



Annual Report 2006



Fraunhofer Institut
Umwelt-, Sicherheits-,
Energietechnik UMSICHT

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Preface



"There is only one proof for ability – action
(Marie von Ebner-Eschenbach)

And as a matter of fact we also did a lot – the year 2006 was a busy and dynamic "year of change", full of action.

During a reorganization process, the profile of the institute was focused on a future concept, along our four key research areas "Biorefinery", "mat-func", "Modular energy technologies", and "Information networks for process and energy technologies". The new organizational chart reflects a new efficient, customer-oriented institute that concentrates R&D activities on growing markets and creates plenty of space for new ideas. We transfer our key research areas particularly into four innovation fields which are the mainspring for a sustainable growth of the institute. With "C4-chemistry based on renewable resources", "biofuels", "impregnation" and "polygeneration", the accent has been put on new promising research lines to position the institute in the research landscape.

Our action program covers also and in particular the successful organizing of events, which over the recent years have become one of our trademarks. In autumn 2007, our facilities will be complemented by a new building, the renovated former Thyssen building which will allow in-house events on a larger scale.

Not only Fraunhofer UMSICHT but also the Fraunhofer-Gesellschaft builds upon the enhanced implementation of white biotechnology in industrial production. The conference "Bio-raffiniert III" was an international forum to discuss the utilization of renewable resources in biorefineries. The target is to produce 20 percent of all chemicals, materials, and fuels from renewable resources by 2020.

Further innovative impulses have been given on our conference on "The future of materials"

which presented the development of materials in the conflicting fields of functionality, sustainable growth and design. Under the slogan "Think and Talk Future", a broad interdisciplinary range from Martin Heidegger to Perry Rhodan was spanned to serve as forum for guests from most varying scientific areas to discuss the role of new materials for new concepts of living and working environments.

Fraunhofer UMSICHT's commitment is also required in the 7th Research Framework Program of the European Union. It is one of our missions to strengthen Europe's scientific and technological fundament to enhance the development of Europe's international competitiveness. We will follow our strategy to actively participate in shaping current research programmes also with the 7th Research Framework Program and hope that this will result in a number of successful projects.

Our optimistic outlook relies on the tireless commitment, enthusiasm and know-how of our staff to whom we are particularly indebted. With pride we may claim that we have been acknowledged as one of the model family-friendly enterprises of 2006 in Oberhausen – we are convinced that family and job requirements must be adjusted to each other to ensure a well motivated and satisfied staff. We also wish to express our thanks to our partners and customers from industry and research, in the State and Federal Ministries and the members of the Board of Trustees and the Circle of Friends and Patrons. We hope that reading our annual report will be entertaining and stimulating and we hope that this will increase your trust in the competencies of Fraunhofer UMSICHT.

We wish you an inspiring read!



Eckhard Weidner



Görgen Deerberg

Highlights 2006

Highlights 2006

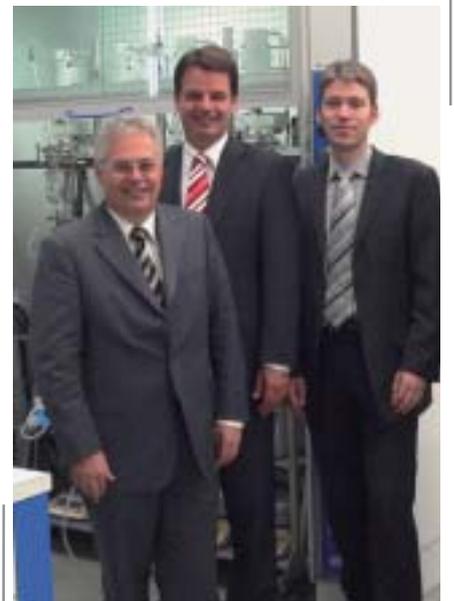
April 2006

The Girls' Day is supposed to give an overview on those professions which are not among the traditional preference of young girls. At Fraunhofer UMSICHT we took this occasion to deliver a first insight into engineering disciplines, information technologies and technical design (CAD). The photograph shows Mandy, Annika, Tamara and Sina who enjoyed performing the sieving analyses and the following evaluation.



August 2006

Sunshiny sky and smiling faces when Dr. Jens Baganz, State Secretary of the Ministry for Economic Affairs, and Energy of North Rhine-Westphalia (in the middle) was welcomed by Prof. Eckhard Weidner and Dr. Christian Dötsch (from left to right). Talks were held on energy efficient technologies.



September 2006

In September, over 120 visitors came together in the Rheinisches Industriemuseum Oberhausen, at a conference organized under the slogan "Think and Talk Future", in order to exchange opinions on the latest solutions in the fascinating world of plastics, metal, wood, glass and co. New ideas of how materials will be developed and utilized in the world of tomorrow were discussed among historians, scientists, engineers, industrial designers, experts in social sciences, linguistics and science fiction authors.





Oktober 2006

At the Entsorga-Enteco Fair 2006, Dr. Thomas Marzi presents the new shape of the “Modular incineration plant with Reduced Flue Gas Cleaning Residues” MARS® to the Minister of Environment and Conservation, Agriculture and Consumer Protection of North Rhine-Westphalia. This pilot plant offers perspectives for the energetic use of high and medium-sized calorific wastes to North Rhine-Westphalian small and medium companies in the waste disposal sector with a high energy demand.



November 2006

The boosting Indian economy and the target set by the Indian Government for 2012 to guarantee the nation-wide supply of electric power, require considerable investment in the Indian energy sector. Shri Vinay Vilasrao Kore, Minister for Renewable Energy of the State of Maharashtra, visited UMSICHT to learn about local energy generation from biomass.



Dezember 2006

Job and family are well compatible at Fraunhofer UMSICHT. On December 6, 2006 the mayor of Oberhausen, Klaus Wehling, “awards the prize for exemplary family-friendly enterprises of Oberhausen 2006” to UMSICHT. We are very happy about having received this award – it shows that we are well on our way.

The Fraunhofer-Institute for Environmental, Safety, and Energy Technology UMSICHT in Profile



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Fraunhofer UMSICHT develops applied and custom-made process engineering technologies. Assuming a leading position in the fields of environmental and material technologies, process engineering and energy technology, Fraunhofer UMSICHT is committed to sustainable economic development, environmentally friendly technologies and innovative approaches designed to improve the standard of living and to promote the innovation capacity of the national economy.

To strengthen its position in the research landscape, the institute has focused its activities on four key research areas, these are:

- "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

and Energy Technology – Utilizing Dispersed Knowledge in Value Added Chains"

This thematic scope is designed to give interdisciplinary scientific impulses across the business units. It is in these key areas that the institute's profile is adapted to the rhythm of social and economic changes and focused 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, Fraunhofer UMSICHT develops and researches the latest

know-how and transfers it 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 line of applied, cutting-edge research and development.

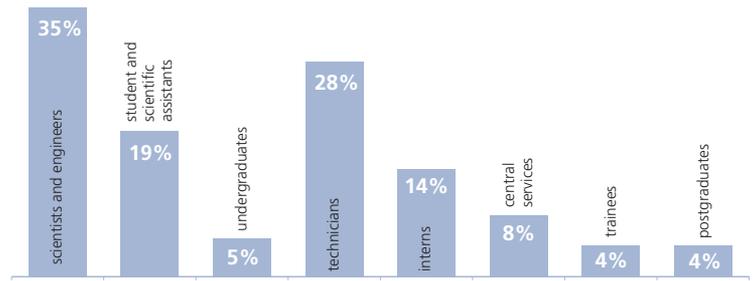
Since its foundation in 1990, Fraunhofer UMSICHT has been engaged in the structural change of the city and the region acting as a catalyst for science and economy. This has been done through technology transfer, spin-offs and the set-up of R&D networks. The institute's international activities presently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

Facts and Figures

Staff

Staff at Fraunhofer UMSICHT 2006 Number

Permanent Staff	144
- Scientists and engineers	94
- Technical infrastructure	28
- Central services	22
Other Staff	124
- Postgraduates	11
- Undergraduates	13
- Student assistants	52
- Interns, guest scientists	37
- Trainees	11
Total Staff	268



Structure of staff at Fraunhofer UMSICHT

Expenditure and returns

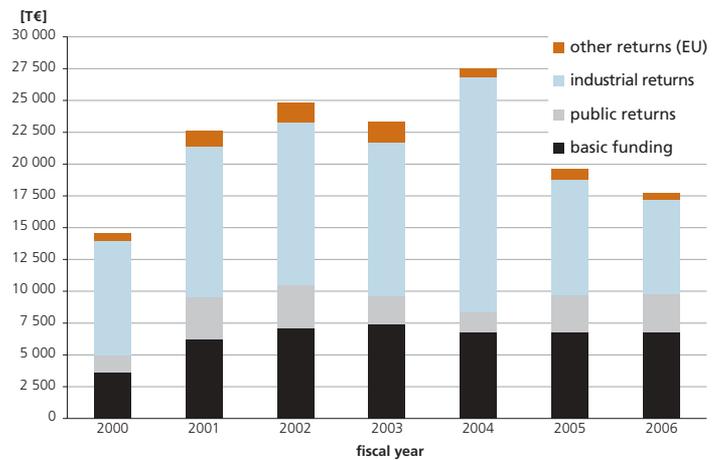
Expenditure 2006 (m €)

Operational Budget	17.7
- Staff costs	7.8
- Other costs	9.9

Investments **3.1**

Returns Operational Budget 2006 (m €)

- Industrial returns	7.4
small and medium-sized enterprises	6.0
large enterprises	1.4
- Public returns	3.0
- Others (EU, communities)	0.5
- Basic funding	6.8
Total Returns	17.7



Development of the operational budget since the establishment in the year 2000

Key research areas and innovation areas

Fraunhofer UMSICHT: Our key research areas and innovation areas

Growing resource conflicts, a flood of information and knowledge, aging societies, globalization, and climate change are all factors that influence our society and markets. Fraunhofer UMSICHT meets the challenge of ever faster growing changes with its key research areas and innovation areas.

Four key research areas form the basis of the technological positioning of the institute within the German and international research landscape. Their thematic scope is designed to give interdisciplinary scientific impulses across the business units. With them, the profile of the institute is adapted to the rhythm of economic and social change and focused on promising research directions. Selected focuses of research with a high innovation potential – the innovation areas – form the building blocks of the expandable and developable technological architecture of Fraunhofer UMSICHT.

Key research area “Biorefinery”

Products from Renewable Resources

We strive to achieve that 20 percent of chemicals, materials and fuels are made from renewable materials in the year 2020. Projects focus on new technologies for the production of biodiesel including the utilization of residues and by-products, the production of diesel and ethanol from biomass as well as the development of bioplastics. Laboratories for the development of bioprocesses, downstream processing and for the production of plastic products form the basis for this work.

• Innovation area “C4-chemistry on the basis of renewable resources”

In this innovation area the focus is put on the development of a process chain from the starch containing raw material via succinic acid synthesis up to application and product development.

• Innovation area “biofuels”

The newly established business unit »Biofuels« has set the objectives to optimize biodiesel syntheses, to pyro-catalytically produce carbohydrates from biogenous waste fats and to thermochemically synthesize ethanol from lignocellulose biomass.

Key research area “matfunc”

Particles, Materials and Membranes with Functionality

Our vision that even the smallest particles can be produced in any defined shape, and that complex structures, layers, and components can emerge through self organization is defining the path to the future. We develop intelligent materials and systems with functionalized surfaces which pave the way for new applications with properties that cannot be predicted yet. The installation of a particle synthesis laboratory as well as a membrane and microsieve laboratory forms the basis for this work.

- **Innovation area “impregnation”**

By using supercritical fluids we functionalize inner surfaces of heterogenous matrices as well as of homogenous, swellable materials and components with the aim of substituting organic solvents and creating products with improved properties.

Key research area “Modular Energy Technologies”

Flexible Solutions for Sustainable Energy Systems

Sustainable energy supply is vital for the growing world population. Decentralized plants, energy efficiency and renewable energies are our answers for the changing energy markets.

We are backing energy from biomass and residues, the utilization of low BTU gases, landfill and sewage gas, biogas feed-in, polygeneration processes, combined heat, cold and power plants (CHCP), organic rankine cycle processes (ORC) and ambient cooling.

This is our contribution to keep energy costs under control, ensure energy supply and to protect the climate.

- **Innovation area “polygeneration”**

In this innovation area we focus on the development of energy concepts for an efficient energy conversion. We concentrate on organic rankine cycle, thermally driven chillers and energy storage media for power and cold.

Key research area “Information Networks for Process and Energy Technology”

Utilizing Dispersed Knowledge in Value Added Chains

In complex production systems the amount of information concerning business processes, organizational procedures, technical and scientific processes in plants and apparatuses is continually expanding.

We are doing our share to make the vision come true that structured knowledge which is needed to solve complex technical problems can be provided at any place and at any time.

For this purpose we develop techniques and systems that can be used during the planning and operation of modern complex production systems.

For further information please refer to <http://www.umsicht.fhg.de/englisch/profil/leitthemen/>

Reorganization 2006: Structure follows strategy

With the reorganization process in 2006, UMSICHT has created the basis for a sustainable growth oriented strategy. The thematic-strategic change became evident above all in defining key research areas, which has entered into the project phase at the beginning of 2006. Selected key areas with high innovation potential are to ensure staff budgets for a longer period of time. Thus, to be consistent, the strategic change entailed an organizational change. Dr.-Ing. Görgo Deerberg was appointed "Deputy Director", a position newly created to support the Director.

The business units as the scientific and economic mainstay of the institute are positioning their offer on the R&D market and compete with other players for profitable orders. Innovation fields and key research areas of the business units are geared to enabling a solid growth.

Five of the established business units have been maintained after refocusing their profiles.

- **"Renewable Resources"**
- **"Process Technology"**
- **"Advanced Materials"**
- **"Energy Technology"**
- **"Energy Systems"**

Three new business units have been created to address innovation topics generated by the key research area definition process. They have the potential for future growth:

- **"Biofuels"**
- **"Information Technology in Process Engineering"**
- **"Resources Management"**

The infrastructure departments develop, apply and transfer methodological approaches which form the basis of the research work. The operative business is to be integrated fully into the business units. Fraunhofer UMSICHT builds on stable and reliable cooperation partners in order to enhance the initiation and realization of projects and to integrate additional competencies. Therefore, the field of "networks" is included in the organizational set-up.

Reorganization is no end in itself but a blueprint of the future of Fraunhofer UMSICHT. The new organizational structure represents a market- and customer-oriented institute which focuses its R&D services on growing markets and leaves a lot of room for new ideas. The new structure is supposed to offer our staff "areas of common interest", which stimulate the creation of new ideas open up new perspectives and help to make work inspiring in interdisciplinary teams.

Organizational Chart

Directorate

Prof. Dr.-Ing. Eckhard Weidner
Director

Dr.-Ing. Görgе Deerberg
Deputy Director

Business Units

Renewable Resources

Dr.-Ing. Stephan Kabasci

Deputy:
Dipl.-Ing. Carmen Michels

- Bioengineering
- Chemical Conversion
- Plastics Technology

Process Technology

Dr.-Ing. Görgе Deerberg

Deputy:
Dipl.-Ing. Josef Robert /
N.N.

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

Biofuels

Dr.-Ing. Axel Kraft

Deputy:
N.N.

- Catalytic Processes
- Refinery Concepts
- Industrial Chemistry of Oils and Fats

Advanced Materials

Dipl.-Ing. Jürgen Bertling

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

- Polymeric Compounds and Components
- Functional Particles and Composites
- Hydrogels, Wood and Leather

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 Technology

Dr. rer. nat. Thomas Marzi (temp.)

Deputy:
N.N.

- Refuse Derived Fuels and Biomass
- Biogenous Low BTU Gases
- Coal Mine Methane (CMM)

Energy Systems

Dr.-Ing. Christian Dötsch

Deputy:
Dr.-Ing. Wilhelm Althaus

- Optimization of Energy Systems
- Polygeneration
- Cooling Technologies

Resources Management

Dr.-Ing. Hartmut Pflaum

Deputy:
Dipl.-Wirt.-Ing. Markus Hiebel MSc

- Material Flow Management
- Networks/Supply Chain Management
- Innovation Processes

Networks

**Development and
Demonstration Centers**

University Cooperations

Board of Trustees

Circle of Friends and Patrons

Branch Teterow

Dr.-Ing. Görgе Deerberg

Deputy:
Dipl.-Ing. Toralf Goetze

- Rotary Kiln Pilot Plant

Branch Willich

Dipl.-Ing. Carmen Michels

Deputy:
Dipl.-Ing Thomas Eisenburger

- Plastics Pilot Plant

Fraunhofer Technology Academy/Training Center

Dipl.-Ing. Anja Gerstenmeier

- infernum

Infrastructure

Administration

Dipl.-Betw. Andreas Weber

Deputy:
Kerstin Schade

- Finances/Controlling/Contracts
- Human Resources Development
- Library

IT Management

Dipl.-Ing. Andreas Schröder

Deputy:
Dipl.-Inform. Christian Knermann

- Network Management
- Individual IT-Infrastructure
- Management of Measuring Data

Chemical Laboratory

Dr.-Ing. Edda Möhle

Deputy:
Dr. rer. nat. Anna Fastabend

- Anorganic Analysis
- Organic Analysis
- Development of Methods

Marketing, Communication, Business Development

Dr.-Ing. Hartmut Pflaum

Deputy:
Dipl.-Chem. Iris Kumpmann

- Marketing/PR/Strategy
- IPR/Licensing
- International Projects/EU

Central Technical Services

Dipl.-Ing. Richard Sprick

Deputy:
Dipl.-Ing. Joachim Hillers

- Pilot Plant Stations and Workshops
- Construction/CAD
- Operational Center

Occupational Safety and Environmental Protection

Dr.-Ing. Ulrich Seifert

Deputy:
Dipl.-Ing. Jürgen Stein

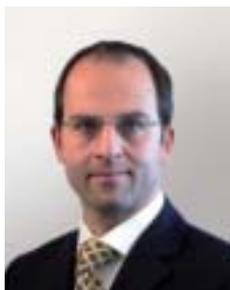
- Consulting and Coordination
- Safety Analysis and Checks
- Approval Procedures

Business Units/Infrastructure

Fraunhofer UMSICHT presents itself in the market for applied research with eight business units. These business units represent the tailor-made combination of products and R&D services with the requirements of the respective business segments. They apply modern methods of project management and realize successful innovation projects. At the same time they use research and science to advance the institute's key research areas "bottom up". The knowledge basis for maintaining and extending our core competencies lies within the business units.

Successful research and development demand good service and adequate management – externally as well as internally! That is the reason why we make allround servicing that our business units profit from available to our customers as well.

RENEWABLE RESOURCES



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Bioengineering

Fermentative synthesis of valuable material; downstream processing; microbial biomass utilization, extract production; biogas production; biological wastewater, waste air and solid waste treatment; testing of compostability of plastic products; enzymatic syntheses

Chemical Conversion

Platform chemicals, monomers and polymers from renewable resources; hydrogenation; analytics (IR, TG, DSC, GC, HPLC, GPC, viscosimetry); biorefinery systems

Plastics Technology

Material development: polymers from renewable resources, biodegradable polymers, wood fiber reinforced compounds, tailor-made blends; compounding; injection molded or extruded prototypes, small scale production; material and component characterization; thermochemical and spectroscopic analysis

PROCESS TECHNOLOGY



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Downstream-Processing

Process development; biorefinery; process development for membranes, microsieves and thermal separation processes; process media cleaning; processing of fermentation solutions; phyto materials; sample batch processing

Water and Wastewater Technology

Valuable material recovery; acid processing; closing of water cycles; decentral water and wastewater technology; degermination; pipeline technology; network and cavitation hammer simulation

Multiphase Reaction Technology

Process development and optimization of multiphase processes in chemical and biotechnology; process intensification; process modeling and simulation; optimization; CFD; reaction calorimetry; sample batch production

BIOFUELS



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Catalytic Processes

Catalytic-pyrolytic conversion of biogenous fats, oils, and waste fats into biogenous diesel; guanidine carbonate as catalyst for the catalytic transesterification of triglycerides with methanol

Refinery Concepts

Integrated utilization of oil plants or oilseed, separation and processing of byproducts (partial glycerides), glyceride-utilization paths, e.g. by pyrolytic conversion

Industrial Chemistry of Oils and Fats

Deacidification processes for crude oils of different type and origin, extraction of minor components from crude oils, thermo-catalytic conversion of fat or oil containing raw or waste material into hydrocarbon fractions

ADVANCED MATERIALS



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Polymeric Compounds and Components

Compounding of technical polymers (TPU, TPE, POM, PBT, PA, PP); fields of application: tribology, sealings, coatings, injection molded powder sintered components; processing technologies: melt mixing, injection molding, profile and foil extrusion, rapid prototyping, powder spraying, fluid bed sintering, comminution and granulation, high pressure spraying, impregnation

Functional Particles and Composites

Production of microcapsules, micro hollow spheres, nano and micro particles, hydrogel particles as carrier systems; biomimetic material concepts (tribology, self-healing); polymers equipped with indicators, latent heat storage (PCM) systems, materials equipped with aroma, effect pigments; FEM and DEM-simulations

Hydrogels, Wood and Leather

Switchable hydrogels; self-repairing sealing systems; volume impregnation of porous and non-porous materials, extraction and decontamination of wood; leather tanning with supercritical carbon dioxide

INFORMATION TECHNOLOGY IN PROCESS ENGINEERING



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Information and Knowledge Management

Information logistics; data acquisition; data consolidation; visualization; customized user interfaces; database architectures; business intelligence; process logic; local-based information providing

Server Based Computing

Application service providing; operational concepts; service oriented architectures; role concepts; access technologies; terminal equipment

Environmental and Safety Law

Legally compliant structural and operational organization, sustainable company documentation; hazardous substance management and information; guidelines; authorization procedure; safety analyses and concepts

ENERGY TECHNOLOGY



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Refuse Derived Fuels and Biomass

Combustion, gasification (e.g. of wood, RDF, sewage sludge), fluidized bed technology, grate firing systems, refuse derived fuels, fuel characterization, development of "waste to energy" concepts

Biogenous Low BTU Gases

Biogas feed-in into gas networks, catalytic and adsorptive cleaning, development of selective adsorbents, "oxygen separation", analytics, mobile test rigs for on-site development, efficiency analysis, landfill gas utilization, burner technology

Coal Mine Methane (CMM)

Innovative combustion technologies, CHPs, danger defense, emission trading, active environmental protection, process development, oxygen enrichment with membranes

ENERGY SYSTEMS



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Optimization of Energy Systems

Energy analyses; simulation and optimization of heat, cold and electricity supply systems; planning models for electricity and CO₂-trading; risk management (deciding under uncertainty); energy benchmarks; low exergy energy systems; integration of renewable energy sources; local energy management; CO₂-monitoring

Polygeneration

Combined heat, power and cold generation/trigeneration; electricity storage systems; low temperature power generation; organic rankine cycle; waste heat utilization

Cooling Technologies

Thermal cooling processes: steam jet ejector chillers, absorption chillers; solarthermal chillers: air conditioning, product cooling; application of advanced fluids, high-performance coolant (PCS, ice slurries) and latent heat storage media (PCM/PCS)

RESOURCES MANAGEMENT



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Material Flow Management

Optimization of material and energy cycles; recycling concepts, benchmarking of technical systems with key figures; cost-benefit analyses for decision support; ecological and economic optimization of waste management networks, identification and assessment of biomass potential, scenario analyses, sustainability management

Networks/Supply Chain Management

Analysis and optimization of material flow and energy flow systems, location planning and optimization, optimization of technical and infrastructural processes, master plans for decision support, development and management of network projects

Innovation Processes

Innovation and knowledge management, brainstorming and realization of ideas, development and monitoring of innovation processes, market research and analyses, technology trends, roadmaps, marketing/PR, IPR and licence strategies

ADMINISTRATION



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Budgeting; finance and controlling; financial project monitoring; accounting; personnel planning, recruitment and development; organization of business trips; contract management; equipment management; purchasing; library; infrastructure

MARKETING, COMMUNICATION, BUSINESS DEVELOPMENT



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Innovation management and marketing; business area planning; market and technology studies; composition and layout of printed media; media work; press and public relations; information medium internet; marketing concepts; strategy; property rights; international project development/EU



IT MANAGEMENT



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DV-auditing; planning, installation and operation of local networks; conception of central data management and security; data base development; development of web applications; client server solutions; system architecture

CENTRAL TECHNICAL SERVICES



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Plant construction; project management; basic and detail engineering; sampling, analytical and pilot programs; technical service; central implementation of measurement and control; operating technology center; mechanical and electronic workshops

CHEMICAL LABORATORY



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Analysis (inorganic/organic), fuel characterization (biofuels/refuse derived fuels), biotechnology (compostability/production processes), chemical-physical measurement methods, material characterization, syntheses, environmental chemistry

OCCUPATIONAL SAFETY AND ENVIRONMENTAL PROTECTION



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Internal coordination and advice in topics related to occupational safety and environmental protection: vocational training and on-the-job courses; registration and notification procedures; monitoring of legislative regulations

LIBRARY



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The UMSICHT library provides basic literature and procures project-related literature. For this purpose it offers among others online researches in online databases (STN). The scientists of UMSICHT can use a portal, where they can research autonomously; at present SciFinder, CEABA, TEMA, INSPEC and some free (or accessible via Fraunhofer framework contracts) databases are available. In addition, the library provides support concerning publications (Fraunhofer IRB-Verlag).

BRANCH TETEROW



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At its site in Teterow, Fraunhofer UMSICHT, supported by the State of Mecklenburg-Western Pomerania and the City of Teterow, operates a rotary kiln pilot plant for the development and sample production of specific high-performance adsorbents made from renewable resources. The link between laboratory research and commercial production is supposed to stimulate agricultural businesses and companies to realize innovative projects in the fields of "utilization of renewable resources" and/or "biofuels".

BRANCH WILLICH



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At its site in Willich, Fraunhofer UMSICHT offers broad customer and future-oriented services in the areas of plastics and recycling technology. Biodegradable plastics, polymers from renewable resources, materials which are gentle to resources, nanocomposites and recycling plastics are developed systematically and produced in pilot and small-scale series. Process optimization, analytics and test engineering, recycling concepts, market and feasibility studies round off the portfolio of this branch.

TRAINING CENTER/FRAUNHOFER TECHNOLOGY ACADEMY



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We qualify specialists and business executives with the aim of strengthening Germany's innovative potential. The interdisciplinary distance learning program for environmental sciences infernum – "official project of the decade of the united nations for the education for sustainable development 2005-2014" – imparts environmental know-how from more than 10 disciplines and qualifies its students – who are mainly enrolled in the program parallel to their job – to think and act in interdisciplinary ways. The master degree infernum is offered in co-operation with the FernUniversität in Hagen (Open University) and is part of the Fraunhofer Technology Academy.
"www.technology-academy.fraunhofer.de"
or
"www.umweltwissenschaften.de"

UNIVERSITY COOPERATIONS

Ruhr-University of Bochum
University of Dortmund
University of Duisburg/Essen
FernUniversität in Hagen
Hochschule Niederrhein
Fachhochschule Göttingen

The market for research and development is changing fast. As an institute operating at the interface between university research and industrial practice and offering cutting-edge and application-oriented services and products we rely on strategic partnerships with universities and universities of applied sciences in Germany and Europe. This way we can integrate basic research into our projects.

CIRCLE OF FRIENDS AND PATRONS

Chairman:
Dr.-Ing. Thomas Mathenia
(Energieversorgung Oberhausen AG)

Deputy:
Dr. rer. nat. Susanne Raedeker
(AGR Deponienachsorge GmbH & Co. KG)

Director:
Dr.-Ing. Görgo Deerberg

Research and development in the region are supported, the scientific-technical renown is sustained and the future executive staff of the economy is invested in. Members of the Circle of Friends and Patrons are offered exclusive services such as free participation in specific events. A list of members can be found on page 115.

From the field into industry

In dialogue with Dr.-Ing. Stephan Kabasci

1. *You are conducting research in the area of renewable resources. What is your specialization?*

We have very good expertise in biogas technology and the development of bioplastics. What is coming up new in our work is the production of chemicals which serve as intermediate products for high quality materials, such as high performance plastics.

2. *Recently, your team has been complemented by a group of scientists which are the winners of a junior research program of the FNR (Agency of Renewable Resources), on behalf of the Federal Ministry of Food, Agriculture and Consumer Protection, set out to give new stimuli to the utilization of renewable resources. What is the special work for this group in your team?*

With this group, we are working on the production of chemicals from renewable resources. The first step will be the biotechnological production of succinic acid, whose salt is in the body of each of us. Succinic acid is an intermediate product in our metabolism during the conversion of sugar into energy. Chemically, succinic acid is an organic dicarbon acid, a molecule made out of four carbon atoms that has an organic group of acids at each end. Succinic acid can either be produced petrochemically or biotechnologically. Some micro-organisms produce succinic acid as final product of their energy generation. And this is the biotechnological production way which we are going to improve. We are working on the entire process chain, ranging from the starch containing raw materials – be it corn, wheat

or potatoes – to the high performance material, in our case high quality plastics.

However, before yielding plastics as final products from succinic acid, the acid has to be produced fermentatively and processed. Once we are able to manufacture industrially usable chemicals, in a next step polymeric final products (technical polyamides and polyesters) may be produced. Our main target is to produce monomer building blocks – such as succinic acid and diaminobutane – and combine these building blocks to polyamids. The team which is working on this task includes one biotechnology engineer, three analytical chemists and one laboratory assistant.

3. *New equipment has been bought for this work. What are you especially happy about?*

Since my special field is bioengineering, I feel most happy about the new parallel fermenter systems. This system, comprising four reaction containers, permits to conduct four fermentation tests to produce succinic acid at the same time. Reaction conditions can be adapted and controlled for any container individually and the testing process can be visualized via the online measurement tools, and this helps to obtain optimized results faster than it used to be. Further advantages of the system are the significantly lower reaction volumes of 200 to 300 ml, which facilitate the scaling up of the results, that is the transfer of the results to larger plants. However, the sample volumes that we yield are still large enough, 250 ml, to permit the testing for downstream processing, for

the processing of succinic acid from aquatic solution.

For the processing of succinic acid solutions we have purchased an electronic dialysis unit. This membrane equipment is capable for instance to separate organic acids from ionic solutions via electric power – which has to be tested for our purposes. What is also new, is our infrared spectrometer coupled with a thermal gravimetric analysis unit that allows the measuring of the composition and properties of the plastics produced.

4. *Partnering with the Unidad de Desarrollo Tecnológico of the University of Concepcion in Chile, Fraunhofer UMSICHT has supported the first conference on biorefineries in Latin America. What is the outlook that you brought back from this congress?*

The utilization of renewable resources – no matter if energetic or as materials – offers excellent perspectives and is an international topic of policy and research. In the 7th Framework Research Programme of the European Union it is a high-ranking topic, since national networking is on its way, but only now in its initial phase. Internationally, the U.S. are a forerunner on the material recycling market. Our target is to position the institute on this market and to keep abreast with the development – which is conforming to the European approach which supports international cross-Atlantic scientific cooperation. As a matter of fact, Germany has a dominating role in the field of utilization of renewable energies among Europe's industrial nations, and this became evident once more at the biorefinery congress in Chile.



Dr.-Ing. Stephan Kabasci (born 1964) studied chemical engineering at the University of Dortmund and received his degree on "Precipitation crystallization as possible production method for fine solid particles". He is also lecturer at the department of process engineering and resources management at the Ruhr University of Bochum preparing junior scientists for the future demands in bioengineering.

Dr. Kabasci is married and has two children.

5. This sounds promising, but are there any improvement potentials left?

Definitely. Germany is market leader in energetic utilization of renewables – thanks to the tax relieves provided in the EEG Law on Renewable Energies. I wish the utilization of biomass for heat generation would be facilitated to the same extent. We are very eager to learn about the outcome of the present debates on this topic. What is still lacking, is the support for utilizing renewable resources as a source for material production. We are lagging behind other nations in this sector. Here, other countries are far ahead of us. In the U.S. materials made from renewable resources have to be preferred in public tenders – if technically possible. To have such general directives for public tenders would be advisable for Europe, too. Other measures that are worth thinking about could be reduced VAT rates or obligations to use renewable materials as in France. There, as of 2010 plastic bags must be biodegradable. Such measures are a

very good initial support which leads to an increase in production, a decrease in costs and helps that biobased materials can compete with their fossil-based counterparts not only with regard to quality but also where prices are concerned.

6. We have learnt a lot about your activities in research, now please let us know something on you personally. Which book would we find on your bedside table?

It is "Das oblatendünne Eis des halben Zweidrittelwissens" by Sarah Kuttner. (S. Fischer, 2006, ISBN 3-596-17108-3)

7. And which is your favourite album in your CD player currently?

The favourite CD of my family during this year's football World Cup has been "You have to win Heimspiel" released by Sportfreunde Stiller. Personally, I like to listen to the "The best of Tocotronic" and albums by the group REM.



Training Center/Fraunhofer Technology Academy

A first-class education is the mainspring for a successful workforce development– this is true today, more than ever. The education model TheoPrax® is a programme that has been made for students at school and university level and combines theory and real-life experience at an early stage. Fraunhofer UMSICHT acts as regional coordinator for enterprises who supply practical problems from industrial practice to schools and universities, where the projects are worked on by pupils and students.

Today, innovations emerge at a breathtaking pace, economic conditions are constantly changing and globalization leads to an increasing competitive challenge from abroad. Those who want to face these challenges successfully can no longer confine themselves to traditional studies or vocational training as it used to be. Lifelong learning is a must today. We offer career development for scientific and management staff in order to strengthen the innovation potential in Germany.

The interdisciplinary distance learning program environmental sciences infernum (www.umweltwissenschaften.de), official project of the “United Nations Decade for the education for Sustainable development 2005 to 2014”, provides environmental know-how in more than ten fields and encourages interdisciplinary approaches in theory and practice. Employees in business, associations, science, administrative bodies, freelancers and qualified junior scientists get insight into cutting edge technologies and interdisciplinary know-

how in environmental technologies. The accredited master studies infernum is offered in cooperation with the FernUniversität in Hagen (Open University) and is part of the Fraunhofer Technology Academy.

The Fraunhofer Technology Academy bundles the career development offer of the Fraunhofer-Gesellschaft and offers excellent career opportunities to scientists and management staff. The latest knowledge in R&D is reflected in the content of teaching. This guarantees a unique transfer of know-how from Fraunhofer research into enterprises.

www.technology-academy.fraunhofer.de

Contact

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Marketing, Communication, Business Development

The marketing of products and services, analyzing, and handling of business sectors, developing new market strategies, and finally representing the institute in public are the tasks of the department of "Marketing, Communication and Business Development". Being directly responsible to the directorate, we support the scientific staff in the positioning of new products and fields and in tailoring them to the customer's requirements. Market surveys and technology studies help to assess

opportunities and risks of new developments at an early stage. In order to protect innovations against plagiarism, we provide support in the field of industrial property rights, we monitor and assist in patenting procedures and offer consulting in licensing contracts.



IT Management

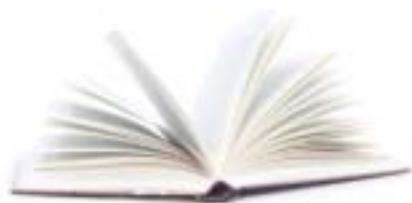
An efficient and reliable information and communication technology service is an indispensable prerequisite for any efficient project work. The IT management provides internal and external services, focusing on the following areas of expertise:

- planning, continuous operation and support of the DP infrastructure
- provision and update of software packages
- assistance in IT-specific problems

A powerful and available network enables the effective utilization of the IT services. In addition to redundant file servers that include capacities in the terabyte range with adequate data security, an increasingly important intranet is at our disposal.

Apart from the IT management supports apprenticeships for computer scientists with a concentration on system integration.





Library – Specialist Information Service

“Knowledge” has long since become an economic factor securing technological advantages of a location. For keeping the scientific-technical qualification of our staff always highly up to date, the scientific specialist library provides literature on the UMSICHT-specific topics environmental, energy, safety, and process and material technology as well as know-how and technology transfer.

The intranet homepage supports the staff in the retrieval of specific and technological information.

Services range from literature and patent research to in-house training in end user services, from documentation of in-house publications for the Fraunhofer Publica database to documentation of conference publications, PhD theses, from author support to the delivery of the printed copy to the Technical Information Library (TIB) at Hanover.

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Central Technical Services

The cycle times of technological innovations are minimizing rapidly in industrial and process engineering.

In order to secure a technological head-start and not only keep pace with others, a smooth and prompt realization must be guaranteed.

The central technical facilities realize technological know-how for internal and external costumers quickly and competently.

Specialized on the sector of test, pilot and demonstration plants our strenghts lie in:

- basic and detail engineering
- implementation of process control systems and
- measurement, control technology and control engineering.

Branch Willich – Plastics pilot plant station



At the Willich site, Fraunhofer UMSICHT offers customer and product-oriented services in the field of plastics compounding and material development. Biodegradable plastics, polymers from renewable resources, nanocomposites and recycling plastics are systematically developed and manufactured in pilot and small series. Process optimization, analytics and test engineering round off the portfolio of the Willich branch.

The target is to generate practice-oriented and economic solutions for the customers' requirements. A broad range of technical facilities from laboratory to industrial scale and our know-how of many years of research are available.

Materials laboratory:

- Hot-cold mixer, Labtech LMX-10-S-VSF)
- Laboratory roll mill, Labtech-.LMR-SC-11013E
- Laboratory press, Labtech LP-S-20
- Laboratory blown film plant, Labtech LCR -300
- Twin screw extruder, TSA EMP 26-40

Extrusion lines:

- Berstorff ZE 50 Ax 47D
- Leistritz ZSE 70-36D
- Leistritz ZSE 40-36D
- APV MP 40TC-40D
- Several granulators units (water-ring, underwater and line-granulators)
- Conveyor systems and gravimetric metering systems for the processing of powder, granulate and liquid raw materials.

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Branch Teterow – Rotary kiln plant



At Teterow, Fraunhofer UMSICHT develops products and technologies for using renewable resources as a source of energy and materials close to the agricultural sector. Together with partners from the region, at Teterow, sustainable operational concepts for bioenergy production and technologies for desulphurization of biogas are developed and tested. The objective of our work is to encourage closed production systems which are called biorefineries today.

High performance adsorbents from renewable resources are developed and produced in batch production in a rotary kiln plant. The target products are specific products on the

basis of activated carbon such as specifically doped and impregnated adsorbents, which are then used for the cleaning of (bio)gas and waste gas. In the technical plants, both new formulae are developed and sample production is conducted.

The technologies available comprise mixing, homogenization, granulation, pressing, drying, pyrolysis, combustion, activating, sintering, calcination, sieving, acid washing and dip impregnation as well as the necessary testing methods. High flexibility in the production process leaves ample space for process engineering investigations so that optimum conditions for the development of custom-made products are given.

The UMSICHT laboratories

The UMSICHT laboratories stand for the solution of analytical, biotechnological and material- und particle-technological problems. A highly qualified and experienced team consisting of scientists and technical staff work closely together to handle to these future-oriented tasks. The laboratories of Fraunhofer UMSICHT comprise the analytics laboratory, the biotechnological lab, the physical and the chemical lab.



Analytics Laboratory

Precise and reliable analytics is a prerequisite for the solution of environmental problems. The institute is equipped with comprehensive facilities including most modern analytical system combinations.

The wide range of services offered includes normative procedures and in particular the development of innovative, customized methods.

Examples from the analytics portfolio:

- Characterization of biofuels
- Analytics of fats, oils, organic acids and alcohols

- Hormone analyses
- Tar analyses
- Fuel characterization

The validation of the measuring results is conducted via comparison with external laboratories (ring testing). Another focus is on the optimization of technical processes for quality improvement and analyses of refuse derived fuels.

Our team offers analytical solutions, consulting services in the planning of examinations and helps evaluating your analytical results.

Biotechnological Laboratory

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

New biotechnological processes and plants are planned step by step, designed and examined to ensure technological feasibility at a high level of efficiency and operational safety. The biotechnological laboratory can realize creative and efficient solutions by co-operating with engineers and natural scientists of the analytics and the engineering departments.

As an approved testing laboratory of "Bundesgütegemeinschaft Kompost e. V." (Federal

association of compost quality standards), and approved testing laboratory of DIN CERTCO for testing of composting capability of materials according to DIN V 54900-1 to -3, ISO 13432, ASTM 6400 we offer:

- microbiological analyses according to DIN, ISO, OECD-processes
- testing of biodegradability under aerobic and anaerobic conditions (e. g. AT_4 and GB_{21} according to "Abfallablagungsverordnung" [Regulations concerning waste disposal])
- Development of biotechnological production processes

Physical Laboratory

For years Fraunhofer UMSICHT has intensively done research and development in the fields of material sciences and particle technology. As a result we can readily offer you a broad-ranged portfolio for the characterization of dispersions, powders, polymeric compounds, hydrogels and specific nano and microparticles.

Our service range comprises in particular the following investigations:

- Particle size and shape (static and dynamic light scattering, sieving, microscopy)
- Interfacial properties and porous structures (e.g. tensiometry, electrophoresis, mercury porosimetry, gas sorption)
- Composition, structure and phase conver-

sions (e.g. thermal analysis, rotation rheometry, IR-spectroscopy)

- Determination of mechanic parameters (e.g. tensile tests, notched-impact strength test, tribological measurements)

Besides providing reliable measurement results – particularly when no standardized methods are available – our team excels in the interpretation of data related to process engineering and to latest trends in materials technology.



Chemical Laboratory

The recently set-up chemical laboratory focuses on four areas of preparative and synthesis chemistry.

- ParMa: A parallel reactor system including fume hood-equipped working places for preparation and follow-up work.
- Biofuels: Besides fume hood-equipped places for the treatment of biodiesel products, two small-scale systems for the cleaning of biodiesel products are available.
- DSP: the downstream processing sector comprises several small-scale systems for the cleaning and concentration of intermediate product flows.
- SynLab: This area also offers fume hood-equipped working places for general chemical syntheses. In addition to the comprehensive lab scale equipment, inert gas and vacuum lines, compression reactors and special gases are available.

Analytical problems are solved in co-operation with the analytics and physical laboratories. One focal point is the analysis of plastic materials using the following methods:

- Chromatographic methods: HPLC-MS, GC-MS, GPC, IC
- Thermo-analytical methods: DSC, TG (range to 1 000 °C and to 1 600 °C)
- Spectroscopic methods; IR (reflection and transmission, film press, TG-IR-coupling, IR-databases, ICP-AOS)
- Elementary analysis

The chemical laboratory synthesis offers outstanding services through the co-operation in a team of chemical experts and chemical engineers of different scientific areas, who offer their competencies for the solution of your technological problem.



“An enormous reservoir of natural raw materials grows every day. Let the diversity inspire us to think of and develop new products beyond crude oil.”

[Dr.-Ing. Stephan Kabasci,
Business Unit Manager
Renewable Resources]

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

We focus on environmentally compatible generation of power, heat and cold, on sustainable production of platform chemicals and on the development of novel materials and products. Our laboratories and pilot plants allow us to scale-up from first samples of new materials to small scale production.

Renewable Resources

Development of a microbial quick-test for the identification of inhibitors in anaerobic digestion processes

New laboratory capacities for research – FNR Junior Scientists Group takes on work

Efficiency improvement of biogas plants through continuous biogas analysis

From the field to a successful product: Corn starch foam

RENEWABLE RESOURCES

Development of a microbial quick-test for the identification of inhibitors in anaerobic digestion processes

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Inhibiting areola test with *Clostridium thermobutyricum*

Manure and organic wastes can be utilized in an environmentally friendly and economically viable manner through anaerobic digestion in biogas plants. However, operational disturbances during operation of digesters and biogas plants after the use of potentially inhibiting feed materials have been reported. This is of particular significance with regard to the disturbing effects of manures containing antibiotics. Fraunhofer UMSICHT is investigating the influence of various digestion inhibitors and is developing a microbial quick-test for a simple, on-site determination of the inhibition potential of fermentation substrates. Comparable quick-tests are already commercially available for the evaluation of milk.

The development and validation of the test is accomplished by using several antibiotics that are used as veterinary pharmaceuticals. In order to determine



On this workbench, we work with anaerobic bacteria

the degree of inhibition of various substances in the presence of manure, so-called inhibiting areola tests are performed. In the development phase, *Bacillus subtilis* are investigated as test germs and *Clostridium thermobutyricum* as a potential anaerobic strain for the quick-test. The substance to be tested is applied to a culture medium containing the appropriate bacteria. If the substance is inhibiting, an inhibiting areola (zone of inhibition) forms in which no growth takes place. Depending on the size of the inhibiting areola, the strength of the inhibition can be classified. In parallel, the inhibition of antibiotics on the biogas process is assessed with the help of fermentation tests.

This project (AiF-Vorhaben Nr. 185 ZN/2), funded by the BMWI (Federal Ministry of Economics and Technology),

is being completed in cooperation with partnering institutes. The Institute for Energy and Environmental Technology IUTA performs the instrumental analytics of the pharmaceuticals and other inhibitors as well as their influence on the continuous anaerobic digestion process. The Food Toxicology Department of the University of Veterinary Medicine Hannover (TIHO) is also performing work on the analytics and toxicology of inhibitors.

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RENEWABLE RESOURCES

New laboratory capacities for research – FNR Junior Scientists Group takes on work

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Parallel fermenters

The production of new polymeric materials on the basis of renewable resources requires precise analytical monitoring and, thus, comprehensive laboratory equipment. By investing in additional laboratory work space and the appropriate preparative laboratory equipment, Fraunhofer UMSICHT has created the best prerequisites to meet those needs. New, non-fossil based alternatives for the production of monomeric raw materials and their conversion into polymeric materials are being researched and developed. From gel-permeation chromatography (GPC) to the coupling of thermogravimetry with infrared spectroscopy (TG-IR), modern analytical equipment is available to support the research efforts. The existing equipment is complemented by investments into high pressure reactors, capillary viscosimetry, and inline/online spectroscopy for reaction monitoring.



Electrodialysis



Coupled thermogravimetry/infrared spectroscopy (TG-IR)

An additional research area in the process chain is the extraction of bio-based raw materials (e.g. organic dicarbonic acids) that can serve as the basis for the manufacture of monomers. With the help of a parallel fermentation system, a series of tests with different, defined parameters for the screening of suitable product strains and for the optimization of the reaction conditions for the biotechnological manufacturing of the raw materials is possible. The utilization of processes for product extraction plays an important role in the development of bio-processes. For this purpose, various unit operations of mechanical and thermal process technology are available. Fraunhofer UMSICHT also has a new electro dialysis unit at its disposal with which organic acids such as succinic acid can be separated and purified.

The equipment investments are put to work by junior scientists for basic research and application development concerning high performance polymers based on C4-stemming chemical raw materials from industrially available renewable resources. The group is funded by the BMELV/FNR. (Federal Ministry of Food, Agriculture and Consumer Protection/Agency of Renewable Resources; FKZ 220-249-05)

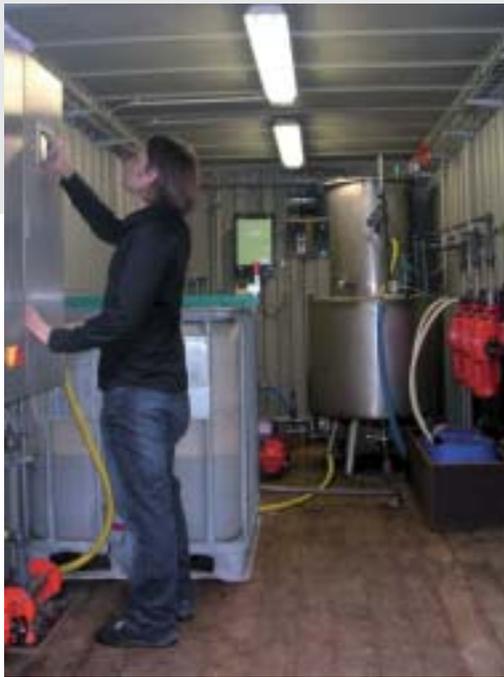
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RENEWABLE RESOURCES

Efficiency improvement of biogas plants through continuous biogas analysis

34

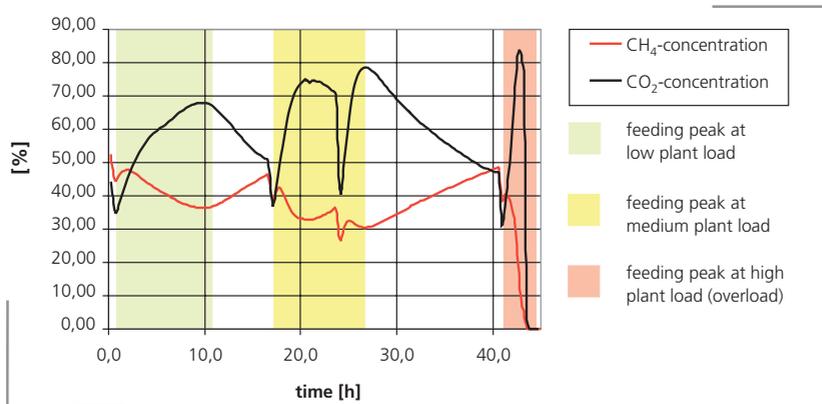


Pilot plant for the treatment of brewery wastewaters

Anaerobic processes for the generation of biogas from renewable resources, biowaste, or industrial wastewaters have long been established and applied globally.

Independent of the widely varying feed materials, the same multi-stage biological process chain is the basis for all of these processes. While evolution has brought up natural processes over two billion years which function optimally in the most diverse environments, the utilization of this process in technical systems is only at the beginning of its optimization: High conversion rates with a stable, problem-free operation are the goal.

In a project funded by the Zukunfts-Wettbewerb Ruhrgebiet (Future Competition Ruhr Area), Fraunhofer UMSICHT has developed a model for the evaluation of the process conditions of biogas plants on the basis of easily



CH₄ and CO₂ concentrations of a pilot plant under various loads

measurable parameters (COH₄ and CO₂ concentrations) in the biogas. This model can be used to develop predictions for the continued operation of the plant.

The determination of operating data and system conditions was performed on two demonstration plants of a semi-technical scale. The units used were a modified UASB reactor (Upflow Anaerobic Sludge Blanket, Patent-No. DE 10 2004 021 022 B3) for the treatment of brewery wastewater and a fully mixed reactor system for the digestion of renewable resources. The research focused on the influences of various plant disturbances on the gas concentrations starting with very low stresses up to deliberate overloading.

The graphs of the CH₄ and CO₂ concentrations showed a significant relation to the specific operational condition of the plant. Due to its strong dependence

to the specific reactor system and the utilized feed materials, the results could not be directly interpreted. In combination with an appropriate expert system which takes the specific characteristics into consideration, the continuous CH₄ and CO₂ measurement becomes a valuable tool for the optimization of the operational safety and the performance of biogas plants.

Contact

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Dr.-Ing. Stephan Kabasci
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Project Partners

- Loick AG
- CHEMEC – Ingenieurbüro für Chemo-Messtechnik GmbH
- Private brewery Moritz Fiege GmbH & Co KG

RENEWABLE RESOURCES

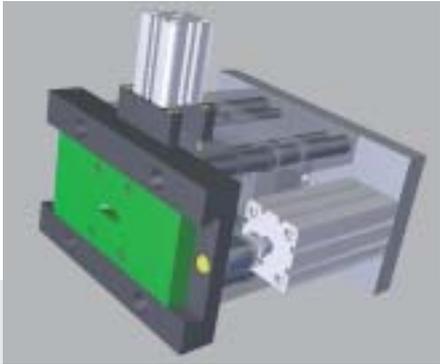
From the field to a successful product: Corn starch foam



Extruded sheets made from corn starch
(Playmais, courtesy of Cornpack GmbH & Co. KG)

Products with short life cycles, when made from renewable resources, can make significant contributions to the reduction of CO₂-emissions, to the independence from fossil raw materials, and to the alternative utilization of agricultural areas. Material recipes from corn starch and corn grit are especially beneficial because the raw materials can be made without technically or chemically extensive process steps. Particularly, loose-fill-chips were able to win a significant market share from oil-based packaging chips made of foamed polystyrene due to their excellent characteristics and competitive price.

Fraunhofer UMSICHT is currently working on various projects on the processing of corn starch and corn grit. In a basic-research oriented project, the rheology and the foam creation of corn starch



Research tool for corn starch foam processing



Extrusion plant for corn starch

in dependence on the recipe, temperature, pressure, and water content is being investigated. The goals of cooperative projects with industrial partners are product developments for the utilization of corn starch and corn grit for molded packaging foam parts and as porosity adder in the brick industry.

The development work has a material and a process focus. On the material side, recipes based on the utilization of raw materials and additives are to be developed to meet the requirements of the end product such as water resistance, abrasion resistance, and price. Regarding the process technology, an economic and reliable process has to be developed. In addition, the requirements to the foam structure, the density, or the surface quality have to be fulfilled.

Fraunhofer UMSICHT is making an important contribution to the transformation of product ideas into successful products from corn starch foam with its basic research and product specific cooperation project with industrial partners.

Contact

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“Process technology means to view the process chain as a whole. Modeling, simulation, and demonstration plants are our tools. That is how theory is turned into tangible practice.”

[Dr.-Ing. Görgo Deerberg, Business Unit Manager Process Technology and Deputy Director]

We develop and realize system solutions for process technology using pilot plants in the laboratory and the technical shops as well as model-based simulation software. In doing so we look at the process chain as a whole: from the idea to the commercial process and from the raw material to the utilization of residues at the end of the product life cycle.

Our strengths lie in membrane, separation and reaction technology as well as in pipeline technology. Our technical services range from closing of water cycles, wastewater treatment, resource recovery from process flows and thermal process engineering up to an extensive know-how in the areas of multiphase systems and downstream processing for white biotechnology and biorefineries.

Process Technology

Technology platform for integrated manufacturing of bio-based chemical products

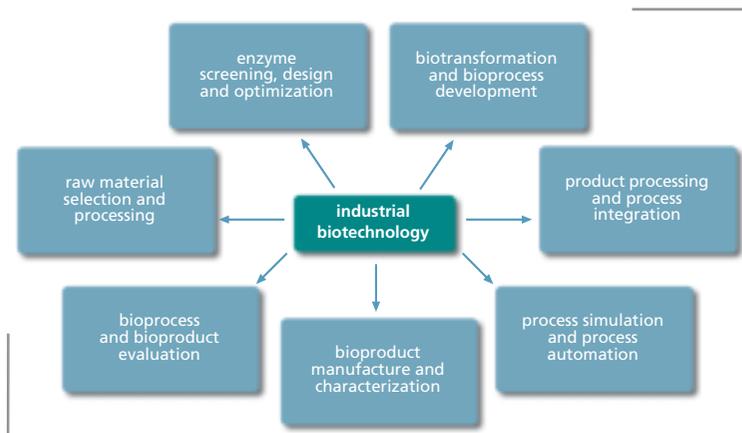
Integrated water resources management in the province Nam Dinh/Vietnam

Fluidic evaluation of the mixing technology in biogas plants

Technology with holes: Microsieves of particulate matter removal

PROCESS TECHNOLOGY

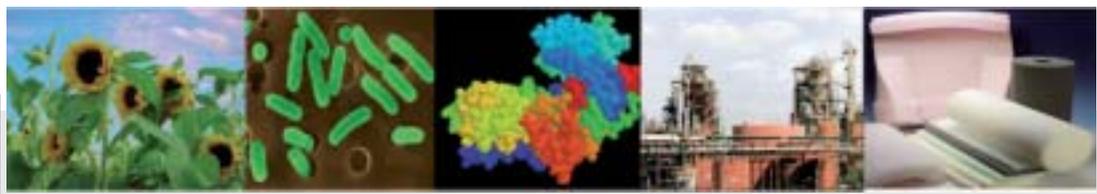
MAVO¹: BioProChem – Technology platform for integrated manufacturing of bio-based chemical products



Research areas of the research alliance

In mid 2005, eight Fraunhofer Institutes joined to form a research alliance. This alliance collaborates on the development of a technology platform for the integrated manufacturing of bio-based products through bio-technological processes. Our approach is integrated and encompasses all process steps from bio-catalytic screening over bioprocesses all the way to bioproduct development and utilization. In addition, the technological development is assessed with regards to its economics and sustainability. As an example, the process chains “1,3-propanediol from glycerol” and “ α,ω -dicarbonic acids from oils” are being investigated.

Fraunhofer UMSICHT has taken the lead role in evaluating the questions of raw material processing (upstream processing, USP), product processing (downstream processing, DSP), process design, and process integration.



From raw material to product

The success of biotechnological processes is determined by the chosen processing steps (USP) as well as by the processes for product isolation and treatment (DSP). In order to make the raw material fractions more accessible to the microorganisms or enzymes of the bioconversion step, various processing steps are required depending on the source material. Following the bioconversion, the raw product mixtures typically only contain low concentrations of the desired constituents. At the same time, there are great requirements on the purity of the final product. These conditions place high demands on the selection and optimal setup of the necessary separation technology. In addition, the process integration of downstream and upstream processes is gaining ever greater importance. It offers an interesting approach for an increase of throughput and an improvement of economic viability. In order to

examine all possibilities for process integration for biotechnological processes, mathematical models are indispensable.

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¹MAVO = Fraunhofer-internal program for
"Market oriented strategic preliminary research"

²participating institutes = IAP, ICT, IGB, IME, IPA, UMSICHT,
IVV and WKI

PROCESS TECHNOLOGY

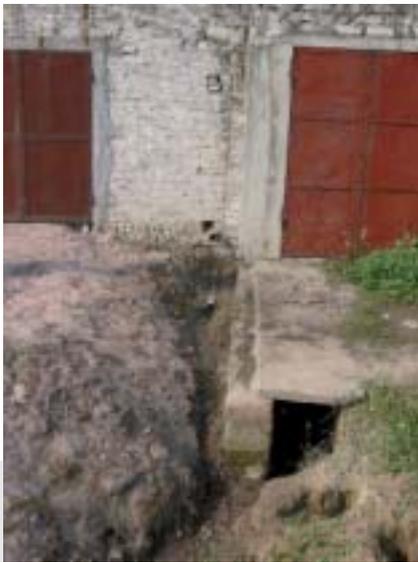
Integrated water resources management in the province Nam Dinh/Vietnam



Casting process with extremely high dust pollution

As a result of war and rapid population growth, the water supply in Vietnam is in a deficient state. Ground and surface waters are extremely polluted due to lacking water treatment systems, causing significant health problems for the population in the water cycle. Therefore, the Vietnamese government has given the construction of water treatment systems a high priority. On this basis, projects between Vietnam and Germany have been initiated to solve the problem via know-how and technology transfer.

Fraunhofer UMSICHT is partner of an IWRM-project network¹ with more than 15 partners. Prognoses and action suggestions in three example areas in Vietnam are being developed for an integrated evaluation for river areas. funded by the BMBF (Federal Ministry of Education and Research). Under the leadership of the University of Greifswald and the participation of two me-



Uncontrolled wastewater discharge from casting factory

dium-sized companies, the aim of the research project in the province Nam Dinh is the development and model-based set-up of wastewater treatment systems. The concepts to be developed pertain to industrial and municipal wastewaters, each for rural and urban areas. The efforts are being supplemented by instructional programs and workshops for Vietnamese decision makers. Fraunhofer UMSICHT will evaluate the possibilities of cleaner production technologies and develop concepts for a sustainable and efficient utilization of the resource water.

In November 2006, the first visit of the project network to Vietnam took place. In greater Nam Dinh City and surrounding ports industrial processes in rural areas and existing as well as planned industrial areas were inspected. Technological standards are lacking in rural areas especially, which leads to significant air and water pollution.



Highly polluted wastewater discharge into a rice field

Subsequently, Cleaner Production (CP) measures are developed for specific small enterprises which then have to be discussed with Vietnamese partners regarding effectiveness and implementability. In addition, aerobic and anaerobic treatment processes for industrial and municipal wastewater will be planned and first steps for the installation of a pilot plant will be completed.

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¹ IWRM = Integrated Water Resources Management

PROCESS TECHNOLOGY

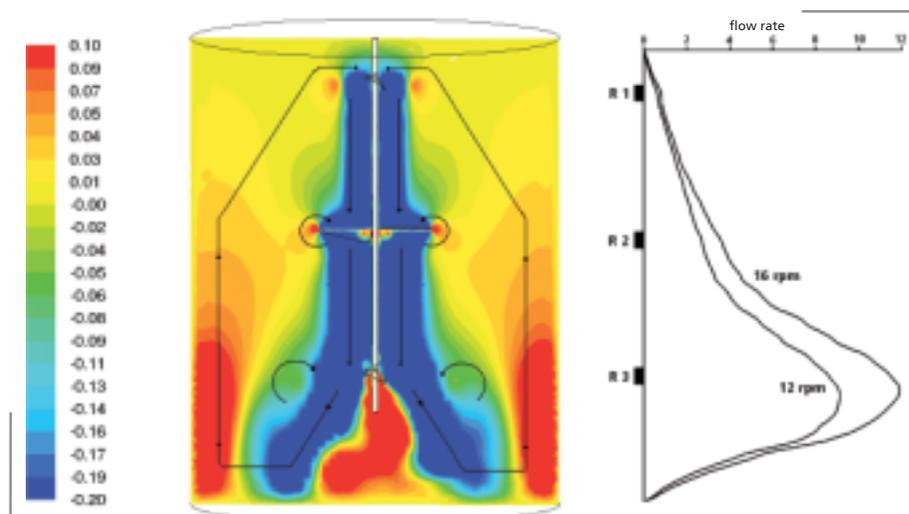
Evaluation of the mixing technology in biogas plants



Feedstock mixing bin, buffer tank and fermenter

The amendment of the Renewable Energy Sources Act (EEG) and the increase of payment for electricity fed into the grid due to various bonuses have created a previously unknown boom in the construction of biogas plants in Germany. Thus, it is expected that by 2010 the number will increase to approximately 10 000 from the roughly 4 000 currently existing. Simultaneously, a trend to ever increasing plant sizes can be observed. This is where process engineering is especially needed: Currently utilized technology for biogas production has to become much more efficient.

In cooperation with the operator of a biogas plant, Fraunhofer UMSICHT is investigating the mixing technology in biogas fermenters. The purpose of the mixers is to assure the homogeneity of the fermenter contents with regard to material and temperature. The biogas yield is very dependent on the mixing



Axial speed [m s^{-1}] in the midplane of the fermenter with associated flow rate of substrate [$\text{m}^3 \text{s}^{-1}$]

quality of the fermenting substance. In addition, the unwanted formation of floating or sinking layers at the surface and bottom of the fermenter should be prevented.

Currently, the selection of appropriate mixers is currently largely based on data of the diameter-height ratio of the fermenter and the dry solid portion of the substrate. Since these numbers only offer a rough guideline, Fraunhofer UMSICHT uses CFD (Computational Fluid Dynamics) in order to put the design and operation of mixers on a theoretical basis. Important global reference data such as power requirements, flow rate, and mixing time can be derived from the calculated three dimensional flow field. In addition, local phenomena such as zones of bad mixing can be made visible. Subsequently, alternative mixer designs can be tested on the computer regarding their effectiveness.

Such information represents a valuable support in the planning process for manufacturers of mixers. Operators of biogas plants benefit from the implementation of optimized technology.

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PROCESS TECHNOLOGY

Technology with holes: Microsieves of particulate matter removal



Main source of the man-made share of particulate matter is industry

The advantages of innovative microsieve filtration for the treatment of food and water were explained in the 2005 annual report. However, microsieves can do more: They have the potential to make a positive contribution to the current particulate matter problem.

What is particulate matter? Is defined as the particles that pass a size selective air inlet that has an aerodynamic diameter of $10\ \mu\text{m}$ and a removal efficiency of 50%. It can cause serious health issues such as (cough, cardiovascular diseases). Based on its lung mobility, it can even be a carcinogenic. The renewal of the 1. BImSchV¹ will soon require the use of technical systems for particulate matter removal even for small combustion ovens (fireplaces included!). Microsieves made from metal can form the basis for an efficient filtration process for the removal of particulate matter due to their material characteristics (heat and corrosion resistance,



Removal of particulate matter will also be required for small combustion ovens



Private households also emit particulate matter via wood pellet heating for example

smooth surface) and very high filtration capacity.

A white light confocal microscope², which has been adapted to perform automatic quality control, was used for the systematic characterization of the microsieve removal. Using the microscope, it could already be proven that ash residues on such a microsieve can be removed from the surface without any residue remaining. In order to measure the pressure drop, a microsieve test station was set-up in the workshop. Previous tensile tests have revealed that the strength of the microsieve films is still seen as too low for long-term use in gas filtration when exposed to stresses from periodic back-flushing. Therefore, research activities are focused on the stabilization of the microsieves with different variants of metal support structures.

Subsequently, it is planned to test the first prototypes of the modified microsieves in combustion plants and to develop a reliable cleaning process.

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¹ BImSchV = Bundes-Immissionsschutzverordnung – Ordinance for the Implementation of the Federal Immission Control Act (Ordinance for small and medium combustion plants)

² Confocal microscope = Variant of the light microscope with which virtual optical cuts through an object can be generated. These cut representation can be combined into a spatial illustration using appropriate software.
(Source: www.wikipedia.de)



“Mobility is seen as the epitome of personal freedom. We conduct research today so that biofuels become important factors in paving the way for sustainable transportation and environmentally friendly mobility with the highest supply security.”

[Dr.-Ing. Axel Kraft, Business Unit Manager Biofuels]

We develop and optimize biofuel production processes. Specializing in biodiesel synthesis we combine experience in the analysis of the reaction process of catalytic conversion using alkaline and in particular nitrogenous catalysts with our know-how in chemical and process engineering and detailed modelling of biological and physiochemical processes.

Our services cover the entire range from basic research to the process-technological concept of plants. Our contribution to sustainable mobility is completed by extensive know-how in the field of pyro-catalytic hydrocarbon synthesis from biogenous waste fats.

Biofuels

Innovative biodiesel production

OILPRODIESEL: Production and utilization of biodiesel from used frying oils in Oeiras (Portugal)

Innovative biodiesel production

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Rising CO₂ emissions, largely generated from the combustion of fossil energy carriers, and growing fuel demand have increased interest in the development of fuels from renewable resources. Since over 30% of the energy consumed in the European Union is attributed to the transportation sector, the goal of the EU is to replace one quarter of fossil fuels with biofuels by 2030. Fraunhofer UMSICHT wants to contribute to the attainment of this goal and is working on the optimization of biodiesel production.

Biodiesel is produced by transesterification of plant and animal oils with methanol to methyl ester and glycerin. Typically a base such as sodium hydroxide (NaOH) catalyzes the reaction. A partial conversion to methyl ester and glycerin can usually be achieved in a first reaction step. Subsequent to the separation of the glycerin phase, a virtually complete transesterification of the oils occurs in a second reaction step. As an unwanted side reaction,

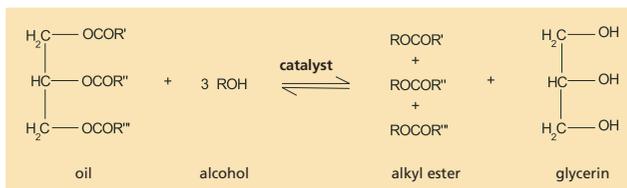


Nitrogen-containing catalysts accelerate the phase separation and product processing for biodiesel synthesis

soaps are generated which use up the catalyst, reducing the biodiesel yield and complicating the product separation. The process therefore requires extensive processing steps such as the washing of the methyl ester phase or the removal of the catalyst.

is currently testing different nitrogen-containing catalysts (amines, guanidines) for their applicability in the production of biodiesel. Accordingly, the influences of various parameters on the methyl ester yield are being investigated. The transesterification occurs in a single stage, much more quickly, and without soap generation.

In Germany, the production of biodiesel currently costs 1.4 billion Euro with a



Transesterification reaction of oils

production volume of approximately 2 million tons. In order to improve the competitiveness of biodiesel, the requirements for product processing have to be reduced, the reaction has to be sped up, and the yield has to be increased. One solution is the substitution of the catalyst. Fraunhofer UMSICHT

The product processing is significantly simplified through the accelerated phase separation, which brings a reduction of production costs within reach.

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BIOFUELS

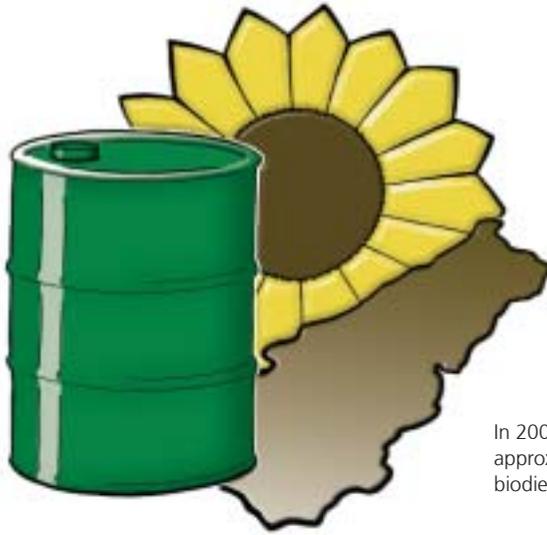
OILPRODIESEL: Production and utilization of bio-diesel from used frying oils in Oeiras (Portugal)

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The prevalence of biodiesel utilization as fuel varies throughout Europe. For example, Portugal produced 1 000 tons in 2005 which represents only 0.2% and 0.6% of the biodiesel amounts produced in France and Germany, respectively. Overall, biofuels constitute 1.2% of the total fuel consumption. An increased biodiesel supply could make an important contribution to reaching the European goal of consuming 5.75% biofuels out of the total fuel consumption in Portugal as set forth in the EU-Directive on the promotion of the use of biofuels (2003/30/EG). Biogeneous waste fats and used frying oils can complement oil seeds.

This is where the international demonstration project OILPRODIESEL, funded



In 2005, Portugal produced approximately 1 000 tons of biodiesel

by the European Union under the "LIFE-Environment"-Program, comes in. In the town of Oeiras near Lisbon with a population of 35 000, used frying oils are collected from households, schools, gastronomy in an integrated collection system and converted into biodiesel on site. The generated fatty acid methyl esters are used as fuels in the municipality's vehicle fleet.

Aside from the provision of the biogenous fuels, the project solves an acute ecological problem by eliminating the disposal of used frying oils in the wastewater system.

Fraunhofer UMSICHT is contributing to this project by developing the technical and legal boundary conditions,

performing safety assessments for the implementation of the required process equipment, experimentally evaluating possible ways for the chemical upgrading of the produced fuel, and providing an ecological and socio-economic technology assessment.

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“There are 20 million known chemicals. Thus, material innovations do not emerge from new materials but by the smart combination and structuring of available materials. Our approach: We develop functional micro and nano particles in order to functionalize polymers!”

[Dipl.-Ing. Jürgen Bertling,
Business Unit Manager Advanced
Materials]

On the basis of your requirements, latest findings in material research or inspirations from nature we develop strategies for new materials and test their industrial practicability under ecological and economical aspects.

One major focus is the equipping and functionalization of thermoplastics, wood and leather with functional additives, nano or microscale particle systems or hydrogels. Matrix materials are modified and processed in laboratory and industrial scale with the help of innovative technologies and industrially established processes. On the basis of virtual and real specimen or prototypes we use intelligent simulation and testing procedures to examine the appropriateness of the respective materials for their special applications.

Advanced Materials

Swellable thermoplastic elastomer composites:
New material basis excels in tests

Evaluation of cutting, breaking, and wear processes
via DEM and FEM

scCO₂ (supercritical carbon dioxide) – Material research
under pressure

Production of thermoplastic nano-composite materials
and characterization of their surfaces

Swellable thermoplastic elastomer composites: New material basis excels in tests



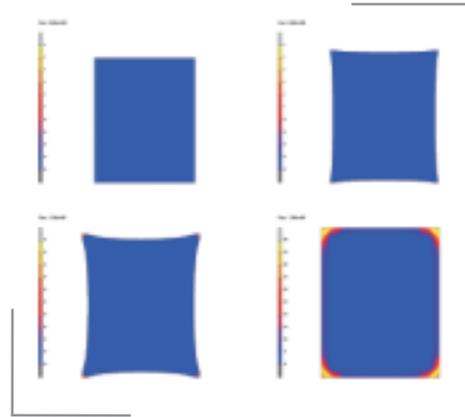
Assessment of Q-TE-C® samples under dry and swollen conditions

Cracks and holes by definition are some of the main problems in the field of sealing technology. "Swellable rubber" products currently used for sealing in the area of engineering and piping construction are cost intensive due to their natural rubber content and extensive production process requirements. Additionally, they can usually only be produced in the form of simple geometric profiles.

Swellable thermoplastic elastomer composites Q-TE-C®, developed by Fraunhofer UMSICHT, offer price effective material alternatives that exhibit excellent shape forming characteristics even for complex profile geometries and are well suited in the field of concrete construction for the sealing of joints or wall/floor connections, for example. The shape forming of the new material class, a combination of thermopla-



Calculation of the dimensional changes of a rectangular seal profile (L x W x H = 300 x 25 x 20 mm), which is typically used for the sealing of wall/floor joints in the construction industry (concrete construction), after 17 days of swelling.



Results of the calculation of a sealing scenario in 2D sections of the profile shown in picture 2

stic matrix with rubber powders and swellable polyacrylates, is achieved with methods from thermoplastic processing. Manufacturers of sealing profiles can melt the rubber-containing plastics and process them like thermoplastic polyethylene, polypropylene, or polyamide. Correspondingly, the Q-TE-C[®] material is inexpensive for injection molding, extruding (extrusion molding), or calendering (pressing into plates or films). Additionally, it is weldable which is especially beneficial for use in the construction industry for example.

As shown by the theoretical evaluation of the swelling process on the basis of the finite element method (FEM), the calculated profile geometries coincide with the experimental ones. Therefore, a goal oriented design of swellable seal geometries is possible on the basis of simulated sealing scenarios.

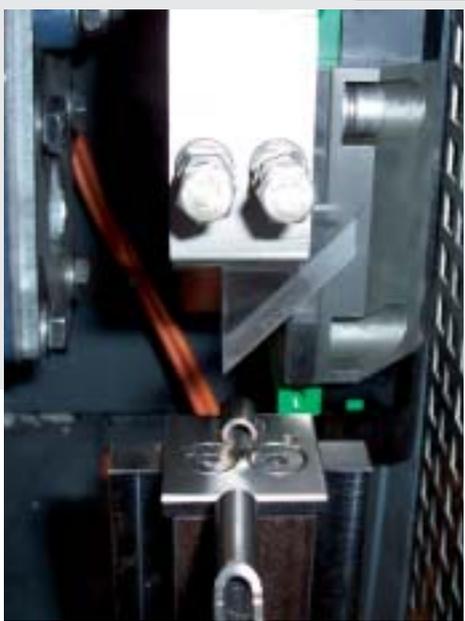
In ongoing efforts, the material development is performed utilizing continuously processing pilot plants, while the material basis and swellability are analyzed mechanically. The construction supervision permit for the use as a swellable joint seal has been applied for.

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ADVANCED MATERIALS

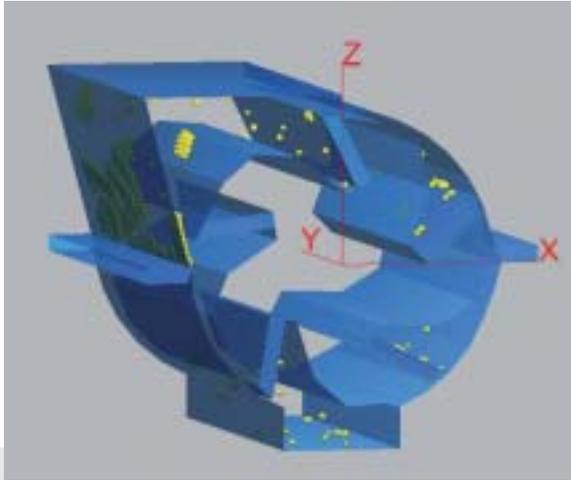
Evaluation of cutting, breaking, and wear processes via DEM and FEM



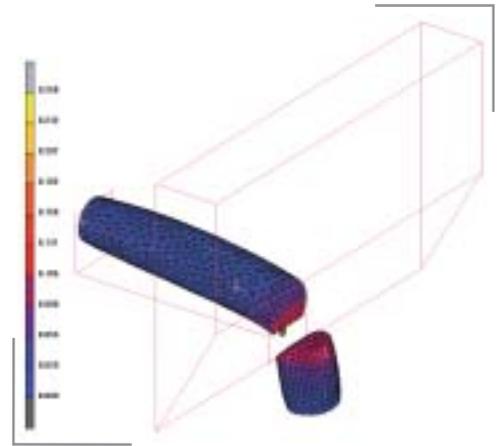
Experimental cutting tests

On the basis of the biological example of rodents, who possess self-sharpening teeth, Fraunhofer UMSICHT is researching cutting tools. In order to better understand the different mechanisms that are advantageous for the severance of materials, simulation models of cutting, breaking, and abrasion processes are generated using DEM (Discrete Element Method) and FEM (Finite Element Method). These are calibrated on the basis of simultaneous cutting trials. The main challenge of this adaptation is the path and time scale order since the wear on cutting tools occurs on different scales:

- Molecular scale (adhesion, corrosion)
- Nanometer scale (abrasion)
- Micro/Millimeter scale (nicking)
- Kilometer scale (total cut length)
- Milliseconds (contact knife/tool)
- Hours/days (downtime of the tool)



Model of a rotor mill with the cuts made up of discrete elements



FEM calculation of cutting to length

In order to deal with this scale problem, the following steps are completed:

- Scale equalization through analogous models for the molecular and nano-meter range
- Time lapse (one cut represents many cuts)
- Development of a method for the conversion of the simulation results to any cut geometry and material

Time lapse is especially important for performing simulations in reasonable time frames since DEM and FEM analyses require large computation capacities. The utilization of simulation software creates a time and cost saving opportunity to test and optimize cutting tools early in their development. As a result, the life of knives can be extended significantly which is also accomplished with the help of the self-sharpening effect. For industrial applications, this leads to a reduction in maintenance and reworking costs as well as an increase in production reliability.

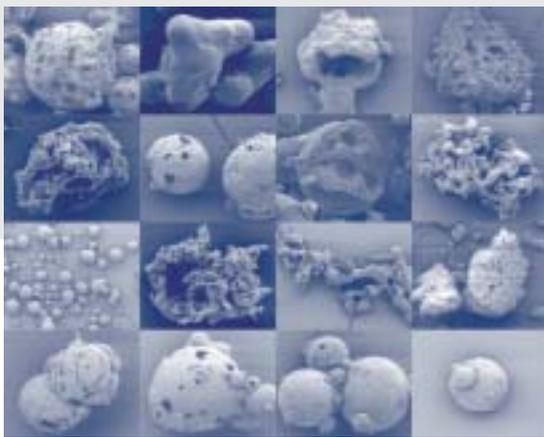
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ADVANCED MATERIALS

scCO₂ (supercritical carbon dioxide) — Material research under pressure

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Solid and liquid active ingredients are prepared in an easily dosable, mixable, and stable form as a powder. In addition, the control of morphology can help influence the release characteristics and reactivities.

Carbon dioxide can reduce the viscosity, surface tension, and melting point of polymers depending on its pressure and temperature. It exhibits beneficial coverage and material transport characteristics and is an advantageous propellant medium for spraying and foaming. In addition, it is inexpensive, readily available, physiologically harmless, inflammable, and is mostly inert towards other materials. In terms of process technology, carbon dioxide is characterized by the fact that it can be readily removed without leaving residues. This eliminates the cost intensive process steps of solvent removal and treatment as well as drying. This makes supercritical carbon dioxide a “green solvent”.

In this context, Fraunhofer UMSICHT has set up an extensive high pressure



Pressures of up to 500 bar are utilized in the high pressure workshop for material processing

technical workshop for the processing and modification of plastics, wood, insulation materials, and leather. The use of supercritical carbon dioxide as a process additive for improved distributive and dispersive mixing of nano and micro filler materials is being investigated in a double screw extruder. Rotary mixers are available for the impregnation and surface modification of porous and homogeneous materials and parts, for example hydrophobizing, silicification, and antistatic finishing. An integrated compounding and spraying plant (PGSS-¹ and CPF-process²) is utilized for the micronization of low to medium viscosity polymers. It allows the production of plastic powders such as glues, coating materials, and sinter powders as well as the production of additive and active ingredient carrier systems.

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¹ PGSS = Particles from Gas Saturated Solutions

² CPF = Concentrated Powder Form

ADVANCED MATERIALS

Production of thermoplastic nano-composite materials and characterization of their surfaces

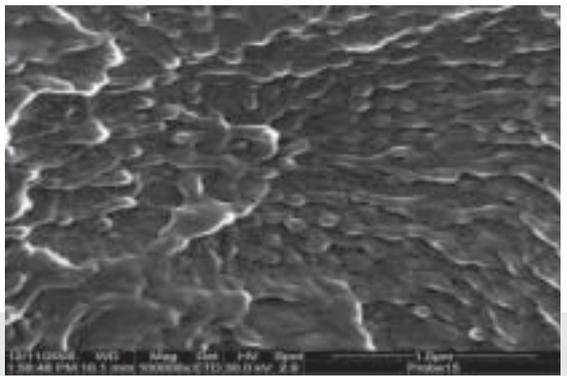
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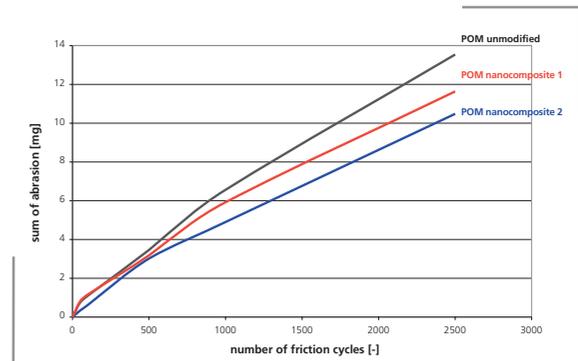
Stick-slip test bench

Nano composites currently represent one of the most exciting and promising research topics in the plastics industry! Polymer nano composites, according to their definition, are combinations of a polymer matrix and nano-scaled fillers, either organic or inorganic particles, which contain at least one dimension in the nanometer range. Using very low filling degrees (far less than 10%), highly efficient strengthening, increased dimensional stability, and improvements in fire protection, barrier, tribologic, and electrostatic characteristics can be achieved.

Nano particles represent a new class of additives on the market that hold large potential to utilize previously non-feasible performance reserves of plastics and thus drive the trend in the polymer material development forward: to design polymer materials as highly functional and intelligent materials.



SEM picture of a PBT-zinc oxide nano composite with optimum dispersion of the nano particles



Improvement of abrasion characteristics of POM through nano particle additives

Against this background, the business unit Advanced Materials has developed processes for the production of tribologically optimized nano-composites – especially for powder applications such as electrostatic coating and laser sintering. Fraunhofer UMSICHT has increased its competence in the manufacturing of nano-composites with kneaders and extruders. As a result, nano particle systems were identified that improve the abrasion characteristics of technical polymers while at the same time positively influencing the processability of the materials by improving their flowability and melt viscosity.

Newly installed measurement techniques can be used in the future to comprehensively characterize material surfaces. This includes equipment for the measurement of dynamic and static friction coefficients, the determination

of the stick-slip risk, for the characterization of the abrasion behavior, and for the determination of the surface tension via a tensiometer. Additionally, we work with energy dispersive x-ray fluorescence analysis (ED-RFA) and digital microscopy.

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¹ Stick-Slip = describes the jerky motion of two solid objects moving against each other. Noises such as the screeching of iron of trains and trolleys during turns or the creaking of leather shoes are commonly known results of this effect. (Source: www.wikipedia.de)



“Every five years the world-wide accessible knowledge doubles. Intelligent target group-oriented information management can help to quickly separate relevant from non-relevant information and thus plays a central role in today's production value added chains.”

[Dipl.-Phys. Thorsten Wack, Business Unit Manager Information Technology in Process Engineering]

According to forecasts of the EU Commission 80 % of technologies applied today will be substituted by new technologies within the next 10 years.

Value added chains in companies are closely connected to the supply of information. Often, optimizations cannot be realized without a sufficient data pool.

The close linking of operational processes to specific organizational and technical information in connection with ergonomic user interfaces bridges existing information gaps. For this purpose service-oriented architectures (SOA) are created and provided in form of application service providing (ASP) which enables the access from any location and from any client.

Information Technology in Process Engineering

Systematic network analysis using LANrunner®

Hazardous material management and information system GEVIS II

Keeping an eye on all data with DAVID (Data Acquisition and Visualization Device)

Hazardous material storage – Optimization of logistics and security

Systematic network analysis using LANrunner®



Keeping an eye on your network

The bigger the size of an IT network, the more difficult it is to keep an overview of it. The LANrunner® (<http://www.lanrunner.de>) system developed by Fraunhofer UMSICHT represents a solution for an effective network analysis which enables the optimization of a network or even an entire IT infrastructure.

Using the LANrunner®-System application, network statistics can be generated and visualized so that the parties responsible for IT can always keep a clear overview and gain important insights for planning. Aside from network traffic, the measurement data collection via SNMP¹ allows the compilation of all SNMP available numerical data such as RAM or hard drive capacity utilization or even the processor temperature of the processor. An intuitively operated web interface encompassing an open link to the GUI² and database – in the future also accessible via SOAP³ – en-



LANrunner®-Server

able a flexible utilization and visualization of the data. The data is saved in a consolidated database so that values are available for evaluation over time periods of months or even years.

Aside from the identification of abnormal conditions, long-term statistics represent a valuable planning tool so that resources can be increased before the hotline rings. What is the source of a problem? When does the bandwidth of an internet connection of a business have to be increased? How long will the capacity of a file server last? In this sense, LANrunner® complements the well known saying: "Never change a running system but always know what it is doing."

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¹ SNMP = Simple Network Management Protocol is a network protocol that helps supervise and control network elements (e.g. router, server, switches, printer, computer, etc.) from a central station. (Source: www.wikipedia.de)

² GUI = Graphical User Interface

³ SOAP = Simple Object Access Protocol is a protocol with which data can be transferred between systems and remote procedure calls (tasks via a network to distant computers) can be performed

Reference system at Fraunhofer

UMSICHT: Locations of the Fraunhofer Gesellschaft

Hazardous material management and information system GEVIS II

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When working in the laboratory, it is important to know which working material is considered hazardous and how to avoid dangers.

When dealing with hazardous materials, many things have to be paid attention to. For example, it is important to know which material is classified as hazardous, how appropriate measures reduce risks during storage, transport, and handling of hazardous materials, etc. The software system GEVIS II developed by Fraunhofer UMSICHT can help with these and other issues.

Approximately 42 institutes of the Fraunhofer-Gesellschaft work with hazardous materials. So far, about 19 500 materials and 15 000 directives have been administered by the software system GEVIS. The new software edition, GEVIS II, is characterized by a centralized, failsafe ASP¹ architecture which provides a client side (institute or location related) presentation level. The utilized holon-architecture (software cells) makes it possible to be flexible with regard to reacting to changes in the GefStoffVO² as well as the work-



Much has to be considered when dealing with hazardous materials: The GEVIS II software helps accomplish that.

flow. An ergonomic and intuitive user guidance via a web front-end makes access to the relevant information for specific jobs and the associated hazardous materials much easier for the employees of the individual institutes.

A particular challenge was the complete data transfer from the previously used systems during the introduction of GEVIS II, which now administers all hazardous materials used by the Fraunhofer-Gesellschaft. During the hardware technology realization, special care was taken to provide the highest performance and availability to the users. The local requirements at the institutes were kept to a minimum. This was achieved by realizing an ASP solution which did not require changes to the network structure, firewall configuration, or something similar at the institutes.

Special attention was paid to the user administration which, according to

certificate of the Fraunhofer-Gesellschaft, realizes a transparent representation of the user under consideration of the corporate directory after login. Thus, no additional account data (user name, password) is required. Security is ensured via the use of SSL-VPN based on the certificates of the Fraunhofer-Gesellschaft.

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¹ ASP = Application Service Providing

² GefStoffVO = Gefahrstoffverordnung (Ordinance on Hazardous Substances)

Reference system at Fraunhofer

UMSICHT: Locations of the Fraunhofer-Gesellschaft

INFORMATION TECHNOLOGY IN PROCESS ENGINEERING

Keeping an eye on all data with DAVID (Data Acquisition and Visualization Device)

70

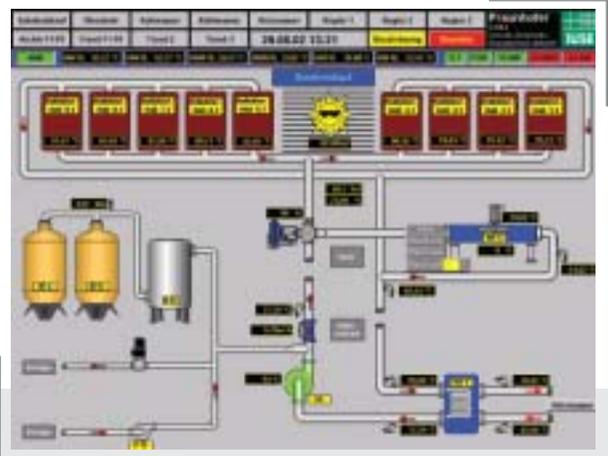


Technical installations deliver data around the clock. Monitoring them costs time and money. The “Data Acquisition and Visualization Device” DAVID of Fraunhofer UMSICHT supports the monitoring of plants and objects and offers a quick overview over the status via process visualization. Users of the DAVID system save resources because they can comfortably access plant data any time from almost any location.

Humans are visual beings, and complex connections are much easier to understand in illustrations rather than in the written form. The trend of visualization has also entered the areas of process and automation technology from the



DAVID enables comfortable access to data any time from almost any location



Process visualization:
Brine circulation loop of the solar plant at Fraunhofer UMSICHT

pure specialty application to the final consumer: Ten years ago only the processes in power plants were visualized, whereas today even processes in private household heating systems are visualized.

Fraunhofer UMSICHT offers an integrated management tool for the implementation of specific monitoring requirements with its modularly constructed DAVID system. The individual modules exhibit extensive functionality from simple data recording to process visualization and description.

Reference system at Fraunhofer UMSICHT

www.solare-kaelte.de

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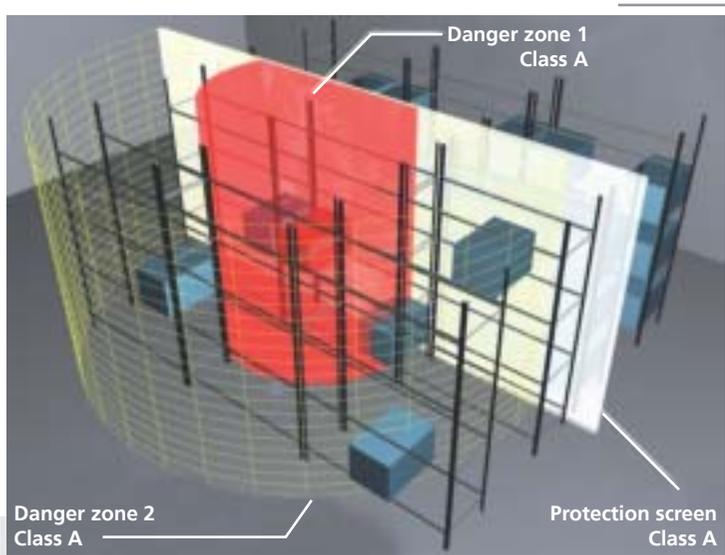
Hazardous material storage – Optimization of logistics and security

During the storage of hazardous materials, the storage facility operator has to pay attention to numerous logistical and regulatory requirements. Especially in storage facilities with broad hazardous material spectrums, conflicts between the economic (logistics) and regulatory (safety technology) goals can arise at times which can only be optimally solved by utilizing appropriate software systems for the storage facility operator. Currently, these systems only offer support for meeting the logistical requirements. The regulatory requirements have to be determined and tested for each hazardous material separately. Particularly, small and medium sized enterprises are having difficulties with this because they do not have the necessary experts at their disposal.

As part of the research project "Development of an assistance system for the



Automated storage location assessment



Simulation of arrangement options

enabling of environmentally sound and economically viable hazardous material storage" of the German Federation of Industrial Research Associations "Otto von Guericke" e. V. (AiF), Fraunhofer UMSICHT is compiling the regulatory requirements for hazardous material storage in the form of rules. In cooperation with Fraunhofer IML, a suitable structure is being developed which allows the coupling of the developed body of regulations with the commercially available storage administration software. Thus, the software is enhanced to consider the regulatory requirements in addition to logistics for the storage of hazardous materials. Additionally, the combined software-supported assessment of regulatory and logistical requirements allows the simulation of future storage occupancy scenarios. If regulatory requirements

prohibit the storage of individual materials (e.g. insufficient ventilation), the operator can determine the necessary modification of the storage facility under consideration of the existing storage situation with the support of the software. The output of the data is accomplished with 2D and 3D visualization methods.

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“Fuels from biomass and waste will play an important role in future energy supply. The central task of research and innovation must be to effectively treat and utilize materials and energy, to save resources and to avoid emissions.”

[Dr. rer. nat. Thomas Marzi, Business Unit Manager Energy Technology]

The objective of our work is an application-oriented development of energy conversion plants for efficient and economic power, heat and cold supply. We use our competencies in the fields of energy conversion, renewable energy sources and "waste to energy/biomass to energy" in order to successfully position our customers in the dynamic energy and waste market.

Our work focuses on the treatment, combustion and gasification of heterogeneous material mixtures as well as on the extraction, cleaning and utilization of biogases and low BTU gases and their utilization in local combined heat and power plant systems.

Energy Technology

Waste to energy/Biomass to energy

Treatment and utilization of biogenous, low BTU gases for decentralized electricity generation

Combustion of low BTU gases in microturbines

Emission trading at Fraunhofer UMSICHT

Waste to energy/Biomass to energy



Starting material:
Industrial wastes of <300 mm (left)
Refuse derived fuel production:
Pellets (upper right)
Fluff (lower right)

The co-cumbustion of wastes and biomass as well as the separate use in RDF power plants leads to new technical challenges. Their solution is the focus of our work at Fraunhofer UMSICHT:

Decentralized, small combustion plant MARS® trial operation and expansion

The MARS® pilot plant is being operated by Fraunhofer UMSICHT and the Chair of Environmental Process Engineering and Plant Design of the University Duisburg-Essen as part of a research project funded by the NRW Ministry of Economic Affairs and industry partners. In 2006, the plant was operated with refuse derived fuels from industrial wastes and rejects from the paper industry. Now the plant also has automated fuel feeding and SNCR¹ technology. Additional investigations of biomass and industrial wastes are planned.



The MARS® plant: the new conveying technology can be seen (white), the water-cooled pipes for the grate (green), and the combustion chamber (red)

Model for the optimization of material flows during RDF production

In cooperation with the Company Tönsmeier, a model was developed for the prediction of material flows as well as product and reject qualities for RDF production. The model can be used to estimate the influences on the qualities of the material flows ahead of time.

Testing of fuels from waste

The Bundesgütegemeinschaft Sekundärbrennstoffe (Federal Quality Assurance Association for Solid Recovered Fuels) has established a proven sampling procedure for quality control of deconditioned RDF. However, the sampling of fuels with large particle sizes is associated with great uncertainties. In this context, Fraunhofer UMSICHT has developed a sampling method that is based on a relatively large sample size basis.

Temperature dependent release of chlorine and sulfur compounds

In cooperation with the joint venture power generating plant Schweinfurt, a method was developed to test the temperature dependent release of chlorine and sulfur compounds in waste fractions. The goal is to derive the corrosion potential of the fuels.

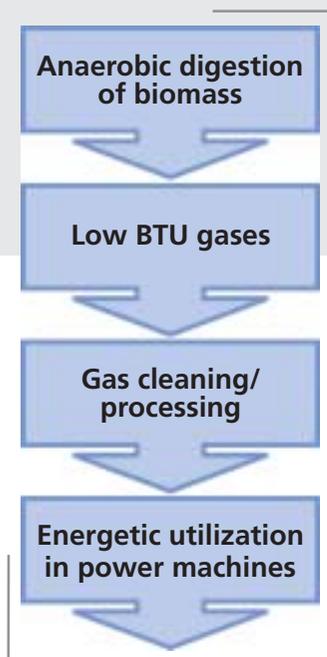
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¹ SNCR (Selective Non Catalytic Reduction) = Denitrification process for the reduction of nitrogen oxides (NO_x) in flue gas (Source = www.wikipedia.de)

Treatment and utilization of biogenous, low BTU gases for decentralized electricity generation

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Trace element composition of biogenous gases

Biogenous low BTU gases (biogas, sewage gas, and landfill gas) are generated by anaerobic digestion of biomass or organic wastes. The energetic utilization of these gases in fuel cells, turbines, and engines reduces climate damaging emissions, and, given the most complete utilization, contributes to sustainable management. Biogases have to be cleaned from many pollutants by suitable processes, especially prior to energetic utilization in fuel cells (see figure). Typical contaminants in low BTU gases are organic sulfur, halogen, and silicon compounds. The installation of an efficient and tailored gas cleaning plant is dependent on three factors: the loading of contaminant trace amounts in the low BTU gases to be used, the intended energetic utilization, and economic factors. For example, landfill gas requires a completely different cleaning process as biogas due to its very complex contaminant loading (see figure).

biogas

- hydrogen sulfide
- organic sulfur compounds

sewage gas

- hydrogen sulfide
- organic sulfur compounds
- aromatic hydrocarbons

landfill gas

- hydrogen sulfide
- organic sulfur compounds
- aromatic hydrocarbons
- halogenated hydrocarbons

Biogenous low BTU gases have to be cleaned to remove a variety of contaminants using the appropriate processes, especially prior to utilization in fuel cells.

Fuel cells exhibit a higher electric efficiency than gas engines which makes the future utilization of low BTU gases in fuel cells especially attractive. Nevertheless, fuel cells have higher low BTU gas purity requirements compared to standard power plants, and conventional gas cleaning processes (e.g. adsorption on activated carbon) have so far only generated average results. This is especially true for downstream fuel cell arrangements. The arising consequential costs reduce or endanger the economic viability of special gas utilization. On this basis, Fraunhofer UMSICHT is investigating innovative gas cleaning processes which are individually tailored to the gas and CHP¹ application. As part of the BMBF-funded "ReGasNet"² project, a catalytic landfill gas cleaning process is being tested in the field in order to clean landfills gas to fuel cell quality.

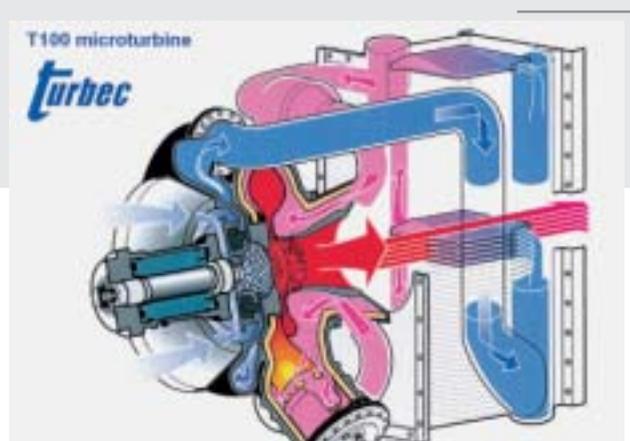
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¹CHP = Combined heat and power

²More about the ReGasNet-Project can be found on pages 102-103

Combustion of low BTU gases in microturbines

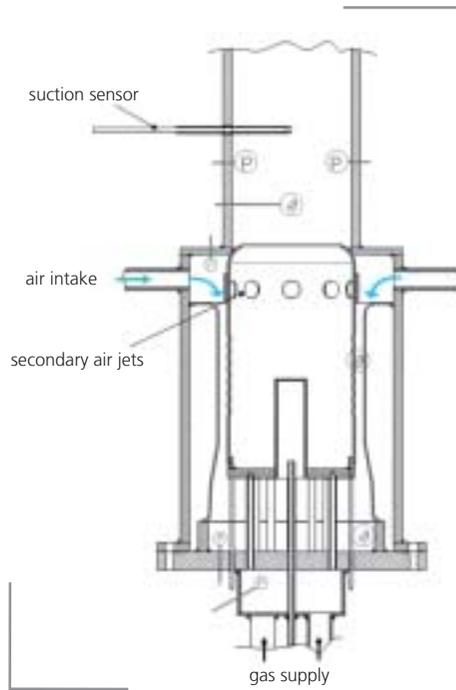


Schematic diagram of the Turbec T100 micro gas turbine

(Printed with permission by Turbec R&D AB, Malmö, Sweden)

The Renewable Energies (EEG, April 2000) in Germany and comparable regulations in the neighboring European countries have led to a dynamic development in the utilization of low BTU gases in gas engines with combined heat, (cold,) and power generation for selling electricity into the grid. Despite these developments, low BTU gases with low heating values ($HV < 14 \text{ MJ/Nm}^3$) are still used sparsely since gas engines and microturbines with conventional burner technologies cannot use these gases without cost intensive upgrading (increase of heating value by mixing with propane or natural gas). A joint project¹ should help provide a solution to that problem. The project encompasses the development and testing of new burner concepts with which it is possible to utilize low heating value gases in microturbines without upgrading.

First, the new burner concepts FLOX²



Design of the COSTAIR®-burner

*(Printed with permission by
Gas Heat Institute, Essen)*

and COSTAIR³ were adapted to the combustion chamber geometry of a commercial micro gas turbine of the type T100 from the Italian manufacturer Turbec S.p.A., Ferrara and tested on an atmospheric burner test stand. Both burners achieved a stable operation with different gas mixtures (gas mixtures comprised CH₄, N₂, H₂, CO and CO₂ in varying compositions). The mixture with the lowest heating value with which a stable operation was still possible contained 15 Vol.-% methane in nitrogen (HV = 5,4 MJ/Nm³). The emission values for NO_x and CO were significantly below the limits of the TA Luft (Technical Instructions on Air Quality Control) for many air-fuel ratio values.

Based on these successful preliminary research results, the new burner concepts will be installed one after the other into an existing micro gas tur-

bine of the type T100 at Fraunhofer UMSICHT and tested under realistic operating conditions (integrated into the electricity and heating network) with a synthetically produced low BTU gas made from natural gas and nitrogen.

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¹ The research project is funded by the AIF under the project number 14472.

The alliance members of the project are:
Gas Heat Institut, Essen (project coordination); Fraunhofer-Institute for Environmental, Safety, and Energy Technology UMSICHT, Oberhausen; Department for Energy Plants and Energy Engineering of the Ruhr University, Bochum; Institute Nowum Energy of the Technical School, Department Jülich, Jülich; Waste Management and Waste Technology Departments of the University Duisburg-Essen, Essen

² FLOX = Flameless oxidation, patented by WS Wärmeprozess-technik GmbH, Renningen, DE 10217913, EP 0685683, EP 0463218

³ COSTAIR = COntinued STaged AIR, patented by Gaswärme-Institut e.V., Essen, EP 0834040 B1, US 6,419,480 B2

Emission trading at Fraunhofer UMSICHT

In the context of the implementation of the Kyoto Protocol adopted in 1997, emissions have been traded in the European Union since 2005. Fraunhofer UMSICHT has been working on the subject across various disciplines since 2001.



Only comprehensive strategies and innovative technologies will help protect the ecological balance

Similarly to the Ruhr area, projects in Eastern European countries have led to international recognition of coal mine methane utilization technology developed by Fraunhofer UMSICHT.

Many large German businesses are consulted by the institute on EU emission trading strategies and the process for the emission permitting application at the German Emission Trading Authority (DEHSt), Federal Environment Agency. A significant increase in the consulting activity is expected with the start of the second EU emission trading phase in 2007.



A reduction of greenhouse gases was agreed upon in the Kyoto Protocol

The activities in the area of emission trading are interdisciplinary at Fraunhofer UMSICHT and make market introduction easier. This holds especially true for energy technology innovations because additional revenues can be earned from emission trading by utilizing these innovations.

Emission trading will become particularly interesting in the countries of Southeast Asia because the production of biofuels is expected to increase significantly there in the next years. Fraunhofer UMSICHT supports a biogas project in Thailand which would not have been feasible without the use of project-related Kyoto mechanisms. Additional biogas projects are planned in Indonesia in which the use of wastewaters is in the foreground.

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“Industrial societies need energy. In order to guarantee a sustainable and economic supply of energy more efficient plants for energy conversion and storage must be developed and integrated optimally into already existing supply systems.”

[Dr.-Ing. Christian Dötsch,
Business Unit Manager Energy
Systems]

Our objective is the intelligent integration of energy systems into existing and new supply structures as well as their efficient utilization. We combine fossil and regenerative energy sources with central and local conversion processes in order to create custom-made, economically and ecologically balanced systems which pave the way for local synergies.

Local regenerative polygeneration plants combined with district heating networks already represent such integrated systems: On the one hand, they open up the possibility of economic and CO₂-neutral heating and cooling, and, on the other hand, they provide competitive products for the electricity market as a "virtual power plant".

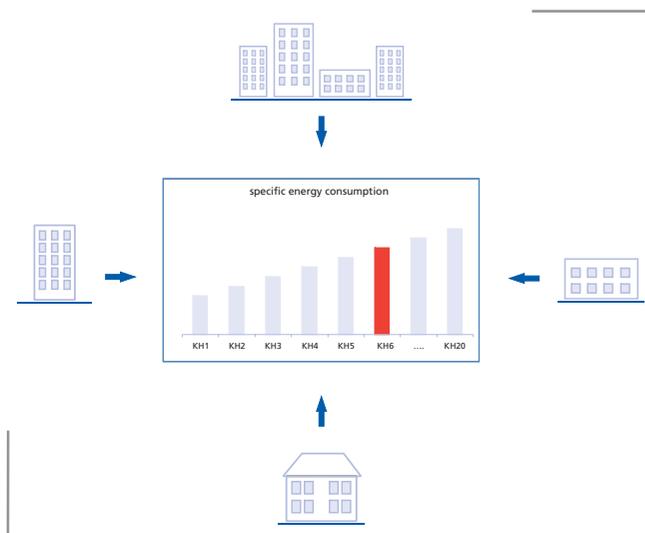
Energy Systems

- Energy efficiency in hospitals
- Decision support for energy management
- Cold from heat
- Storing energy efficiently

Energy efficiency in hospitals

Hospitals require a large amount of energy for heating, warm water, ventilation, and the operation of medical equipment. An efficient energy supply secures the continuous operation and is important for the economic viability of the whole organization. If you are looking for savings, you have to know your supply structure.

Therefore, Fraunhofer UMSICHT is conducting a research project with 20 hospitals. Previously, detailed information on the operation of energy plants did not exist for most hospitals so that a determination of the efficiency was not possible. Based on extensive energy measurements, the project offers a wide database which contains much information about the efficiency of the energy plants. Energy saving potentials can be identified directly and improvement measures can be taken.



Compared: Hospitals with different characteristics



First, measure – then, save



Load measurement as basis for the multi-criteria key figure comparison

Using a multi-criteria approach, new key performance figures are developed which take the characteristics of the hospitals into consideration. The goal is to compare hospitals with different structures and to identify worthwhile savings potentials. Furthermore, best-practice solutions show which savings measures have been successfully implemented for the best benchmarking candidates. The results of the project should form the basis for also achieving savings at other hospitals. In addition, it will be possible to transfer the benchmarking method to other industries such as foundries, breweries, to hotels as well as to production plants and in general for energy optimization.

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Decision support for energy management

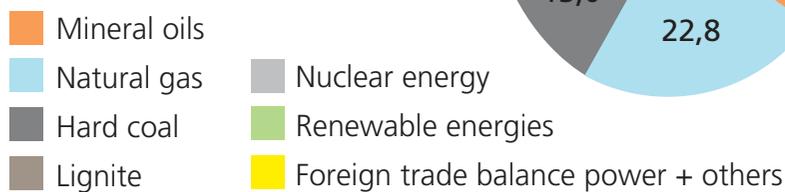
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Energy management strategies that adapt reliably to competitive pressure, high price, volume, and financial risk, as well as changing political and social conditions are in greater demand than ever. Therefore, decisions in planning and business management of energy systems are increasingly supported by simulations, scenario analyses, and mathematical optimization.

The goal of the research initiative "Research Networks Fundamentals of Renewable Energies and Efficient Energy Utilization" of the BMBF (Federal Ministry of Education and Research) is to utilize renewable energies better. Together with the University of Duisburg-Essen, the Humboldt University Berlin, the Ruhr University Bochum, the Technical University Darmstadt, and the University of Dortmund, Fraunhofer UMSICHT is developing stochastic optimization processes for the design and operation of energy systems with a large share of power generation from renewables supply in the project "Innovative Modeling und Optimization".

Everything depends on the right mixture,
in a cocktail bar as well as in the energy industry.



Source: AGEB
AG Energiebilanzen

One focus is the optimum coverage of fluctuating grid feed-in with technical tools (storage, controlling) and methods for decentralized energy and risk management.

The application of methods for analyzing energy systems for a better control of uncertainties is a main focus of the Fraunhofer Alliance "Energy" in which ten Fraunhofer Institutes combine their competencies in energy technologies and research. Their concentration is on control and operational behavior of complex systems such as the control of distributed power plants or the energy management coordination for electricity, natural gas, and heat/cold. In-house Fraunhofer research is offered to industry and the energy economy, accelerating innovation transfer into practice.

The European emission trading represents an important change in the framework of the energy business. Fraunhofer UMSICHT consults more than 25 businesses with the strategic

and operational implementation of their CO₂-management. CO₂-monitoring and report generation as well as risk management are the focal points of our consulting activities.

Climate protection and resource conservation are the central requirements for a sustainable heat supply. The expansion of ecologically advantageous local district heating networks on the basis of decentralized combined heat and power and renewable energy sources (e. g. biomass) also has to meet economic criteria. As a part of the project "Rural District Heating", investment decisions concerning small-scale district heating networks are compared by the development and application of economic, ecological, and technical evaluation criteria.

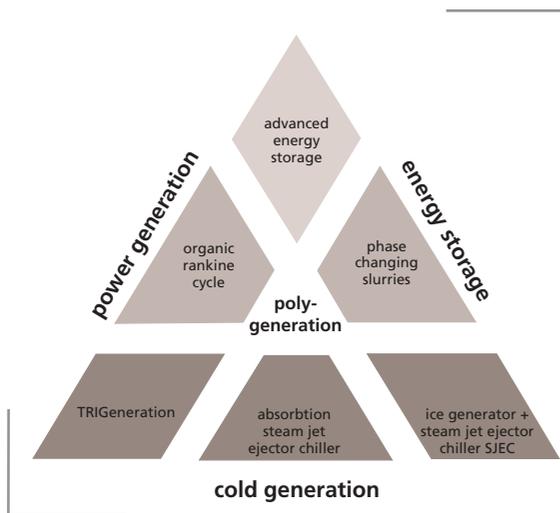
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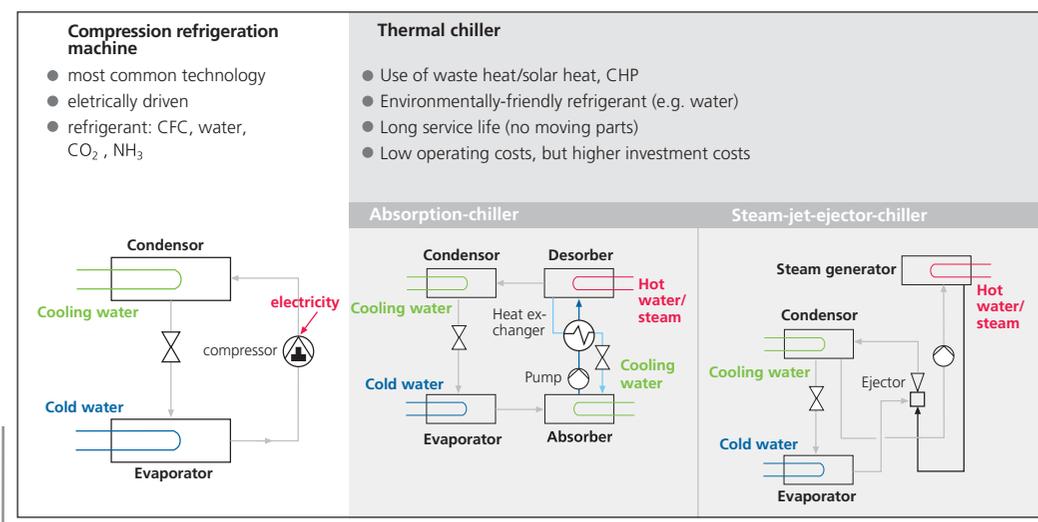
Cold from heat

The growing worldwide demand for energy carriers combined with their decreasing availability is moving the energy markets. The energy economy is required to ensure supply security by economic interests and environmental protection. In contrast, it is the citizens and industry's responsibility to utilize the resource energy efficiently and to realize savings potentials. In the context of the innovation field "Polygeneration", Fraunhofer UMSICHT is developing technologies for the efficient conversion and storage of energy which will help to meet both requirements.

The growing cold demand is driving up global energy consumption and is straining the climate. In Germany, 6% of the primary energy consumption is associated with technical cold generation. Energy efficient technologies for the operation of electrically, mechanically, and thermally driven chillers are in high demand. The combined generation of electrical and thermal



The development of energy technologies for the efficient energy conversion and storage are the focus of polygeneration



Processes for cold generation

energy is especially efficient because the waste heat produced during electricity generation is used for heating or cooling by thermal cooling processes. Thus, thermal chillers, which are driven with waste heat or solar heat, make a significant contribution to a rational and sustainable energy supply. Fraunhofer UMSICHT develops and optimizes thermal cooling processes with regard to their implementation for combined heating, cooling, and power (CHCP) energy systems or for solar cooling.

A small-sized absorption chiller (cooling capacity < 10 kW_{th}, working fluids LiBr solution/water) driven by CHCP or solar heat is currently under development for decentralized building cooling.

As part of an Austrian-German cooperation project, a small, standardized steam jet ejector (cooling capacity 10 kW_{th}) is being developed in combination with a parabolic trough collector in order to offer an environmentally

friendly technology for decentralized solar cooling.

In addition, a compact steam jet ejector chiller fitted into a container (planned cooling capacity 100 kW_{th}) is being developed. It will be set-up on the institute's premises during the summer of 2007 as a demonstration plant. It will be driven by the on-site block-type combined heat and power plant as a CHCP.

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Storing energy efficiently

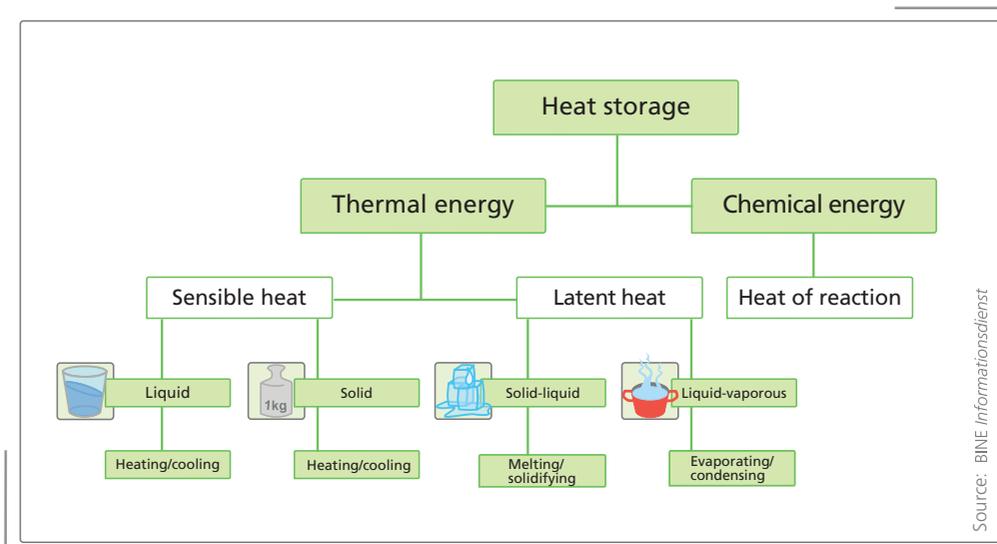


Energy is a volatile quantity – to store it without losses requires intelligent technologies

Supply and demand are rarely matched. The energy economy is no exception here. Energy storage can help smooth out supply and demand and make energy available when it is needed. Fraunhofer UMSICHT develops and optimizes technologies which store energy so efficiently that as much as possible of it can be used.

Storage of electrical energy

Storing electrical energy has always been one of the big challenges of the energy technology field and is currently gaining the status of key technology during times of increased utilization of intermittent renewable energies. The expansion of renewable energy generation has resulted in growing temporary discrepancies between energy generation and utilization: Peak loads but also an oversupply of energy are the consequences leading to problems in energy supply networks.



Classification of heat storage types

Electrical energy storage is ideal for smoothing peak loads, overcome brief grid problems, as well as balancing supply and demand. The business unit Energy Systems heads the Fraunhofer Alliance project for the development of decentralized energy storage units which are scalable with regard to their capacity and storable energy.

Storage of thermal energy

If thermal energy (heat) is to be stored, it is accomplished via a storage medium. Conventional thermal storage technologies in the cold supply are chilled water buffers and ice storage units. However, these have a low energy density (chilled water buffer), or they require a charging temperature significantly below 0 °C (ice storage) which has a negative effect on the performance of the chiller. Phase Change Slurries (PCS)¹ as a heat carrier medium offer interesting opportunities for cold storage and distribution.

Fraunhofer UMSICHT offers CryoSol[®], an ice slurry (for more details, please see Annual Report 2005) as a PCS. For the temperatures range above 0 °C, cold carriers on the basis of paraffin/water emulsion/suspension are investigated which can be used for air conditioning. The goal of the investigation is the development of a PCS which can be used in conventional cooling network systems for performance enhancement.

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¹ PCS are suspensions or emulsions made of a Phase Change Material (PCM) and a liquid phase which can be pumped through pipes with the PCM in a solid or liquid state and can be heated or cooled in conventional heat exchangers. These media use latent and sensible heat for heat storage. The resulting higher energy density reduces storage volumes and pumping power requirements.



“Materials and energy, knowledge and ideas: with these we supply complex networks and let new networks emerge from. This reservoir of resources is worth being used in a sustainable and intelligent way.”

[Dr.-Ing. Hartmut Pflaum,
Business Unit Manager Resources
Management]

We examine the use of materials, energy, goods, knowledge and human resources in processes, process chains and value added networks and find ways to optimize them according to economic, ecological and technical-infrastructure criteria.

The focus of our R&D-services is on production systems, locations, regions and their integration into larger networks. Our objective is to use resources in such a way that they lead to progress and innovation.

We combine modern management instruments with the know-how on resources and technologies. The results enter into strategic studies and consulting services focussing on resources management, waste management, renewable energies and innovation management. Thus, technical and infrastructural processes and procedures can be optimized.

Resources Management

European Waste Sector Assistant EUWAS – Knowledge and information for waste management in a “one-stop-shop”

Potential study:
The path to individual decisions

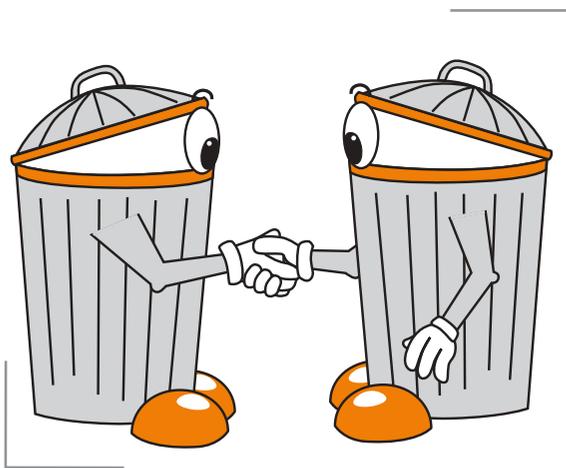
BioRegio: Strategies for the sustainable energetic utilization of biomass in chosen model regions

Network for gas treatment technologies and processes “ReGasNet”

RESOURCES MANAGEMENT

European Waste Sector Assistant EUWAS – Knowledge and information for waste management in a “one-stop-shop”

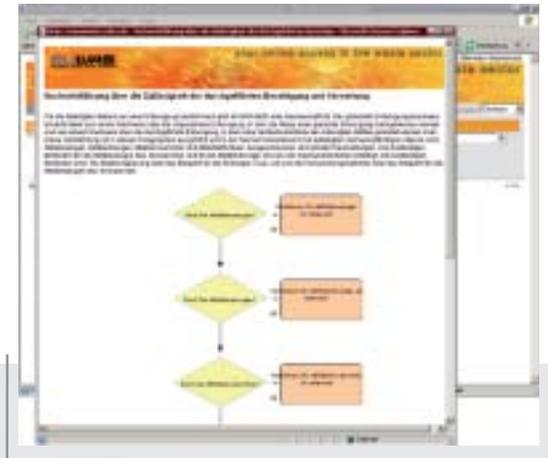
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International collaboration within Europe requires availability and exchange of knowledge and information. The accession of the first ten Eastern European states to the European Union has significantly increased the amount of information that needs to be processed but also the demand for know-how, a trend that is expected to continue in the foreseeable future. This concerns European administrative processes, data and information for solicitations, and European programs in the area of municipal and industrial waste management, among others. In order to meet this informational demand, Fraunhofer UMSICHT, in concert with seven other European partners is developing the “EUWAS¹ – European Waste Sector Assistant” platform: a target group-specific, IT-supported, multi-lingual information portal for businesses and governments in the waste management field.



EUWAS: Introduction in "Best Available Technology"



Step-by-step guide

The portal provides industry relevant contents for five selected countries (Estonia, Germany, Latvia, Lithuania, and Poland), and explains laws and directives of European waste management.

In addition to personalized registration, the following services can be found at EUWAS, among others:

- The **waste management services** provide a structured representation of the national (European) processes/operations and general waste management data.
- The **suppliers and co-operation exchange** serves to exhibit one's own service spectrum presentation as well as helping bring together partners for mutual projects.
- The **tender platform** offers a collection of national and European tenders with simultaneous support with the completion of a proposal/tender.

- The area **BAT²/Best Practice** offers an up-to-date selection of best available technologies as well as national best practice examples.

In addition, the portal distinguishes itself by providing multiple language support and user-friendly support functions such as step-by-step guides, educational modules, and structured information databases. An open source based content management system forms the basis of the portal.

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¹Co-financed through the European program eContent/Distribution measures are funded by the Federal Environment Agency

²BAT: Best Available Technology

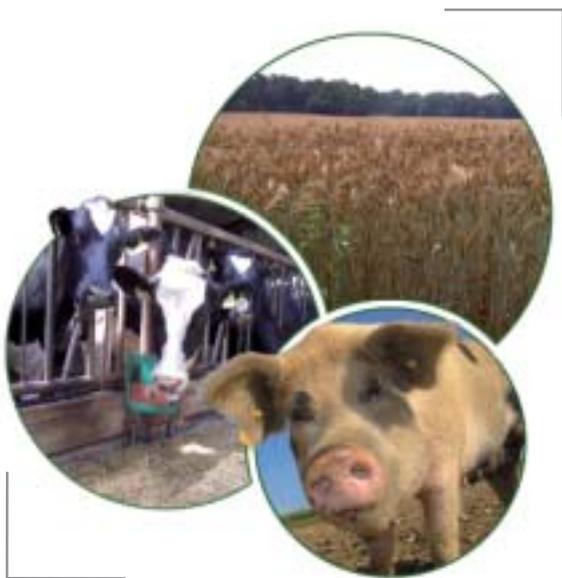


RESOURCES MANAGEMENT

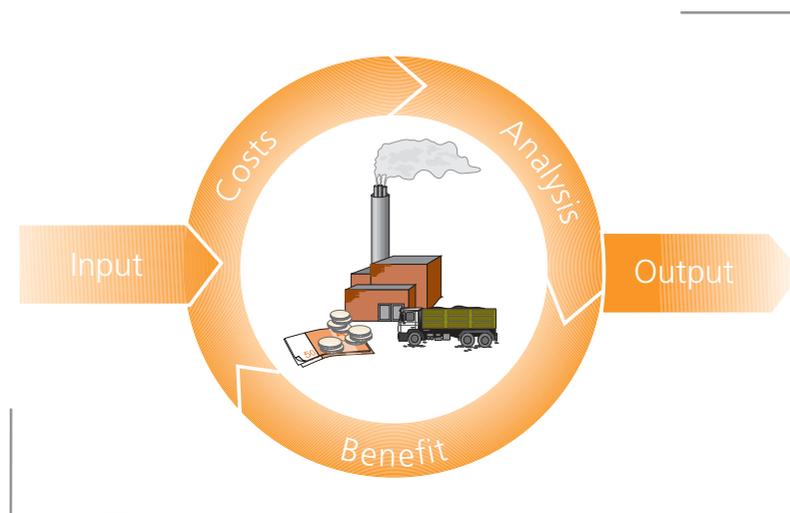
Potential study: The path to individual decisions

The business unit Resources Management lays groundwork for individually suited project and investment decisions for the industrial and public sectors with strategic potential studies and roadmaps. The utilized analysis and evaluation methods are tailored, advanced further, or developed completely new for the given objective. Whether based on estimations or concrete market data: Each potential study exhibits strategic measures in order to secure future decisions.

Bioenergy is en vogue as an alternative and sustainable energy source. However, which raw material, utilization, and infrastructure potentials really exist in a specific area in order to venture the investment into bioenergy? These questions were answered for several companies from the energy sector and assessed based on market data and political trends. Biogas generation and feeding into the grid as well as the industrialization of bioenergy were the



These are the potentials for the utilization of bioenergy



Cost/benefit assessment
in waste management

focal points. The results were generated using expert workshops, in-house data collection and analysis tools for energy potentials, and GIS¹-supported analyses.

In cooperation with Fraunhofer IPA, a strength and weakness profile regarding regenerative energy was developed for the East Frisian City of Emden. Alternative courses of action, which should contribute to the concept of a future-oriented and sustainable energy economy for Emden, were validated and complemented by expert opinions.

In recent years, several studies for cost/benefit assessments in waste management have been carried out on European level. They often assessed various material streams and non-standardized sets of ecological and economical parameters. Contracted by the Federal Environment Agency, Fraunhofer UMSICHT analyzed the comparability and results of the studies. This resulted in a better

assessment scheme for the domestic waste which was tested for mechanical-biological treatment and incineration.

The environmental impact of a PC and a Thin Client supported supply of IT services was compared for an IT business. As part of the project, the direct consequences of the manufacturing, use, and disposal phases were taken into consideration using secondary data, model calculations, and in-house measurements.

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¹ GIS: Geographic Information System

RESOURCES MANAGEMENT

BioRegio: Strategies for the sustainable energetic utilization of biomass in chosen model regions

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Wood harvest in a forest



Energy en masse: Pigs as manure producers

As part of the BioRegio Project “Strategies for the sustainable energetic utilization of biomass”, which was coordinated by the Institute for Future Energy Systems (IZES), regional biomass potentials were analyzed and utilization strategies were developed. The research partners of the project (Fraunhofer UMSICHT, Eco-Institut, Institute for Energy and Environment, Institute for Applied Material Flow Management) investigated innovative bioenergy technologies on the basis of six specific model regions in Germany and determined biomass potentials on a regional level from 12/2004 until 3/2007. One significant goal was to ensure the transferability of the results to other regions.

In 2006, Fraunhofer UMSICHT created and coordinated a network in the Em-scher-Lippe region, which is made up of the district of Recklinghausen as well as the cities of Bottrop and Gelsenkirchen. The theoretical biomass potential was determined in the forestry, agriculture



Bioenergy technology with potential:
Biogas plants

and waste sectors. Overall, a theoretical biomass potential of 3 520 TJ¹/a is available. In the agricultural sector, the potential amounts to 404,5 TJ/a (for example from liquid/solid manure and hay). In the forestry sector, the potential is approximately 558,8 TJ/a (represents around 31 750 t_{dry}/a of wood). The waste sector exhibited the largest potential with about 2 585 TJ/a. It encompassed biowaste, waste wood, and sewage and landfill gas.

The comparatively large biomass amount in the waste sector of the Emscher-Lippe region can be attributed to the high population density and to large plants such as the central landfill Emscherbruch and the wastewater treatment plant in Bottrop. Aside from the energetic utilization of already existing biomass, the development of new biomass sources is a crucial prerequisite for the increase of the renewable energy portion of the overall energy consumption.

The region is currently represented in a model in order to calculate various scenarios, e.g. for the year 2020, and to assess the influence of different biomass utilization options. It is planned to develop a roadmap with recommendations on actions from the project experiences in order to sustainably support the development of additional regional energetic biomass utilization.

Additional information on the BioRegio project, which was funded by the Ministry for Environment, Nature Conservation, and Nuclear Safety, can be found at: www.bioregio.info.

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¹TJ: Terajoule, which means 10¹² or 1 trillion Joule

Network for gas treatment technologies and processes "ReGasNet"

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Concrete network activities: Meeting in March 2006 at Fraunhofer UMSICHT

"The share of regenerative low BTU gases of the total energy supply portfolio should increase significantly". This is the goal of 14 German and Polish research organizations that have come together under the management of Fraunhofer UMSICHT to form a network for gas treatment technologies and processes "ReGasNet¹".

The range of the investigated low BTU gases includes biogas, coal mine methane, landfill gas, sewage gas, and raw gas from biomass. During the first phase of the network activities, a total of 15 research and development activities along promising utilization paths will be realized. These include, among others:

- the development and optimization of appropriate trace gas analysis for biogases,
- the development of catalytically oxidative desulphurization processes, both polishing and general,



Everything fits together somehow: Technical systems form complex networks

- the investigation and improvement of polishing and general desulphurization processes,
- the hydrogen production through anaerobic fermentation or in-situ separation from allothermic steam gasification,
- different high temperature gas cleaning processes and
- the methanation of raw gas from biomass gasification.

At the same time, a system-analytical assessment of the research results and the state of the art is performed.

The utilization of different tools (e.g. regular project meetings, use of project internal website) helps connect the participants with one another. This way the already existing experience and expertise from other partners can be utilized for the research work. In addition, the bi- and multi-lateral discussions of the insights gained contribute significantly to the success of the work.

The partners have come a significant step closer to the goal of identifying promising technologies and eliminating hurdles and knowledge gaps that could hinder their implementation. The research work of the first phase of the network activities are nearing their conclusion. In parallel, the development of promising strategies to determine further development approaches are currently under way.

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¹ ReGasNet funded by the Federal Ministry for Education and Research (BMBF).

“The most useful books are those of which readers themselves compose half.”

Voltaire (1694-1778), Philosophical Dictionary

With this quotation in mind we wish you many inspiring moments.



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*Celanese Chemicals Europe GmbH

**Universität Dortmund

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*RWE AG, Essen

**E.ON Ruhrgas AG, Essen

*** Adsorption Technology Research and Development Linde AG, Hoellriegelskreuth

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A

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 Abwasserverband Kempen/Lauben (Allgäu)
 AdFis Adsorptive Filtersysteme GmbH, Teterow
 AEG SVS Power Supply Systems GmbH, Warstein-Belecke
 AEE Intec, Gleisdorf, Austria
 AGR Deponienachsorge GmbH & Co. KG, Herten
 AgriCapital GmbH, Greven
 AiF Arbeitsgem. industrieller Forschungsvereinigungen Otto von Guericke e.V., Berlin
 Airplanko, Bernd Michalak, Oberhausen
 Albutec GmbH, Rostock
 Alfried Krupp von Bohlen und Halbach Krankenhaus gGmbH, Essen
 Alpes Lasers, Neuchâtel, Switzerland
 ALPINE-ENERGIE Deutschland GmbH, Biberach
 ALSTOM GmbH, Frankfurt a. M.
 Altenburger Maschinen Jäckering GmbH, Hamm
 Andritz AG, Graz, Austria
 Apex Energy Teterow GmbH, Teterow
 Aqua-Society GmbH, Herten
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 Architektenpartner Reuss & Reuss, Memmelsdorf
 ASZ GmbH & Co. KG, Bad Rappenau
 A-TEC Anlagentechnik GmbH, Duisburg
 Aufbereitungstechnologie Noll GmbH, Bobingen
 AVG Abfall-Verwertungs-Gesellschaft mbH, Hamburg
 AVIT Hochdruck Rohrtechnik GmbH, Essen
 Axima Refrigeration GmbH, Lindau

B

Baerlocher GmbH, Unterschleißheim
 Barcelona Semiconductors SL, Barcelona, Spain
 BASF Aktiengesellschaft, Ludwigshafen
 Bau- und Liegenschaftsbetrieb NRW, Dortmund
 Bayer AG, Leverkusen
 Bayer Schering AG, Berlin
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 Bayer Technology Services GmbH, Leverkusen
 BAYERNOIL Raffinerieges. mbH, Ingolstadt
 Beer GmbH, Hellenthal
 benefit GmbH, Hirschau
 BGA Entwicklungs-Verwaltungsges. mbH, Willich
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 Bioenergie Steinfurt GmbH & Co. KG, Steinfurt
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 BKB Hannover GmbH, Hanover
 Blatzheimer Sand- und Kieswerke Jakob H. G. Nowotnik e.K., Kerpen
 BKT Energietechnik GmbH, Oberhausen

BKV Beteiligungs- und Kunststoffverwertungsgesellschaft mbH, Frankfurt a. M.
 Borealis GmbH, Linz, Austria
 Borromäus-Hospital, Leer
 Brandschutz u. Bauwesen GmbH, Niestal
 Britta Loick Consulting GmbH, Dorsten
 Brunel GmbH, Mannheim
 Buchhandlung und Verlag K.-M. Laufen, Oberhausen
 Bückmann GmbH, Mönchengladbach
 Büro für Technikfolgen – Abschätzung beim Deutschen Bundestag (TAB), Berlin
 build.ing Gesellschaft für Planen, Bauen, Betreuen mbH, Berlin
 Bundesamt für Bauwesen und Raumordnung, Berlin
 Bundesamt für Wirtschaft und Ausfuhrkontrolle (BAFA), Eschborn
 Bundesamt für den Zivildienst, Cologne
 Bundesministerium für Bildung und Forschung, Berlin
 Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, Berlin
 Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz, Berlin
 Bundesministerium für Wirtschaft und Technologie, Berlin
 Button Energy/Knopf Glastechnik, Vienna, Austria
 BWS Technologie gGmbH, Grevenbroich

C

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 Centrum für internationale Migration und Entwicklung (CIM), Frankfurt a. M.
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 Clariant, Masterbatches (Deutschland) GmbH, Ahrensburg
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 Cornpack GmbH & Co. KG, Dorsten
 Creative Concepts & Projects Establishment, Schaan, Liechtenstein
 CUT Membrane Technology GmbH & Co. KG, Erkrath

D

D1 Deutsche Funkturm GmbH
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 DaimlerChrysler AG, Stuttgart
 Dalkia GmbH, Neu-Isenburg
 DataPool engineering GmbH, Oberhausen
 Degussa AG, Frankfurt a. M.
 DELU AG, Gladbeck
 Deron Systemhaus GmbH, Stuttgart
 DBU - Deutsche Bundesstiftung Umwelt, Osnabrück
 DECHEMA Gesellschaft für chemische Technik und Biotechnologie e.v., Frankfurt a. M.
 Deutsche Gesellschaft für Technische Zusammenarbeit GTZ GmbH, Eschborn
 DMT GmbH, Essen

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 Drewag Stadtwerke Dresden GmbH, Dresden
 DVGW Deutsche Vereinigung des Gas- u. Wasserfaches e.V. twV, Bonn

E

EADS Deutschland GmbH Forschung, Munich
 EBRO Armaturen Gebr. Bröer GmbH, Hagen
 EcoEnergy Gesellschaft für Energie- und Umwelttechnik mbH, Walkenried
 Ecoprog e.K., Cologne
 EDI Exploration Drilling International GmbH, Haltern am See
 E. J. M. Abbenhaus GmbH, Clausthal-Zellerfeld
 Elastogran GmbH, Lemförde
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 EnBW Energie Baden-Württemberg AG, Karlsruhe
 ENR Energiegesellschaft nachwachsender Rohstoffe mbH, Dorsten
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 emano Kunststofftechnik GmbH, Teterow
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 ERNST KOCH GmbH & Co. KG, Hemer
 ESBI ENGINEERING & FACILITY MANAGEMENT LTD, Dublin, Ireland
 ESP-Chemie, Premnitz
 EUS Gesellschaft für innovative Energieumwandlung und -speicherung mbH, Gelsenkirchen
 EUS GmbH, Dortmund
 Evangelisches Krankenhaus Bergisch-Gladbach GmbH, Bergisch-Gladbach
 Evangelisches und Johanniter Klinikum Niederrhein Duisburg/Dinslaken/Oberhausen GmbH
 Evang. Krankenhausverein zu Aachen-Luisenhospital, Aachen
 Evang. Krankenhaus Kalk gGmbH, Cologne
 EVD Entwicklungsgesellschaft für Verbundmaterial Diez mbH, Diez
 EVO Energieversorgung Oberhausen AG, Oberhausen
 ewmr Energie- und Wasserversorgung Mittleres Ruhrgebiet GmbH, Bochum

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 Frey & Lau GmbH, Henstedt-Ulzburg

G

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 GAS. Gesellschaft für Antriebs- u. Steuer-technik mbH, St. Georgen
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 Gaswärme-Institut e.V., Essen
 GDX Automotive Rehburg GmbH & Co. KG, Rehburg-Loccum
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 GEA Wiegand GmbH, Ettlingen
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 Gelsenwasser AG, Gelsenkirchen
 Gemeinschaftskraftwerk Schweinfurt GmbH, Schweinfurt
 Gesellschaft zur Förderung von Medizin-, Bio- und Umwelttechnologien e.V., Fachsektion »Funktionelle Schichten«, Dresden
 GNS - Gesellschaft für Nuklear-Service mbH, Essen
 GET mbH Gesellschaft für Energietechnik, Lobenstein
 GfEM Ges. für Energiemanagement mbH, Berlin
 GIGATON GmbH, Viernheim
 GKT Gummi- und Kunststofftechnik Fürstenwalde GmbH, Fürstenwalde/Spree
 Gleitsmann Security Inks GmbH, Berlin
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 G.R.A.S. Sound & Vibration A/S, Vedbaek, Denmark
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 Groep Machiels Recycling Technology, Wilsel-Leuven, Belgium
 Günter Schulze Düding, Steinfurt
 GVT - Forschungs-Gesellschaft Verfahrens-Technik e.V., Frankfurt a. M.
 GWE Wärme- und Energietechnik GmbH, Osterode

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 Henneke GmbH, Sankt Augustin
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 Hubert Loick VNR GmbH, Dorsten-Lembeck
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 Hündgen Entsorgung GmbH & Co. KG, Swisttal
 Hüttenwerke Krupp Mannesmann GmbH, Duisburg
 HV Umweltservice GmbH, Swisttal-Ollheim
 HYDAC Accessories GmbH, Sulzbach

I

ILBau - Illertaler Biomasse Bau- und Eigentums GmbH & Co. KG, Stuttgart
 IEV-Industrie, Lübeck
 IGEL Technology GmbH, Bremen
 IGW - Ingenieurgemeinschaft Witzzenhausen Fricke & Turk GmbH, Witzzenhausen
 imat - ue gmbh, Mönchengladbach
 IMG - Dr. Manfred Peritsch, Graz, Austria
 Immobilien Strebersdorf Verwaltungsgesellschaft m.b.H., Vienna, Austria
 Impreglon AG, Lüneburg
 INDACO Manufacturing Ltd., Scarborough, Canada
 INEOS Phenol GmbH & Co. KG, Gladbeck
 Informationszentrum Entwässerungstechnik Guss IZEG e.V., Bonn
 infra fürth gmbH, Fürth
 Innovatherm Gesellschaft zur innovativen Nutzung von Brennstoffen mbH, Lünen
 Instytut Ekologii Terenów Uprzemyslowionych, Katowice, Poland
 Institut für Energetik und Umwelt GmbH, Leipzig
 Institut für Energie und Umwelttechnik e.V., IUTA Duisburg
 INSTYTUT ENERGETYKI, Warszawa, Poland
 Intensiv-Filter Deutschland GmbH & Co. KG, Velbert
 Interessenverband Grubengas e.V., Rhede
 INTERMET Neunkirchen GmbH, Neunkirchen/Saar
 Intier Automotive Eybl Interiors GmbH, Straubing
 Intier Automotive Interiors, Alzenau i. Ufr.
 Invenio Kunststoff Engineering GmbH, Erwitte
 ISO-mk Innovation, Berlin
 Itasca Consults GmbH, Gelsenkirchen
 IUQ Dr. Krengel GmbH, Grevesmühlen
 IZES - Institut für ZukunftsEnergieSysteme gGmbH, Saarbrücken

J

Jackon Insulation GmbH, Mechau
 Jenbacher GmbH & Co. OHG, Jenbach

Jenbacher Energiesysteme S.L., San Sebastian de los Reyes, Spain
 Jesco GmbH, Wedemark
 Johanniter-Krankenhaus Rheinhausen, Duisburg
 Johnson Controls GmbH, Burscheid
 Johnson Controls Interiors GmbH & Co. KG, Grefrath
 Joline GmbH & Co. KG, Hechingen
 Josef Baust Holzbetriebs GmbH, Eslohe

K

KBG Kommunalbetrieb Goch, Goch
 KEC Kölbl Engineering und Consulting GmbH, Kamp-Lintfort
 Kelman Limited, Lisburn, Northern Ireland
 KHT Fahrzeugteile GmbH, Grevenbroich
 Kiriaki Michaludi, Nikiti, Greece
 Kisters AG, Aachen
 Kliniken Maria Hilf GmbH, Mönchengladbach
 Klinikum Emden Hans-Susemihl-Krankenh. gGmbH, Emden
 Kluber Lubrication Benelux S.A.-N.V., Dottignies, Belgium
 Knappschaftskrankenhaus, Bottrop
 Kocks Consult GmbH, Koblenz
 Kommission der Europäischen Union, Brussels, Belgium
 Konnex Unternehmensberatungsgesellschaft mbH, Güstrow
 Korn GmbH, Albstadt
 Kreiskrankenhaus Gummersbach GmbH, Gummersbach
 Kreisverwaltung Recklinghausen, Recklinghausen
 Kreisverwaltung Neuwied, Linkenbach

L

Lakufol Kunststoffe GmbH, Henfenfeld
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 LEG Standort- und Projektentwicklung Köln GmbH, Cologne
 Lichtwer Pharma GmbH, Berlin
 Linde AG, Unterschleißheim
 Lippeverband, Essen
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 Ludmillenstift Meppen, Meppen
 LÜNTEC Förderverein e.V., Lünen
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M

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 MAN Turbo AG, Oberhausen
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 Mark-E AG, Hagen

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 Messe Frankfurt GmbH, Frankfurt a. M.
 Messer Griesheim GmbH
 MGT Maschinen- und Gerätebau GmbH, Groß Wokern
 Microdyn-Nadir GmbH, Wiesbaden
 MinerWa Umwelttechnik GmbH, Gmunden
 Mingas-Power GmbH, Essen
 Ministerium für Arbeit und Soziales, Qualifikation und Technologie des Landes NRW, Düsseldorf
 Ministerium für Innovation, Wissenschaft, Forschung und Technologie des Landes NRW, Düsseldorf
 Ministerium für Wirtschaft, Mittelstand und Energie des Landes Nordrhein-Westfalen, Düsseldorf
 Modernbau GmbH, Saarbrücken
 Momen Performance Materials Holding Inc., Leverkusen
 MSA AUER GmbH, Berlin
 mtm plastics GmvH, Niedergebra
 MVA Bielefeld-Herford GmbH, Bielefeld
 MVV Energie AG, Mannheim

N

NanoFocus Meßtechnik GmbH, Duisburg
 National-Bank AG, Oberhausen
 Nature Environmental Worldwide Technologies GmbH, Dortmund
 Neumann Krex & Partner - Ingenieurbüro für Brandschutz und Baukosten GmbH, Nietetal
 Neurochirurgisches Zentrum der Uni Klinik Bonn, Bonn
 newtec GmbH, Dortmund
 NovoPlan GmbH Oberflächen- und Werkstofftechnik, Aalen
 NRW.BANK, Düsseldorf
 nv VAM, Wijster, Netherlands

O

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sche Fabriken, Lahnstein
Zweckverband Abfallbeseitigung Mülldeponie
Kahlenberg, Ringsheim

Patents 2006

Issued Patents:

Biodegradable, mechanically strong, food-com-
patible composition, useful e.g. for producing
cutlery or tableware by extrusion or injection
molding, comprising cellulose ester, plasticizer
and inorganic filler
(Kern, Kesselring, Dolfen, Zimmermann*, An-
genheister*, Breuer*) – Germany

Sealing system (Berger*, Wack, H.) – Germany

Method for the production of an adsorption
material, adsorption material as well as the use
thereof (Sohnemann, Horn, Bertling, R., Meller) –
Germany

Method and device for cleaning used bulk bags
or the like (Ixkes*) – Europe

* = external inventors

Registered trademarks:

BohrLock (word trademark)

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Systems for oxygenation
www.airox.de

Andreas Schröder IT-Consulting GmbH, Schermbeck
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www.atec.de

DataPool Engineering GmbH, Oberhausen
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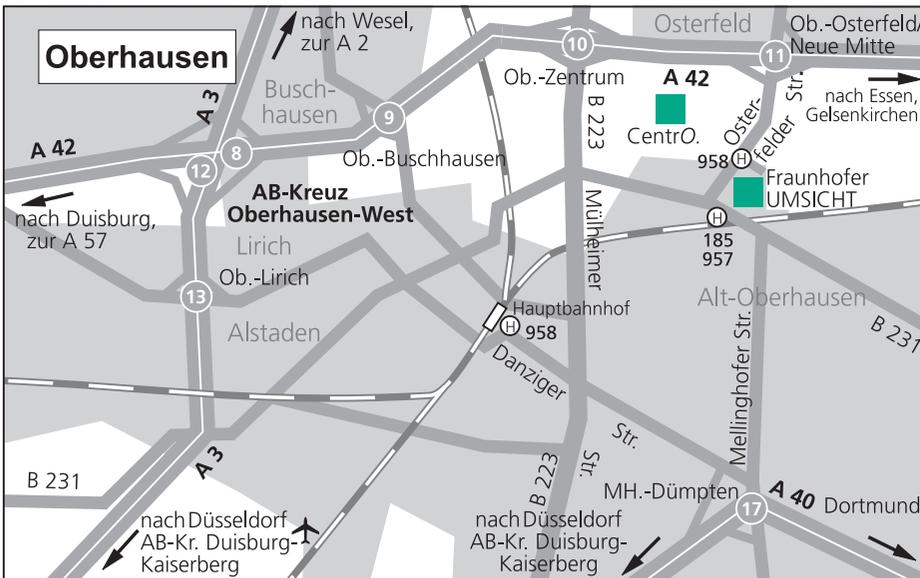
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How to Find us

**By car**

Freeway A42

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 the access road to the institute.

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 the access road to the institute.

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 either with bus number 185 (towards Essen Borbeck Bf.) to Fraunhofer UMSICHT, 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.

Address

Fraunhofer Institute for Environmental, Safety, and Energy Technology UMSICHT

Director:

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E-mail: info@umsicht.fraunhofer.de

Your way to us online:

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Guidelines

The guidelines of the organization "Fraunhofer UMSICHT" describe the basic self-conception of the Institute and its staff. Therefore, they are kept in a general form and build a frame which is to be completed and acted out but which also is to be advanced.

Guidelines are to bring continuity and stability into dynamically changing requirements of environment and daily routine. They are to accompany the institute's work beyond office hours

and are to be communicated inside and outside the institute. Thus, mission, policies, and expectations the institute operates with and wants to be perceived with in its surroundings with are reflected in the guidelines.

The ten guidelines of the organization "Fraunhofer UMSICHT" are deduced from the regulations and guidelines of the "Fraunhofer Gesellschaft" and concretize them for the concerns of the institute's work.

- 1 Fraunhofer UMSICHT sees itself as a link between its business partners, staff members, the "Fraunhofer Gesellschaft", the scientific community, and other social actors.
- 2 Fraunhofer UMSICHT wants to be a reliable research and development partner for its clients, relieve them during all project phases, give them all respective services from one hand, and support them in accessing subsidies and commercial funding.
- 3 Fraunhofer UMSICHT offers its clients high-quality scientific, results-oriented, interdisciplinary, and innovative research and development work. It provides them with competitive advantages through advance in know-how and recognized competence in problem solving.
- 4 The staff members form the institute's backbone. Fraunhofer UMSICHT encourages and challenges the staff's professional, scientific, entrepreneurial, and social skills. These skills determine the institute's efficiency. Fraunhofer UMSICHT wants to fill its staff with enthusiasm for research and development.
- 5 Fraunhofer UMSICHT acts according to the principles of the "Fraunhofer Gesellschaft" and contributes to enhancing the reputation of the "Fraunhofer Gesellschaft". The institute cooperates in partnership with the board of directors, headquarters, and other Fraunhofer institutes and facilities.
- 6 Fraunhofer UMSICHT is actively committed to the formation of strategic alliances and networks in economy, science, politics, and society.
- 7 Fraunhofer UMSICHT forces up activities abroad in respect of project work and exchanging staff members (know-how transfer).
- 8 Fraunhofer UMSICHT acts actively in the scientific community. The institute cooperates with other research facilities, universities, technical colleges, and industrial partners in the national and international research and development scene, and faces up to scientific debate.
- 9 Fraunhofer UMSICHT is independent. It supports clear, understandable, and interdisciplinary consolidated positions and aligns its objectives according to these positions. Fraunhofer UMSICHT aims at a long-term realization of social visions through concrete innovations which can be efficiently transferred into economically utilizable progress and can be transferred into the environment.
- 10 Fraunhofer UMSICHT sees itself as a pathfinder for technical changes in the areas of environment, energy, process engineering, and safety. The institute promotes effective management, environmentally friendly technologies, and environmentally conscious behavior in order to enhance society's overall quality of life.

The Fraunhofer-Gesellschaft

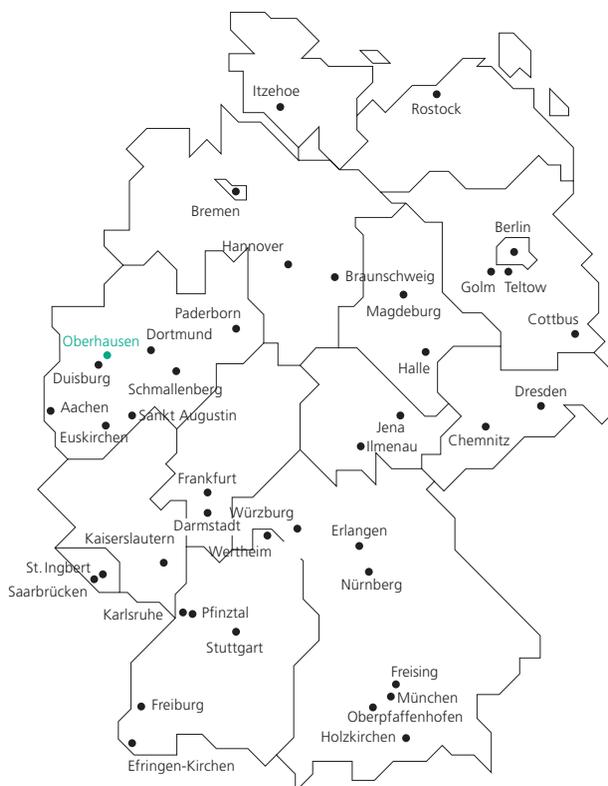
The Fraunhofer-Gesellschaft

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. The organization also accepts commissions from German federal and Länder ministries and government departments to participate in future-oriented research projects with the aim of finding innovative solutions to issues concerning the industrial economy and society in general.

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, accelerating technological progress, improving the acceptance of new technologies, and not least by disseminating their knowledge 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, in other scientific domains, in industry and in society. Students working 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.

At present, the Fraunhofer-Gesellschaft maintains more than 80 research units, including 56 Fraunhofer Institutes, at 40 different locations in Germany. The majority of the 12,500 staff are qualified scientists and engineers, who work with an annual research budget of €1.2 billion. Of this sum, more than €1 billion is generated through contract research. Two thirds of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Only one third is contributed by the Ger-

man federal and Länder governments in the form of institutional 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 research centers and representative offices in Europe, the USA and Asia provide contact with the regions of greatest importance to present and future scientific progress and economic development.

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