization of multiphase chemical syntheses
- Process modeling and simulation, computational fluid dynamics (CFD)
- Development of adsorbents
- Polymeric process additives
- Fluid process technology

## 3 questions for Prof. Dr. Gorge Deerberg (Business Unit Manager)



**1** Which of the crisp ideas of your team are you particularly proud of?

**1** In the business there are a lot of different projects in progress and the team is working on the most diverse types of process technology problems and is developing numerous new approaches. As a result, it is already quite difficult for me this year to pick a mere four projects for the annual report to introduce in more detail. Therefore, I would rather not highlight a single crisp and bright 2010 idea that I am particularly proud of. We are having increasing success in finding synergies between the worlds of chemistry, process technology and systems technology in very interdisciplinary teams. As illustrated by the following examples, resulting from this are new processes and products that we bring to application maturity jointly with our partners.

**2** What is becoming more important from the customer's/ industry's point of view?

**2** It is becoming more and more important to better interlink processes and technologies, and to integrate new approaches into existing structures. This is of particular relevance for the area of utilizing renewable resources at biorefineries. However, the same applies to all industries, since quite often sustainability can also be achieved through optimization of existing capacities quite unspectacularly, yet efficiently.

**3** What are you hoping for in 2011?

**3** I hope that we, at UMSICHT, will continue to identify current trends in the scientific landscape early on and design them successfully jointly with our project partners. In addition, with my new professorship for environment and process technology at the Ruhr University in Bochum (Germany), I would like to contribute towards strengthening our already intense cooperation with universities.

# GAS HYDRATES: ENERGY SOURCE AND CO<sub>2</sub> STORAGE OF THE FUTURE

Gas hydrates are considered a potential energy source and at the same time a carbon dioxide storage. They occur in natural form in permafrost areas as well as on the sea floor and are stable at high pressures and low temperatures. According to estimates, gas hydrates contain considerably more carbon than all conventional natural gas deposits combined. To be able to sustainably use gas hydrates, Fraunhofer UMSICHT is researching their creation, extraction and transport in a group project.

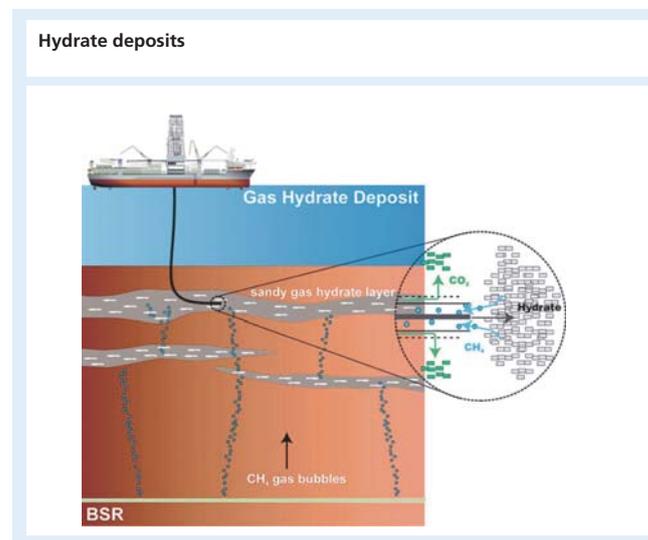
Massive amounts of natural gas are stored in the sea floor as solid, ice-like methane hydrate. These natural occurrences contain more carbon than all conventional deposits of coal, oil and gas combined. The group project "SUGAR" serves to establish new technologies for the whole potential hydrate processing chain – from tracking down new deposits to transporting the retrieved methane in suitable ships. Fraunhofer UMSICHT is, in particular, developing the fundamental expertise for building and destabilizing gas hydrate systems. The group project is sponsored by the German Federal Ministry for Economics and Technology, by the Ministry for Education and Research and by the industry.

Gas hydrates are cage- and ice-like inclusion compounds consisting of gas and water molecules that are built at high pressures and low temperatures. Fraunhofer UMSICHT is developing and optimizing different numerical simulation models for efficient and technically feasible extraction methods and is researching the physical and chemical properties of gas hydrates in a high pressure laboratory. The gas hydrate deposits can concurrently serve as both an energy source and for depositing CO<sub>2</sub>. One potential methane hydrate extraction method works by injecting CO<sub>2</sub>. Here, the maritime methane hydrates are decomposed by CO<sub>2</sub>, which releases natural gas, and – given the right pressure and temperature – CO<sub>2</sub> is permanently bound in stable hydrates. By feeding heat and polymers, the conversion speed can be further accelerated. The researchers at Fraunhofer UMSICHT were able to prove the general feasibility of simul-

taneous gas extraction based on simulations using the mammoth pump principle as an example.

## Simulation model for real conditions in hydrate deposits

The objective is to achieve a maximum natural gas yield and simultaneously fixate CO<sub>2</sub> in hydrates, while taking into consideration ecological and security-relevant aspects. For this, the researchers constantly optimize the simulation models to identify technical parameters for different geological conditions. To this end, Fraunhofer UMSICHT has developed the UMSICHT-HyReS simulation software for the complete hydrate process. In addi-





tion, the commercial simulation software CMG-STARs is used. They serve as the basis for the further technology assessment. In the next project phase, specific drilling and mining technologies will be derived from them. The simulation range of the models encompasses the processes in deep maritime gaseous layers, in the surface layers and, in particular, the interaction between the bore hole and the deposit. Furthermore, the model takes the natural gas production rates and the CO<sub>2</sub> storage amounts into consideration which are put in relation with the costs of development and production. Risks and safety-relevant processes such as the potential escape of methane and CO<sub>2</sub> into the soil water, the intrusion of sea water into the deposit, or the destabilization of the bore hole construction are also analyzed and assessed. In a high pressure reactor system, the researchers additionally investigate the behavior of hydrate systems. Here, optimized operating parameters for the extraction of methane hydrate and the storage of CO<sub>2</sub> are to be determined. In addition to the development of concrete extraction technologies, Fraunhofer UMSICHT is also working on the development of a decision-making tool for businesses to plan large-scale production processes.

The interest in methane hydrate as energy source of the future has been increasing for several years. Internationally, Germany is in a top position in hydrate basic research. In the Asian area, there are already first field tests scheduled for the years ahead. At present, the numerically determined production rates for methane production from a bore hole are at a magnitude of 2,500 Nm<sup>3</sup>/h per bore hole in the assessed conservative scenarios.

*Image: Methane hydrates are also referred to as "burning ice". They consist of water and methane molecules. As a potential environmentally friendly energy source of the future, natural gas can be extracted from them and in addition, carbon dioxide can be disposed of in them.*

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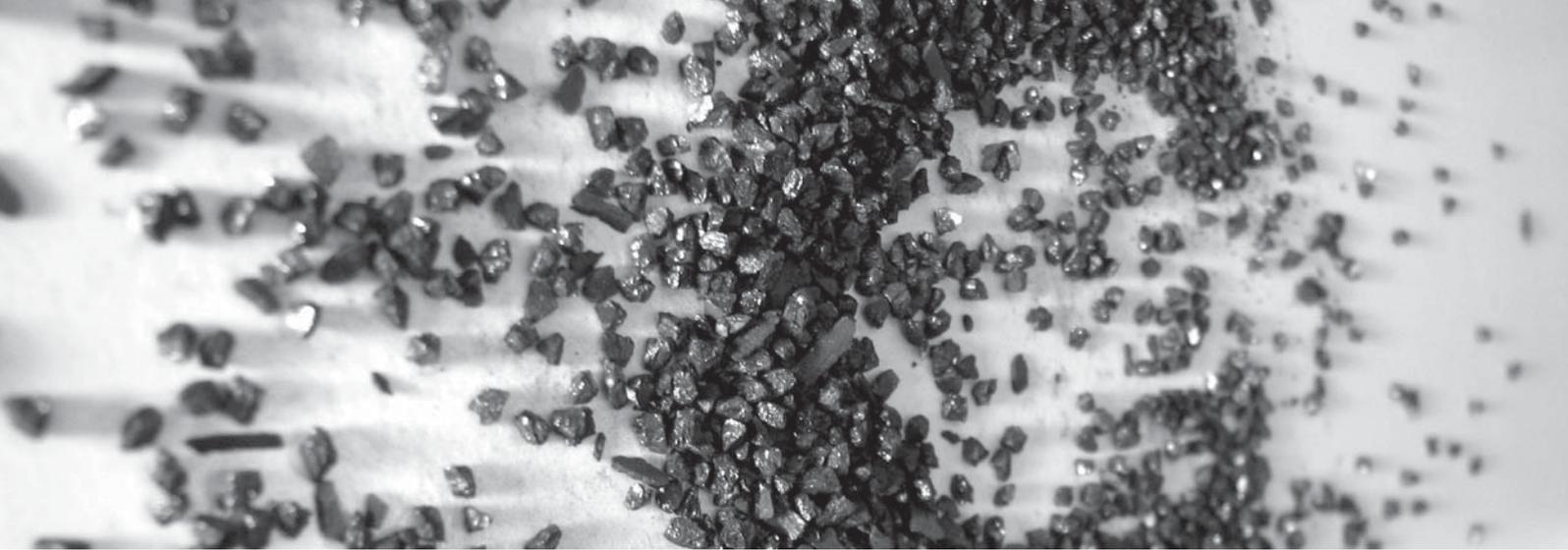
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### **Global climate warming**

In case of increasing global warming and the associated rise of the sea temperature, the methane hydrates on the sea floor could melt and enter the ocean and the atmosphere uncontrolled. This would have a negative impact on the climate since methane is more harmful than carbon dioxide. As the hydrates are additionally stabilizing the structure of the sediment, their disintegration could destabilize the continental shelves. By using the methane hydrate as an energy source, this uncontrolled disintegration can be countered. CO<sub>2</sub> hydrate, as opposed to methane hydrate, is stable across a larger temperature range and would strengthen the sediment over a longer term. In addition, anthropogenic CO<sub>2</sub>, for example from power plant emissions, could be permanently stored and immobilized in hydrate form.



## OPTIMIZING ADSORPTION PROCESSES

The adsorption technology is very important for the separation and purification of materials of different industrial processes. Especially for energy technologies and for keeping air and water clean, adsorption is becoming more and more important. Its degree of efficiency very strongly depends on the media used. In three ongoing projects, Fraunhofer UMSICHT is studying the chemical, physical and mechanical influences on adsorption and is thus optimizing the adsorption processes and their possible applications.

Adsorption plays an important role in gasoline tanks: through a vapor recovery system (VRS), vapors from the vehicle's tank – volatile hydrocarbons – are retained. The VRS operating principle has been well studied for fossil fuels. In case of biofuels, however, the adsorption processes and the functional efficiency of the VRSs have to be analyzed and modified, depending on the fuel's composition. According to the EU Biofuel Guideline, until 2020 almost 10 percent of all fossil fuel in traffic must be replaced by biofuels. Therefore, the development of corresponding VRSs and adsorbents for the passenger car segment is increasingly gaining significance.

In a project sponsored by the German Federation of Industrial Research Associations (AiF) Fraunhofer UMSICHT analyzes the process flow and the efficiency of vapor recovery systems when used with biofuels. Here, the researchers are particularly studying the impact that the addition of bioalcohols has on the efficiency of the charcoal traps used in vehicles. Up to now measurements of the adsorber capacities for hexane, ethanol, certified gasoline and corresponding mixtures are done. The objective is to provide an advanced simulation model that allows a quick technical response to a changed fuel composition. It simulates the process flow in typically used vapor recovery systems when using biofuels and calculates adsorption efficiency and capacity for different process scenarios.

In a new project, sponsored by the Fachagentur Nachwachsen-

de Rohstoffe (FNR, Agency for Renewable Resources) on behalf of the German Federal Ministry for Food, Agriculture and Consumer Protection, Fraunhofer UMSICHT investigates the impact of proportions of water on gasoline/ethanol mixtures. One problem here is the miscibility of ethanol with water which can lead to disruptive inclusions of water in the fuel. Ethanol can be mixed with both gasoline and water without limitations. If water – for instance due to impurities – ends up in gasoline containing ethanol, a separation of the ethanol gasoline mixture can take place. But since the dehydration of bioethanol is very energy-consuming, the researchers are trying to determine how much residual water content in bioethanol is tolerable. The studies planned include the adsorption of fuel components on activated charcoal preloaded with water, the determination of breakthrough curves, and the simulation of the processes in the charcoal trap.

### Storing carbon dioxide through adsorption

The main question of the EU project COALSWAD is to what extent abandoned coal seams can be used for storing anthropogenic CO<sub>2</sub> to reduce the amount of CO<sub>2</sub> in the atmosphere. The objective is to gain data regarding the swelling behavior of coal from German and Czech seams during the adsorption of CO<sub>2</sub>. Adsorption measurements and relevant NMR (Nuclear Magnetic Resonance) and/or SAXS (Small Angle X-Ray Scattering) tests have been conducted. Now the most important

task is an analysis of all received results by all project partners involved regarding the adsorption and swelling properties of mineral coal. This way, the project's results could contribute to environmental protection, power generation and the alternative use of coal.

*Image: Coal may provide a geological storage option for CO<sub>2</sub>.*

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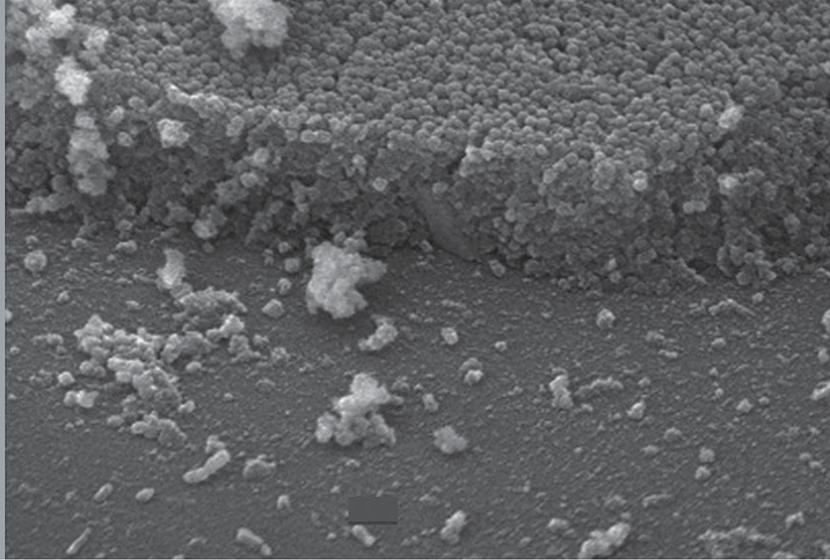
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### **Vapor recovery systems**

They ensure that fuel vapors created in the tank due to heating or evaporation of the fuel do not reach the atmosphere. The fuel vapor is fed from the fuel tank to the charcoal trap. There, the fuel vapors are adsorbed. Since the activated charcoal would get saturated quickly, the filter has to be regenerated in regular intervals. To achieve this, the engine pulls fresh air through the charcoal trap. In this desorption process the coal releases the stored fuel vapors which then are burned by the engine when it is started again. This regenerating air is fed into the engine bypassing the throttle valve and the air filter. A regenerating valve assures that the regeneration only takes place when this admixed air does not disrupt engine operations.



## MULTIBARRIER SYSTEM FOR WATER TREATMENT WITH NANOTECHNOLOGY

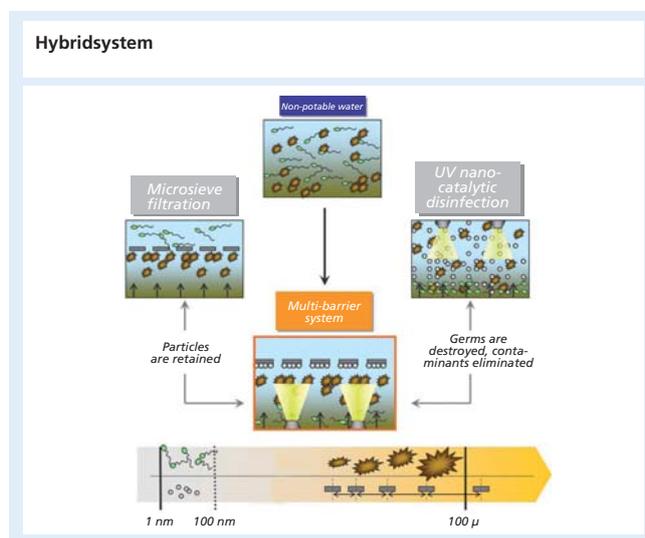
Water shortages and water quality as well as the disposal of wastewater will be posing essential global challenges in the next 20 to 30 years. Nanotechnology provides solutions for treating drinking water hygienically without large amounts of chemicals and for wastewater conditioning. Fraunhofer UMSICHT is optimizing membrane processes, developing microsieves and complete nano-based hybrid systems for the cleaning of water and wastewater.

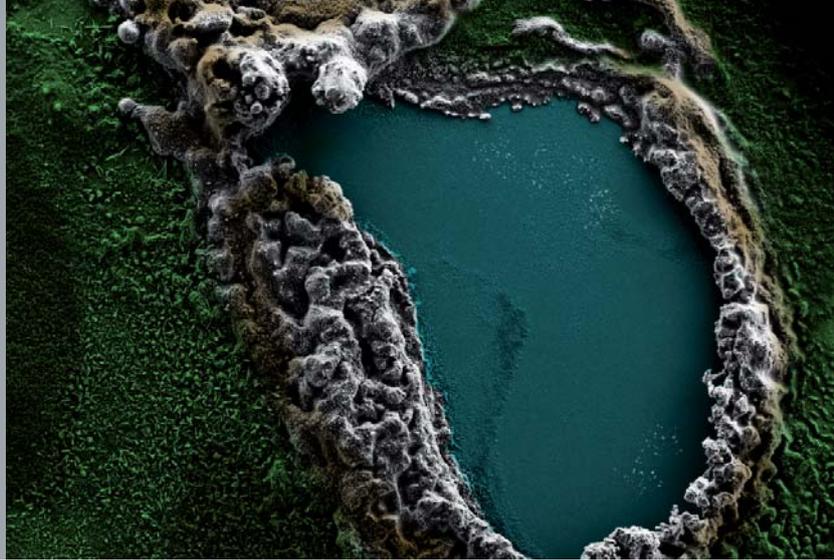
The established water treatment technology processes and products are reaching their limits. A billion people are living without access to clean drinking water. About 2.6 billion people, or 42 percent of the total, lack access to basic sanitation. But even Germany needs new technologies in the water and wastewater sector: even though municipal water and wastewater treatment plants are capable of removing solids and easily oxidizable organic components from the raw water, endocrine substances, spores and nitrosamines, which in part are toxic already at trace levels, are eliminated only to a very limited extent without additional effort. Nanotechnology is among the key technologies that have a leveraging effect on the

water treatment industry. In the BMBF project “nanoPurification”, Fraunhofer UMSICHT, in cooperation with partners from industry and science, is developing a novel nano-based multi-barrier system (NanoPur) that can be established as an innovative process for companies in the water treatment industry.

In a first step, the researchers optimized the microsieves so that they have a better performance, are more energy-efficient and easier to clean. The objective of the research work now is to combine the mechanical wastewater treatment by nanotechnological functionalized composite filters with UV treatment systems. These two components of NanoPur feature additional decontamination effects and can, in combination, build a highly efficient barrier system against bacteria, germs and trace substances. The team of researchers intends to produce high quality metallic micro filters with nano-scaled coatings based on  $\text{TiO}_2/\text{Ag}$ . At the same time, instead of the standard mercury vapor lamps, for instance light emitting diodes (LEDs) can, be implemented in an energy-efficient system for UV decontamination.

In the case of the ongoing tests, photo-catalytically active silver/titanium dioxide nano composite layers of 100 to 200 nanometer thickness are deposited on the micro filter. The layers adhere permanently, are anti-corrosive, have an anti-fouling effect and are highly abrasion-resistant. At present, the photo-catalytic activity of the nano composite layers relative to the conditions for separation is being systematically investigated.





In photo catalysis, the catalyst is irradiated with UV light. The so formed radicals cause chemical reactions inducing an almost complete degradation of contaminants and bacteria. At first UV LEDs are electro-optically characterized. A very important aspect in the development of UV LED modules is an efficient thermal management. The light emitting diodes are integrated into an efficient and long-lasting UV LED module which sets itself apart from conventional UV treatment systems through a low space requirement and high flexibility in the reactor design. Depending on the wavelength of the UV light used, the LED module has a direct decontaminating effect.

In the development of NanoPur, the Fraunhofer UMSICHT researchers obtain new scientific insights regarding nanoscaled material in water and wastewater applications, material compatibility and the mechanisms of UV irradiation sources for degradation of contaminants and eliminating bacteria. At the same time, the risks of nanotechnology for the aquatic environment are being investigated.

For additional information of the project, refer to [www.nano-water.de](http://www.nano-water.de)

**Project partners:**

Christian Albrechts Universities Kiel, Germany  
Cornelsen Umwelttechnologie GmbH  
Kryschl Wasserhygiene  
EnviroChemie GmbH  
Gelsenwasser AG

Please note the following conference date:  
nANO meets water III – nanotechnology for water applications  
10 November 2011, Fraunhofer UMSICHT

*Left image: A view through the scanning electron microscope: a photo-catalytically active anti-fouling coating made of titanium dioxide*

*Right image: Scanning electron microscope (SEM) image by Baytron-C® on ITO (indium tin oxide)-coated glass*

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## Nanotechnology

Nanotechnology is an interdisciplinary science which deals with research and construction in very small structures: one nanometer (nm) is equivalent to one millionth of a millimeter. Nano (Greek: dwarf) encompasses research areas from both animate and inanimate nature. Applications arise in energy technology (fuel cells and solar cells), in environmental engineering (materials cycles and disposal), in information technology (new memory/storage and processors), but also in the healthcare sector. The mechanical, optical, magnetic, electrical and chemical properties of these smallest of structures do not solely depend on the type of source material but in a particular way also on their size and shape.

(Source: BMBF; [www.nanopartikel.de](http://www.nanopartikel.de))



## BIOCOAL UTILIZES POTENTIAL OF WET BIOMASS

Sewage sludge, lop, leaves, biowastes and other residues from agricultural and silvicultural production: the range of wet biomass is broad. Large amounts are accumulating worldwide. The wet biomass potential can be raised by converting it into biocoal and using it as a primary fuel. Fraunhofer UMSICHT is developing optimized process engineering solutions for the production of biocoal.

Biomass is a CO<sub>2</sub>-neutral, renewable resource whose utilization contributes to the disposal of organic wastes. To date, the utilization is difficult due to the high water content, which results in a low calorific value that makes transport more expensive, as well as the inhomogeneity, the ash content and the poor processability of wet biomass.

Those who want to use wet biomass energetically can convert it into a secondary energy source. Yet, there is still a large poten-

tial for improvement with respect to the process control, the collection, the transport and the storage of fresh wet biomass. Fraunhofer UMSICHT develops thermochemical processes to convert the large amount of low-grade feedstock into high quality products. The following thermochemical conversion processes are relevant: pyrolysis, charring, torrefaction and hydrothermal carbonization (HTC).

### Hydrothermal carbonization for the production of biocoal



During the hydrothermal carbonization biomass is heated with water and an additional catalyst to 180 °C within a closed pressure vessel. Primarily water and in small quantities also carbon dioxide are separated from the biomass. This significantly increases its energy density. The calorific value of HTC biocoal is comparable to brown coal. Simultaneously a porous material is produced that can be dried much easier than the input material and used as a fertilizer if applicable. Thereby the porous structure improves the water retention of the soil for example.

Hydrothermal carbonization is furthermore characterized by its ability to process a broad range of wet biomass as illustrated by the figure. In addition, almost all carbon contained

in the biomass is made available for fuel production by HTC. The properties of the produced HTC biocoal can be adjusted by modifying pressure, temperature or residence time in the reactor.

Fraunhofer UMSICHT is developing optimized process technology solutions for the complete biomass range (wet and dry) to produce biocoal. Process conditions and biomass feedstock used for HTC can be assessed via mass and energy balances. To create a reliable data base for strategic decisions, carbonization tests are accomplished on a laboratory and pilot scale. Thereby the heat of reaction is determined and the carbonized products are analyzed regarding their chemical composition and calorific value.

Against the background of sustainable business practices, economic manufacturing of biocoal for the substitution of fossil fuels is desirable.

*Image: Pelleted biocoal has a similar calorific value as fossil brown coal.*

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### Relevant thermochemical processes for biocoal production

Biomass is decomposed in pyrolysis under oxygen exclusion and at temperatures about 500 °C. In addition to gaseous and liquid products, a solid residue, pyrolytic coke, is generated. With charring biomass is primarily converted into solid products (e. g. charcoal as a special form of pyrolytic coke). Basically the same steps as in pyrolysis are run through. Gasification and oxidation processes occur to a small extent. In torrefaction, also referred to as mild pyrolysis, biomass is thermally treated at 200 to 300 °C under exclusion of air. The process lasts from a few minutes to several hours depending on the temperature. The product is easy to grind. All three processes work best with wood-like biomass.

(Source: Energie aus Biomasse: Grundlagen, Techniken und Verfahren, Hrsg. M. Kaltschmitt, et. al.; Springer, 2009)

# BIOFUELS

Sustainably mobile.



## Main topics

- Catalytic Processes
- Refinery Concepts
- Biofuel Processes

## Information/Administrative office

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## Industries and target groups

- Agriculture
- Energy industry
- Biofuel producers
- Chemical industry
- Automotive industry
- Plant construction

The discussion with respect to reducing CO<sub>2</sub> emissions and limited fossil raw material sources has triggered and intensified the search for economical ways of producing fuels from renewable resources and from bio-based residues. The latter may also be part of a multiple utilization of raw materials in cascades. Hence, one of the main objectives is the holistic utilization of the biomass used by including biofuel production in biorefinery concepts.

## Our competencies

We develop and optimize technology for biofuels and bio-based chemicals, e.g. biodiesel, second generation bio-based diesel and higher alcohols. Raw materials are fats and oils, sugars and other renewable resources of different purity.

We point out strategies for the future on how to produce fuels, energy and chemicals in a sustainable and competitive way and also engage ourselves in the European Biofuels Technology Platform. Our service portfolio ranges from fundamental research to initial process engineering designs and cost estimates. Our work is hinged on a broad knowledge in the area of catalytic synthesis of fuels and chemical products from renewable resources.

## Our R&D service

- Chemical process development at a mini plant and pilot scale (also under pressure)
- Catalyst screening and catalyst development
- Development of holistic utilization concepts for biofuels (refinery and biorefinery)
- Economic feasibility studies
- Optimization of reaction engineering and separation processes for biofuels and by-products
- Development of analytic methods (chromatographic and wet-chemical methods)
- Preparation of proposals and cooperation in European networks (e.g. as part of the EU's Seventh Framework Program for Research and Technological Development)

# 3 questions for

**Dr. Axel Kraft**  
(Business Unit Manager)



**1** Which of the crisp ideas of your team are you particularly proud of?

**1** This year, our business unit has filed multiple patents and thereby opened up new areas of technology. In addition, there are still several new ideas in the pipeline and/or already in the screening phase.

**2** What is becoming more important from the customer's/industry's point of view?

**2** It becomes more and more important to find affordable, sustainable technologies for mass, special and niche products that are based on renewable resources. Additionally, innovations have to be implemented much faster than in the past.

**3** What are you hoping for in 2011?

**3** We hope that we, jointly with our cooperation partners, succeed in bringing several technologies currently under development to the market very soon.

# HIGHER ALCOHOLS INCREASE THE VALUE GENERATION OF ETHANOL

Bioethanol is one of the most significant products made from renewable resources. The biggest customer is the fuel industry. Fraunhofer UMSICHT has developed a process that converts ethanol in a catalytic gas-phase reaction into higher alcohols whose value generation is significantly above that of the raw material. Also research has been conducted to determine if the separation of the resulting product mixture is technically and economically feasible.

Currently 39 million tons of bio-based ethanol are produced world-wide. Two thirds (66 percent) of it are provided to the fuel industry, followed by the chemical sector (21 percent) and the food industry (13 percent). Ethanol is primarily made from agricultural products containing edible sugars and starch.

In the medium term, the raw material basis will shift towards lignocellulosic feedstocks and in the long term probably additionally towards algae. Both feedstocks will be available in large quantities in the future and are not competing with food. Additionally they imply savings of up to twice the amount of greenhouse gases compared to the edible feedstocks.

However on short term, either the conversion costs must be reduced, or the oil price has to rise significantly above 100 dollars per barrel to make lignocellulosic feedstock economically viable. In the medium term, the market need for ethanol will probably increase and ethanol will become also a feedstock for chemicals and materials like plastics resulting in a significant growth potential.

At present, the utilization of ethanol as fuel is increasing continuously. Many companies in the chemical, pharmaceutical and cosmetics industry use it also as a low-value intermediate or solvent.

Mass products and special products based on higher alcohols (derivatives)

Derivative	Applications
Phosphoric acid esters	Solvent, softener, lubricant/fire-retardent
Citric acid esters	Environmentally friendly plastics softener
Aromatic esters	Softeners
Alkanoic acid esters	Solvent
Fatty acid esters	Lubricant, wax, herbicide additive
Ethoxylates	Surface cleaning agents, cosmetics, drilling fluid additive
Alkohol blend	Solvent, floating agent for coal extraction
Nitric acid esters	Cetane number elevator for diesel fuels
Sugar ethers	Foaming agents (e. g. detergent for the kitchen)
Dialkyl ethers	Cosmetics, solvent, latent heat storage agents, printer ink
Guerbet alcohols	Cosmetics, fatty alcohols, tensides

The objective of UMSICHT is to develop new ways of utilizing ethanol, with significantly higher value generation than fuels. In order to achieve this, the catalytic condensation of ethanol to higher alcohols was envisioned. Higher alcohols are a known feedstock for chemical derivatives, but are not yet available in market as bio-based intermediates, in particular the shorter carbon chains. Their application potential is huge and ranges from hydraulic liquids, cetane enhancers, fragrances, lubricants and extracting agents to plasticizers and surfactants. More than 20 million tons of those derivatives are produced annually worldwide. Already today, the conversion of ethanol to higher alcohols looks economically attractive since the sales price of higher alcohols is in the range of 0.80 to 1.30 US dollars per liter, whereas ethanol costs only 0.40 to 0.50 US dollars per liter.



*Image: Pilot plant for higher alcohols at Fraunhofer UMSICHT*

Green process alternative to the conventional oxo process

Fraunhofer UMSICHT has developed a new catalytic gas-phase process that converts ethanol into higher alcohols. Roughly 1 to 1.5 tons of carbon dioxide per ton of higher alcohol in comparison to the current fossil-based oxo-process could be saved this way if second generation ethanol is considered as feedstock. The product mix consists of a mixture of alcohols and water, next to lower amounts of aldehydes. This "green" process alternative will only be feasible commercially if it is cost competitive compared to oxo-process. To assess this, Fraunhofer UMSICHT has already proven by simulation and an investment cost estimation that separation of the product mixture by distillation could be feasible.

Alternative separation processes e.g. membranes, could even further improve the competitiveness of this new green technology.

Fraunhofer UMSICHT is grateful to the RWTÜV foundation for sponsoring this project.

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## Higher alcohols

Higher, linear and branched-chain alcohols such as butanol, hexanol or octanol represent alternatives to ethanol in the fuel sector. They can be added to fuels without the disadvantages of ethanol (high water absorption capability, high vapor pressure and corrosiveness). Besides biofuels, additional demand has emerged in the chemical industry for various derivatives. At present, they are manufactured from fossil resources in the so-called oxo-process, also called hydroformylation. Fraunhofer UMSICHT is developing an alternative route to higher alcohols combining economic and ecologic advantages.

# BIOFUEL MADE FROM ALGAE

Algae have the potential to climb in the hit list of renewable resources. They serve as food and can be converted into fuel, electricity, heat, fodder, food, chemicals and materials. Fraunhofer UMSICHT is part of an EU consortium that is culturing micro algae at a wastewater processing plant in Spain in order to generate methane and biodiesel next to other value-added products.

Algae were perfectly suited as a renewable resource if their production costs could be lowered. A former study on algae cultivation compiled by Fraunhofer UMSICHT showed that significant savings potentials can be realized by maximizing algae growth and by utilizing improved, energy-efficient harvesting techniques. Effective April 2011, an EU-sponsored demonstration project coordinated by Aqualia S.A. will start. The project is geared towards sustainable algae cultivation for biofuel production on an industrial scale.

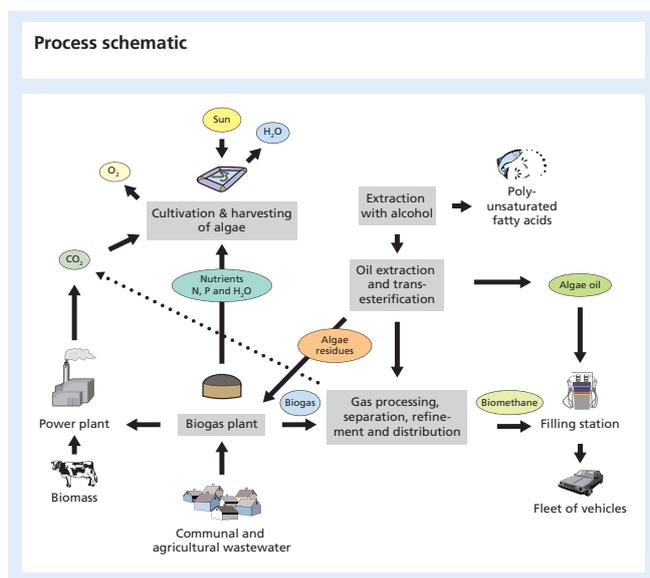
The consortium's objective is to develop an integrated process for generating fuels, electrical heat and recycling materials from algae within the next five years. The envisioned value chain com-

prises nutrient elimination from wastewater, algae cultivation and harvesting as well as the extraction and characterization of algae oil. Moreover, potential high value-added materials from algae and their corresponding market potential, next to production of biofuels downstream, will be investigated.

## Cultivation of algae at wastewater processing plants

To keep the costs of algae cultivation low, the algae are cultivated in wastewater ponds of approx. 10 hectares size. The wastewater contains most of the nutrients required for growing algae. The first step will be to determine which type of algae is suited for this environment. Once the algae have grown, the algae biomass must be separated from the water, i.e. harvested. Harvesting can be achieved through methods like sedimentation, filtration or centrifugation. Finally the crude algae oil is extracted. The remaining algae biomass, consisting of organic residues and wastewater slurries is fermented into biogas. The biogas is either refined into methane for fuel or is incinerated in suitable power plants.

The residues from the biogas process implying a nitrogen and phosphorus containing slurry serve again as nutrients for the algae. The CO<sub>2</sub> needed for growing the algae is funneled to the cultivation from the biogas cleaning unit. To optimize the algae overall yield additional CO<sub>2</sub> is generated from the incineration of agricultural residues. The biogas plant will generate enough energy to operate the whole plant (pumps, impeller and centrifuges etc.).





Within the project Fraunhofer UMSICHT will be analyzing the chemical composition of the algae oil and support the project partners in identifying value added products. Polyunsaturated fatty acids in algae oil are not suited for biodiesel, but they can be utilized in the food and fodder industry as a value-added product and will be separated up-front. The remaining algae oil will be refined and converted into biodiesel. Biodiesel will be made via a new method developed by Fraunhofer UMSICHT and according to another method.

Once all process steps have been optimized on laboratory and on pilot scale, the results are to be transferred to an industrial scale by the project partner BDI. In addition to wastewater cleaning, the project objective is to achieve a biofuel manufacturing process that is autonomous with respect to nutrient and energy supply. Assuming a net algae oil content of approx. 20 percent only, 200 cars can be operated with biodiesel made from algae oil and 200 cars with bio-methane made from algae residues.

**Project partners:**

- Aqualia – Aqualia Gestión Algae S. A., Spain (project coordinator)
- Feyecon, Netherlands, with its Spanish subsidiaries, Clean Algae S. L. and Algae Biotech S. L., Spain
- BDI BioEnergy International A.G., Austria
- Hygear B.V., Netherlands
- MTD Alternative Energies, Turkey
- University of Southampton, UK
- Fraunhofer UMSICHT, Germany

*Image: Algae could be the ideal renewable resource. For their growth, they need carbon dioxide, they live in water and therefore do not need any fertile ground for cultivation.*

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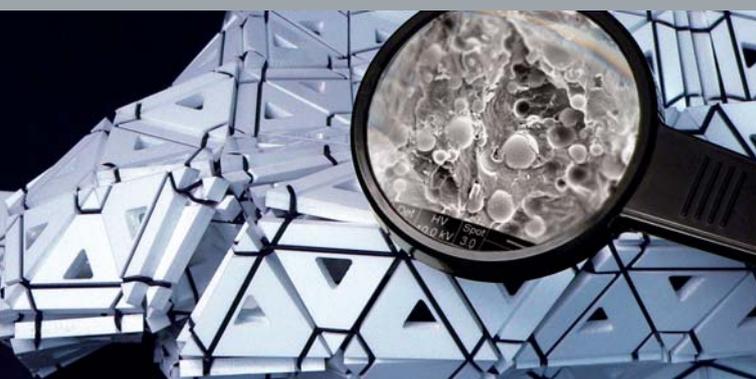
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**Algae**

Algae live in water, grow fast and do not require any fertile ground. Moreover, they do not compete for agricultural land as opposed to other known plants rich in oil. In addition, compared on a per hectare basis, their oil productivity can be several times higher than that of palm trees, rapeseed and soybean plants. Algae clean wastewater by binding nutrients that otherwise would lead to eutrophication of river water. It is not surprising that the fuel industry is looking at algae as a raw material as source of bio-based oil. Additional ingredients such as pigments, antioxidants and omega-3 fatty acids can generate extra value in the food, fodder, cosmetics and pharmaceutical industry. The great thing about them: for their growth, algae need mainly carbon dioxide rendering them as a selective greenhouse gas trap for CO<sub>2</sub>.

# MATERIALS AND INTERACTION

From the idea to perception.



## Main topics

- Materials and Product Design
- Processing Technology
- Biomimetics and Haptics

**Information/Administrative office**  
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## Industries and target groups

- Plastics processors
- Product developers, industrial designers
- Materials and additives manufacturers
- Sealing and surface technology companies
- Manufacturers of processing technology

Plastics and biomaterials can be customized in a multitude of ways. By equipping them with intelligent additives and particle systems, multiple functions can be implemented. Here, the environmentally and at the same time user suitable formulation of the materials system poses an important future task.

## Our competencies

Based on customer-specific requirements, we develop concepts for new materials, products or machine technologies and review their industrial implementability with regard to ecological and economical aspects.

Here, the focus is on the equipment and functionalization of plastics, wood and leather with additives and particle systems. In addition to the functional properties of the materials, we also take into consideration their sensory and aesthetic perception by the user. For the processing of materials, we have developed efficient process and machine technologies. We realize innovative products and applications based on new materials and test them based on virtual and real prototypes.

## Our R&D service

- Strategies for biomimetic and sustainable materials innovations
- Development of additive, particle and materials systems
- Product development and industrial design (construction, automotive, consumer products)
- Component design and rapid prototyping
- Production of samples and process optimization in the areas of compounding, comminution, microencapsulation, impregnation, spray processes and generative manufacturing
- Utilization of supercritical fluids as auxiliary process agents
- Simulation, test and analysis of plastics, wood, leather and functional materials

## 3 questions for

**Dipl.-Ing. Jürgen Bertling**  
(Business Unit Manager)



**1** Which of the crisp ideas of your team are you particularly proud of?

**1** We have developed an elastomer compound with excellent self-healing properties. After a crack the original breaking elongation is almost achieved again. We were also particularly captivated by the idea of cultivating mosses on customized material surfaces. This way, facades would be created that reduce fine dusts.

**2** What is becoming more important from the customer's/ industry's point of view?

**2** Materials act in a complex environment that they influence to a large degree. The increase in material mixes and highly dissipative utilization structures for critical or scarce materials that can be observed today in a lot of cases has to be conquered. Therefore, reduction of pollutants, recyclability and also user integration require new, more radical concepts. That is what we are working on.

**3** What are you hoping for in 2011?

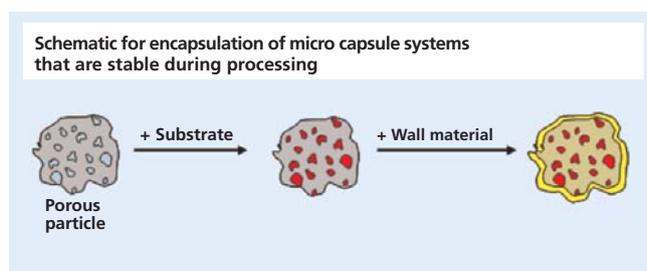
**3** That we will continue on the path towards sustainable materials and products jointly with our partners and customers, and that you will be just as enthused by our visionary ideas all around biomimetics, haptics and urban greening as we are.

## DEFECTIVE PLASTICS REPAIR THEMSELVES

Things that cannot be destroyed are an invention of the advertising industry. Even plastic components that must endure high mechanical stresses can break due to microcracks that can be present in any component. To stop the cracks from growing, Fraunhofer UMSICHT developed elastic polymers that heal themselves. The rubber tree and weeping benjamin were the biological role models.

It can happen quite unexpectedly. Car tires burst, seals fail and even the much-loved panton chair, the free-swinging plastic chair, gets cracks and the material fatigues. Oftentimes, the reason is a sudden, unforeseeable material failure caused by microcracks that can be present in any component. These cracks grow quickly or slowly, however, they are hardly noticeable. This also applies to fractures in components made of elastically deformable plastics material. Sealing rings or tires are made of such elastomers that tolerate high mechanical stresses particularly well.

In order to stop the fracture from growing already in the beginning phase and to avoid spontaneous material failure, Fraunhofer UMSICHT in Oberhausen, in the German BMBF (German Ministry for Education and Research) project named



“OSIRIS” developed self-healing elastomers that can repair themselves autonomously. The inspiration for this were the rubber tree *Hevea Brasiliensis* and other latex plants, such as the weeping benjamin (*Ficus Benjamina*) that were thoroughly

researched by the project partner, Plant Biomechanics Group Freiburg. The latex contains capsules that are filled with the protein hevein. If the rubber tree is injured, latex is exuded, the capsules break open, release hevein which interlaces the latex particles also contained in the milky sap to close the wound. The scientists transferred this principle to elastomers.

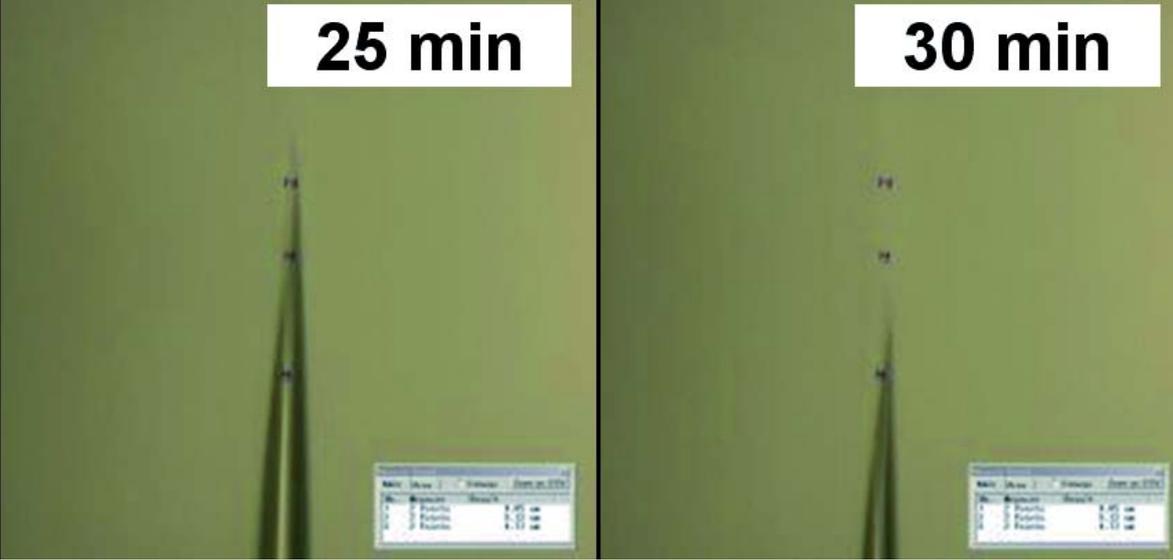
### Microcapsules filled with one-component glue should initiate the self-healing

In order to initiate a self-healing process in plastics, microcapsules were loaded with polyisobutylene, a one-component glue, and inserted in elastomers made of synthetic rubber. The capsules burst if pressure is put on them and exude the viscous material. This material mixes with the polymer chains of the elastomer and thus should close the cracks. We were able to manufacture initial capsules that were stable during production, but they did not provide the desired self-healing effect. Good results were obtained when the self-healing component, the polyisobutylene was inserted into the elastomer non-encapsulated. The test samples from differing synthetic rubbers such as NBR, EPDM and SEBS showed a very clear self-healing behavior: after a macroscopic cut and a healing period of 24 hours they showed a restored tensile strength of 40 percent.

The results could even be improved by providing the elastomers with ions. The rubber tree, again, was the inspiration for this

**25 min**

**30 min**



*Image: Chronological sequence of the closing of the fracture in a polymer self-healing component.*

method: when injured, the released hevein proteins interlace by means of ions. If the material of the elastomer is damaged, then the oppositely charged particles look for a new partner to bind to; a positively charged ion attracts a negatively charged ion and thus develops an adhesive effect. Loading the elastomers with ions ensures a stable wound closure. The healing process can be repeated as often as desired, which is a great advantage as compared to the micro-capsule process.

There are already duromers with a self-healing function. They are being utilized in the form of self-repairing paints in the automotive area. So far, no elastomers have been developed that can close their fissures without outside action, and they open an extremely interesting market segment. The automotive sector, in particular, would probably gain from the new development. The prototype of a self-repairing exhaust pipe suspension was presented at the 2011 Hanover Fair at the Biokon joint booth.

The group project is financed with funds from the BMBF and carried out in cooperation with industry.

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**Utilizing biological models as a guiding inspiration for future development of materials and components**

The potential of plant models for identifying technical material solutions does not only lie in self-healing: the properties of biological systems to offer several functions at the same time in conjunction with each other is of great interest for technical components. One thing one could imagine would be, for example, paints that not only repair damage, but that could also wash away pollutants before the intact surface is built out again. Basically, where self-healing is concerned, it is a typical success principle of biological organisms, a complete system function that has the potential for a fundamental guiding idea for the development of future materials and components.



## TANNING LEATHER WITH CARBON DIOXIDE ENVIRONMENTALLY FRIENDLY

The manufacture of leather is a process intensive, time-consuming and environmentally damaging technology. To produce durable leather for shoes, furniture or cars from animal skin, raw material requires up to 70 process steps. One ton of leather causes 60 tons of wastewater. Fraunhofer UMSICHT has developed a completely new process for the tanning of leather that is environmentally friendly and shortens the processing duration enormously; wastewater and chemicals are reduced and time is saved with the aid of compressed carbon dioxide.

The objective of the tanning process is to turn raw skins or furs that are highly susceptible to rot into a durable material, leather. The total process encompasses numerous complex chemical reactions and mechanical processing steps. Here, the tanning step is the basic process step which makes the leather durable and where it receives its essential characteristics. During the tanning process, tanning agents get into the skin and ensure that a bridge is built between the collagens of the skin. This causes the skin to interconnect even more strongly than it did in its original condition and becomes durable and stable.

The mineral salt chromium (III) is being used 90 percent of the time as tanning agent. In conventional processes, the skins are put into a rotating tanning drum for a period of 12 to 24 hours and soaked in a solution of water and chromium (III) mineral salt so that they are in intense contact with it. But before that, the skins have to be processed in the "pickling" process step, using acid, so that they can absorb the tanning agents optimally. In the conventional process, the tanning drum is filled to 50 percent with the tanning solution and hides. This means that half of the drum volume is filled with air from the environment. This air will now be replaced by compressed carbon dioxide (CO<sub>2</sub>). This makes it possible to reduce the tanning duration by a factor of four to ten, to reduce the chromium-polluted wastewater by 90 percent, and to reduce the use of tanning solution (chromium) by approximately 25 percent.

### From laboratory testing to pre-industrial scale

At the beginning of the project in 2006, which was sponsored by the German Federal Ministry for Education and Research (BMBF), it was analyzed in laboratory tests how tanning works under the influence of compressed carbon dioxide. The hide pieces were exposed to a pressure of 100 bar in a high pressure viewing cell. The tanning solution consisted of water, chromium (III) salts, sodium chloride, formic acid and sulfuric acid. A mixer ensured that the mixture is distributed as intended. The carbon dioxide pumped in was compressed and, due to the high pressure that resulted, the chromium tanning agent got into the fibrillar structure of the skin in the shortest period of time and interlaced itself there. The result: tanning time was reduced from 30 hours to 5 hours. The measurable indicator for the tanning success and thus for the quality of the leather is the chromium content. The researchers determined with the aid of an emission spectrometer that this method as well provides the desired chromium content of three percent (or rather, 4 percent Cr<sub>2</sub>O<sub>3</sub> by weight).

In order to transfer this process to larger material samples, the optimum conditions such as temperatures, pressures and pH values were tested in a 20 liter plant to tan pieces of hide. The new plant made it possible to tan leather at a pressure of up to 320 bar and a temperature of 60 degrees Celsius in a basket that was rotating. The rotation ensures a high-quality leather, since the vacuum effects are increased and the



leather achieves greater flexibility. In this process, a significant reduction of the wastewater was realized: after the pickling process, the skins are wrung out. Subsequent to this step, only as much highly concentrated tanning liquid is used as the hides can absorb. Then, by using CO<sub>2</sub> and high pressure, the chromium is transported into the fibrillar structure and no water remains in the tanning drum. This way at least 90 percent less wastewater is generated. During the traditional tanning process step, roughly 1 to 2 tons of water containing chromium are generated for each ton of leather. Using the new process, the amount of water is less than 100 kg of wastewater, down to zero wastewater. At a pressure of between 30 and 60 bar and a temperature of 30 degrees Celsius an optimal leather tanning result was achieved after approximately 2.5 hours.

In order to demonstrate the possibilities of the new tanning process, Fraunhofer UMSICHT, with the sponsorship of the German Ministry for Education and Research (BMBF), built a tanning plant on a pre-industrial scale. The plant makes it possible to tan up to 500 kilograms of hide – 10 whole hides with an area of approximately 100 square meters in a volume of 1,700 liters in one step.

*Left image: In the 20 liter plant, the optimum conditions for the tanning of leather up to a pressure of 320 bar and a temperature of 60 °C were tested.*

*Right image: The results in detail – chromium-tanned piece of leather with zero wastewater that was tanned at 60 bar in only 2.5 hours.*

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## Tanning leather

The European Union is the second-largest producer of leather in the world, after China. In 2008, the states of the EU produced approximately 400 million square meters of leather in 1,633 factories with approximately 26,000 employees. With approximately 10 to 15 percent of the global production and with 50 percent of the volume of leather produced in the EU from cow and calf leather, Italy is, with respect to the number of employees, production and sales, the most important production site in Europe. Globally, most leather is used for making shoes. The leather industry is an industry that has a very high potential for polluting the environment. Most tanneries have their own wastewater treatment plants or their own connection into the wastewater canal system.

(Source: World Statistical Compendium for Raw Hides and Skins, Leather and Leather Footwear, 2008, Food and Agriculture Organization of the United Nations)



## DESIGNING PLASTICS HAPTICALLY

We perceive our environment with our senses. We see, hear, smell, touch and taste. Our senses affect our decisions. But how? In the case of haptic perception, Fraunhofer UMSICHT is pursuing this question in a scientific and systematic manner. The objective is to design the surfaces of plastic products in the future such that they have a good feel to them and that they be functionally perfect for the respective haptic application.

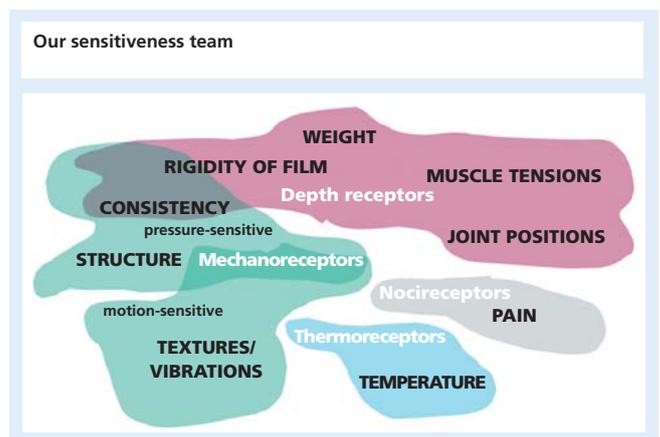
Babies do it in the womb of their mothers. Neanderthals did it, as does modern man. We feel our environment. We handle things, touch them, distinguish soft, hard, cold, warm, wet, dry and categorize them to be either pleasant or unpleasant. During the first months of life, exploring the environment with hands and mouth is “up there” as an important stimulative factor. As we get older, sensual perception is shifted towards optical perception. However, to consumers the touching of goods is often so important, that they touch the products in the store and test them and only then make their decision as to what to buy. Haptics affect purchasing decisions greatly, however, mostly in a less conscious manner than optics and acoustics.

It is for this reason that the consumer industry is utilizing primarily visual and acoustical channels. But some industries are forging ahead where haptics are concerned. The manufacturers of mobile telephones have been paying attention for a good while already to a good touch, the so-called “touch and feel”. They pack additional weights into the interior of the units so that they feel better in your hand. The automotive industry knows as well that how the upholstery feels, how the shifter feels in your hand and how high-quality the dashboard feels to be when you run your hand over it, often is the decisive factor in the purchase of a car.

Fraunhofer UMSICHT considers the innovative field of haptic design and researches the interdisciplinary character of this

young field with the goal to design the surfaces of plastic products such that they have a pleasant feel to them and are optimally adapted to the respective requirements. To date, there is only very little available with respect to scientific foundations. Research was done on how quickly the consistency of objects is being felt by touch – test subjects required only 200 milliseconds – blinking your eye takes almost twice as long. However, there are no studies in literature on how to distinguish hardnesses, e.g. in case of plastics.

First, fundamental research has to be conducted. Research was performed on the connection between the composition and structure of surfaces and how they are being perceived by potential users and which effect they have on them. What happens between the skin and the surface of the material?





Which describable material characteristics have what kind of describable impact on haptic perception? How to derive a systematic haptic design from formulas for plastics and texturizing? Those are core questions that need to be answered. We designed a haptics test station which was presented as an innovation for the first time at the K 2010, the international fair for plastics and rubber. This test station makes it possible to scientifically investigate the haptic perception of plastics, the interaction of human and material.

### Haptics test station allows subjective assessments to be measured objectively

While the test subject analyzes and evaluates subjectively how a material feels, measuring instruments indicate a number of characteristic data such as the condition of the skin, finger movements and heat development as a result of friction. An IR thermograph, a video camera and a 3D force measurement plate, speed measurement devices as well as measuring devices for skin moisture and skin elasticity supply objective measurement data that allow, for the first time, in coordination with the subjective evaluations by the test subject, an application-specific haptic materials design.

Initial tests at the haptics test station proved assumptions to be empirically wrong that appear to be logically reproducible, such as "the softer the plastic (shore hardness), the more the finger will stick to the surface" or "a plastic that is felt to be slick will be even slicker when felt with wet hands".

Haptics is a research field that has an enormous potential for innovation through the linking of psychological findings with the opportunities for modifying materials and surfaces. The bottle of shampoo that does not slide out of your hands in the shower is just the beginning.

*Left image: On the trail of haptic perception – here, someone is feeling the structure of concrete.*

*Right image: How do man and material interact? A measurement is taken at the haptics test station.*

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#### Our sensitiveness team

Many receptor groups are involved in the perception process. When touching something, a whole team of sensor receptors is in action. The application determines which receptors are being activated. The brain decides which stimuli we pay attention to. Depth receptors are responsible for muscle tension and the position of the joints and help to determine weight, contour and consistency. However, contour and consistency can also be defined via the pressure-sensitive mechanoreceptors. Fine textures, however, are felt exclusively by the movement-intensive receptors in the form of vibrations, while thermoreceptors determine how we perceive temperatures and nociceptors determine how we feel pain.

# INFORMATION TECHNOLOGY IN PROCESS ENGINEERING

Using information intelligently.



## Main topics

- Information and Knowledge Management
- Environmental and Occupational Safety Law
- Server-based Computing

## Information/Administrative office

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## Industries and target groups

- Operators of waste treatment plants
- Operators of wastewater treatment plants
- Production plants
- Chemical industry

The knowledge available worldwide doubles every five years. Intelligent, target-group-specific information management aids in promptly separating valuable from unnecessary information and occupies a central role in today's production value adding chains.

## Our competencies

According to projections of the EU commission, 80 percent of the technologies in use today will be replaced by new ones within the next ten years.

Value adding chains in companies are closely connected to making information available. Optimizations cannot be carried out without having a sufficient data base available.

The close interlinking of the operative processes with specific, organizational and technical information closes, in connection with ergonomic user interfaces, any existing information gaps. To achieve this, service-oriented architectures (SOA) are being created and made available as application services (ASP) independently of location and client.

## Our R&D service

- Data extraction
- Data consolidation
- Data visualization
- Customer-specific systems analysis and software development
- IT mapping of organizational and procedural structure

# 3 questions for

**Dipl.-Phys. Thorsten Wack**  
(Business Unit Manager)



**1** Which of the crisp ideas of your team are you particularly proud of?

**1** Not a specific idea as such, but I am proud of the good intuition that we have proven in the business area. As an example, we initiated a project for the virtualization of servers already in 2009, the results of which we are presenting below. The idea to no longer work on and store software and data locally but on an infrastructure that is made available centrally was downright fascinating to us. And this is how we have developed strategies already very early on to establish at Fraunhofer-Gesellschaft, from the start, the subject that currently is known as cloud computing.

**2** What is becoming more important from the customer's/ industry's point of view?

**2** Let's stay with cloud computing. Here, services are outsourced that the customer used to do himself before. This turns capital investments that used to be for the purchase of servers and software solutions into variable costs for leasing capacities. The customers save money, effort and become more flexible. That is exactly what the industry wants. We consider it to be important that our services continue to be operationally functional at the client's on an industrial scale even after the implementation. In the future, outstanding full service for maintenance, service and implementation for turn-key IT solutions will be an important criterion for selecting the IT service provider.

**3** What are you hoping for in 2011?

**3** In order to be able to develop IT solutions that are even more targeted and fitting, 2011 for us will see us focusing the portfolio of the business unit. To make this process stimulating for all – internally and externally – that is what I wish for in 2011.



## SAVE ELECTRICITY AND PROTECT THE CLIMATE WITH VIRTUAL DESKTOPS

In contrast to desktop PCs with applications that are installed on it, in virtual desktops, data processing is performed through central servers. That kind of infrastructure requires less electricity and affects the climate less. In an ecological study, Fraunhofer UMSICHT studied the climatic relevance of two operational scenarios, using virtual desktop infrastructures (VDI) from the time of manufacturing over several years of operation up to the disposal phase.

For desktop virtualization, the regular desktop of a user, with all its applications that had been installed locally, is made available in the computer center with the aid of virtual machines. Access is gained by means of desktop PCs or thin clients that can be configured centrally by means of a special administration software. Administrative and operating costs thus are lower, less electricity is used and less CO<sub>2</sub> is emitted. For an ecological study, the researchers from UMSICHT investigated the use of VDI and thin clients from different suppliers at the Dutch aid organization Carante Groep and at the own institute. In the first scenario a combination of VMware View™-based virtual desktops and IGEL thin clients was used; at UMSICHT, an infrastructure is used that is based on Citrix XenApp™ and Citrix XenDesktop™.

The result: the set-up with an installed VMware View™ proved to be 47 percent less damaging to the climate than a usage-equivalent desktop PC with applications installed on it. For the solution with Citrix XenApp™/XenDesktop™ the global warming potential calculated over the entire life cycle for a usage period of three years was, depending on the type of user, 30 to 63 percent below that of the comparison scenario. The study also showed that the climate-relevant advantages of the thin client-/VDI solutions are the result of savings mainly during the operating phase – 61 to 77 percent less emitted greenhouse gases. This means that the electricity costs during the operational phase will sink by an even higher percentage than the emissions determined over the entire life cycle.

### Virtual desktops for demanding users

For the installation at its own institute, UMSICHT differentiated between three user types, the medium user and two types of power users with higher requirements where the IT environment is concerned. For the first group, a combination made up of the IGEL thin client and a shared desktop made available via Citrix XenApp™ (terminal server) was the best and most energy-efficient solution from an ecological viewpoint. In comparison to the scenario with a traditional desktop PC, the global warming potential was lower by 63 percent. The CO<sub>2</sub> equivalent for a traditional desktop PC for a medium user was 417 kilograms, for the thin client with a terminal server share it was only 156 kilograms.

Since at Fraunhofer UMSICHT the solution with the terminal servers does not suffice for the individually higher requirements of so-called power users, virtual desktops on the basis of the software solution Citrix XenDesktop™ are also used in addition. It is also accessed via the IGEL thin clients. In the two power user scenarios, the respective greenhouse gas emissions are decreasing by 30 and 42 percent, respectively, in comparison to the respective PC scenario. In the case of a medium user, the terminal server share is 34 kilograms of CO<sub>2</sub>. The climatic effectiveness caused by the server share of the virtual desktop at Fraunhofer UMSICHT is 277 kilograms CO<sub>2</sub> (leasing-dependent duration of usage: 3 years), at Carante Groep it is 178 kilograms CO<sub>2</sub> (used until replacement investment:



5 years). A direct comparison does not appear to make much sense, since the local preconditions and user requirements are different. In addition, the average greenhouse gas emissions for the generation of electricity are somewhat lower in the Netherlands than in Germany.

The conclusion of the study: thin clients are always an alternative to the desktop PC. Viewed in a direct comparison to a typical desktop PC, the compactly-built thin client with a usage life of three years only emits 122 kilograms CO<sub>2</sub>, a desktop PC used just as long by a medium user or a power user emits between 417 and 692 kilograms CO<sub>2</sub>.

Details about the study can be found on the Internet at: <http://it.umsicht.fraunhofer.de/TC2011/>

*Image: A compact built thin client causes only 122 kilograms CO<sub>2</sub> in three years, a desktop PC between 417 and 692 kilograms of CO<sub>2</sub>.*

**Contact:**

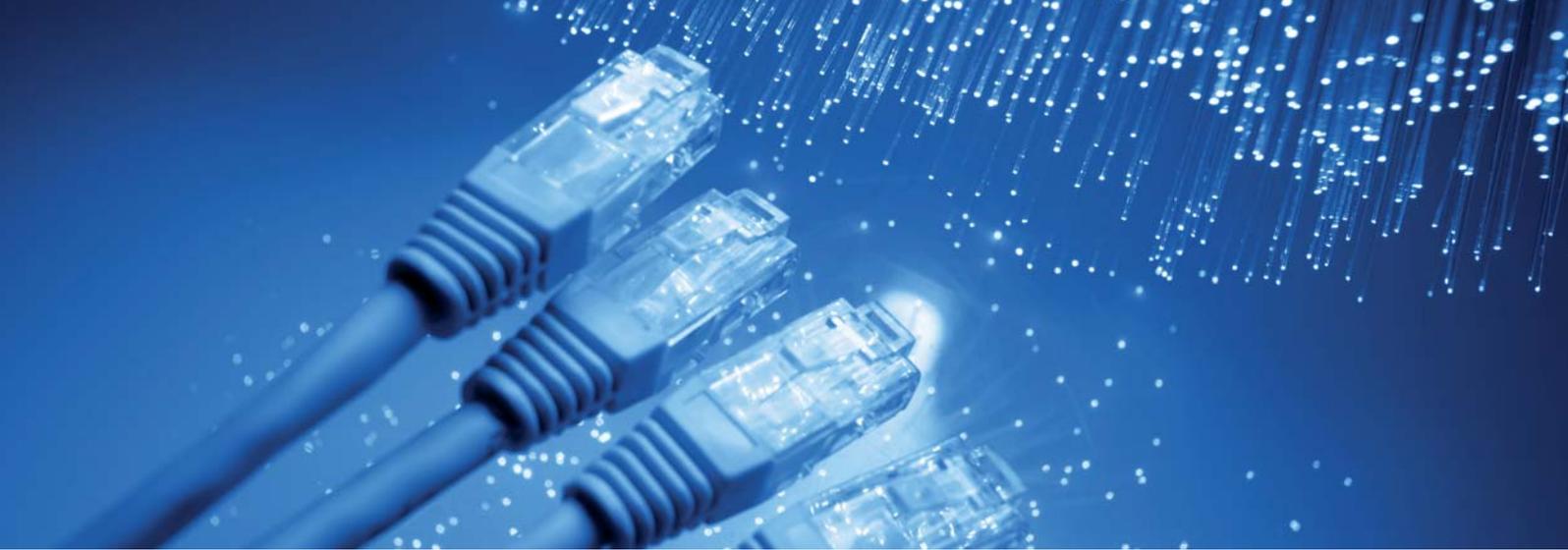
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## Virtualization

Server virtualization plays an ever increasing role in an optimized utilization of server hardware and computing centers and for offering energy-efficient and cost-reduced IT solutions. It can be used to abstract logical IT systems from physical hardware. This makes it possible to make different operating systems as well as multiple versions of the same operating system available on one and the same physical hardware. A virtual server can be installed more quickly and maintained more flexibly and replaced more quickly if it fails than dedicated hardware. Another step for more energy efficiency and climate protection is desktop virtualization. The objective here is to separate the desktop operating system from the terminal device and to consolidate them at the computing center to simplify the management, to utilize the hardware more efficiently, and to reduce operating costs and power consumption.



## SERVER VIRTUALIZATION PLATFORM FOR THE FRAUNHOFER-GESELLSCHAFT

In business units of large institutions a common infrastructure is quite often formed by different server systems. Servers that are made available centrally, but are operated decentralized are serviced by different IT teams. Here, Fraunhofer UMSICHT designed and developed the concept for the introduction and operation of a virtualization platform for the entire Fraunhofer-Gesellschaft. The advantages: less hardware, a more cost-efficient remote maintenance and centralized, uniform updates.

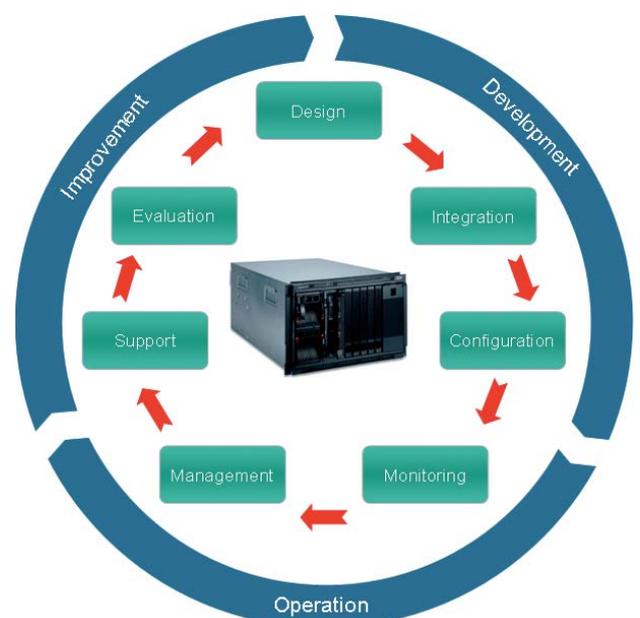
More than 80 research institutions, of which 60 are institutes in locations all across Germany – at institutions of this size there are usually servers at each decentralized location that do form a network, yet, are maintained and operated decentralized. So far, the competence centers of the Fraunhofer-Gesellschaft made centralized IT services available. The maintenance and operation of the services was carried out decentralized, through the competence centers and, in some cases, through outside companies. In doing so, each team that is responsible for a machine develops its own concepts for roll-out, logistics and updating mechanisms. In view of an increasing number of decentralized operated servers, this is not economical and it also impedes the innovation cycles of the services.

With the aid of server virtualization, several virtual servers can be run on one hardware platform. The servers can then be consolidated in the form of virtual machines. The technical committee "IT infrastructure" considered this approach to be necessary and future-oriented and agreed to its implementation. This means that only one hardware platform must be delivered and managed per institute location. The required services can be performed on the virtual machines. The virtualization is part of an IT optimization strategy by Fraunhofer-Gesellschaft. The objectives: to reduce hardware, costs and maintenance costs, and to improve the eco-balance, since, in the future, for example, no new expensive hardware components will need to be installed during an update – only an image will be made available through defined processes, which

can be installed on-site on the virtualization machine without any further effort.

### Road map for making virtualization available at all institutes

Fraunhofer UMSICHT developed the technical and organizational concept for the roll-out and the operation of the virtualization platform – from designing the platform to the operation and the deployment all the way to making support available. Developing the platform includes, among other things,



configuring the blade systems, investigating the security aspects and defining the interfaces between the virtualization platform, the institute's network and central management. 40 virtualization platform systems were purchased at the end of 2009 already; approximately half of all institute locations can be furnished with them. The productive operation in the pilot phase began in the second half of 2010. The researchers are currently working on validating and fine-tuning the concept. At the same time, the necessary 2<sup>nd</sup> level support is being built and integrated into the service structure of the Fraunhofer-Gesellschaft. The productive operations and the deployment of the initial virtual machines on the virtualization platform have also started already.

Fraunhofer UMSICHT's standardized solution aims to decouple the virtualization components as much as possible from the current landscape of hardware and software. Despite this, the institutes can individualize the server virtualization to in-house concerns and add more blades to the blade centers made available. The side effect of this is that for the institutes, when they adopt this technology, they have no huge initial investment requirements. This does not affect the operation of the virtual machines by the competence centers.

*Image: With the aid of a virtualization platform, it is possible to reduce the hardware, the costs and the maintenance costs.*

**Contact:**

*Dipl.-Phys. Thorsten Wack*

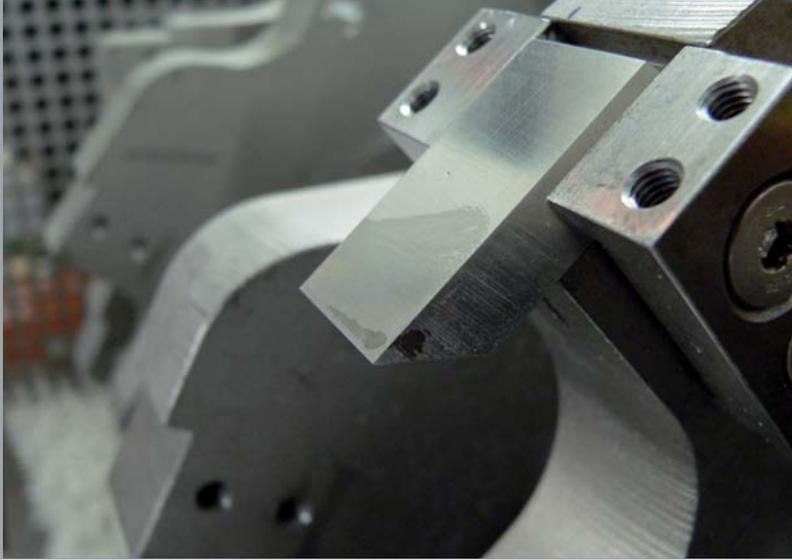
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## Blades

A blade server, a server blade or in short "blade" is a module that, together with others of the same kind, forms a battery of non-independent computers. Blades are installed into producer specific racks and are all using the same power supply units installed therein. As a rule, blades only have one motherboard with microprocessors, RAM and zero to two hard drives that are intended for the operating system. If more hard drive space is required, then this can be effected either via an adaptor in the BladeCenter (SAN, NAS) or by means of an expansion module with hard drives which, however, requires its own slot in the blade center. Blades therefore use the same resources, are administered centrally and have a common power supply and ventilation.

(Source: [www.wikipedia.org](http://www.wikipedia.org))



# STATISTICAL METHODS ASSURE CONSTANT SHARPNESS OF BLADES

Many products are being cut during the course of a production process. With some applications, it is necessary that the blades are exchanged or resharpened every hour. That limits productivity. Fraunhofer UMSICHT controls the wear that occurs during the cutting of abrasive materials and steers the abrasive forces onto the blade such that it sharpens itself constantly. Data mining systems are intended to help control the abrasion in a more targeted manner and make cutting on an industrial scale more economical.

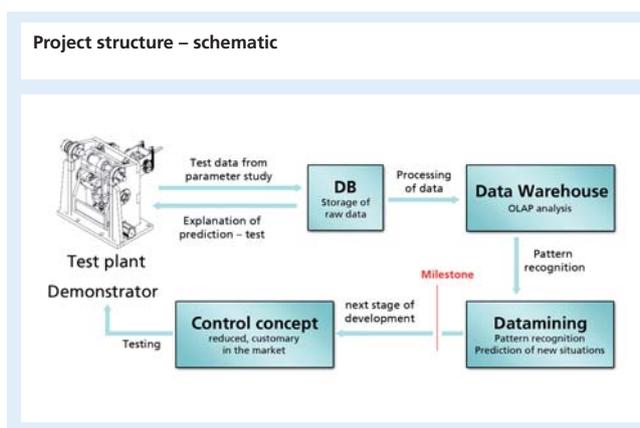
Cutting processes are very important in the industry. Plastics are being granulated and cut, and cut again during the recycling process. Entire trees are sliced into very thin sheets of veneer. Every newspaper, every magazine or book must, as a matter of printing technology, be cut on three sides. Industrial cutting systems are complex structures and, in terms of control engineering, integrated very elaborately into the production line. The cutting speeds and throughputs are high. Only the knife as the core piece of the process is still on the technical level that existed one hundred years ago: a sharpened piece of steel that is inflexibly built-in into the machine.

Copious knowledge about tribology, the theory of friction, abrasion and lubrication, resulted in knife materials made of hard metals and ceramics that can be selected depending on

the optimum toughness, hardness and resistance to abrasion required for the respective application. However, increasing material hardness its brittleness and danger of breaking are rising, which is why blades made of hard metals and ceramics have not achieved the desired market penetration. In some applications where abrasive cuttings such as plastics and paper are cut that abrade the blade material heavily, the blades are exchanged and resharpened every hour even today. That severely limits productivity.

On the basis of bionic principles, Fraunhofer UMSICHT developed the so-called "Rodentics concept<sup>®</sup>", with which the wear of cutting tools for abrasive materials became controllable for the first time. The concept uses the abrasive forces and guides them on to the cutting blade such that the blade is constantly being sharpened by "itself". Special steel alloys and a treatment and coating concept for the open area of the knives make that possible. Since these knives stay sharp permanently, only low cutting forces or friction forces are affecting them, which cause the amount of abrasion on these knives to be reduced considerably.

Previously, the abrasion was controlled by modifying the material. Now the abrasion processes at the cutting edge of the blade are to be controlled actively with the objective to permanently have an ideally sharp blade. The cutting performance of the process would thus be permanently optimized.



## Demonstrator supplies basis data for developing an adaptive control concept

Currently under development is a demonstrator for the adaptive, adjustable control of cutting processes. Data mining systems, statistical mathematical methods record the complicated connections of "cutting", they administer, analyze, evaluate and decipher the physical mechanisms. A simple, marketable control system can be realized once the connections are identified. The control variable could be the cutting force. A testing plant for cutting abrasive plastics serves as the cutting system to collect the data (parameter study); in the course of this project, this facility will be expanded into an adaptively controlled cutting system.

Since every cutting system forms an individual, tribological system, a method for the development of an adaptive control concept will be developed in the course of the project that can be applied to individual cutting processes and in industrial applications.

To work with the principle of controlling the abrasion in a way that is economically optimized, the knives have to be readjusted due to the contour geometries that are always changing. The controls are to ensure that this can be carried out lastingly with a regeneration/self-sharpening of the cutting edge. Guaranteeing that the blade is constantly sharp also guarantees that the cutting forces are permanently lower and thus assures a lower energy requirement during the process. The user thus has a triple economic potential available: energy efficiency due to low cutting forces, material efficiency due to low friction forces, or rather, the lowest material loss, constantly high-quality cuts despite the abrasive effects of the material being cut.

*Image: Industrial cutting tools – controlled sharp?*

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## **Data mining**

To find data treasures is the goal of data mining. The liberal explanation of the term approximates its meaning quite well as data mining applies statistical mathematical methods to data to recognize the patterns therein. Large databases in particular are being searched to find knowledge in them. In order to be able to analyze large amounts of data in defined timeframes, efficient statistical methods on the basis of artificial neuronal nets, fuzzy clustering processes and genetic algorithms are being used. When dispensing with the assumptions for the model with respect to the data generation process, there are useful application opportunities even for small or medium-sized data pools.

# ENERGY AND RECYCLING MATERIALS

Resources for our future.



## Main topics

- Biogenous and Chemical Energy Media
- Recycling Technologies
- Thermochemical Storage

## Information/Administrative office

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## Industries and target groups

- Energy supply
- Recycling and waste management industry
- Plant construction
- Chemical industry
- Wastewater treatment plants, landfill sites, fermentation plants
- Municipalities
- Small and medium-sized enterprises (SMEs)

Population growth and the growth of the economy, increasing prosperity and global competition result in energy and resources becoming scarcer and more expensive. In the future, it will be necessary to utilize fuels more efficiently and to use regenerative energies. It is also of equal importance to make energy storable or to find alternatives made from recycled materials.

## Our competencies

The goal of our work is application-oriented development of processes for efficient energy and material conversion. Our expertise includes opening up new sources of energy and recycling materials.

Our technical expertise is in the areas of biomass and syngas, sorption technology, catalytic processes, chemical heat storage, fuel characterization and GIS (geographic information systems) applications.

Sorptive and catalytic gas processing, catalytic conversion of biogases and syngases as well as the development of processes for chemical energy storage and for the recycling of "critical materials" are focal points of our work.

## Our R&D service

- Biomass to energy/waste to energy
  - Mechanical processing of biomass and alternative energy sources
  - Thermochemical conversion (combustion, gasification, pyrolysis)
  - Biogenous gases (analysis, processing, feed-in and utilization)
  - Sampling and analysis of biomass, waste products, residual materials and slags.
  - Characterization of fuels
- Catalytic processes
  - Cleaning and chemical conversion of syngas
  - Preparation and cleaning of biogenic gases
- Thermochemical storage
  - Product and process development
- Development of recycling technologies
  - Process development and assessment

# 3 questions for

**Dr. Thomas Marzi**

(Business Unit Manager)



**1** Which of the crisp ideas of your team are you particularly proud of?

**1** To highlight an individual idea would not be fair to the team. I would rather single out the outstanding cooperation. Ideas and their implementation usually cannot be attributed to an individual, but rather to a team effort to which many have contributed their share.

**2** What is becoming more important from the customer's/ industry's point of view?

**2** We must provide a "one-stop-shopping offer" to the customer. This includes the ideal composition of the project consortium, acquisition of funds and the successful implementation of the project.

**3** What are you hoping for in 2011?

**3** I hope that we will be able to further expand the cooperation with the project partners we have gained at the beginning of the year.

# CHARACTERIZING THE BURNING BEHAVIOR OF REFUSE DERIVED FUELS

The burning properties of fossil fuels such as coal, gas or crude oil are well known. Refuse derived fuels (RDF), on the other hand, comprise a very heterogeneous group of materials, whose burning properties vary, depending on their composition. The efficient energetic utilization of wastes that as materials can no longer be reused is gaining increasing economic importance. In a group project, Fraunhofer UMSICHT is conducting research to identify and test suitable processes for characterizing alternative fuels.

Refuse derived fuels are waste products that consist of, for example, paper, cardboard, wood, textiles or plastic materials and differ greatly in their composition. Due to their high thermal value they are being used as fuel in power plants. However, since there is as of yet insufficient empirical data with respect to their burning properties, refuse derived fuels cannot be used efficiently enough. Therefore, the long-term goal of the energy project of North Rhine-Westphalia called "Refuse derived fuels of the future" is to be able to characterize refuse derived fuels such that power plants are more in tune with the fuel to be burned and thus can achieve greater degrees of efficiency. Fraunhofer UMSICHT is working on that together with partners from industry, research institutions and universities.

Using characterization processes that have already been developed, Fraunhofer UMSICHT is testing plastics, wood and paper mixtures in the laboratory and in the technical shop for three characteristics: the energy content and the composition of the volatile compounds of the fuel particles, their release speed as well as the flight performance of individual particles. Results are exchanged regularly between the project partners and methods that are promising and have good prospects are expanded and developed further.

## Fingerprint process for technical shop developed

Fraunhofer UMSICHT developed a laboratory method, the fingerprint process, to determine the energy content of the

volatile fuel components. Here, it can be determined how much of the calorific value of the fuel particles changes to the volatile phase at the different temperatures. The investigations are carried out with a modified elemental analyzer. The test results are included in a calculation model of the project group that examines the pyrolytic processes during the incineration.

In a next step, UMSICHT transferred the fingerprint method to a technical shop facility to examine larger amounts, as well as to be able to also take material and heat transfer effects into consideration. The LOKI (Largescale Oven for Kinetic Investigation) fixed bed reactor is a two-step system with inert and oxidizing areas. A scale measures the loss of mass of the fuel and the flue gas is being analyzed. In addition, it is possible to examine the release behavior of the volatile fuel components and the burn-up behavior. The development of the technical shop facility is being continued further. Another goal is to develop a fully automatic sample feed, so that samples can be heated up instantaneously.

To measure the release speed of the volatile particles in dependence on the temperature on the individual refuse derived particle, Fraunhofer UMSICHT is using a twin-tube pyrolysis system with two separate heating zones. In the first heating zone, the fuel particles are heated in an inert atmosphere, the gases thus released are oxidized in a subsequent furnace zone and the oxidation points determined.



The researchers at UMSICHT measure the sinking speed of the fuel particles in a drop chute. It is not uniform, like that of coal dust. Here, the tumbling and acceleration behavior can be tested as well, relative to the different sizes, densities and masses. The measuring system: a line-laser based optical system and a camera system with automatic image assessment. This makes it possible to record a spatial movement pattern of the particles at 10 sites in the drop chute, while the position of the particles is determined every second in a particular section by two camera systems set up at a defined angle.

#### Project partners:

- Polysius AG
- Hitachi Power Europe GmbH
- RWE Power AG
- DI MATTEO Förderanlagen GmbH & Co. KG
- ABG, Waste Consulting Service Secondary Fuel Preparation (Abfallberatungsgesellschaft)
- Ruhr University Bochum, Department of Energy Plant Technology
- University of Duisburg-Essen, Chair of Environmental Process Engineering and Plant Design
- Münster University of Applied Sciences, Laboratory for Waste Management, Waste Water Management
- Federal Quality Association for Derived Fuels and Wood Recycling (Gütegemeinschaft Sekundärbrennstoffe und Recyclingholz e.V.)

*Image: The fixed bed reactor makes it possible to examine representative sample amounts of original fuel samples of varying particle sizes.*

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### Refuse derived fuels (RDF)

Currently there is no uniform definition for the product and its preparation. Refuse derived fuels are also called secondary fuels, fuels from waste or special fuels. It is a fuel substitute made up of product-specific waste mixtures of great calorific value. The wastes used to produce refuse derived fuels can come from households, industry or commerce. The calorific value, the particle size and the chlorine content are important fuel parameters. Refuse derived fuels are utilized together with traditional fuels in so-called co-incinerators, largely at industrial power plants. At heat and power plants, refuse derived fuels can be used as the only fuel.

# NEW PRODUCTS FROM SYNGAS THANKS TO HETEROGENEOUS CATALYSIS

Catalysts help to save energy, open up new energy sources and create chemical products. A cooperation between Fraunhofer UMSICHT and the Max-Planck-Institut für Kohlenforschung (Coal Research) combines basic research in the area of catalyst development with applied research in the area of technical processes. The group wants to develop catalytic processes to their testing on an industrial scale.

More than 80 percent of the products being sold on a daily basis are being produced with catalysts. Catalysts reduce the activation energy of a reaction and increase its velocity, they improve their selectivity and open up new, economical reaction paths for the manufacture of products. Catalysis research is relevant, scientifically and economically, as soon as the results can be transferred to an industrial scale. The North American Catalysis Society (NACS) estimates that for 2007, the global gross national product (GNP) share of processes driven by catalysis to be roughly 1,000 billion US-Dollar and that the lion's share of it is for the production of fuels. According to the NACS, the global market for catalysts was twelve billion

US-Dollar in the same year.

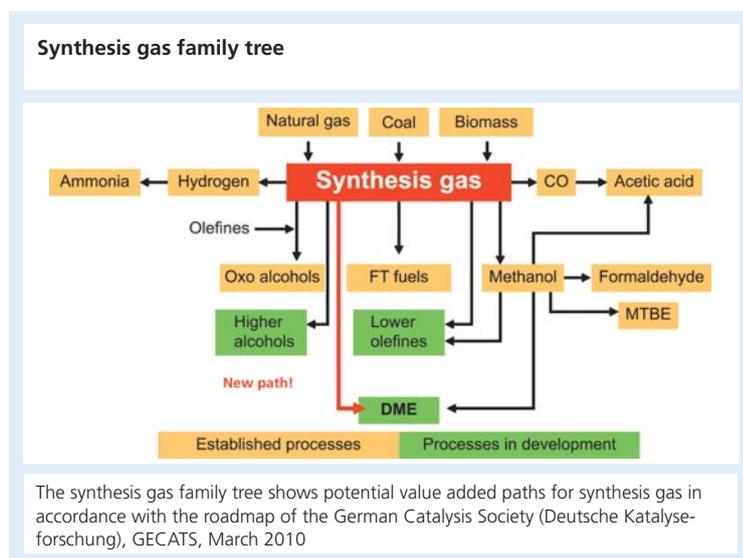
As relevant as catalysis is for the current economic structures, that is how relevant it will be for future developments. Driven by the fact that, in the medium-term, crude oil will become scarcer and more expensive and by the goal to reduce fossil CO<sub>2</sub> emissions, fuels and basic chemicals are to be manufactured increasingly from biomass in the future. These changes in the raw materials basis require adaptations in the value added chain and the development of powerful, catalyst-supported chemical processes. So that this will happen successfully, basic scientific work and application-oriented research must go hand in hand.

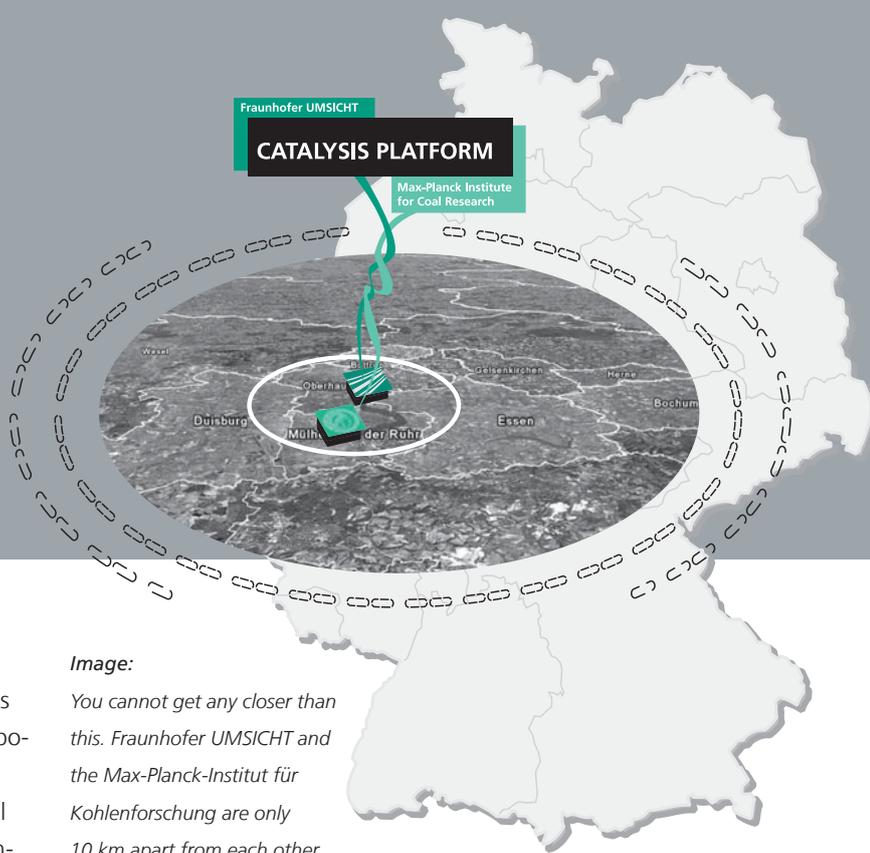
The Max-Planck-Institute (MPI) für Kohlenforschung and Fraunhofer UMSICHT joined forces to form the "Heterogeneous Catalysis Research Platform".

## Production of dimethyl ether from biomass as the starting project

The first goal of the research cooperation is the development of a new, continuous catalytic process for the manufacture of fuel-capable dimethyl ether (DME) from syngas (synthesis gas) that is made of lignocellulose-containing biomass.

Syngas is one of the most important platforms to produce fuels and chemical basis materials. It is produced by means of gasification of crude oil, coal or biomass





from various raw material sources. The gas mixture contains carbon monoxide (CO) and hydrogen (H<sub>2</sub>) as essential components. In addition to heat and electricity, chemical products can be produced from syngas. As a fundamentally universal intermediate step for chemical synthesis, syngas can be considered to be a fundamental raw material source of the future.

Dimethyl ether is a basic chemical compound from which alkenes are synthesized, primarily the quantitatively most important ones, ethene and propene, as well as gasoline and aromatic compounds. In addition to its use as fuel, it also has, as a chemical raw material, a high potential for value creation and can, due to its characteristics, be integrated into the existing utilization chains.

Currently, DME is produced from fossil methanol which is dehydrated catalytically in an additional process step. However, it can also be produced directly from syngas through methanol as an intermediate product. The catalytic process to be developed shall make a one-step direct synthesis possible and be linkable to biomass gasification. This will create an integrated process that basically can provide electricity, heat, fuel and basic chemicals. The project is to establish the foundations for achieving a large-scale technical DME production from lignocellulose biomass more efficiently than with the catalysts that are currently commercially available.

**Image:**

*You cannot get any closer than this. Fraunhofer UMSICHT and the Max-Planck-Institut für Kohlenforschung are only 10 km apart from each other.*

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**Max-Planck-Fraunhofer Heterogenous Catalysis Research Platform**

With the Max-Planck-Institut für Kohlenforschung in Mülheim an der Ruhr which works on basic research in the field of the development of catalysts and Fraunhofer UMSICHT in Oberhausen, which covers the technical process development from up-scaling the catalyst synthesis to the development of the technical catalyst process, two facilities combine that complement each other perfectly with respect to direction and expertise. The iterative networking at Fraunhofer of a process development that is oriented toward reuse and recycling together with the basic catalyst development taking place at Max-Planck combines the flexibility of basic research and the targeted focus of applied research and development in one development platform.



## STORING RENEWABLE ENERGIES BY MEANS OF CHEMICAL REACTIONS

An important prerequisite to increasingly utilize renewable energies is being able to have intermediate storage for that energy. It is only in this way that variable occurring power generation can be adapted to a demand for power that fluctuates with respect to time and region. In addition to electrical storage, storage can also be achieved thermally, mechanically and by materials. In one research project, Fraunhofer UMSICHT works on developing custom-made materials as thermo-chemical energy storage devices.

The share of renewable energies in the European Union is supposed to increase to 20 percent by 2020. Existing power supply systems must be adapted accordingly for this – a task that is keeping a lot of researchers busy. A great deal is expected from thermo-chemical storage systems, since here thermal storage is possible in a small space by utilizing chemical reactions. For this, the use of industrial waste heat flows is particularly energy-efficient.

Industry is using approximately 28 percent of the total energy in Europe, and this share is mostly applied to generating heat in production processes. One third of this heat is used in the low temperature range of up to 100 degrees Celsius. There are no storage media with high specific energy densities available for this range. In the food industry, in particular, there is great potential for storing and utilizing waste heat from condensers, refrigeration units and air conditioning units. The waste heat in turn could be used for processes that require a great deal of heat. The positive results: energy efficiency and reduced processing costs.

In a project sponsored by the German Federal Ministry for Economics and Technology, Fraunhofer UMSICHT intends to develop suitable materials as thermo-chemical energy storage units in the low to medium temperature range (up to 200 °C). In particular, application opportunities are to be sought and evaluated for the food industry. The requirements: the heat accumulators must have high storage densities and, at the same time, low

energy losses; it must be possible to affect the material properties in a targeted way and they must be pumpable and environmentally friendly. In the project, Fraunhofer UMSICHT bundles expertise from the areas of process engineering, reaction and energy technology and provides its knowledge from the field of energy storage media.

### Higher energy densities via thermo-chemical heat storage

Storage technologies for the low temperature range, another field of research for Fraunhofer UMSICHT, are latent and absorption-type heat storage devices. The achievable energy densities can be increased markedly with new materials for thermo-chemical storage. Currently, there are only a very few patents for the thermochemical methods in this field. The use of the current reaction systems, however, requires a processing technology that is complicated and expensive, since the materials are hardly suitable for pumping. For this reason, the technologies can, for the most part, not be ecologically or economically implemented, and there are no market-ready products.

In particular, the project aims to investigate thermoreversible reaction systems that change the position of the balance reaction simply as a result of a change in temperature. There are a number of reaction systems for assembling or disassembling molecules, however, only few can be controlled reversibly and can be utilized for thermal storage in an economically and ecologically sensible way. The challenge lies, in particular, in the

fact that the storage densities decrease greatly with sinking temperatures and that so far only purely physical processes have been used for storing low-temperature heat.

A first milestone in the project is to find a suitable thermoreversible reaction system and to characterize them by thermoanalysis. Building on this, UMSICHT selects the reactions with optimized energy efficiency and transfers them to a laboratory scale. At the same time, researchers analyze the current potentials for applications, such as heat pumps, refrigeration and air conditioning systems. In the end, the goal is to develop a process-engineered utilization concept for the new heat storage materials.

*Image: For many processes, the food industry requires energy in the low to medium temperature range of up to 400 °C. There are currently no energy-efficient thermochemical storage media for this.*

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## Thermal energy storage

There are latent, sensitive or thermo-chemical heat storage. Latent heat storage (PCM – phase change materials) utilize the copious amounts of heat that are taken up or released during the phase change from liquid to solid, gaseous to liquid or the other way round. Sensitive heat accumulators change their noticeable temperature during the charging and discharging process. Thermochemical storage use thermal conversion or reversible chemical reactions – they store heat by means of endothermal reactions and release it again through exothermal reactions. This includes sorption storage traps that accumulate heat through sorption of water on technical adsorbants and later releases it again through desorption. To date, water, concrete, pyrites in the form of salt melts, metals and ceramics are used, depending on the temperature range.

(Source: Roempp online, Techniklexikon)

# ENERGY EFFICIENCY TECHNOLOGIES

Smart energy supply.



## Main topics

- Electrical Energy Storage
- Polygeneration/ORC
- Thermal Cold Production/Storage
- Energy System Optimization

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## Industries and target groups

- Energy supply companies
- Operators of renewable energy plants
- Complex energy-intensive consumers
- Producing industry
- Companies in the innovative process
- Architects, building planners, technical building services equipment

Our objective is the development of new technologies to increase energy efficiency and their integration into existing energy systems. To achieve this, we combine the experience and research results we obtained from our laboratories and test stations using simulated tools – always focusing on the market and the addition of value.

## Our competencies

Our technical focal areas are electrical energy storage devices that are required to balance the fluctuating consumption levels and discontinuous feed of renewable energies into the grid; Organic-Rankine-Cycle (ORC) plants that currently turn unused waste heat, such as from biogas plants into usable and profitable power; thermal chillers that provide cold from solar heat or waste heat, from the single-family home to the remote cooling grid. In addition to these technological focus areas, the entire power supply concept is being optimized systemically, where we develop the supply structures for electricity, heat and cold as well as the operations management as well as possible.

## Our R&D service

- **Electrical energy storage**  
Development of redox flow batteries, testing of lithium batteries as well as optimization of CAES systems, integration and usage optimization of storage devices in the grid
- **Polygeneration/ORC**  
Development, optimization and construction of ORC plants for biogas facilities, solar ORC or wood ORC in the output class of 50-200 kW<sub>el</sub>.
- **Thermal cold production/storage**  
Steam Jet Ejector Chiller (SJEC) technology (waste heat, solar) and absorption cold; solar cooling, cold storage (PCM/PCS)
- **Optimization of energy systems**  
Modeling and optimization of central and decentralized energy systems for the supply of electricity, heat, cold; LowEx

# 3 questions for

**Dr. Christian Dötsch**  
(Business Unit Manager)



**1** Which of the crisp ideas of your team are you particularly proud of?

**1** We achieved two great breakthroughs in 2010: within the scope of a field trial, we installed the fourth ORC plant for obtaining electricity from biogas waste heat. During the last few years, Fraunhofer UMSICHT developed this technology to the prototype level. Together with the colleagues from Fraunhofer ICT and ISE, we developed the 1 kW Fraunhofer redox flow stack. This is the core component of redox flow batteries that are to be used to equalize the fluctuating regenerative energies.

**2** What is becoming more important from the customer's/ industry's point of view?

**2** Due to new and further technical developments as well as clear cost reductions in the area of renewable energies, the energy market is clearly moving. In the future, the energy system will therefore become clearly more decentralized, the consumers will generate power or will become "smart", meaning intelligently controlled consumers. Power will no longer flow simply from the large power plant to the consumer, but increasingly more often between the consumers themselves or vice versa, from decentralized power generators into medium-voltage power lines or even high voltage power grids.

**3** What are you hoping for in 2011?

**3** The positive developments from 2010 will hopefully continue in 2011. I hope that not only will renewable energies continue to expand, but that the measures for an efficient way to use energy will be developed further and will be implemented. Our energy system could be based more and more on renewable energies, and could become more intelligent without taxing the consumer overmuch.



# STORING RENEWABLE ENERGIES BY MEANS OF COMPRESSED AIR

One of the major challenges in the utilization of renewable energies lies in its fluctuating energy output. Sun and wind energy cannot be planned like fossil energy sources. The intermediate storage of energy offers solutions to equalize fluctuations and to keep the grid balanced. Fraunhofer UMSICHT has developed a new physical model for the layout of efficient and emission-free compressed air energy storage plants.

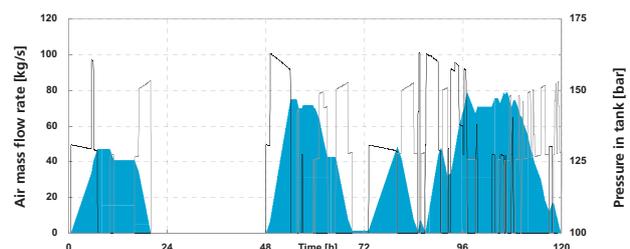
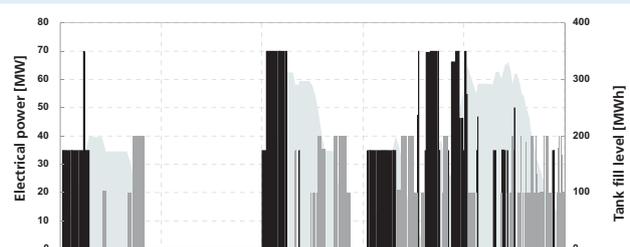
Compressed air energy storage (CAES) plants have the potential to more closely coordinate the supply and demand of energy with one another. The demand for power is not continuous, but moves between demand highs and lows. For this reason, high demands are placed on the intermediate storage of energy: it must ensure a reliable equalization mechanism for a large amount of electric energy, so that the same amount of power is fed in as is used. In addition, it must also be free of emissions, cost-effective and efficient. The overriding objective of the research project at Fraunhofer is to develop methods to optimize the technical layout of CAES plants.

Adiabatic compressed air energy storage (A-CAES) plants are the technology of the future. In contrast to diabatic storage the heat produced during the process is utilized further. A compressed air energy storage plant stores the excess energy for later use by pressing the compressed air into salt caverns or subterranean porous layers of rock. When the air is allowed to stream out, it flows through a turbine which in turn drives a generator that produces electricity. In contrast to the diabatic compressed air energy storage, the heat from the compressed air is not lost in adiabatic compressed air energy storages, but it remains within the process and is reused. Therefore, adiabatic systems clearly allow much higher degrees of effectiveness of up to 70 percent, and no natural gas is required for heating.

**Dynamic model integrates the economic aspects of the energy market**

The A-CAES model developed by Fraunhofer is designed as a dynamic one, therefore it also takes the operation of the plant into consideration and shows possibilities to integrate wind energy, in particular, better into the power grid. Furthermore,

## Compressed air storage



- Fill level
- Compressor capacity
- Turbine capacity
- Pressure in tank
- Air mass flow ON
- Air mass flow OFF



in the model, two levels are linked to each other: in addition to the further technological development of the CAES, it also takes the economic aspects of energy systems such as varying prices for electricity or political-regulatory framework conditions into consideration. The generic optimization model for energy storage (GOMES®) permits the determination of optimized storage operations.

The first results of the analysis: the time required to ramp up and shut down power plants must be shortened to guarantee economic storage operations. In addition, the ratio between compressor and turbine capacity must be optimized in an application-specific way to realize a cost-efficient storage system.

Once the optimized storage operation has been found, the technological realization can be initiated in a second step. Here, the challenge lies mostly in storing compression heat at very high pressures of up to 150 bar and temperatures of around 600 degrees Celsius. Extensive new developments in compressors are required, since the compressor technology on the market currently is not made to work with these high temperatures. The results of a Fraunhofer UMSICHT research project show that an alternative conversion of the adiabatic plant concept succeeds even at lower process temperatures, where regular and cost-efficient compressor technology can be utilized.

*Left image: The spiral tube heat exchanger transfers heat to the liquid salt which is the storage medium in this CAES.*

*Right image: The layered high temperature heat storage of the CAES pilot plant.*

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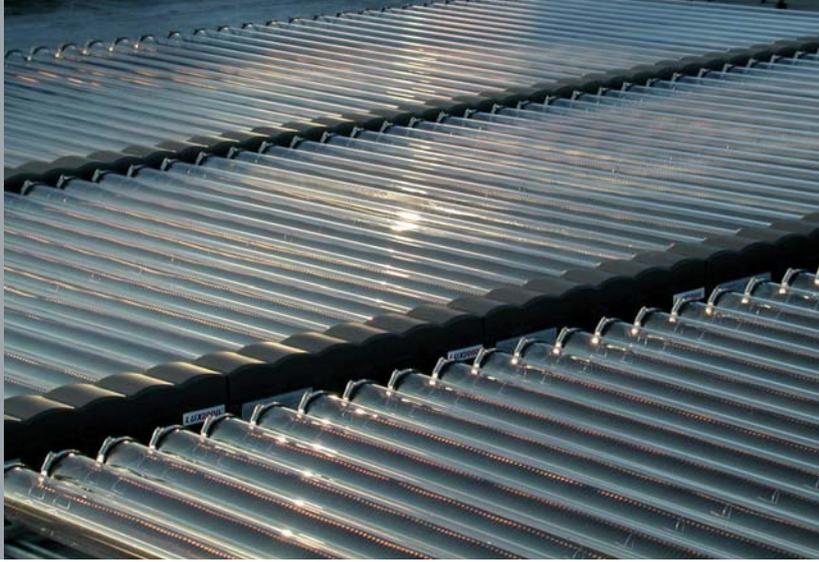
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## Compressed air energy storage plants

CAES plants are able to do intermediate storage of large amounts of electricity. The only alternative to providing an intermediate storage of large amounts of electricity are pump storage power plants that, for reasons of costs and environment protection, can hardly be expanded. Currently, there are only two CAES plants, which, however, still work in a diabatic way: one plant is located in Huntorf, Germany, the other in McIntosh, USA. For this, the compressed air is warmed by utilizing natural gas before entering the turbine. Increasing the degree of efficiency and lowering investment costs are important targets in the development of CAES.



## SOLAR COOLING FOR BUILDINGS FOR THE INDIAN MARKET

In India, the demand for air conditioning buildings and computer facilities is growing steadily. The power grid is not stable, and numerous black-outs are the result. For this reason, high solar radiation presents a large potential for energy supply in India. With a cooperation partner from India, Fraunhofer UMSICHT intends to establish solar cooling for buildings as an energy-efficient and power-saving technology on the Indian market.

The International Energy Agency (IEA) assumes that the power requirements for cooling a building will be growing roughly twice as quickly as the total energy requirements for buildings. In Europe alone, the demand for air conditioning units is projected to grow by more than 10 percent by 2020. In a comparison of the amounts of insolation received for various regions of the world, Indian cities such as Bangalore, Madras or New Delhi achieve top numbers, with approximately 2,000 kilowatt hours per square meter and year. Furthermore, for conventional air conditioning, the load peaks in the electrical grid as a result of the simultaneous activation during the noon and afternoon hours are particularly problematic. The power grid that exists in India is very unstable, since not enough installed power plant output is available. For this reason, 90 percent of the industrial companies are using diesel generators as supplementary power supply and to provide emergency power. They are thus providing 20 to 50 percent of the required power. In fact, the poor infrastructure is a major obstacle for the growth of the Indian economy. Solar-thermal cooling offers an opportunity to establish cooling of buildings on the basis of existing solar energy without stressing the electrical power grid and emitting CO<sub>2</sub>.

Fraunhofer UMSICHT has been doing research on thermally driven steam jet ejector chillers as well as on thermally driven absorption chillers. Both types of machines can be powered with district heat, waste heat or solar thermal heat. For the first type, UMSICHT realized a prototype and is continuing to work on the further development of a final product. At the

Oberhausen site the institute already has a demonstration plant of a solar thermally driven absorption chiller running. It has a cold capacity of 16 to a maximum of 58 kilowatts, a collector surface of 108 square meters and generates cold water that is 7 degrees Celsius for cooling of buildings. Just as in traditional refrigeration machines, the cold is produced by evaporating a refrigerant. In contrast to traditional refrigeration machines, however, solar heat is used as generating energy instead of electricity. Currently, the researchers are working to further optimize this system to increase its efficiency. In addition, there are existing challenges in the heat rejection and in optimizing the control strategy of the entire system.

### Spin-off in India

Together with a partner, Fraunhofer UMSICHT entered into a joint venture agreement to take the existing expertise in the field of solar-thermal cooling and to turn it into a marketable product and to market it. To facilitate this, they founded VSM Solar Private Limited, headquartered in Bangalore, India. Initially, a demonstration plant for the solar cooling of the headquarters will be built and taken into operation. Then, together with the Indian partner, UMSICHT will market the technology and will build additional units for the cooling of office buildings or office complexes. In addition, Fraunhofer UMSICHT will, in close cooperation with VSM Solar Private Limited, develop and optimize the total concept further.



Fraunhofer UMSICHT was, in order to establish initial customer contacts, at the Indian trade fair Renewtech India 2011 in Mumbai and presented itself and the technology. Due to the fast growth of the economy in India, the demand for air conditioning and cooling systems is growing enormously. With the use of solar-thermal energy systems an environmentally friendly technology is established and the primary energy demand is lowered.

*Left image: Solar energy can also be used to cool buildings.*

*Right image: A typical streetscape – a multitude of splitter systems of air conditioners on a single building.*

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## India

With a growth rate of 7.2 percent in the year 2009/10, India has, right behind China, the economy that is expanding the most. The mere size of the Indian economy and its continuously high growth rate make the sub-continent the most important market of the future after China. As a result of the economic growth, the demand for energy will increase by eight percent annually during the next years. The Indian government plans to open the energy infrastructure for foreign investors and to clearly increase the share of renewable energies in the energy mixture.

(Source: [www.auswaertiges-amt.de](http://www.auswaertiges-amt.de); [www.exportinitiative.de](http://www.exportinitiative.de))



## WASTE HEAT CONVERSION WITH SMALL ORC PROCESSES

An ORC process, a steam-powered process with an organic working fluid, is particularly suited to generate electricity from waste heat at low outputs. Although small ORC processes are interesting for the market, currently ORC under 200 kW<sub>el</sub> have not been established on the market. Fraunhofer UMSICHT is closing this gap and developing small ORC processes that are driven by the waste heat of large engines.

New energy efficiency technologies that are able to convert smaller flows of relatively low temperature (waste) heat into electricity have a future. In cooperation with Cyplan Ltd., Fraunhofer UMSICHT has been driving the development of an ORC process for utilizing the waste heat of gas piston engines since 2005. The first prototype of such an ORC system was put into operation with two biogas motors at the Wasmerstage site already in 2007. The system is CE-certified, has been accepted by the customer and in December 2010 it had operated already for 23,000 fully automatic hours with only few unplanned downtimes.

Building on that, and within the scope of a field trial sponsored by the Federal Ministry for Economics and Technology, the development partners have started to build a model program and the testing of two high-temperature (HT) ORC modules and one low-temperature (LT) ORC module. The objective is to further develop the processes, in particular with respect to optimizing the efficiency, the reliability and the cost of manufacturing.

First, the design of the waste heat powered ORC process was reworked and a prototype of the low-heat powered LT ORC process driven by hot cooling water of engines was realized. In 2010, two more high-temperature ORC processes, model HT A-100 could

be realized with motors that had an output of 804 and 1,063 kW<sub>el</sub>, respectively. They were turned over to the operators, who then continued to operate the automatic operation properly. The first low-temperature ORC process LT W-25 on a 536 kW<sub>el</sub> biogas motor is about to go operational. The smaller, waste gas powered ORC modules, model HT A-50, are about to have their first operational run in 2011. There are projects planned for 2011 for two additional motor sites with a total of four ORC processes.

The initial operational degrees of efficiency of the redesigned HT-ORC modules A-100 are, at partial load, at approximately 80 kW<sub>el</sub> to 18.5 percent gross and 16 percent net. The use of new hydrocarbons as a working medium was successful. The ORC modules that were operated with it showed lower levels of auxiliary power than when traditional silicone oil is used

ORC MODULE TYPE	A-100 (HT)	A-50 (HT)	W-25 (NT)
Gross capacity of module	60-120 kW <sub>el, ORC</sub>	30-60 kW <sub>el, ORC</sub>	20-50 kW <sub>el, ORC</sub>
Efficiency Full load/50 % partial load	18 %/14 %	18 %/14 %	8 %/6 %
Heat supply	Exhaust gas 400-530 °C		85-110 °C
Supplied heating power 50 % partial load/full load	430-670 kW <sub>th</sub>	215-335 kW <sub>th</sub>	330-625 kW <sub>th</sub>
Maximum process temperature	270 °C	270 °C	110 °C
Heat removal/kWK	Cooler 30/40 °C Up to 50/70 °C Up to 550 kW <sub>th</sub>	Cooler 30/40 °C Up to 50/70 °C Up to 275 kW <sub>th</sub>	Direct condenser Up to 575 kW <sub>th</sub>



and promise higher degrees of efficiency at higher outputs. The cost of modules installed at a site that is ready-to-run is roughly 20 percent less than those at the first system at Wasmerslage. As a result of a systematic approach, the time frames for operational readiness and optimization could be reduced.

The availability of the systems could be increased significantly and is currently achieving operational readiness values of more than 80 percent (> 7,000 h/a). Since it has proven to be useful to have replacement parts on hand, a maintenance vehicle was purchased that carries replacement parts and tools for maintenance. In addition, a monitoring/control solution was developed that, in the future, will make automatic measurement value monitoring with error diagnoses possible.

A project supported by the German Federal Ministry of the Environment, Nature Conservation and Nuclear Safety involves work on deploying these small ORC processes in the coupling of power and heat in small solid biomass heating plants with an output performance of approximately 400-1,000 kW<sub>th</sub>. In addition, solar-thermal generation of electricity using concentrating collectors, heat accumulation systems and HT ORC processes is being examined in a preliminary project.



*Left image: Fraunhofer UMSICHT's  
ORC-maintenance vehicle*

*Right image: Evaporator ORC process  
with waste heat from a gasoline engine*

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### **Organic Rankine Cycle – ORC steam power process**

Instead of water, the ORC steam power process is using organic media as a working medium. The organic working fluids are adapted to the temperature requirements of the circulation process and the waste heat source, for example, paraffins, aromatics, alcohols and silicone oils are being used. Currently, the ORC processes are used globally mainly for generating electricity in the output range of between 300 and 7,500 kW<sub>el</sub> per module for wood-fired power plants and geothermal power plants. Coupling it with biogas-gas piston engines is something new. However, the number of small, decentralized plants that use biogas for generating electricity is growing continuously, and with it the demand for smaller ORC plants that open the output range under 300 kW<sub>el</sub> for the generation of electricity from (waste) heat.

# RESOURCES MANAGEMENT

Utilizing potentials.



## Main Topics

- Material Flow Management, Eco-Assessment
- Sustainability Management
- Innovation Processes, Networks

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## Industries and target groups

- Waste management industry
- Energy industry
- Water and wastewater industry
- Process industry and manufacturing industry
- Public administration (planning authorities, federal and state governments, municipalities)
- Banks and insurance companies, investors
- Groups and associations, politics

Resources find their way into products and services which we need to live, which increase our quality of life and which form the foundation for the future. Resources – be they limited or renewable – must be used in a sustainable and economical way. We offer you suitable tools and services to control materials and energies, knowledge and ideas in an optimized way.

## Our competencies

We examine the use and effects of materials, energy, goods and knowledge in processes, process chains and value added networks.

We optimize them according to economic, ecological and technical-infrastructure criteria. The focus of our R&D services is on production systems, locations and regions. Our objective is to use resources in such a way that they lead to progress and innovation.

We combine modern management instruments with expertise regarding resources and technologies. The results enter into strategic studies and consulting services. For you and your customers, we calculate the contributions for the sustainable development of products, processes, services and company sites as a whole.

## Our R&D service

Research, development, optimization and realization in the following sectors:

- Resources Management (e.g. CO<sub>2</sub>-balances, carbon footprints, water footprints and ecological balances, life cycle management)
- Material flow systems (e.g. analyses of energy potentials, bio-energy plants)
- GIS applications for planning and analyses (e.g. optimization of regional biomass use, site development)
- Roadmaps for strategic decision-making (e.g. research agendas)
- Management of R&D projects (on a national and EU level)
- Targeted innovation and knowledge management (e.g. technology integration, trend analyses, strategies)

## 3 questions for Dr. Hartmut Pflaum (Business Unit Manager)



**1** Which of the crisp ideas of your team are you particularly proud of?

**1** I am particularly proud of two very important projects from 2010 which we describe in more detail on the following pages of the annual report: firstly, it is the energy potential analysis for the city and county of Bamberg and the study on sustainable biogas. We successfully made progress with the latter project in particular, we created the right networks and also a continuous promotion with respect to this subject.

**2** What is becoming more important from the customer's/ industry's point of view?

**2** Anything to do with sustainability and efficient use of resources will become ever more important. Those are the subjects that industry, companies and today's society are grappling with more and more and for which we, as a research institute, are offering new solutions.

**3** What are you hoping for in 2011?

**3** I hope that we will be able to work on many future-oriented projects. And we would absolutely love to position our institute as the expert contact in the area of sustainability.



## RECYCLING OF STAINLESS STEEL SCRAP SAVES MILLIONS OF TONS OF CO<sub>2</sub>

In 2010, Fraunhofer UMSICHT conducted a CO<sub>2</sub> balance for the Oryx Stainless Group. We examined and quantified how much environmentally damaging CO<sub>2</sub> could be saved if high-quality stainless steel scrap were used to manufacture new stainless steel instead of using primary raw materials.

Using a CO<sub>2</sub> analysis, the emissions of particular production processes can be determined exactly – and with that, solutions can be found to reduce these emissions. The production process of steel and, in particular, stainless steel, is very intensive with regards to energy use and raw materials requirements. Globally, the share of energy required for the production of steel is five percent. In view of this background, the German-Dutch Oryx Stainless Group asked UMSICHT to conduct a CO<sub>2</sub> study to find a more efficient way of working with the resources and to indicate where CO<sub>2</sub> could be saved.

The Oryx Stainless Group provides the producers of stainless steel with the raw material mixture they require. The process chain includes purchasing, logistics, analytics, preparation and the correct “mixing” of the stainless steel scraps as well as the transport to the customer. For the CO<sub>2</sub> analysis, UMSICHT examined processes during the manufacture of stainless steel for any emissions of CO<sub>2</sub>. In doing so, the manufacture of stainless steel from high-quality secondary raw materials was compared to those done with primary materials (iron ore, nickel ore, chromium ore, etc.). The Oryx stainless blend from stainless steel scraps was used as a reference value for using high-quality secondary raw materials for the manufacture of stainless steel. The convincing results: on average, the steel-producing industry could save more than 4.5 tons of CO<sub>2</sub> per ton of stainless steel scrap blends that they use.

The methodology in detail: first, UMSICHT, in cooperation

with Oryx Stainless, determined the system boundaries and separated the manufacturing processes into primary and secondary processes. Primary processes include the processes where the product stainless steel is manufactured from primary material. This included the mining of the raw materials, all logistical processes it encompasses and the melting of the primary material in the blast furnace and arc furnace. The secondary process describes how the product is manufactured from recycled material. This secondary process includes the preparation process, such as collecting, sorting and conditioning the material and the utilization process, the smelting in the arc furnace.

### CO<sub>2</sub> balances per ton of stainless steel scrap and stainless steel

Oryx Stainless determined the relevant primary data for the processes indicated for the locations in Mülheim an der Ruhr (Germany) and Dordrecht (Netherlands). Fraunhofer UMSICHT utilized additional data from databases such as GaBI or ecoinvent for its balancing process. Independent experts examined the existing data and the data that was obtained to validate the analysis. During the next step, Fraunhofer UMSICHT calculated the CO<sub>2</sub> balance for all processes per ton of stainless steel scrap and per ton of manufactured stainless steel from primary materials and was thus able to compare the various CO<sub>2</sub> balances and the total savings. All calculated data refer to a single circuit in the economic circuit, even though steel can



be recycled as often as one would like and without any loss of quality. Each ton of stainless steel scrap that is used corresponds to a CO<sub>2</sub> savings of approximately 4.5 tons of CO<sub>2</sub>. The main influencing factor for the CO<sub>2</sub> savings in the stainless steel industry is the share of the ferrous elements and raw iron, which is being replaced by secondary raw material mixtures.

Currently, already 50 percent of the input amounts are stainless steel scraps. If these figures are applied to the entire stainless steel industry and calculated to the projected production numbers for 2015, this means that using 75 percent of stainless steel scrap blend for the manufacture of new stainless steel would mean an additional reduction in CO<sub>2</sub> that amounts to the annual emissions of a mega-city with more than 10 million people. In the medium term, the CO<sub>2</sub> emissions during the manufacture of stainless steel could be reduced by 37 million tons annually or, in other words, be lowered by 50 percent. The prerequisite for that is access to the global stainless steel scrap reserves and an intelligent use of the reserves by using blending. In the next five years, the global production of stainless steel will increase by 50 percent.

*Left image: High-quality stainless steel scrap is a sustainable secondary raw material for the steel-producing industry.*

*Right image: Cutting of metal blocks to extract samples*

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### **Raw materials blend**

Blending is the term used to describe the upvaluation of secondary raw materials by mixing various steel and stainless steel scraps for electric steel mills. This is how important primary raw materials can be replaced and how resources can be utilized more efficiently. The use of Oryx blends saves on iron ore, nickel ore and chrome ore. The Oryx Stainless Group therefore supports, as a consequence of the CO<sub>2</sub> analysis, open world trade markets for stainless steel scraps to achieve the biggest possible CO<sub>2</sub> savings. Recycling also contributes to saving resources and ensures better security regarding supply reliability in the steel industry.



## WAYS TO ENERGY INDEPENDENCE IN BAMBERG IN THE YEAR 2035

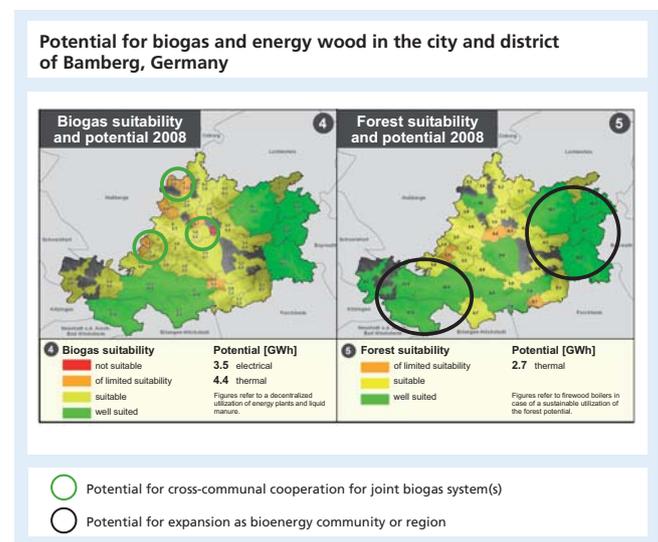
The city and the district of Bamberg, Germany, have, in a joint climate alliance, set the goal to become energy-independent by 2035. To achieve this, they commissioned a potential analysis on renewable energies for these areas. Fraunhofer UMSICHT was responsible for the expert design and the science as well as the implementation of the working program.

Energy independence is defined in this study as the total energy use (heat, electricity, fuels) that will be covered exclusively by renewable energy sources from the region itself. In the first step of the analysis, Fraunhofer UMSICHT identified the necessary data regarding the current energy usage and the store of the existing renewable energies for the city and the district of Bamberg and analyzed them. In a further step, UMSICHT calculated the energy potentials for wind, solar, biomass and geothermal and developed concrete action recommendations, using a strengths and weaknesses, opportunities and threats analysis (SWOT<sup>1</sup>). The project was sponsored by the German Federal Ministry of the Environment, Nature Conservation and Nuclear Safety (BMU).

For the situation analysis by means of a geo-information system (GIS), UMSICHT created a master data sheet for every municipality or city in the region on general data such as inhabitants, housing, energy usage and the respective CO<sub>2</sub> balances, status of the energy sources and their potentials. The people in the region are already very aware of the problems of climate protection. In the area of renewable energies, the German state of Bavaria occupies a top position in Germany by itself. Small and medium-sized companies dominate the economic area.

To calculate the potentials for renewable energies for each municipality separately, UMSICHT developed suitability categories. They show what kind of potential a municipality has for certain renewable energies and what kind of opportunities

to utilize those potentials. The GIS-based depiction of the suitability categories makes it possible to obtain information on the various types of energies for a municipality quickly and,



if required, base action options on them. In the area of biomass, primarily silage corn or grass silage is suited for biogas plants. In this area, wood is used most often in private households. The areas along the rivers are most suited for close-to-the-surface geothermal energy. New locations for hydropower are not available though existing plants could become more efficient. Legal conditions have to be taken into consideration when using wind power, however, wind power has the largest potential for expansion despite this limitation.

## Positive initial situation for energy independence

To answer the question if, when and in what manner the energy independence of the region, the city and the district of Bamberg can be achieved, various scenarios were calculated out. For the first scenario, the use of renewable energies as used in 2008 was continued; in the other scenario UMSICHT calculated the potentials in the area of renewable energies that are possible from a technological, legal and ecological viewpoint as of the status of 2008. Both were compared to the projected energy requirements for electricity, heat and fuel for the year 2035. The differences noted there show a coverage gap between energy usage and energy generation from renewable resources: the potentials for "improvement" to achieve the goal of energy independence by 2035.

In the region, the initial situation for becoming energy independent is basically positive. In comparison to the rest of Germany, the energy used in households, commerce, industry and traffic per inhabitant is less and the share of renewable energies fed into the grid is higher per inhabitant. From the current point of view, the potentials that have been determined are below the projected energy usage for 2035 for heat and electricity. In order to achieve the goal of energy independence in 2035, measures must be implemented in the area of increased efficiency and all potentials to expand renewable energies must be utilized to the fullest. For this, it is important to bundle, for example, forces and expertise by involving citizens or through cooperations. Unified targeted public information work is required so that the measures taken by the climate alliance of the city and the district of Bamberg are put into the public focus and noticed even more.

<sup>1</sup>SWOT-Analyses: Strengths-Weaknesses-Opportunities-Threats

*Image: The goal to become energy independent by 2035 as a result of renewable energies from the region can be achieved. Wind power offers a great deal of potential for expansion. To achieve this, an increase in the efficiency for all existing technologies is required.*



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## Renewable energies

The share of renewable energies in the feed-in of the annual energy output in Germany in 2009 is as follows: 51 percent wind, 31 percent biomass, 7 percent water, 9 percent solar, 2 percent gas. (Source: German Federal Network Agency, 2010)

With respect to the protection of the environment and the climate Germany is the global leader. This is the result of the 2010 Environmental Report. The report takes the results of the environmental policies of the last four years and shows the outlook where further government work could be done. Currently, the German share in the world market for environmental technologies and services is 224 billion euro, which is 16 percent. 1.8 million people find employment in this field, and 340,000 of them work in the area of renewable energies. The core competencies lie in generating energy in an environmentally friendly way and in separating out and re-using waste. (Source: BMU)



## BUNDLING EXPERTISE ABOUT BIOMASS AND PROVIDING REGIONAL CONSULTING

To strengthen the utilization of biomass in Central and Eastern Europe is the goal of the European COACH BioEnergy group project. At its center is the building of a consulting net spanning across all of Europe that provides bioenergy knowledge on the regional level. The Fraunhofer Center for Central and Eastern Europe (Fraunhofer-Zentrum für Mittel- und Osteuropa (MOEZ)) coordinates the entire project. Fraunhofer UMSICHT is responsible for the conceptual creation and the implementation of the virtual consulting network.

Biomass is a renewable source of energy that permits a sustainable and efficient use. The countries of Central and Eastern Europe, in particular, provide the prerequisites for the energetic use of biomass due to their large agrarian areas. By building a broad, demand-oriented consulting network, COACH supports bio-energy project regions in their strategic energy planning and in the implementation of projects in the area of utilizing energetic biomass. Supported by Ukrainian partners, altogether 18 organizations from the Czech Republic, Slovakia, Poland, Hungary, Germany and Austria have been working together in a group for almost three years now, since January 2009. The project is sponsored by the CENTRAL EUROPE program of the European Union.

The job of the scientific project partners – universities and research institutes – is to bundle European knowledge about the cultivation of biomass and its conversion and the logistics thereto and to get it ready for day-to-day life. In doing so, they collect important research results and technological innovations on the various aspects of biomass and its ecological and socio-economic valuation and prepare specific information that is adapted to the region and user-friendly. In this way, the regional consulting offices receive current information about scientific findings and technical innovations that are suitably prepared for the practical requirements of the local participants and that support them in their daily work.

### Access to expert information and individual consulting

In addition to the personal networks a virtual net was built for communication and exchange of information. This virtual net provides the regional consulting offices and the decision makers and interest groups on site with a high-performance information structure.

Fraunhofer UMSICHT designs the demand-oriented virtual network and implements it technologically. The net offers instruments for analysis to calculate energy yields and the potential costs of projects, in addition to scientific data, examples for best practices, feasibility studies, expertise regarding the socio-economic and political development. The scientific institutions feed the required multi-lingual scientific information into the virtual net. The net then automatically transports the information to the regional consulting offices. A multilingual forum is available for concrete questions and a direct exchange of information, which automates the questions and forwards them to the respective specialists. The collection of questions and answers is available to the target group for research purposes. Moreover, the participants may also ask separate specialized questions that are then forwarded directly to the contact office of the regional consulting office. The COACH BioEnergy website is used to access this and other offers on the network.



The target group of the project is decision makers in public administration, as well as local and regional decision makers. The results of the project also serve as an information base to develop regional policies, strategies and business activities in the field of biomass.

*Left image: Countries in Central and Eastern Europe offer good prerequisites for the utilization of biomass.*

*Right image: Altogether 18 organizations have been working on the project since January 2009 – here at the project meeting in Leipzig.*

[www.coach-bioenergy.eu](http://www.coach-bioenergy.eu)

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## Biomass

Biomass is generally considered to be the totality of organic substances that result from or are created by plants, animals or humans. When using biomass for energy-generating purposes, a distinction has to be made between renewable raw materials, plants grown for energy, and organic residuals materials. With a roughly 70 percent share of the renewable energies, the utilization of plant-base biomass (bio-energy) delivers the largest contribution to electricity, heat and fuels. Production processes can be established that are more environmentally friendly and the dependence on fossil raw materials can be reduced. The demand for bio-energy that is increasing globally will also result in an increased demand for technologies. This offers opportunities for exports and also the chance to support climate protection in other countries by means of technology. (Source: BMBF and C.A.R.M.E.N. e.V.)



## SUSTAINABLE BIOGAS

In order to sustainably produce and utilize biogas on an industrial basis, the requirements made by the energy industry, the water and agricultural sector must be harmonized. Fraunhofer UMSICHT developed a feasibility study for a decentralized biogas feed-in system. This system takes all the significant factors into consideration that affect the respective eco-systems and makes a sustainable biogas-generation and distribution system possible.

In regions dominated by agriculture with intense farming of livestock, there are larger hurdles with respect to the production – and feed-in – of biogas in a way that is ecological, economical and that makes sense technologically. During the generation of biogas fermentation residues are produced that are normally utilized as fertilizer. This fertilizer contains nitrate and phosphate which, in high concentrations, affect the nutrition content of the soils and can even endanger the quality of the drinking water. A possible solution to avoid the negative effects by the biogas industry on the environmental areas is called “nutrient management”.

The goal of the research project therefore was to develop a new model of a decentralized biogas feed-in system that has the technical and economic possibilities to use renewable raw materials for producing biogas and to keep the nutrient situation of the soils and the quality of the drinking water in an ecological balance. In addition, the model included an eco-assessment of the climate-relevant process emissions such as methane and carbon dioxide. The study was designed as a model study for the Lower Rhine region, but the technology can be transferred to other target regions. The project was supported by the German Ministry of Economic Affairs, Medium-sized Industry and Energy of the State of NRW (North Rhine Westphalia) and the European Union.

The model offers the basis for calculating differing variations of a decentralized biogas feed-in system with respect to process engineering and cost, while ecological effects can be pro-

jected. Fraunhofer UMSICHT took the entire value-adding chain into consideration, farmers as suppliers of raw materials, operators of biogas plants and users of the fermented residues as well as the gas supply industry, the water industry and the users of gas. With fixed framework conditions set, UMSICHT set forth three possible scenarios in the study for which the biogas potentials were calculated. The “realistic regional” scenario takes the availability of spaces and the availability of liquid manure into consideration; the scenario “agriculture” takes the nutrient situation of the soils on the basis of agricultural specialized law into consideration and the “water industry” scenario includes the quality of the drinking water in the calculation. The model thus included all the affected ecosystems such as drinking water, soils and air. Using geo-information systems, it was possible to determine potential sites for decentralized biogas plants and the biogas collection pipelines as well as restrictions.

During the ecological assessment it became obvious that the nitrogen emissions have a considerable effect on the nutrient situation in the target region if there is a large number of livestock. To be still able to calculate a business model for livestock-intensive regions, the researchers from UMSICHT developed a version in which the operators of the biogas feed-in system turn a part of the fermented residues to fertilizer at a centralized location. This just might be the key technology to improve the nitrate situation in the groundwater in the region that was examined. The condition that was derived from this: when adding biogas plants, a regional fermentation residue and fertilizer

management must be required already during the planning stage.

### Promote the adding of regional value by employing a holistic approach

The study also includes a business plan for a period under review of 20 years. The payment for the purchase of the raw biogas, or rather, the profits, the length of the required raw biogas net and the degree of the necessary processing of the fermenting residues that occur are significant factors. What is absolutely necessary is, above all, a communication concept for the concrete conceptualization to include all participating groups in a way that makes sense.

The ecological advantages of the model at a glance: biogas is generated exclusively from regional biomass. The assumption is for a moderate availability of space, so that there is no utilization challenge. There is no export of unprocessed fermented residue from the region, and the greenhouse gases balance sheet is expected to produce savings in CO<sub>2</sub> gases. For this reason, Fraunhofer UMSICHT recommends a holistic approach to the planning of a biogas feed-in system that is sustainable, and all participants in the value added chain must be involved in this approach. An early cooperation between the sectors water, energy, agriculture and the government takes the burden off the regions, and a regional development can be strengthened. Economic success that can be achieved in the short run should make way for a manner of thinking and acting that offers a permanent perspective for generating energy from renewable resources in concert with the ecology.

*Image: Large numbers of cattle – high nitrogen emissions.  
With a nutrient program that makes sense livestock-intensive regions can still generate biogas in a sustainable manner.*

#### Project partners:

Gelsenwasser AG

PlanET Germany GmbH

Fachhochschule Münster – Münster University of Applied Sciences

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### Biogas feed-in from decentralized biogas plants

The process chain for the generation of biogas in a decentralized biogas plant that the study is based on can be separated into the following steps: raw biogas from liquid manure/non-liquid manure is generated in agricultural biogas plants, decentralized and with assured quality. The next step is preconditioning and compression, thereafter it is fed into a biogas collection pipeline. At the end of this line, the raw biogas is treated at a central treatment plant (methane enrichment) and then it is fed into the transport gas networks. Furthermore, a portion of the fermented residue should be treated. Depending on the treatment quality, biogas can be used in different ways: without separating out the CO<sub>2</sub>, it can be used in combined heat and power plants, with a separating out of the CO<sub>2</sub>, it can be fed-in into the natural gas net or used as fuel for vehicles fuelled with natural gas. For each utilization version the local conditions have to be examined.



# 4 Sustainability

“The future requires research.”

# Sustainability

“Sustainable development is a development that meets the requirements of the present without running the risk that future generations will not be able to meet their requirements.”

(Source: Brundtland commission)

## OUR RESPONSIBILITY FOR THE FUTURE

In the last years, the question to what degree research at Fraunhofer UMSICHT and in the Fraunhofer- Gesellschaft as a whole contributes to a sustainable development, has gained increasing importance. Regarding the subjects of environment, safety and energy, the institute is already featuring three of the central elements of a sustainable development in its name and notably has, for just this reason, the responsibility to take a stand with respect to them.

As an active party in applied research, Fraunhofer UMSICHT has a particular responsibility for sustainable developments: technological innovations form the basis for future sustainable processes and products. Thus, striving for sustainability in research becomes a basic prerequisite (*conditio sine qua non*) that in the future must have the same importance as the factors that are currently being implicitly taken into consideration, like quality, costs and time.

### The Fraunhofer-Gesellschaft prepares its own sustainability strategy

Currently, the Fraunhofer-Gesellschaft is developing a sustainability strategy for the 60 Fraunhofer Institutes in Germany. At the end of 2010, the Executive Board of Fraunhofer appropriated 1.1 million Euro for the internal "Sustainability Strategy" project. The guiding principles are prepared by, among others, Fraunhofer UMSICHT in the open "Fraunhofer Sustainability Network" which 20 Fraunhofer Institutes and research institutions have joined to date. With the first comprehensive sustainability concepts for a scientific research organization as a whole, the decision for which will be made by the Executive Board at the end of 2011, the Fraunhofer-Gesellschaft intends to help the idea of sustainability become more important – internally with respect to research and administration and externally with respect to customers and the public. Thus, for the first time, one of the major domestic scientific organizations is prominently taking a position on the subject matter of sustainability.

In addition to being responsible for developing the guiding principle, Fraunhofer UMSICHT is responsible for the sub-project of the overall project "Sustainable Research and Business Processes". The main objective of this sub-project is the implementation of the idea of sustainability in all research activities, even those for which no direct reference to traditional sustainability subjects can be seen ("sustainable research"). Projects are to be optimized on the operational level to reduce costs, increase the quality and quantity of the results and to comply with ecological and social requirements. In addition, steps are to be suggested and implemented to optimize business processes (travel, personnel development, energy efficiency and resource efficiency, reduction of administrative tasks, etc.).

Since recognized indicator principles are currently in effect mainly for sustainability reporting for companies in the private sector, another important goal is to identify sustainability indicators that also include the concern of research institutions. In addition, sensible instruments must be developed so that these indicators can be documented and followed.

An additional, even more important aspect consists of evaluating the institute's research results with a view to their contribution to a sustainable development. To facilitate this, a "R&D Project Sustainability Management Toolbox" is being developed. The knowledge and implementation aids thus gained are not intended to only work within the Fraunhofer-Gesellschaft – above all, they are supposed to provide additional benefits to customers. An even stronger emphasis on sustainability in R&D



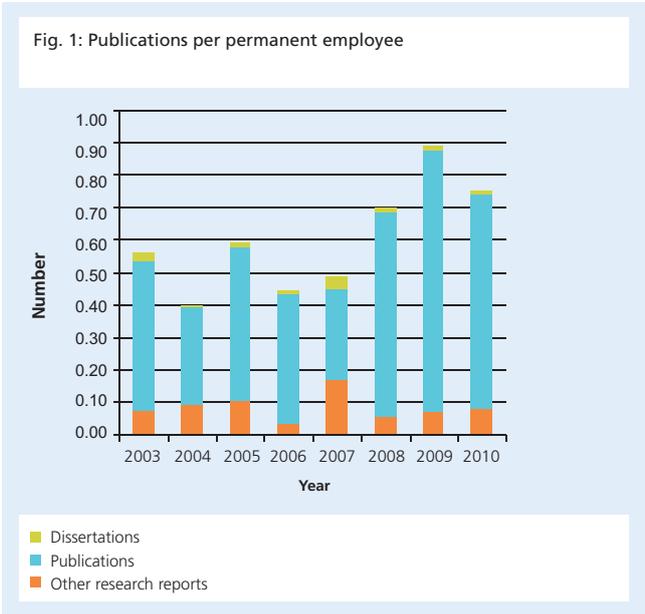
The UMSICHT annual report has a new chapter: sustainability. In addition to the separate sustainability report, which is published every two years, we are now, for the first time in this location, providing information about the current projects for the sustainability strategy of the Fraunhofer-Gesellschaft as well as about the activities of the Sustainability Working Group (Nachhaltigkeits-AG) of Fraunhofer UMSICHT and are introducing indicators selected new every year.

projects leads to even more future-capable products and technologies that ensure increased acceptance and improved ability to compete in the market place and ensure that society is provided goods in the long term that have been produced in a sustainable manner. A serious assessment of the products that were developed in cooperation with Fraunhofer may serve companies as an additional publicity-effective marketing instrument.

The project started in November 2010 and is, for the time being, planned for one year: the declared goal is to contribute to ensuring that the Fraunhofer-Gesellschaft and thus also Fraunhofer UMSICHT responds to its overall responsibility to society even better.

### Sustainability Report at Fraunhofer UMSICHT

In 2010, Fraunhofer UMSICHT published its second sustainability report already. Since the exhaustive sustainability report is being prepared every two years and is supposed to be published only in digital form, there will be a short sustainability report chapter in every annual report. In it, two to three important indicators are introduced and a report is provided in a compressed manner about specific measures. This year, the focus is on indicators that can provide information about the increase in knowledge and research findings. In order to contribute to a sustainable development, the knowledge capital available in a society should be developed such that the economic performance capability can be maintained or improved. One of the additional objectives of a research institute lies in increasing knowledge and innovation; it is maybe this circumstance that accounts for the most important difference to companies in the private sector.



One of the indicators that in this context plays a major role and is very important, in particular for research institutes, is the number of publications. Fraunhofer UMSICHT supports the development of the knowledge capital by publishing scientific papers, dissertations and research reports (see chapter on publications). This published knowledge helps the industry to improve products and services and to produce them in a manner that saves resources. Passing on current findings thus also helps ensure that in future, society will be provided securely with goods that were produced in an environmentally friendly way. In 2010, every one of our permanent staff at Fraunhofer UMSICHT published 0.7 publications, which – despite a slight reduction in comparison to the previous years – constitutes a high level (see Fig. 1).

Building up founded knowledge requires a long-term and intense immersion into the respective field of research. For the purpose of permanently maintaining and expanding knowledge, projects that are rather large and last for several years are more suitable than smaller and short-term projects. As Fig. 2 shows, the average number of projects per staff member before 2006 was around 2.5 projects, and in the last three years the num-

ber was roughly 2 projects per person. In the last few years, the average project duration has increased, which benefits the stability of the research and the permanent gain of scientific knowledge.

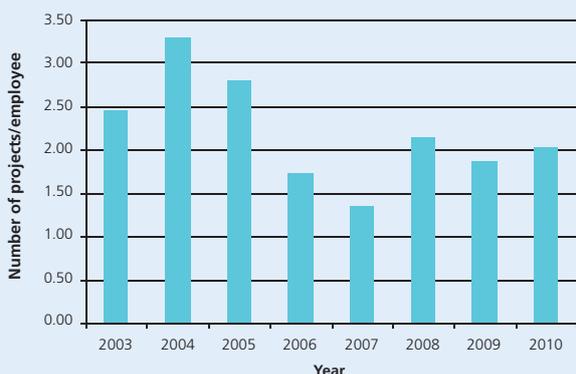
Another significant step for gaining and maintaining knowledge is training. Acting on this, Fraunhofer UMSICHT supported roughly 55 scientific qualification projects by students in 2010 and continually offers its staff numerous internal and external opportunities for continued education. One indicator that proves the importance of training young people at Fraunhofer UMSICHT is the percentage of trainees, which in 2010, with 8.3 percent, reached its highest point to date (see Fig. 3). For Fraunhofer UMSICHT, passing on knowledge is not only a task that directly benefits the institute, but also serves to educate the university students in the region. The interdisciplinary distance learning program for environmental sciences infernum offered by Fraunhofer UMSICHT in cooperation with the distance learning university in Hagen in 2010 celebrated its 10<sup>th</sup> anniversary and 100<sup>th</sup> Master's degree graduate. More info: page 12.

### Implementation of measures

In addition to the constant recording of in-house indicators and their development at the institute it is particularly important to suggest and implement concrete measures. Not only do they make the staff aware of the subject, but they also help save resources and increase employee satisfaction. They are particularly important to ensure that sustainability reporting does not become just another publicity-effective activity.

One example of a measure that was implemented successfully is the "debate" on various subjects taking place at UMSICHT since 2008. This free evening event is not only for all staff, but the invitation is extended to all outside parties who may be in-

Fig. 2: Number of projects per permanent employee



terested. After a discussion of the competing acreage requirements for biofuels and foodstuffs in 2008, the event in 2009 had the "Stability of Financial Systems" in the program. In 2010, Professor Niko Paech from Oldenburg University held a talk and discussions on the subject of "Post Growth Society".

Furthermore, staff was informed during meetings of the institute about the current state of the Sustainability Working



Group at the institute – the intent is to continue this in the future. Staff was also asked which concrete measures they consider implementable in their professional lives so that they, as individuals, can make a small contribution to sustainable development. The 20 measures with the most votes were printed out on posters and hung in all office buildings to help mark the 20-year anniversary celebration of the institute. The feedback provided for this will give the working group new ideas as to in which direction the subject of sustainability at the institute can be developed further. To discuss this with other participants outside the institute, a blog was set up. Last year, the implementation of further measures resulted, for the first time, in a meeting of interested regional participants

on the subject of "Sustainability in the Region". In future meetings in 2011, more participants from Oberhausen and the surrounding area will be taken on board to develop ideas for cooperative or multilateral activities or projects. A regional sustainability conference is already being planned for November 2011.

One of the focal measures of the year will be completion of a concept for a photovoltaic system operated by staff. The "Child Included" office is one of the measures already implemented that is increasingly gaining in popularity. Within the scope of an employee satisfaction survey in all Fraunhofer Institutes, direct questions on sustainability subjects are to be integrated to obtain suggestions for improvement in this area as well. Another important step is the sustainability assessment of our research and development work that is to be carried out specifically on a few selected projects.

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#### Additional information on the Internet:

- Sustainability activities at the Fraunhofer-Gesellschaft: [www.nachhaltigkeit.fraunhofer.de](http://www.nachhaltigkeit.fraunhofer.de)
- You will find the current UMSICHT sustainability report at: [http://www.umsicht.fraunhofer.de/publikationen/nachhaltigkeitsberichte/09\\_nachhaltigkeitsbericht.pdf](http://www.umsicht.fraunhofer.de/publikationen/nachhaltigkeitsberichte/09_nachhaltigkeitsbericht.pdf)
- Information about studies on the environmental science course: [www.umweltwissenschaften.de](http://www.umweltwissenschaften.de)
- UMSICHT blog with subjects on sustainability: <http://www.umsicht-blog.de>

# <sup>5</sup> People

Research has lots of human factors: behind our work, there are people; we would like to introduce some of them to you, since without them we would be nothing.

Nermin Adrovic, Sabine Ajeti-Althoff, Berxedan Ali, Wilhelm Althaus, Thiemo Ansorge, Clemens Backhaus, Carsten Beier, Teresa Belkot, Sascha Berthold, Jürgen Bertling, Ralf Bertling, Siegfried Bleche, Jan Blömer, Pia Borelbach, Julia Borkes, Inna Bretz, Karlheinz Bretz, Birgit Brosowski, Michaela Bruisten, Stefano Bruzzano, Christian Brzoska, Jörg Buck, Martin Buckermann, Björn Bülden, Daniela Buschmann, Leonardo Canello, Petra Corbeck, Philipp Danz, Joachim Danzig, Görgе Deerberg, Christina Demmer, Martin Distelhoff, Christian Dötsch, Boris Dresen, Tim Drews, Günter Drißen, Jan Drißen, Anja Drnovsek, Andreas Dudlik, Mona Duhme, Bärbel Egenolf-Jonkmanns, Ulrike Ehrenstein, Thomas Eisenburger, Christina Eloo, Arif Emini, Christoph Epping, Rene Dirk Eppler, Anna Fastabend, Klaus Feja, Walter Fischer, Jasmin Folly, Geza-Marie Frahn, **Huasheng Gao**, Jane Garstka, Ilka Gehrke, Anja Gerstenmeier, Ute Gessner, Marcel Gewehr, Kai Girod, Christoph Glasner, **Markus Gläßer**, Patrycja Gondek, Jürgen Grän-Heedfeld, Anna Grevé, Johannes Grob, Sofian Bastian Guetari, Lucian George Hanu, Ernst Heiken, Erika Heiken, Volker Heil, Torsten Hennig, Markus Hiebel, Joachim Hillers, Sabine Hillesheim, Damian Hintemann, Kerstin Hölscher, Nils Hohmann, Björn Hunstock, Aylin Hustermeier, Michael Jandewerth, Georg Janicki, Erich Jelen, Nina Junen, Stephan Kabasci, Christel Kang, Annedore Kanngießer, Tobias Kappels, Nicole Karow, Lena Karsch, Ulrich Kern, Anneliese Kesselring, Volkmar Keuter, Andreas Kilzer, Thomas Klein, Uwe Kleinwegen, Kerstin Klocke, Thomas Klose, Nina Kloster, Volker Knappertsbusch, Christian Knermann, Michael Knoll, Sabine Köhler, Rodion Kopitzky, Hans-Jürgen Körner, Axel Kraft, Joachim Krassowski, Simone Krause, Burkhard Krüger, Peter Krüger, Iris Kumpmann, Joanna Kurek, Kai Andreas Laichter, Kay-Uwe Laux, Bernd Lehrke, Frank Letzner, Miriam Löffler, Heiko Lohmann, Daniela Lucke, Hildegard Lyko, Daniel Maga, Thomas Marzi, Karl Meller, Andreas Menne, Stefan-Mario Menning, Ute Merrettig-Bruns, Michael Metz, Gertrud Michels, Edda Möhle, Nils Mölders, Gerhard Mrosek, Asja Mrotzek, Christine Mühleib, Ralf Müller, Torsten Müller, Judith Mundt, Sandra Naumann, Anke Nellesen, Nicole Nowara, **Rasit Özgüc**, Thomas Ombeck, Katrin Ortmann, Gabriela Ortmann, Eva Otter, Sylke Palitzsch, Frank Pape, Ralf Paucker, Sebastian Pfeifer, Hartmut Pflaum, Udo Piontek, Astrid Pohlig, Clemens Pollerberg, Sebastian Pörschke, Sascha Pott, Henry Rübiger, Krishnan-Venkata Rajendran, Svenja Raschke, Marcus Rechberger, André Reinecke, Manfred Renner, Jens Reschke, Manuela Rettweiler, Thorsten Ricker, Josef Robert, Susanne Rölleke, Iris Romeike, Jorge Iván Salazar Gómez, Olga Salijow-Samus, Kenny Saul, Bettina Sayder, Elisabeth Schaberg, Florian Schellhase, Peter Scheuern, Eva Schieferstein, Stefan Schlüter, Aline Schnur, **Sabrina Schreiner**, Ludger Schrempf, Andreas Schröder, Stefan Schroer, Anita Schulze, Tim Schulzke, Kerstin Schwarze-Benning, Peter Schwerdt, Ulrich Seifert, Andreas Sengespeick, Annette Somborn-Schulz, Martin Spitz, Richard Sprick, Andrea Springer, Esther Stahl, Jürgen Stein, Sabine Strauch, Max Tapavicza, Simone Taube, Peter Timmermann, Christoph Unger, Barbara Vatter, Holger Wack, Thorsten Wack, Andreas Weber, Stephanie Wehr, Eckhard Weidner, Kevin Werth, Katharina Weßling, Andrea Paula Wilmsen, Thomas Wodke, Daniel Wolf, Heike Wünnenberg, **Kim Florian Wüstkamp**, Barbara Zeidler-Fandrich, Stefan Zepnik

# OF SOURCE CODES, CLOUD COMPUTING AND AUSTRALIA

The avid bicyclist and bicycle DIYer Kim-Florian Wüstkamp comes from Oberhausen, Germany, and works as an IT specialist in the application development area. After obtaining his intermediate school leaving diploma, the now 22-year old entered into a school training program to become an IT assistant.

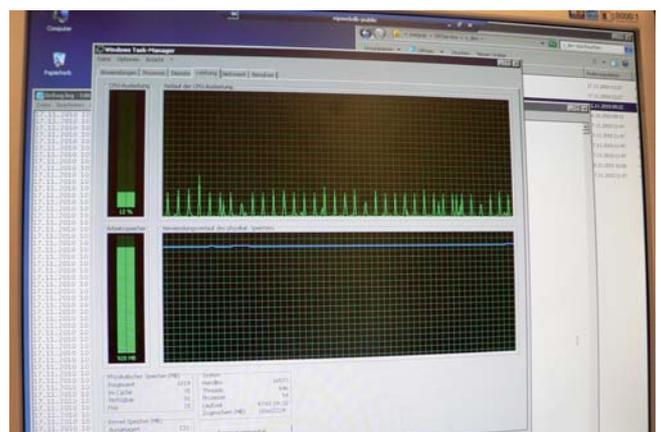


*As early as age 15, Kim discovered his still unwavering enthusiasm for computers.*

For the practical portion of this training, he decided for an internship with Fraunhofer UMSICHT. UMSICHT liked the computer enthusiast and hobby guitarist so much that he was immediately offered an apprenticeship training position. That this was a good decision was proven when Kim was honored as the best by the IHK, the Chamber of Commerce and Industry, due to having received a final degree of A and an award by the Fraunhofer-Gesellschaft as one of the best trainees of his year of graduation. The editorial team of UMSICHT asked him three questions.

## **What are the responsibilities of an IT specialist in the area of application development?**

You plan, develop and execute applications. On the one hand, you learn programming during your training, meaning the writing of source code, and on the other hand, you learn how to realize a whole project. Typically, the sequence of events is such that you meet with a customer, discuss his or her expectations regarding web pages or web applications, and then implement them. In-house, meaning at UMSICHT, the majority of my activities focus on project web pages of the business units and platforms for communication or data exchange. Off-site, many other Fraunhofer Institutes are among our customers. In addition, we are also quite often accepting orders from private enterprises. In general, we develop



*Resource monitor for monitoring server load*

custom applications for our external customers. This means, not a software of which millions of copies are sold, but rather programs directly customized to the customer's requirements which is used by two or three customers at a branch at most.

### Why did you stay at UMSICHT after finishing your training?

At UMSICHT, trainees typically receive a one-year contract after graduating from their training. This time is intended for orientation and to be able to gather initial job experience. My plan is to start on a college or university degree in my discipline or in the area of media and design once that year

### Which IT topics of the future are you interested in?

I am particularly interested in the areas of cloud computing and web applications in the browser: at present, we are in a phase where all programs one has on the computer are being replaced so that they can simply be opened through the browser. If you simply project this ten years into the future, the local computer will be nothing more than a browser. That is quite exciting to me.



*Kim, while planning the current project*

is up. But before doing so, I will go to Australia for one year, starting in April. There I will participate in the so-called Work & Travel Program, in which you earn money through odd jobs in different locations. I would like to first get to know the country a bit better and to travel. In the last three months, I would like to be a trainee at an IT company. That is what I am taking care of right now.

## ALLROUNDER IN THE BACKGROUND

What is it that industrial mechanics actually do? And what do they do at Fraunhofer UMSICHT? To find out, the editorial team of UMSICHT followed Markus Gläßer (age 21), industrial mechanic by profession, around for one day.

The day starts early for the guys at the workshop. Twenty minutes to eight, sharp, is when the work starts, but Markus is there even earlier since a change of clothes is required before work. "Working in everyday clothes is impossible since the work is rather dirty," he explains. Once the clothes are changed, he first goes to the office. What has to be done is defined in weekly plans and is once more distributed during the daily early meeting. For a reminder, Markus takes a look at the board. Here, he finds the list with everything that needs to be taken care of: a heater needs to be repaired, and the remaining pallet jacks that he had not been able to finish the



*Markus repairs the pallet jack with patience und accuracy.*

previous day are also still waiting. The floor conveyors have

lost oil. But the athletic Markus – who recently started to practice indoor climbing in addition to the weight training at the fitness studio where he works out three times a week – is quite capable of handling this. He is one of seven men who keep the



*His own workbench is perfectly organized.*

infrastructure at UMSICHT running smoothly.

As employees of the "Central Technical Services" department, they perform work that for the most part nobody sees but that keeps everything up and running, like laying water pipes or repairing machines. On the other hand, they are also quite often

participating in projects since they manufacture prototypes from various materials. As such, the industrial mechanics are among the true allrounders at UMSICHT. Markus likes everything about his job – but especially the repair and maintenance tasks as well as “all things mechanical and that you can do something with your hands. What I like most, are especially welding and working on the lathe.”

Markus, who was born in Oberhausen und is living in Bottrop, learned the metal processing that is typical for industrial mechanics, which he describes as “welding, lathing, milling, drilling, countersinking and polishing” from the ground up at UMSICHT. In addition, he is the living embodiment of the motto “Cleanliness + Order = Safety”, practiced at the work-

Markus laughs this away.

At 4 PM it is finishing time. The day has passed rather quickly. Markus had quite a lot to do but that is how he likes work best. “I don’t like to sit around without anything to do”. But due to the diverse work this does not happen. “I prefer having a lot to do.” Now just a change of clothes and then he is heading home. How to let the day end, he is deciding on a whim. Maybe he’ll be visiting a friend or his girlfriend, or go to the gym, or start reading the book “Bayou of Pigs” by Stewart Bell. That one he bought because of its quite interesting sounding German title: “Come on, let’s steal an island”.



*The large protective glasses must not be missing during his favorite work activity, welding.*

shop and punched on an aluminum sign. Not only is this reflected in his own work bench which has the correct appearance, but also in the meticulously lined up tools that he has laid out for the repair of the pallet jacks. Despite the rather tight rules at the workshop painted in gray-green, the atmosphere seems to be extremely relaxed amongst all of them. That’s why you have to be able to handle comments like “Wouldn’t have hurt if you had taken care of your hair for the photo shooting”.

## MATERIAL SAMPLE RAIDER FOR HAPTICS

Haptic perception is congenital, just like our other four senses. But that her teachings, haptics, as opposed to optics and acoustics, so far have been completely neglected is hard to understand when you start to think about it. Qualified designer Sabrina Schreiner thinks so, too: "Especially against the background that the sense of touch is among those capabilities that are developed first in the mother's womb, it is unbelievable that there still is no fundamental work for this field."

As such, it is also no surprise that the 26-year-old came to the topic of haptics without any prior knowledge. As part of her industrial design studies at the Folkwang University in Essen, she was looking for a topic for her thesis in 2009. She found it in the job offerings of UMSICHT which included an advertise-



*At first glance, the plastics samples all look the same. Their differing structure can only be sensed.*

ment specially targeted at industrial designers. It did not take long until she caught fire for the exciting area of haptics. The haptics test station was developed by the scientist from the Bergisches Land jointly with a team of technicians. "The

concept of this test station is to collect and query subjective impressions that a person has of material while said person is feeling the surfaces," that is how Sabrina Schreiner describes



*During tests, the qualified designer has the option to choose from various profiles such as video recording or force recording.*

the purpose of the station in brief. During this time, data is

generated based on thermography, force measurement, skin condition and finger movement. The purpose of these tests is to find correlations. The focus is on identifying on how objective conclusions can be derived from the test subjects' subjective data in combination with the test station's analyses. Sabrina Schreiner knows that the subjective work in particular



*The different materials are mounted on the force measurement plate for analysis.*

has a deterrent effect on many since it is considered non-scientific, but she explains: "In the area of acoustics, the methods are in principle the same. There, for instance, you test how a vacuum cleaner should sound in order to be given the impression of full suction power. By using subjective methods, acousticians then can develop methods to filter out undesired noise." In theory, all materials can be felt on the test station, however, the team around the design is primarily dealing with plastics. The reason for this is that on this material, as opposed to metal or wood, a particular large number of different textures can be created. To conduct broad tests, the employee of the materials and interaction business unit, according to her own statement, has become a hunter and gatherer of material samples for haptics.

Sabrina Schreiner herself favors soft-touch surfaces, meaning surfaces that present a soft optical and haptic effect. A coated

material, for example, can feel soft even though the core material is very hard. This surface softness results from the skin's contact surface with the material and, for example, not because it can be indented. "People generally have a lot of different perceptions of what they consider to be 'soft'. For this reason, it is important to introduce known rating scales in case of test subject tests. In haptics tests, these quite often correspond to the school grades. Yet, it is not just the different understanding but also the differing condition of the skin that leads to diverging results. For instance, a surface that feels slippery with dry fingers may be perceived as sticky with wet hands. Accordingly, effects can be completely turned around, depending on the condition of the skin," explains the haptics expert.

The areas of use of haptics research is endless and can range from the automotive area over cell phone manufacturing to packaging for bottles of shampoo. It has not yet been decided with which specialization the team at UMSICHT will deal.

Because, to expand the pre-research to a concrete project, sponsors have to be found now, first. Once they have been found, the designer definitely wants to find a lot of results, "and then thinking of a doctoral dissertation might be an option. Let's see what the year ahead will bring." We wish her good luck for this. More info: page 48.

# HUASHENG GAO: CHINESE VISITING PROFESSOR CONDUCTS RESEARCH AT UMSICHT

Foreign culture, foreign country, foreign language. All this Huasheng Gao took on in order to conduct research at Fraunhofer UMSICHT. And why? Because UMSICHT's good reputation reaches all the way to his homeland of China. Supported by the Fraunhofer Fellowship Program "PROF.x2" and the "K. C. Wong Magna Fund" of Ningbo University, the professor set out on his trip. Shortly before his return home, the 45-year-old is telling us what he had wanted to achieve during his eight-month stay in Germany and which intercultural experience he gained during his first visit to Europe.

## Why did you come to Fraunhofer UMSICHT?

In China, we know that the Fraunhofer-Gesellschaft for Applied Technology Development not only is the most important research organization in Germany, but in all of Europe. That I am now at the Fraunhofer Institute UMSICHT is due to a visit of the deputy director, Prof. Görges Deerberg. As a member of the Fraunhofer-Gesellschaft he was a guest at a congress in Ningbo on the topic of "Innovative Water Technologies" in 2009. At the conference, we learned a lot from him and other members of the delegation about the Fraunhofer-Gesellschaft and the UMSICHT Institute. That is why I decided to work here as a visiting scientist, supported by my university.

## In which area specifically are you working at UMSICHT?

In the last 30 years, the newly arising industries and the accelerated urbanization in China have led to an increased demand for water supply and to a serious pollution of water bodies. To get a handle on these problems, we have to find new solutions for cleaning the wastewater. Because, at the respective quality, this water can then be reused in the areas of private households, industry, and agriculture. At UMSICHT, we have worked on the development of innovative, dynamic

filtration technologies which can be used cost-effectively for wastewater treatment and reclamation. In combination with a biological treatment, this technology can be used for a small

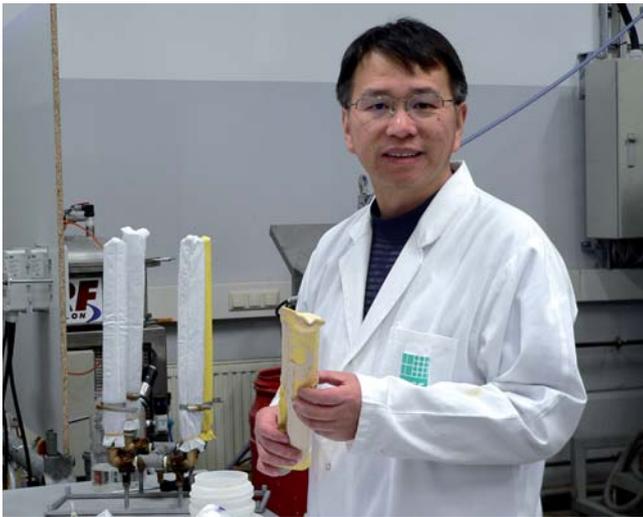


*Huasheng Gao in the laboratory, together with students Sabrina Lohmar (l.) and Jessica Fenty*

wastewater treatment plant based on a membrane bio-reactor (MBR). Not only can this special technology provide water of a higher quality at its outflow than that from conventional small wastewater treatment plants, but it is also significantly more cost-effective.

## Is working at UMSICHT different from working in your home country?

Yes, the work is completely different. However, that is primarily because I normally teach at a university and at UMSICHT I am working as a scientist. If I compare my experiences from the area of research in China with those in Germany, then there are better opportunities at a German institute to work together with



*The objective for the research work at UMSICHT was to develop an innovative, dynamic filtration technology for the treatment and reclamation of wastewater.*

specialists of diverse backgrounds and training in that you can get the help of both students and scientists from other countries. Furthermore, the exchange with other institutions and abroad seems to function better. I think, we should promote this type of personnel exchange in China. In addition, I find the concept of student aids exemplary, in particular, since it provides students with an opportunity to gain initial job experience and the institute maintains and expands its contact to the universities this way.

#### **What will you take with you to China after your return from Germany?**

My eight-month stay in Germany has really been worthwhile. At UMSICHT, we have worked on a new wastewater treatment technology and have already been able to complete several successful tests. In China, I will continue to work on this with colleagues. But, not only will I take this promising technology with me to China, but also my understanding of the development and application of environmentally friendly technologies in Germany and my experiences in scientific research and project work at a Fraunhofer Institute. But also my impression of the Germans and their sense for environmental protection as

well as the German students, due to the quality of their work, will remain on my mind.

#### **What do you like to do in your leisure time?**

My leisure time is very limited since I spend most weekends working for my university in Ningbo. In addition, I have to get up very early in order to take advantage of the time difference between Germany and China. Typically, I do this in the morning, before going to UMSICHT. My daughter is 13 and is attending a junior middle school in China. I am trying to meet with her on the Internet each Saturday afternoon and chat with her. During the summer, when the days are longer, I also like to ride a bicycle after dinner or to take a walk at the canal or around the Gasometer. And since the Gasometer as a landmark can be seen well from everywhere, I never had to worry about getting lost.

#### **Did you notice the activities of the Cultural Capital "RUHR.2010"?**

Yes, of course. Especially the Gasometer, the Oberhausen symbol particularly of RUHR.2010, I know very well. But I have also taken a look at some other industrial monuments of the Ruhr region, such as the mine and coking plant Zollverein in Essen and the Duisburg-Nord Landscape Park. It is really interesting and inspiring that these old plants were converted into parks and museums. Thanks to their restoration, they received new functions and this way can tell the younger generations about the city's past. What I am most impressed with is the fact that the Ruhr region, which was characterized by heavy industry and heavy pollution even just a few decades ago, has turned into a really beautiful place with a varied culture and recovering ecology.

# RASIT ÖZGÜC MAKES LAMPS SAFE AND COMPATIBLE

Volker Heil, an employee in the Biofuels business unit, originally approached the electrical engineering master Rasiit Özgüc, an employee in the Materials and Interaction business unit, because he was worried his child might receive an electric shock while playing with the nightstand lamp. In 2003, they jointly developed the so-called "Kids' Light," a lamp unit that was safe from electric shock not only while the bulb was being changed, but also additionally did not provide any reason for worries if the child might play with its socket.

Through this idea, 34-year-old Rasiit Özgüc, jointly with Volker Heil, arrived at the current development: a novel safety circuit for LED bulbs which makes the installation of complicated and fault-prone external safety circuits superfluous. "The problem that LED light media have, as opposed to regular fluorescent tubes, is the safety gap during insertion. Because, when you touch one end of the tube during installation while the other is already in the socket, you receive an electric shock," explains the resident of Dinslaken. "With conventional fluorescent tubes, these problems do not exist because they use a gas as light media that acts as an insulator when not switched on. The new LED tubes, on the other hand, feature an electrical consumer inside which has a resistance and therefore is conductive." For this reason, none of the LED tubes on the market to date has received a TÜV, let alone a GS ("Tested Safety") certification mark.

In a team with Udo Piontek from the business unit Information Technology in Process Engineering, Rasiit Özgüc and Volker Heil developed the safety and compatibility device. Thanks to this device, LED lamps as replacements for T8 fluorescent tubes with double-ended caps will receive this safety seal in the future. Aside of avoiding accidental voltages, the new technology also has the following additional advantages,

according to Rasiit Özgüc: "In addition, LED bulbs equipped with our safety technology guarantee full compatibility with existing luminaires. This means that when the lamp is installed, no modifications to the wiring and components need to be performed, since it works according to the "plug and play" principle. These "retrofit LED lamps" will be available in all common color temperatures and will feature more than 50 percent energy savings in comparison to conventional fluorescent tubes and will feature a significantly longer useful



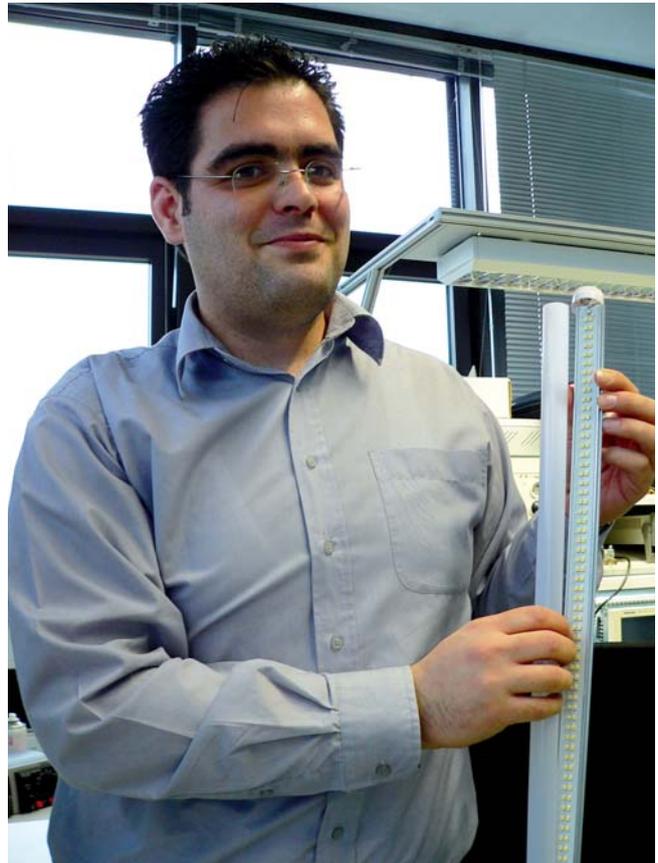
*The LED tubes are subject to several tests, such as with respect to their life or energy consumption.*



*While soldering the safety device*

life. Their use would be particularly advantageous in retail stores and at discounters such as in supermarkets or similar locations, since the lamps there are lit approx. 14 hours per day.

Rasit Özgüc, who has been working at Fraunhofer UMSICHT since 1996, is very proud of the fact that the usage rights to the industrial property rights for the safety device developed at Fraunhofer UMSICHT were exclusively licensed Europe-wide rather quickly. The father of two is looking forward towards spending a little more time with his family after a year of hard work. Both his family and his hobby, playing soccer, came up short recently because, in addition to his work at UMSICHT and his volunteer work as a tester at the Chamber of Commerce and Industry of the city of Essen, he also wrote two books (Specialized Knowledge for the Electrical Profession, Learning Situations and Tasks) for the cooperative degree training of electronics.



*Rasit Özgüc is presenting the innards of an LED tube.*

# <sup>6</sup> Technical shops & laboratories

Overview of our technical equipment

Research requires space.

We are making available more than 4,500 square meters for our:

## Technical shops & laboratories

# TECHNICAL SHOPS

Fraunhofer UMSICHT makes an expansive technical infrastructure available for the performance area of product and application oriented research and development that is closely intertwined with the laboratory areas of the institute. Here, we are presenting the portfolio of the technical shops, the test, pilot and demonstration installations on a selected excerpt basis. If you have any questions concerning applications, please do not hesitate to contact the specialist for that field.

## PLASTICS TECHNICAL SHOP

At the Willich site, Fraunhofer UMSICHT offers comprehensive services in the areas of plastics and recycling technologies, always customer-oriented and product-oriented. Biodegradable plastics, polymers from renewable resources, resource-friendly materials, nanocomposites and recyclable plastics are being developed systematically and manufactured in pilot series and small batches. Process optimization, analytics and test engineering, recycling concepts, market and feasibility studies round out the portfolio of the plastics technical shop.

The plastics technical shop is separated into a material laboratory, a compounding technical shop and a testing laboratory.

After the development and the optimization of the compounds in the materials laboratory, larger sample amounts can be produced in the industry-like compounding technical shop. Six twin screw extruders with a throughput performance of 10 to 600 kg/h are available for this. The short development times that can be achieved when up-scaling offer our clients an advantage in the market when launching products. Concurrent with the development of processes and materials, mechanical and tribological material indicators are determined in the test laboratory, and analyses on the rheology are carried out, as well as on the thermal behavior, the chemical composition and the structure.

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## MEMBRANE TECHNICAL SHOP

Membrane processes are an ecological and economical alternative to the traditional cleaning and recovery processes. Very often, laboratory and pilot tests are required to evaluate the separation behavior of the membrane. Test stations and installations for microfiltration, ultrafiltration and nanofiltration, and installations for reverse osmosis as well as microsieving filtration are available for on-site operations. Suitable processes were selected based on preliminary examinations, on the basis of which membrane processes are being developed for obtaining recycled materials, for the recycling of water and for downstream processing. Systems engineering to produce microsieves, membranes and membrane modules complete the technical infrastructure.

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## PARTICLE TECHNICAL SHOP

The market for customer-specific, powdered substances with defined distribution of particle sizes is growing all the time. Temperature-sensitive, visco-elastic and fibrous materials can be shredded only with a great expenditure of energy and costs. In its particle technical shop Fraunhofer UMSICHT uses innovative chilling technology to develop suitable solutions.

The range of the R&D goes from test grinding and sample batch production to ten tons, from classification, feasibility and profitability studies to cryogenic fragmentation (including process



development) to the development, planning, construction and optimization of customer-specific grinding installations. A sintering station as well as a sintering test station are completing the particle technical shop.

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### HIGH PRESSURE TECHNICAL SHOP

In its high pressure technical shop, Fraunhofer UMSICHT has facilities for the impregnation as well as processing of plastics and for atomization by means of super-critical carbon dioxide. In the high pressure technical shop, pressures up to 500 bar and temperatures of up to 250 degrees Celsius can be achieved. Through-puts of up to 100 kg/h can be realized for high-pressure compounding and high-pressure spraying. The high-pressure facilities can work with sample sizes of 63 milliliters to 20 liters. The portfolio of facilities includes, among other things, a semi-industrial research and production facility to generate particles according to the PGSS® and the CPF process.

The high pressure shop is working on the following projects:

- Production of polymer powders using high-pressure spray processes
- Optimization of the mixing effect and wetting during the melt-mixing
- Impregnation and modification of polymer materials and components
- Process-integrated separation of residual monomers and solvents

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### BIOMASS TECHNICAL SHOP

The inclusion of biogenic energy materials into the existing structure for supplying energy is an important step in a power supply system that is geared towards sustainability and future-capability. The central task of research consists of finding and tapping into alternative energy sources and to make them usable with suitable technologies.

For the mechanical and thermal preparation of biomass and the thermal conversion of herbaceous and timber-based biomass and the mechanical preparation of various types of biomass Fraunhofer UMSICHT keeps machines and devices available. They range from installations for flash pyrolysis and rotary kilns for biomass conversion to grinders and shredders for cutting to the briquetting press and pelleting press for molding. The quantitative analysis of biogenic gases such as biogas, landfill gases and waste treatment gases takes place in the laboratories of the institute.

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### TEST STATIONS

- for cutting plastics,
- to stimulate powders to vibration,
- for impact crushing,
- for measuring swelling pressure,
- for biogenic sulfuric acid corrosion (BSK) as well as
- the examination of haptic perception of plastic surfaces,

just to mention only a few, are rounding out the portfolio of the technical infrastructure.

# LABORATORIES

Fraunhofer UMSICHT has a widely varied laboratory infrastructure, in which cross-functional teams from science and technology are working.

## CHEMICAL ANALYSIS LABORATORY

Having an analysis that is precise and reliable is a prerequisite for working on environmental and process-engineering problems. The institute has a well-equipped laboratory available for this, it also includes the latest analytical system combinations. The broad range of the services on offer include standard procedures as well as, in particular, the development of innovative, custom-tailored methods. Examples from our analysis portfolio include:

- Chromatographic methods: HPLC, GC, IC, GPC with different detectors: FID, MS, ECD, DAD, RI  
Analysis examples: organic acids, alcohols, sugars, hormones, PFT, siloxanes, PAK
- Element analytics with ICP-OES
- Elementary analysis, released carbon (TOC), calorimetry, BET
- The focus is on characterizing fuels and biobased oils, greases and fossil fuels.

The validation of the results of the measurement is carried out, among others, by comparing them with those of outside laboratories (round robin tests).

## BIOTECHNOLOGY LABORATORY

The biotechnological laboratory handles tasks regarding the cleaning of polluted media (water, soil, air), examines biological decomposition and production potentials and develops novel microbiological processes, from a laboratory scale to a technical shop scale.

As an approved testing laboratory in the federal association of compost quality standards (Bundesgütegemeinschaft Kompost) and an approved testing laboratory of DIN CERTCO for

the compostability according to the industrial standards DIN EN 13432, DIN EN 14995, and ASTM 6400, we offer:

- Microbiological analyses in accordance with DIN, ISO and OECD processes
- Testing of biological degradability under aerobic and anaerobic conditions (e.g., AT4 and GB21 as per regulations governing waste disposal)
- Development of biotechnological production processes
- Fermentation tests in accordance with VDI guideline 4630

## PHYSICS LABORATORY

The portfolio for the characterization of materials for material-scientific questions includes:

- Particle size and shape (among others, static and dynamic dispersion of light, sieving, microscopy)
- Interface properties and structure of pores (among others, tensiometry, electrophoresis, gas sorption)
- Composition, structure and phase transformations (among others, thermoanalysis, rotational rheometry, IR spectroscopy)
- Determination of mechanical parameters (among others, tensile tests, impact bending tests, tribological measurements)
- Thermoanalytical methods: DSC, TG (to 1,000 °C and STA to 1,600 °C)
- Spectroscopic methods: IR (reflection and transmission, inline-/online coupling, TG-IR coupling, film press), UV/VIS, IR databases

## CHEMICAL LABORATORY

The chemical laboratory includes:

- Parallel vessel systems, reaction calorimeter
- Biofuels: small technical installations to produce and clean



biofuels (mini-installation to produce biodiesel, short path distillation)

- Small technical installations for the cleaning and concentration of product streams (rectification, extraction, crystallization)
- Chemical synthesis, protective gas and vacuum installations as well as pressure vessels, utilization of special gases

#### HIGH PRESSURE LABORATORY

The high pressure laboratory consists of four test facilities equipped with modern measuring and automation technology:

- Two fixed bed reactor systems that are laid out for different throughputs,
- a discontinuous stirred tank reactor and
- a plant for the chemical conversion of biogenous synthesis gases.

The fixed bed reactors and the stirred tank reactor are fully automated and therefore can be operated around the clock. An IR device with sensors that is suited for high pressures and temperatures is available for online monitoring.

#### ENERGY STORAGE LABORATORY

battery-lab.umsicht.fraunhofer.de



#### Lithium-battery test laboratory

Fraunhofer UMSICHT operates a testing set-up for lithium batteries with which they can be examined and tested independently in a selectable test environment.

Range of R&D:

- Testing of lithium battery packs for mobile and stationary applications
- Performance and durability tests
- Testing with standardized or freely selectable test cycles
- Impedance spectroscopy
- Development of battery models

#### REDOX FLOW BATTERY TEST LABORATORY



Fraunhofer UMSICHT operates one of the largest testing laboratories in Europe for redox flow batteries in which it is possible to not only test individual cells, but also large stacks and which can be tested separately from the selectable test environment.

Range of R&D:

- Development, design and construction of redox flow battery stacks
- Measuring of redox flow batteries
- Selectable operating parameters
- Reproducible test environment
- Impedance spectroscopy
- Development of battery models

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#### Contact

##### Chemical analysis laboratory

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##### Biotechnology laboratory

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##### Physics laboratory

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##### Chemical laboratory/High pressure laboratory

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# <sup>7</sup> Network

Fraunhofer, Board of Trustees,  
UMSICHT Circle of Friends and Patrons,  
Involvement with Universities

Luckily, we are not alone in this world. We construct networks, link into existing networks, work in cooperation with partners, friends and patrons. We are happy to introduce some of them to you.

## Network

# FRAUNHOFER-GESELLSCHAFT GROUP FOR PRODUCTION

## The Fraunhofer-Gesellschaft

Research of practical utility lies at the heart of all activities pursued by the Fraunhofer-Gesellschaft. Founded in 1949, the research organization undertakes applied research that drives economic development and serves the wider benefit of society. Its services are solicited by customers and contractual partners in industry, the service sector and public administration.

At present, the Fraunhofer-Gesellschaft maintains more than 80 research units in Germany, including 60 Fraunhofer Institutes. The majority of the more than 18,000 staff are qualified scientists and engineers, who work with an annual research budget of €1.65 billion. Of this sum, more than €1.40 billion is generated through contract research. More than 70 percent of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Almost 30 percent is 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 until five or ten years from now.

Affiliated international research centers and representative offices provide contact with the regions of greatest importance to present and future scientific progress and economic development.

With its clearly defined mission of application-oriented research and its focus on key technologies of relevance to the future, the Fraunhofer-Gesellschaft plays a prominent role in the German and European innovation process. Applied research has a knock-on effect that extends beyond the direct benefits perceived by the customer: through their research and

development work, the Fraunhofer Institutes help to reinforce the competitive strength of the economy in their local region, and throughout Germany and Europe. They do so by promoting innovation, strengthening the technological base, improving the acceptance of new technologies, and helping to train the urgently needed future generation of scientists and engineers.

As an employer, the Fraunhofer-Gesellschaft offers its staff the opportunity to develop the 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 in industry by virtue of the practical training and experience they have acquired.

The Fraunhofer-Gesellschaft is a recognized non-profit organization that takes its name from Joseph von Fraunhofer (1787-1826), the illustrious Munich researcher, inventor and entrepreneur.

## Group for Production

Fraunhofer UMSICHT is a member in the Fraunhofer Group for Production. Seven Fraunhofer Institutes have joined together with the goal of jointly working on production-oriented research and development to be able to offer the customers in industry, trade and the service sector comprehensive holistic solutions to problems from one source by bundling the manifold expertise and experience of the individual institutes.

# ALLIANCES FRIENDS AND PATRONS

By using the latest findings from production and engineering and computer sciences, the Fraunhofer Group for Production is offering a range of services that comprises the entire production cycle and/or the entire value added chain.

## Focus of the group:

- Product development
- Manufacturing technologies
- Production systems
- Production processes
- Production organization
- Logistics

## Fraunhofer Alliances

In addition, UMSICHT is participating in seven Fraunhofer Alliances. These alliances have joined together with the intention to jointly work on a business segment or to market it. They consist of institutes or departments of institutes that have different competencies. In its work, UMSICHT concentrates on the following alliances.

- Automotive production
- Construction
- Energy
- Generative production
- Lightweight construction
- Numerical simulation of products and processes
- SysWate

## UMSICHT Circle of Friends and Patrons

The "Verein zur Förderung der Umwelt-, Sicherheits- und Energietechnik e.V." (Association for the Promotion of Environmental, Safety, and Energy Technology) works in the area of applied research in the areas of environment, safety and energy technology.

The UMSICHT Circle of Friends and Patrons flanks the measures that strengthen the role of Fraunhofer UMSICHT in the region and on the market for applied research. The coal and steel-producing areas of North Rhine-Westphalia that are subject to structural changes in particular can thus access the future-capable and sustainable developments in technology. The members of the UMSICHT Friends and Patrons Group are utilizing the R&D network of the Fraunhofer-Gesellschaft. They are informed in a timely manner about promising future trends, they can initiate their own research projects and contribute to establishing important fields of research in the region.

**The UMSICHT Circle of Friends and Patrons is open to new members! We invite you to become a member, as well.**

They promote research and development, strengthen their scientific-technical reputation and invest in the upcoming generation of managers in industry. They use the services that Fraunhofer UMSICHT offers exclusively to the members of the Friends and Patrons Group.

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## SCIENCE AWARD

For the first time, the Fraunhofer UMSICHT Circle of Friends and Patrons awarded the "UMSICHT science award for industry and market-oriented research in the areas of environment, safety and energy technology and its comprehensible presentation to the public" which has a value of 15,000 euros. The patron, Prof. Dr. med. Dietrich Grönemeyer, Chairman of the "Wissenschaftsforum Ruhr e.V." (Science Forum Ruhr) awarded the prizes on June 23, 2010 at the 20-year anniversary celebration of Fraunhofer UMSICHT.



### Positive reaction – sophisticated, high-quality applications

The reaction to the award offered for competition by the Friends and Patrons Group of the Fraunhofer Institute UMSICHT was very positive. The range of the work submitted was very varied and included, among other things, passive-heating/cooling houses, coupling of power-heat-cold, adhesive technology and robotics. "The last eight finalist applications for the UMSICHT science award are all qualitatively of extremely high value and sophisticated. I consider this to be an impressive sign for the attractiveness of the competition," summarizes Prof. Dr. Rolf Kümmel, a member of the jury.

### Sterilization of (bio)polymers

Dr. Claudio Cinquemani received the UMSICHT science award for his work "Sterilization of implantable (bio)polymers with ozone in highly compressed fluids – environmentally friendly deactivation of biocontaminants". The uncontrolled proliferation of unhealthy microorganisms, in particular in implantation medicine, is increasing constantly. The result: post-surgical complications due to infections. Up to now, to keep implants as sterile as possible they had to be treated with toxic substances, since that does not affect the characteristics of the material, which in itself is alarming for reasons of occupational health and environmental reasons. With this as a background, Dr. Cinquemani developed a sterilization procedure based on over-critical CO<sub>2</sub> which can be used to have processes that are friendly to the patient and the environment, without having to utilize damaging chemicals.

### The sun as a power plant – energy from space

Joachim Mahrholdt received the UMSICHT science award for his 15-minute-long TV report "The sun as a power plant – energy from space". When the talk turns to renewable energies, it is impossible to exaggerate the potential and the opportunities for utilization of solar radiation. The award-winning TV report was dedicated to the industrial utilization of the sun and presented the largest solar power plant in the world, the Andasol facility in Spain.

### Precise beyond belief

Dr. Jan Lublinski received an award for his article "Precise beyond belief". In this work, Dr. Lublinski deals with the primary kilogram, the weight of which is decreasing for reasons unknown. This makes the search for a replacement of the metal cylinder that is more than 100 years old all the more urgent, as the cylinder has, as a global reference value, great significance for business.

### The successful concept that will continue

The competition for the award will continue. You'll find more information in the Science Award section under: [www.umsicht-foerderverein.de](http://www.umsicht-foerderverein.de)

*Sculpture "Innovation" designed by Hans-Dieter Godolt of the copper studio Godolt in Alpen exclusively for the award*

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*Left image: Dr. Thomas Mathenia, Chairman of the UMSICHT Circle of Friends and Patrons and Chairman of EVO AG; Prof. Eckhard Weidner, Fraunhofer UMSICHT; Joachim Mahrholdt (award winner in the journalism category), Dr. Claudio Cinquemani (award winner in the science category); Dr. Jan Lublinski (award winner in the journalism category); Dr. Görgo Deerberg, Fraunhofer UMSICHT, and Prof. Dietrich Grönemeyer, Chairman of the Wissenschaftsforum Ruhr e.V. (Science Forum Ruhr)*

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## INVOLVEMENT WITH UNIVERSITIES

Prof. Dr.-Ing. Eckhard Weidner manages both Fraunhofer UMSICHT and teaching as the professor for "Process Engineering Transport Processes" at the Ruhr University Bochum. This provides the institute with a direct connection to the university and strengthens the scientific network of both research facilities.

Prof. Dr.-Ing. Görgo Deerberg, Deputy Director of Fraunhofer UMSICHT, has been adjunct professor at the mechanical engineering faculty for "Environmental and Process Engineering" since January 2011 at Ruhr University Bochum. This expands the involvement with the Ruhr University.

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“The most useful books are those of which readers themselves compose half.”  
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# COOPERATION PARTNERS AND CLIENTS

## Cooperation Partners and Clients

*Fraunhofer UMSICHT successfully cooperates with customers from all industrial sectors and with companies of all sizes. The following excerpt from the institute's reference list is an overview on project and cooperation partners and customers. For reasons of clarity we refrained from listing the partners from the Fraunhofer R&D network separately.*

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IZEG Informationszentrum Entwässerungstech-  
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Logo tape GmbH & Co. KG, Harrislee

## M

Max-Planck Institut für Kohlenforschung,  
Mülheim an der Ruhr  
MedEcon Ruhr GmbH, Bochum  
Ministerium für Wirtschaft, Energie, Bauen,  
Wohnen und Verkehr des Landes Nordrhein-  
Westfalen, Düsseldorf

## N

Niederrheinische Fettschmelze Kalkar,  
Wöllstadt  
NOLL Processing Technology and Powder  
Processing, Bobingen  
Novamelt GmbH Klebstofftechnologie, Wehr  
Novoplastic GmbH, Mannheim  
nova Institut GmbH, Hürth  
NuTech Solutions GmbH, Dortmund

## P

Polyplast Müller GmbH, Straelen  
Polysius AG, Beckum  
PUR Technologie Hegemann, Essen  
Purac, Gorinchem, Netherlands

## R

Ralf Hacker Anlagenbau, Lübbecke  
Ritter-Pen GmbH, Brensbach  
rpm rapid prototyping and manufacturing rpm  
GmbH, Helmstedt  
Rubotherm Präzisionsmesstechnik GmbH,  
Bochum  
Ruhr University Bochum, Department of Energy  
Plant Technology, Bochum  
Rural Development Initiatives Ltd (RDI),  
Northumberland, Great Britain  
RWTH Aachen University, Aachen

## S

S+B Minerals, Kifissa, Greak  
Silcarbon Aktivkohle GmbH, Kirchhundem  
Siloa Engineering AG, Essen  
Solex Thermal Science Inc., Zevenaar, Netherlands  
SOLID Composites GmbH, Voerde  
Solvay Fluor GmbH, Frankfurt  
Sprenger GmbH, Moers  
Stadt und Landkreis Bamberg, Bamberg  
Stadtwerke Duisburg, Duisburg  
Stadtwerke Strausberg GmbH, Strausberg  
swb-Gruppe, Bremen

## T

Thermergy AG, Niederlassung Köln, Cologne  
Thermoprozess GmbH, Essen  
Thyssen Krupp Bilstein Suspension GmbH,  
Ennepetal  
Thyssen Krupp Xervon Energy, Duisburg  
Technische Universität Berlin, Berlin  
Technische Universität Dresden, Dresden

## U

UBE Engineering Plastics S.A., Düsseldorf  
Uhde GmbH, Dortmund  
Universität Leiden - Institute of Chemistry,  
Leiden, Netherlands  
University of Rostock, Institute for Environ-  
mental Engineering, Rostock  
University of Siegen, Institute of Fluid- and  
Thermodynamics, Siegen  
University College Dublin, School of Agricul-  
ture, Food Science and Veterinary Medicine,  
Dublin, Ireland

## V

Verein zur Förderung der Energie- und  
Umwelttechnik e.V. (VEU), Duisburg  
Viking GmbH, Langkampfen/Kufstein,  
Austria  
Volkswagen AG, Wolfsburg  
VTT Technical Research Centre of Finland,  
Finland

## W

Wacker Chemie AG, Werk Burghausen,  
Burghausen  
WAGRO Systemdichtungen GmbH,  
Dortmund  
WEKO-Werkzeuge Kolks GmbH, Bocholt  
WETEC ELEKTROTECHNIK/SYSTEMTECHNIK  
GmbH, Moers  
WiN Emscher-Lippe GmbH, Herten  
WRH Walter Reist Holding LTD, Hinwil,  
Switzerland  
Wuppertal Institut für Klima, Umwelt, Energie  
GmbH, Wuppertal

# PATENTS SPIN-OFFS

## Patents 2010

### Issued Patents:

Apparatus for power generation by gasification of biomass with subsequent catalytic removal of tar compounds from the heating gas (Ising) – Germany

Device and method for catalytic purification of biogenic or anthropogenic gases containing methane (Urban, Unger, Lohmann) – Europe

### Registered Trademarks:

Calomer (word trademark)

GOMES (word trademark)

EPMT (word trademark DE + European word trademark)

BlueNovation (word trademark)

VIFE (word trademark)

## Spin-offs

**AIROX GmbH, Alpen**  
Systems for oxygenation  
[www.airox.de](http://www.airox.de)

**A-TEC Anlagentechnik GmbH, Duisburg**

Innovative solutions concerning coal mine gas; hazard prevention: analyses, extraction, safety concepts; utilization for power and heat generation: energy concepts, design and operation of plants  
[www.atec.de](http://www.atec.de)

**Carbon-TF B.V., Venlo, Netherlands**  
Emissions trading  
[www.carbon-tf.com](http://www.carbon-tf.com)

**DataPool Engineering GmbH, Oberhausen**

Software development, system analyses, EDP-consulting  
[www.dp-e.de](http://www.dp-e.de)

**design4science GbR, Dortmund**

Product design, product development, communication and distribution of haptics event boxes; animations, short films and information charts concerning scientific topics; design and material-oriented innovation management, development and organisation of collaborative networks  
[www.design4science.eu](http://www.design4science.eu)

**Emissions-Trader ET GmbH, Alpen**

Emissions trading  
[www.emissions-trader.de](http://www.emissions-trader.de)

**FKuR Kunststoff GmbH, Willich**

Innovative solutions concerning plastics and recycling; comminution technology; extrusion, injection molding; elastomer recycling; material analyses; test technology; recycling concepts  
[www.fkur.de](http://www.fkur.de)

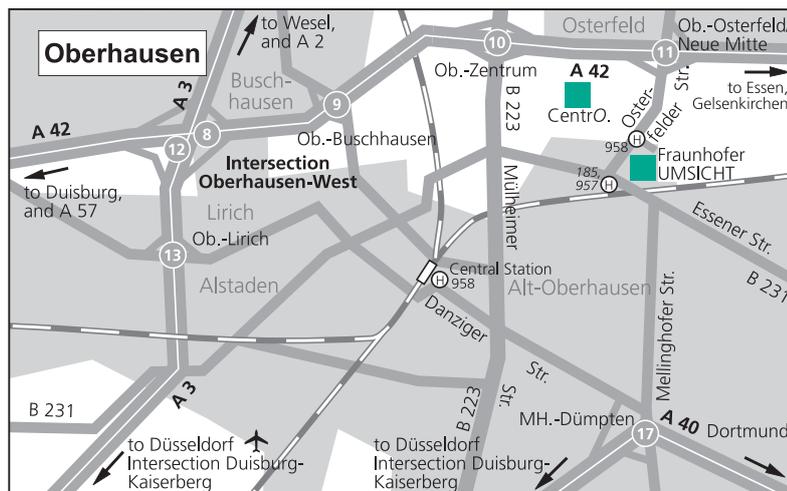
**SOLid Composites GmbH, Voerde**

Plastic powder at its finest!  
Thermoplastic coating powders, laser sinter powders, functional filler systems  
[www.solidcomposites.de](http://www.solidcomposites.de)

**WAGRO Systemdichtungen GmbH, Dortmund**

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[www.wagro-systemdichtungen.de](http://www.wagro-systemdichtungen.de)

# HOW TO REACH US



Fraunhofer UMSICHT is situated outside Oberhausen's green zone and can be reached without an environmental badge by following the directions below:

## By car

Freeway A42

### Coming from Dortmund:

Exit Oberhausen-Osterfeld/Neue Mitte. Go straight forward onto Osterfelder Strasse. Follow Osterfelder Strasse towards "Neue Mitte Oberhausen" or "Oberhausen-Zentrum/Essen" respectively. After approximately 1.5 kilometers (behind the sign "Fraunhofer UMSICHT") turn left into "Brammenring", after 100 m turn right and then again right onto the institute's premises.

### Coming from Duisburg:

Exit Oberhausen-Osterfeld/Neue Mitte. Turn right at the end of the exit onto Osterfelder Strasse towards "Neue Mitte" or "Oberhausen-Zentrum/Essen" respectively. To continue please follow the instructions above.

Freeway A40

### Coming from Dortmund:

Exit Mülheim-Dümpten. Turn right at the end of the exit. At the next intersection turn left onto Mellinghofer Strasse and at its end turn left onto Essener Strasse. At the next major intersection turn right onto Osterfelder Strasse. At the first traffic lights turn right into "Brammenring", after 100 m turn right and then again right onto the institute's premises.

### Coming from Duisburg:

Exit Mülheim-Dümpten. Turn left at the end of the exit. At the next intersection turn left onto Mellinghofer Strasse. To continue please follow the instructions above.

## By train

From Oberhausen central station to Fraunhofer UMSICHT, either with bus number 185 (towards Essen Borbeck Bf.), 957 (towards Oberhausen Sterkrade Bf.) or 958 (towards Oberhausen Spechtstraße), exit at the stop "UMSICHT".

## By plane and train/car

From Düsseldorf Airport terminal A/B/C take the Sky Train to Düsseldorf Airport Station, then change into the Regional Express to Oberhausen Central Station. To continue see: by train

### Or if you are traveling by car take

Freeway A 44 from the airport till you reach intersection "Düsseldorf-Nord". Take freeway A 52 (direction Essen/Oberhausen). At intersection "Breitscheid" change onto freeway A 3 and keep going until you get to intersection "Oberhausen West"; from there turn onto freeway A 42 (direction "Dortmund") and take the exit "Oberhausen-Osterfeld/Neue Mitte"; to continue see: by car.

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