



Fraunhofer
UMSICHT

FRAUNHOFER INSTITUTE FOR ENVIRONMENTAL, SAFETY, AND ENERGY TECHNOLOGY UMSICHT



ANNUAL REPORT
2008

CONTENT

The Institute

4	Preface
6	Highlights 2008
8	Fraunhofer Institute for Environmental, Safety, and Energy Technology UMSICHT
9	Facts and Figures
10	A Word or Two, Ernst Gerlach (Chairman Board of Trustees)
11	A Word or Two, Dr. Thomas Mathenia, Dr. Susanne Raedecker (UMSICHT Circle of Friends and Patrons)
12	A Word or Two, Prof. Dr. Meier (Department of Mechanical Engineering, Ruhr-University of Bochum)
13	A Word or Two, Roland Stroese (Member of the Board INTERSEROH SE)
14	Key Research Areas
15	Organizational Chart
16	Business Units and Infrastructure
22	In Dialogue with Dr.-Ing. Christian Dötsch (Business Unit Manager Energy Systems)
24	Training Center/Fraunhofer Academy
25	Marketing, Communication, Business Development and IT Management
26	Library – Specialist Information Service and Central Technical Services
27	Branches Willich and Teterow
28	Laboratories of Fraunhofer UMSICHT
30	Business Unit Renewable Resources
32	High Temperature Polyamides from Renewable Resources
34	Development of Professional Biogas Projects in South Korea
36	Bioplastics – Innovative and Application-Oriented
38	Chemistry under Pressure
40	Business Unit Process Technology
42	Optimized Adsorption Processes
44	DSP – Downstream Processing
46	Use of Enzymes for the Conversion of Renewable Resources
48	Fine Particulate Filters for Wood Combustion
50	Business Unit Biofuels
52	Automated Process Development for Biofuels and Bio-refineries
54	The Waste-to-Fuels-Process greasoline®
56	Business Unit Advanced Materials
58	Wood through Modification – Fit for the Future
60	Leather Tanning under the Influence of Compressed Carbon Dioxide
62	Microencapsulation: Small Capsules with a Large Effect
64	New Thermoplastic Coatings
66	Business Unit Information Technology in Process Engineering
68	CDIS (Collaborative Documentation and Information System)
70	Workflow Expansion in GEVIS II
72	Smoke Control During Fires – Help With Testing and Evaluation

74	Business Unit Energy Technology
76	Development of a Rapid Test for Refuse-Derived Fuels
78	Using Lean Gases in Micro Gas Turbines
80	Biogas Feed-In into the Natural Gas Grid
82	Business Unit Energy Systems
84	Reliable Electricity from Sun and Wind
86	Eenergy is not One-Dimensional – The ExergyFingerprint
88	Absorption Chillers using Membrane Technology
90	Innovative Recovery of Waste Heat with Small-Scale ORC-Applications
92	Business Unit Resources Management
94	Application Potentials of Industrial Biotechnology in North Rhine-Westphalia
96	CO ₂ -Balances in the Recycling Industry
98	Sustainability in Research
100	Socio-Economic Aspects in the Waste Management Sector
102	Names, Data, Events
104	Publications
110	Selected Clients and Contacts
116	Patents
116	Spin-offs
117	How to Find us
118	The Fraunhofer-Gesellschaft
119	Board of Trustees
120	Imprint



PREFACE

We've done it! In 2008 we have accomplished quite a lot of the targets we had set out for. A new office building which has been growing along with our staff during the planning and renovation phase has now been moved into and filled with new life. With the additional space, a new conference hall equipped with complex multimedia technology, a spacious info lounge, a succession of art exhibitions and public readings the new building presents an attractive environment for work, meetings and events to the members of our staff, our partners and our clients.

However, in 2008 we have not only made investments into property assets, but we have continued to refine what is our true asset: in more than 4 000 individual units, our staff members ranging from technical assistant to unit manager and director have been trained to raise their qualification in order to lay the foundation for technical and scientific success. We are proud of our highly motivated and committed staff who do not share the wide-spread pessimistic outlook, and who instead see challenges in what otherwise is looked upon as impediments. Our success proves that we are on the right way.

The Fraunhofer future topic "Energy storage in power grids" which is coordinated by our institute in Oberhausen has been met with high interest and attention world-wide. Our GEVIS system, a management tool for hazardous substances, has been proven in daily practice at Fraunhofer institutes. The ORC technology developed by UMSICHT is able to raise the energy output of biogas plants, through a high efficiency rate and long life cycle. The catalyst systems developed by us generate high quality biodiesel at a considerably reduced energy consumption.

And just another point about resources: In 2008 we were one of the first research institutes to present a sustainability report. We are going to gradually expand the objective of sustainability to the end of viewing and balancing our activities against the requirements of cost-effectiveness, eco-friendliness and civil responsibilities.



The mission of our institute, to develop technologies that pay, can only be put into practice thanks to the high commitment of our staff to which we are particularly indebted. We would like to express our thanks to all our business partners, our clients, and all friends of our house, for their confidence and cooperation.

Dear readers:

We hope that we have roused your interest in reading our annual report. Have a look into the range of our activities and get informed and inspired by our projects. Inspiration is very valuable in times like these. However, everything has to be done in dialogue. So let us talk with one another, let us develop ideas together and put them into practice. That is what we are here for.

Yours faithfully

Eckhard Weidner

Görge Deerberg

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.

HIGHLIGHTS 2008



April 2008

47 girls were invited on the national Girls' Day to have a look into typical "male" jobs. The workshop offer was extended due to the increased demand and ranged from the production and testing of bioplastics over analyses of swellable materials to the programming of websites.



May 2008

To discuss topics related to "Energy storage in the power grid – electricity on demand from sun and wind", the Wissenschafts-Presskonferenz (WPK), the Association of Science Journalists and Fraunhofer UMSICHT invited to a conference. This future topic was discussed among Norbert Lassau, Head of the Science department of the newspaper "Die Welt", Prof. Hans-Jörg Bullinger, President of the Fraunhofer-Gesellschaft, Dr. Manfred Fishedick, Vice President of the Wuppertal Institute for Climate, Environment, Energy GmbH and Dr. Christian Dötsch, Fraunhofer UMSICHT.



May 2008

Swellable materials in sealing technology, the interactive water technology platform [www. aqua-latina.info](http://www.aqua-latina.info), microsieves for application technologies, the European Center for Elastomeric Powders euCEP – these were the topics Fraunhofer UMSICHT presented at the IFAT 2008, the international leading trade fair for environmental technology.



June 2008

With an experimental lecture to a capacity filling audience, the worldwide unique PGSS® plant was inaugurated. This plant is based on the PGSS® process (Particles from Gas Saturated Solutions) and the CPF® process (Concentrated Powder Plant), both specifically developed high pressure technologies for the production of particles in industrial scale.



October 2008

The South-Korean research institute I'REE (Institute of Renewable Energy & Environment) and Fraunhofer UMSICHT adopted a cooperation agreement for the development of professional biogas projects in South Korea. On 22 October, the Director of the Institute, Mr. Young lee, Ph.D. and Dr. Stephan Kabasci, Fraunhofer UMSICHT, signed a common Memorandum of Understanding in Seoul.



November 2008

Partners from industry and science sent out invitations to Oberhausen to present the newly built demonstration plant of the decentralized high-tech water recycling system "Komplett". This plant is capable to process gray and black waters for large building complexes and was tested on the premises of Fraunhofer UMSICHT over several months.
www.komplett-projekt.de



FRAUNHOFER INSTITUTE FOR ENVIRONMENTAL, SAFETY, AND ENERGY TECHNOLOGY

UMSICHT IN PROFILE

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 technologies and transfers them into industrial applications and marketable products. No matter whether the customer is a small or medium-sized enterprise, a major enterprise or a public institution, UMSICHT can guarantee a one-stop-shop service.

Starting from the project idea over proposal procedures to the development and market introduction, Fraunhofer UMSICHT offers its clients R&D expertise and thus provides them with competitive benefits and opens up international markets for them.

As a member of the Fraunhofer-Gesellschaft, the institute follows the 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 at Fraunhofer UMSICHT

	Number
Permanent Staff	170
Personal in scientific business units	123
Personal in infrastructure departments	47
Other Staff	132
Apprentices	14
Undergraduate students (diploma, master, bachelor)	30
Student assistants	73
Interns and persons in civilian service	15
Total Staff	302

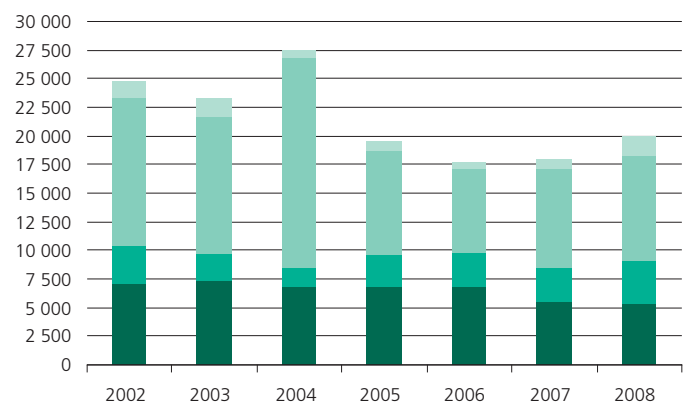
Expenditure and Returns 2008

	(m €)
Operational budget	19,9
Staff costs	9,5
Other costs	10,4
Investments	2,0

Returns Operational Budget 2008

	(m €)
Basic Funding	5,4
Public Returns	3,7
Industrial Returns	9,1
Others	1,7
Total Returns	19,9

[T€]



fiscal year

■ other returns (EU)
 ■ industrial returns
 ■ public returns
 ■ basic funding

A WORD OR TWO – BOARD OF TRUSTEES

Ladies and Gentlemen:

2008 has been a hard year. World-wide. Economic crisis, capital markets on risk, recession. These are negative catchwords that have labelled the past year. All the more are we impressed that people in our Federal Land have not lost spirits in view of these challenges and look ahead to the future. Only in North Rhine-Westphalia, more than 90 000 persons took upon the risk to start a business and thus created jobs. This makes clear that also in times of economic and financial hardships there is one thing which will always be popular, and these are innovative ideas which can be put into practice.

This capability, namely the development and economically feasible implementation of innovative ideas is the core competency of Fraunhofer UMSICHT. The institute has a leading role in the development of energy storage in the power grid – one of the twelve future topics of the Fraunhofer-Gesellschaft, and thus helps to expand the use of renewable resources.

In order to keep up a leading role in the field of applied research, we must not forget the promotion of junior scientists. Particularly in Germany which relies on its know-how resources the lack of qualified manpower in the engineering and scientific fields has to be counteracted. This is a task of urgent importance, to be tackled the sooner the better. Engineering sciences so far have the lowest share of female students among all junior scientists so that as a result only part of the nation's brainpower is used in this field. This is another area of Fraunhofer UMSICHT's innovative activities. Girls at secondary school level spend one day at the institute on the occasion of the annual Girls' Day to experience jobs in applied sciences at an early stage, students of different levels are further supported in their career in a manifold range of internships and similar offers.

Another important factor when seeking for qualified staff, is also the attractiveness of the location. Often this is afflicted with financial problems in municipal planning, since the local authorities as a matter of fact lack money for providing a wide-ranging cultural offer to the staff of companies in town. Fraunhofer UMSICHT therefore has started to actively contribute to this offer – an initiative which I greatly appreciate. The institute regularly organizes art exhibitions and other cultural events such as readings and theme meetings, in particular in the newly renovated D building. An offer which already has met with ample attention and wide acceptance and helps make the City of Oberhausen more attractive.

And even if I am annoying, I cannot help to repeat my words of last year: Keep it up!



*Ernst Gerlach,
Member of the Board of
NRW.BANK and Chairman
of the Fraunhofer UMSICHT
Board of Trustees*

The NRW.Bank is the financing bank of the federal state of North Rhine-Westphalia. As governmental partner of banks and saving banks, the NRW.Bank offers the whole range of loan management financing products: such as the financing of business ventures and financial support to small and medium-sized companies, the financial support of community housing, and the financing of local institutions, infrastructures as well as the financing of individual projects.

A WORD OR TWO – UMSICHT FRIENDS AND PATRONS

Dr. Thomas Mathenia

North Rhine-Westphalia is among the European regions with the most densely spread and most efficient research activities. This is a definite asset facing the challenges of the future: We have to save energy and resources, we are on our way to protect the climate and to improve our standard of living. We have to develop new technologies to enhance more efficient production methods and products of better quality, and we need qualified and committed manpower to achieve this. The UMSICHT Friends and Patrons group is dedicated to the support of applied research in the field of environmental, safety and energy technologies in North Rhine-Westphalia, particularly in the Ruhr area.

As Friends and Patrons, we are prepared to create the conditions for this process: making good ideas become innovations and stimulating employment opportunities in the region through education, research and development.

Dr. Susanne Raedeker

Our society is more and more becoming an information and science society. Those who can rely on good networking, recognize trends early and are able to identify new technologies which have an impact on competitiveness, are among the winners. Besides the goals mentioned by Dr. Mathenia, the UMSICHT Friends and Patrons group therefore concentrate on the exchange of experience and know-how among universities and industry, in the R&D network of the Fraunhofer-Gesellschaft, and among its members. This furthers innovative approaches and activities, supports research and also helps promote the creation of value for own activities. We cordially invite you to join us!

THE UMSICHT SCIENTIFIC AWARD

For the first time, in 2009 the UMSICHT friends and patrons group is awarding the UMSICHT scientific award for industry and market oriented research in the fields of environmental, safety, and energy technologies. The papers should be easily comprehensible to a wide audience. The 15 000 EUR prize is expected to encourage innovative approaches and activities in the related fields. All contributions from the fields of environmental, safety, and energy technologies that are no older than 2 years are invited for application. We particularly call for those papers which have been prepared in collaboration between industrial partners and science.

Applications for the award have to be submitted by 31 October 2009 at the latest at www.umsicht-foerderverein.de!

Contact: Dr. Görgе Deerberg, Managing Director UMSICHT Friends and Patrons Group
via Ms Aylin Hustermeier, Phone +49 208 8598-1114, E-mail aylin.hustermeier@umsicht.fraunhofer.de



Dr. Thomas Mathenia, Chairman of Technical Board, EVO Energieversorgung Oberhausen AG (Energy Supplier of the City of Oberhausen) and Chairman UMSICHT Friends and Patrons



Dr. Susanne Raedeker, Managing Director of the AGR Deponienach-sorge GmbH & Co.KG (AGR Waste management company) and Deputy Chairwoman UMSICHT Friends and Patrons Group



Professor Dietrich H. W. Grönemeyer, Chairman of Wissenschaftsforum Ruhr e.V. and Director of the Grönemeyer Institute for Micro-therapy is the Patron of the UMSICHT Scientific Award

LET'S WORK TOGETHER

DEPARTMENT OF MECHANICAL ENGINEERING

The Department of Mechanical Engineering of the Ruhr University Bochum is divided into 4 institutes with 23 teaching units. The teaching units encompass the conception, construction, and manufacturing of functional and construction parts for technical components, machinery, and plants as well as their sale, operation, management, and maintenance.

The department has set itself the task to assume a leading position – on the basis of excellent basic research – in the development of innovative industrial products, processes and services. The department focuses on 4 strategic research areas:

- Biomedical & Micro Engineering
- Energy & Environmental Engineering
- Materials Engineering
- Product & Service Engineering

Publically funded basic research projects are complimented by research cooperations with leading companies. The department is the coordinator of the Collaborative Research Center 459 – shape memory technology, SFB/TR 29 – Industrial product service systems – Dynamic interdependency of products and services in the production area, and the Max Planck Research School for Surface and Interface Engineering in Advanced Materials. The DFG-Emmy-Noether-Junior Research Group “Twinning in structural and functional engineering materials” and the DFG-Heisenberg professorship “Materials in Microtechnology” are further, outstanding examples of the close connection between the department and basic research.

In June 2008, the new Research Centre ICAMS (Interdisciplinary Centre for Advanced Materials Simulation) was officially opened. ICAMS develops new materials on different scales via computer simulation – an approach that combines the previously separate worlds of natural and engineering science for the first time. International networking in these research projects is of great importance which is further evidenced by the integration into a large number of EU research consortia.

Over 30 % of the research funds for the department are provided by industrial companies. A clear signal that the department strives to transfer research findings into innovative products in addition to performing basic research.

In 2008, over 12 million € of third-party funds were acquired which reflects the quality and attractiveness of the department as a research partner.

In teaching the department represents modern engineering with target-oriented, practical courses. The Department of Mechanical Engineering offers the following Bachelor/Master studies: Mechanical Engineering, Sales Engineering and Product Management, Environmental Engineering, and Resource Management.



*Prof. Dr.-Ing. H. Meier,
Dean of the Department of Me-
chanical Engineering of the Ruhr
University Bochum*



LET'S WORK TOGETHER INTERSEROH

Recycling not only conserves resources but also reduces CO₂-emissions. This was the conclusion of a study that Fraunhofer UMSICHT completed for the stock exchange-listed Cologne based raw material and recycling group INTERSEROH SE. About 5,2 million tons of carbon dioxide, approximately 0,6 percent of the total CO₂-emissions in Germany, were avoided through the utilization of secondary raw materials which were processed and marketed by interseroh in 2007. Roland Stroese, member of the board of the company and responsible for the areas of services and raw material trade, reports about the collaborative project.

When in mid 2006 we first sat together with the scientists from Fraunhofer UMSICHT in order to discuss the CO₂-savings potential through recycling the task that we had set for ourselves seemed unreachable due to its complexity: Based on which criteria should the CO₂-emissions in the from the numerous production and logistic processes in the recycling industry and industrial production be compared?

How can the emissions even be determined? How should we represent all aspects of our complex recycling activities?

Numerous workshops, data collection and calculations later, the results are available which were a positive surprise to us. We had suspected that our business activities can help conserve natural resources and protect the climate. However, nobody would have thought that our contribution would be so large: The recycling activities of interseroh alone save as much CO₂ as a city with a population of 500 000 such as Duisburg causes.

At the same time, the recycling process conserves limited resources. This brings sustainability within reach.

For the calculations the UMSICHT-Team evaluated the whole process chain from recovery, and collection, of raw materials and logistics up to production and processing and, finally, re-use. For this purpose, real data from our production and logistic processes were also used. interseroh always set great store by using conservative assumptions and not leaving out any CO₂-relevant aspects.

However: Fraunhofer scientists not only deliver reliable and proven data, they can also clearly present them to a broad audience. According to the motto: "Recycling for Environmental Protection" we presented our CO₂-study to approximately 150 guests at the World Environment Day (Weltumweltag) on 5 June, 2008 in Cologne. The interest was and still is great. Several presentations and publications in specialized media followed. The interest and compliments from customers and partners motivate us to carry on.

We have already commissioned Fraunhofer UMSICHT with preparing another study and we are working together on new project ideas for sustainable raw material management.



Roland Stroese,
Member of the Board
INTERSEROH SE



interseroh
www.interseroh.com

"As a worldwide active environmental service and raw material provider, we work at the interface between economy and ecology. The topic of sustainability is of high importance to us. Therefore, interseroh has decided to critically analyze the use of secondary raw materials compared to the utilization of primary raw materials with regard to CO₂-balances. Our scientific partner is Fraunhofer UMSICHT."



KEY RESEARCH AREAS

Fraunhofer UMSICHT: Our Key Research Areas

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.

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.

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.

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
www.umsicht.fraunhofer.de/englisch/profil/leitthemen/

ORGANIZATIONAL CHART

Directorate

Prof. Dr.-Ing. Eckhard Weidner
Director

Dr.-Ing. Görgе Deerbеrg
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 Deerbеrg

Deputy:
Dipl.-Ing. Josef Robert

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

Biofuels

Dr.-Ing. Axel Kraft

Deputy:
N.N.

- Catalytic Processes
- Refinery Concepts
- Biofuel Processes

Advanced Materials

Dipl.-Ing. Jürgen Bertling

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

- Plastic 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

Deputy:
Dr.-Ing. Barbara Zeidler-Fandrich

- Refuse Derived Fuels and Biomass
- Biogenous Low BTU Gases
- Biomass Conversion

Energy Systems

Dr.-Ing. Christian Dötsch

Deputy:
Dr.-Ing. Wilhelm Althaus

- Energy Storage
- Polygeneration
- Optimization of Energy Systems

Resources Management

Dr.-Ing. Hartmut Pflaum

Deputy:
Dr.-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 Deerbеrg

Deputy:
N.N.

- Rotary Kiln Pilot Plant

Branch Willich

Dipl.-Ing. Carmen Michels

Deputy:
Dipl.-Ing. Thomas Eisenburger

- Plastics Pilot Plant

Fraunhofer Academy/ TrainingCenter

Dipl.-Ing. Anja Gerstenmeier

- infernum

Infrastructure

Administration

Dipl.-Betw. Andreas Weber

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

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

IT Management

Dipl.-Ing. Andreas Schröder

Deputy:
Dipl.-Inform. Christian Knerrmann

- 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



Dr.-Ing. Stephan Kabasci
Phone: +49 208 8598-1164
Fax: +49 208 8598-1424
stephan.kabasci@umsicht.fraunhofer.de
Information/secretariat: +49 208 8598-1227

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



Dr.-Ing. Gorge Deerberg
Phone: +49 208 8598-1107
Fax: +49 208 8598-1290
goerge.deerberg@umsicht.fraunhofer.de
Information/secretariat: +49 208 8598-1282

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; sample batch production; process intensification; process modeling and simulation; optimization; CFD; reaction calorimetry

BIOFUELS



Dr.-Ing. Axel Kraft
Phone: +49 208 8598-1167
Fax: +49 208 8598-1295
axel.kraft@umsicht.fraunhofer.de
Information/secretariat: +49 208 8598-1282

CATALYTIC PROCESSES

Gas phase transformation of fats, oils and renewable materials to biogenous diesel and gasoline; alternative ways to biodiesel and partial glycerides; processes for the use of raw glycerol from the biodiesel production; synthesis of butanol from ethanol; synthesis of catalyst prototypes, catalyst lifetime and recycling tests; chemical process development

REFINERY CONCEPTS

Sustainable use of oil plants; conversion of biobased alcohols, poly alcohols and sugars to intermediates and products; production of lactic acid and its derivatives from renewable resources; chemical lignin cleavage; analysis of fuels and chemical intermediates with chromatographic methods (GC, GC-MS, LC-MS); on-line analytics; thermal analysis

FUELS

Development of processes and syntheses for biobased gasoline, diesel, kerosene, butanol and LPG; fixed bed and pressure reactors; batch and continuous reactors; downstream processing by distillation; processing of biological residues to fuels

ADVANCED MATERIALS



Dipl.-Ing. Jürgen Bertling
Phone: +49 208 8598-1168
Fax: +49 208 8598-1424
juergen.bertling@umsicht.fraunhofer.de
Information/secretariat: +49 208 8598-1227

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



Dipl.-Phys. Thorsten Wack
Phone: +49 208 8598-1278
Fax: +49 208 8598-1425
thorsten.wack@umsicht.fraunhofer.de
Information/secretariat: +49 208 8598-1278

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



Dr. rer. nat. Thomas Marzi
Phone: +49 208 8598-1230
Fax: +49 208 8598-1423
thomas.marzi@umsicht.fraunhofer.de
Information/secretariat: +49 208 8598-1270

SOLID FUELS FROM BIOMASS AND WASTE

Combustion (e.g. of wood, RDF, sewage sludge), grate firing systems, refuse derived fuels, fuel characterization, development of "waste to energy" concepts; ashes and slags

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

BIOMASS CONVERSION

Synthesis gas utilization; studies/surveys; development of biomass-CHP-technology; catalytic tar reforming; tar measuring

ENERGY SYSTEMS



Dr.-Ing. Christian Dötsch
Phone: +49 208 8598-1195
Fax: +49 208 8598-1423
christian.doetsch@umsicht.fraunhofer.de
Information/secretariat: +49 208 8598-1270

ENERGY STORAGE

Investigation and development of electric energy storage: Network integration, regulation/management; development and generation of hybrid cold/heat carriers as phase-change materials/phase change slurries (PCM/PCS)

POLYGENERATION

Development and construction of ORC plants (waste heat into power); planning and optimization of CHCP cogeneration plants; development of thermally driven chillers

OPTIMIZATION OF ENERGY SYSTEMS

Energy system analysis, benchmarking and optimization of heat, cold and power supply system operations; CO₂-emissions management (monitoring/trading), elaboration of feasibility studies

RESOURCES MANAGEMENT



Dr.-Ing. Hartmut Pflaum
Phone: +49 208 8598-1171
Fax: +49 208 8598-1289
hartmut.pflaum@umsicht.fraunhofer.de
Information/secretariat: +49 208 8598-1122

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



Dipl.-Betrw. Andreas Weber
Phone: +49 208 8598-1226
Fax: +49 208 8598-1290
andreas.weber@umsicht.fraunhofer.de

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



Dr.-Ing. Hartmut Pflaum
Phone: +49 208 8598-1171
Fax: +49 208 8598-1289
hartmut.pflaum@umsicht.fraunhofer.de

Dipl.-Chem. Iris Kumpmann
Phone: +49 208 8598-1200
Fax: +49 208 8598-1289
iris.kumpmann@umsicht.fraunhofer.de

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



Dipl.-Ing. Andreas Schröder
Phone: +49 208 8598-1131
Fax: +49 208 8598-1425
andreas.schroeder@umsicht.fraunhofer.de

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



Dipl.-Ing. Richard Sprick
Phone: +49 208 8598-1182
Fax: +49 208 8598-1425
richard.sprick@umsicht.fraunhofer.de

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



Dr.-Ing. Edda Möhle
Phone: +49 208 8598-1231
Fax: +49 208 8598-1424
edda.moehle@umsicht.fraunhofer.de

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 ENVIRONMENT PROTECTION



Dr.-Ing. Ulrich Seifert
Phone: +49 208 8598-1127
Fax: +49 208 8598-1290
ulrich.seifert@umsicht.fraunhofer.de

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 – SPECIALIST INFORMATION SERVICE



Dipl.-Bibl. Kerstin Hölscher
Phone: +49 208 8598-1201
Fax: +49 208 8598-1290
kerstin.hoelscher@umsicht.fraunhofer.de

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



Dr.-Ing. Görges Deerberg
Phone: +49 208 8598-1107
Fax: +49 208 8598-1290
goerge.deerberg@umsicht.fraunhofer.de

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



Dipl.-Ing. Carmen Michels
Phone: +49 2154 9251-14
Fax: +49 2154 9251-61
carmen.michels@umsicht.fraunhofer.de

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

FRAUNHOFER ACADEMY/ TRAINING CENTER



Dipl.-Ing. Anja Gerstenmeier
Phone: +49 208 8598-1111
Fax: +49 208 8598-1290
anja.gerstenmeier@umsicht.fraunhofer.de

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's degree infernum is offered in co-operation with the FernUniversität in Hagen (Open University) and is part of the Fraunhofer Technology Academy.
"www.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
University of Rostock
Unidad de Desarrollo Tecnológico (UDT),
Institute of the Universidad de Concepción,
Chile

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)

Managing Director:
Dr.-Ing. Görges Deerberg

The objective of the Friends and Patrons Group (UMSICHT Förderverein) is to initiate innovative research and development projects, ideally and by monetary means, at an early stage to open up the access for North Rhine-Westphalia – and in particular for the Ruhr area – to sustainable technology developments. The focus is on project ideas for environmental, safety and energy technology in the research areas "biorefinery", "materials and membranes with "functionality", "decentral, modular energy technologies" and "networks for process and energy technology". Additional to technical-oriented preliminary work (e.g. proof of principle) the member companies invest in forecast-studies about current topics, shape the public opinion concerning the sponsorship of events and they encourage the next generation of economy executives.
www.umsicht-foerderverein.de



ABOUT ENERGY ON DEMAND, ORC PLANTS, AND DANGEROUS BOOKS

In dialogue with Dr.-Ing. Christian Dötsch

1. You do research in the area of energy systems. What does the future hold for the energy industry?

The power supply of the future will continue to be based on an energy mix which will, however, increasingly shift towards renewable energy. Shorter to medium distances will be covered in electrically driven cars. Our entire energy system will be based on electricity as the central energy carrier. Decentralized energy conversion will grow in the areas of solar thermal, surface-near geothermal and waste heat utilization because these energy sources are spread out over an area, i.e. are decentralized. The efficiency of the energy systems will be increased through efficiency improvements but also through efficient technologies such as power generation from waste heat (ORC), combined heat and power generation, thermal or solar cooling, and thermal and electrical storage systems.

2. Renewable energies will play an increasing role in the energy mix of the future, but they are difficult to calculate (or predict) and the amount of power fed into the grid is dependent on weather conditions and time of day. However, we are dependent on stable power grids. You are working on making the supply of wind and solar energy just as predictable as the supply from conventional power plants. What approaches are you taking?

A prerequisite for that are new powerful energy storage systems. During strong winds, a wind turbine generates a

surplus, but customers also need power when there is no wind. Storage can even out these fluctuations. Currently, surplus energy is stored in conventional pump store systems which pump water into an elevated reservoir. However, additional building of pump store facilities is virtually impossible in Germany. Therefore, Fraunhofer is developing alternative energy storage methods, a redox-flow energy storage system, and concepts for optimized compressed air storage power stations. Cost efficient storage systems can make a significant contribution towards integrating renewable energies into the power supply system. As such they are an important pillar for our secure power supply of tomorrow. "Energy storage in the electric grid" is one of twelve future topics in the research portfolio of the Fraunhofer Gesellschaft. More on this topic can be found on page 85.

3. You see power generation from waste heat as another pillar for the future energy industry. You mentioned the subject of ORC – Organic Rankine Cycle. Please elaborate on this topic.

If you generate power or operate high-temperature processes, you generate waste heat and not too little at that. It is still too common for this waste heat to go unutilized because there is no economic use for it. Operators of biogas plants know this problem all too well. Small Organic Rankine Cycle (ORC) plants promise help: They make the waste heat usable by converting it to electricity without limitations, increase



efficiency, and reduce CO₂-emissions. So far the ORC steam power process, which uses organic media instead of water as working medium, is offered globally largely for power generation in the capacity range of 200 to 7 500 kW_{el} for wood-fired cogeneration plants and geothermal plants. The coupling of biogas combined heat and power plants is new. However, the number of small, decentralized plants that use renewable resources for power generation is steadily growing and, as a result, the demand for smaller ORC plants which offer capacities below 200 kW_{el} for power generation from waste heat increases. There are currently 3 700 biogas plants operating in Germany alone. For a large portion of these plants, the waste heat generated by a combined heat and power plant goes unused. Small, scalable ORC processes, which Fraunhofer UMSICHT is developing with medium-sized partners for the use of exhaust and engine heat from biogas engines, can help. For additional information see page 91.

4. We have learned much about your professional activities.

Now we would like to also know something about your private life. What do you do to save energy?

I ride a bicycle to work and use a train for the majority of my business trips.

5. Which book is currently lying on your nightstand?

Dangerous book for boys: The only real book for fathers and their sons by Conn and Hal Iggulden. My son is still 1-2 years too young, but I am not too old for it.

6. And which CD has been in your CD player mostly?

Currently, unfortunately none.

Dr.-Ing. Christian Dötsch

(born in 1969)

studied chemical engineering at the University of Dortmund.

His dissertation was about "Experimental Investigations and Modeling of the Rheologic Behavior of Ice Slurries".

His main competencies are in the areas of electrical and thermal energy storage as well as energy system optimization.

Since 2008, he is the coordinator of the Fraunhofer Future Topic "Energy Storage in the Grid".

He is lecturer for the module Renewable Energies within the interdisciplinary distance learning program environmental sciences and holds the seminar "Cooling Technology" at the Ruhr University Bochum.

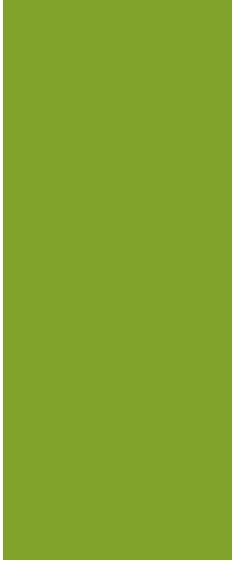
Dr. Dötsch is married and has a son.

Dangerous book for boys:

The only real handbook for fathers and their sons

(Das einzig wahre Handbuch für Väter und ihre Söhne, Conn und Hal Iggulden)

(Blanvalet, 2009, ISBN-10: 3442369541)



TRAINING CENTER/ FRAUNHOFER 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 program 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 for environmental sciences infernum (www.umweltwissenschaften.de) – in 2005 assigned the label “official project of the United Nations Decade 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. 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 Academy.

The Fraunhofer 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.

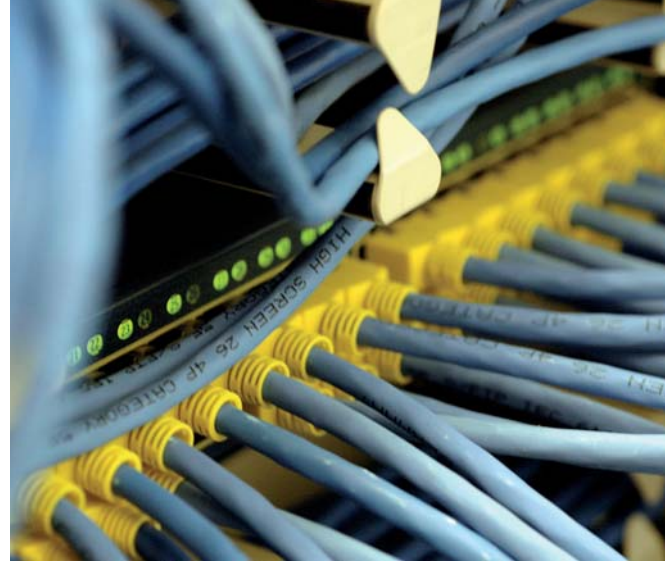
www.academy.fraunhofer.de

Contact

Dipl.-Ing. Anja Gerstenmeier

Phone +49 208 8598-1111

anja.gerstenmeier@umsicht.fraunhofer.de



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

You will find the contact data of our infrastructure departments on page 20/21.



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 library provides literature on the UMSICHT-specific topics environmental, energy, safety, process and material technology as well as on know-how and technology transfer.

Scientists may access licensed data pools easily via an internet portal. Services range from literature and patent research to in-house training in end user services, from documentation of internal publications for the Fraunhofer Publica database or Fraunhofer e-prints (full texts accessible worldwide); services also comprise the documentation of conference publications, PhD theses, ranging from author support to going to press.

Contact: Dipl.-Bibl. Kerstin Hölscher, Phone +49 208 8598-1201
kerstin.hoelscher@umsicht.fraunhofer.de

CENTRAL TECHNICAL SERVICES

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

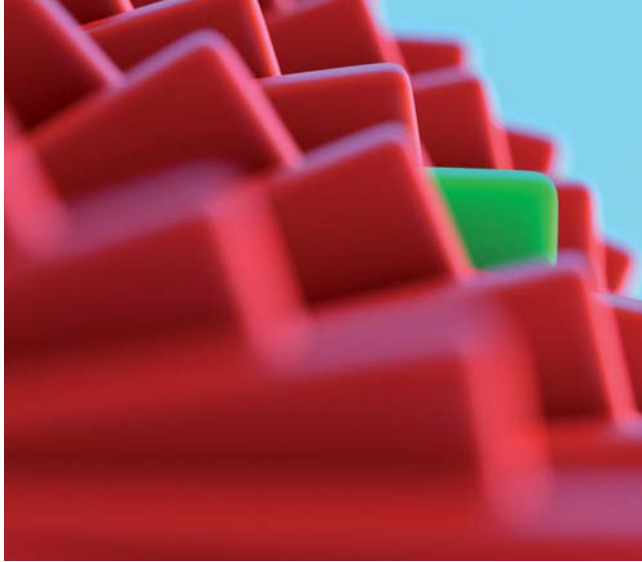
In order to secure a technological head-start and not only keep pace with others, a smooth and prompt realization must be guaranteed.

The central technical facilities realize technological know-how for internal and external customers 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.

Contact: Dipl.-Ing. Richard Sprick, Phone +49 208 8598-1182
richard.sprick@umsicht.fraunhofer.de



BRANCH WILlich

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-110/3E
- 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

BRANCH TETEROW

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 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.



ANALYTICS LABORATORY

Precise and reliable analytics is a prerequisite for the solution of environmental and process technological 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:

- Chromatographic methods: HPLC-MS, GC-MS, IC
- Analytics of fats, oils, organic acids and alcohols
- Hormone analyses
- Tar analyses

- Fuel characterization
- Characterization of biofuels
- Elementary analysis
- ICP-AOS

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 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 EN 13432, DIN EN 14995, 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
- Fermentation tests according to VDI guideline 4630



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 offer 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 conversions (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 chemical laboratory focuses on:

- Parallel reactor system, reaction calorimeter
- Biofuels: small-scale systems for the cleaning of biodiesel products (flash distillation, miniplant for the production of biodiesel)
- DSP: small-scale systems for the cleaning and concentration of product flows (rectification; extraction; crystallization)
- SynLab: chemical synthesis. Inert gas and vacuum lines, compression reactors and the use of special gases.

At present the high-pressure laboratory is in development.

Analytical problems are solved in co-operation with the analy-

tics and physical laboratories. One focal point is the analysis of plastic materials using the following methods:

- Chromatographic methods: GPC
- Thermo-analytical methods: DSC, TG (range to 1 000 °C and to 1 600 °C)
- Spectroscopic methods; IR (reflexion and transmission, on-line-coupling, TG-IR-coupling; film press), UV/VIS, IR-databases

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

RENEWABLE RESOURCES

A man with glasses, wearing a dark suit, white shirt, and a red patterned tie, stands in a modern office environment. He is gesturing with both hands raised, palms facing forward. The background features a white wall with several bright, rectangular light fixtures and a dark, vertical wooden paneling on the right side.

"An enormous reservoir of natural raw materials grows every day. May this 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.

HIGH TEMPERATURE POLYAMIDES FROM RENEWABLE RESOURCES

DEVELOPMENT OF PROFESSIONAL BIOGAS PROJECTS IN SOUTH KOREA

BIOPLASTICS – INNOVATIVE AND APPLICATION-ORIENTED

CHEMISTRY UNDER PRESSURE

RENEWABLE RESOURCES



HIGH TEMPERATURE POLYAMIDES FROM RENEWABLE RESOURCES

Polyamides, polyesters, and other polycondensates are well established technical plastics with high performance, a wide application spectrum, and high price levels. Therefore, these polymers were chosen as target products within the scope of a project investigating the process chain from renewable resources over the platform chemical succinic acid to high quality, bio-based and innovative materials. These research and development activities are taking place as part of a young academics research team (funding reference 22024905) funded by the BMELV/FNR¹.

There are three possible synthesis methods for the production of polyamide 44. One of those is the interfacial polycondensation of succinic acid dichloride and 1,4-diamino-butane. The polycondensation of succinic acid diester (e.g. diethyl succinate) represents another synthesis method. The advantage of this synthesis lies in the fact that the occurrence of side reactions is minimized. The third method for producing polyamide 44 is the polycondensation of the so-called succinic acid – tetramethylene diamine salt. This reaction was performed in a polyclave from the company BüchiGlasUster AG. The production of PA 44 through such a mass polycondensation is accomplished in a two-stage process. First, the pre-polymers are produced which are then condensed into higher molecular polymers in a second step through a solid-state polycondensation. Based on thermal analyses (DSC) of the produced polymers, the melting point, which is expected to be in the range of 300 °C due to the high specific amide group density of PA 44, was confirmed.

The research results of PA 44 showed that the molecular weight of the pre-polymers is still too low. Future research activities will optimize the reaction parameters in order to yield a polymeric material with good processing properties.

Contact:

Dr. Inna Bechthold

Phone: +49 208 8598-1313

E-mail: inna.bechthold@umsicht.fraunhofer.de

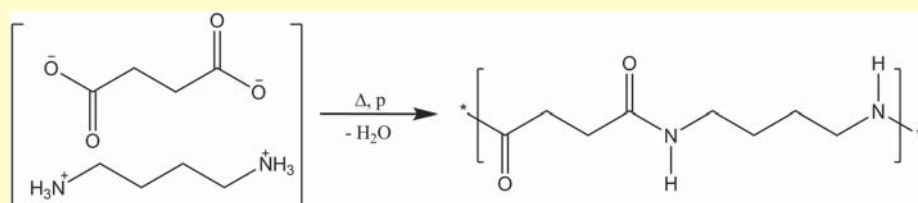
Dr. Andrea Springer

Phone: +49 208 8598-1266

E-mail: andrea.springer@umsicht.fraunhofer.de



¹Federal Ministry of Food, Agriculture and Consumer Protection/Agency for Renewable Resources



Reaction scheme

RENEWABLE RESOURCES



DEVELOPMENT OF PROFESSIONAL BIOGAS PROJECTS IN SOUTH KOREA

Fraunhofer UMSICHT has contracted a cooperation agreement with the renowned South Korean Research Institute I'REE (Institute of Renewable Energy & Environment) for the development of professional biogas projects in South Korea. The official signing of the MOU (Memorandum of Understanding) occurred on 22 October, 2008 in Seoul. At the same time, Fraunhofer UMSICHT was commissioned to prepare an initial market study for a biogas project in Hong Seong County.

Many of the southern provinces of South Korea are characterized by agriculture and intensive pig and cattle breeding. The large manure amounts generated by them are currently not being used for biogas generation but instead processed by energy and cost intensive processes. Currently, there are only few pilot plants for biogas generation in South Korea, and know-how in this field comparable to that in Germany does not exist yet.

Supported by South Korean legislation, which fosters the generation of power from biomass through investment subsidies and feed-in tariffs for biogas-based electricity as part of its "Bio-mass Korea 2020" directive, the first professional biogas plants for manure digestion are to be built in South Korea now. The South Korean research institute I'REE wants to use these opportunities to establish professional biogas plant technology in South Korea.

Fraunhofer UMSICHT will provide scientific assistance for the first projects and will support the implementation of the first plants on the basis of the close cooperation with I'REE. Fraunhofer UMSICHT can build on over a decade of experience and the knowledge from numerous research and development activities in the area of biogas technology and, thus, represents the ideal partner for I'REE for this undertaking. The erection of the biogas plants will be performed by the experienced German biogas plant manufacturer PlanET Biogastechnik GmbH.

Contact:

Dr.-Ing. Stephan Kabasci

Phone: +49 208 8598-1164

E-mail: stephan.kabasci@

umsicht.fraunhofer.de

Dipl.-Ing. Joachim Krassowski

Phone: +49 208 8598-1162

E-mail: joachim.krassowski@

umsicht.fraunhofer.de

Project partners:

- *I'REE, Daegu, South Korea*
- *PlanET Biogastechnik GmbH*

RENEWABLE RESOURCES



BIOPLASTICS – INNOVATIVE AND APPLICATION-ORIENTED

Plastics made from renewable resources are currently already available with an acceptable spectrum of characteristics and are especially utilized for short-lived applications.

For many products however, the characteristics of plastics available today such as cellulose acetate or polylactide (PLA) have to be specifically modified to meet customers requirements. With regard to this Fraunhofer UMSICHT follows two strategies:

- In the short-term, tailored compounds are developed on the basis of today's commercially available biopolymers, where natural fillers and reinforcement materials (e.g. wood or stone dust) as well as other characteristics enhancing additives are utilized.
- In the long-term, Fraunhofer UMSICHT focuses its research on new synthesis methods for the production of innovative technical polymers based on renewable resources.

The product line Bio-Flex® developed by Fraunhofer UMSICHT and the FKUR Kunststoff GmbH shows how the selection of appropriate blending components and additives can influence the characteristics of PLA-compounds. The properties of e. g. Bio-Flex® F 1130 based on a combination of PLA and a copolyester are similar to polyethylene (PE). Films from Bio-Flex® F 1130 can be used for laminating film, mulch and agrofilm, shopping bags, and sacks.

The transparent blow-molding capable PLA-blend (Bio-Flex® A 4100 CL) is the latest innovative development. The melting characteristics of this material were influenced by using selective additives to make it applicable for conventional processing methods. Blow-extrusion film made from Bio-Flex® A 4100 CL is suitable for various applications such as flower packaging, packaging for bread, fresh food, and vegetables, paper coating, and as barrier film for multi-layer systems or for diverse deep drawing applications.

Contact:

Dipl.-Ing. Carmen Michels

Phone: +49 208 8598-1265

E-mail: carmen.michels@

umsicht.fraunhofer.de

Anneliese Kesselring

Phone: +49 2154 9251-24

E-mail: anneliese.kesselring@

umsicht.fraunhofer.de

Project partner:

- *FKuR Kunststoff GmbH,
Willich*

RENEWABLE RESOURCES



CHEMISTRY UNDER PRESSURE

The fossil basis for energy supply and the chemical industry is finite. Therefore, renewable resources are being discussed as source material for fuels and chemical syntheses. Fraunhofer UMSICHT plays a decisive role in the development of key technologies and concepts for the realization of biorefineries. It is especially advantageous if the products can be integrated into existing process chains.

In contrast to fossil-based raw materials, a significant characteristic of the most important components (on a volume basis) of renewable resources – carbohydrates and lignocellulosis – is their high oxygen content. "White biotechnology", which generates base and fine chemicals from renewable resources with a high oxygen content, is another highly discussed topic. In this context, it is necessary to remove oxygen for the manufacture of marketable products via reductive methods or, for example water splitting, aldol condensation, or aminolysis. Such reactions mostly have to be performed under high pressures (20 bis 250 bar) in order to achieve economic reaction turnovers and space-time yields.

In this context, subsidies from the central strategy fund of the Fraunhofer-Gesellschaft were used in order to install the necessary small-scale pilot plants and infrastructure. Overall the high-pressure laboratory consists of four pilot plants equipped with modern measurement and automation technology:

- two fixed bed reactors which are designed for different capacities
- a batch stirred tank reactor and
- a plant for the chemical conversion of biogenous synthesis gases.

The new high-pressure laboratory puts Fraunhofer UMSICHT in a position to develop and optimize high pressure reactions for the development of process chains for the processing of renewable resources.

Contact:

Dr. Andrea Springer

Phone: +49 208 8598-1266

E-mail: andrea.springer@

umsicht.fraunhofer.de

Dr. Axel Kraft

Phone: +49 208 8598-1167

E-mail: axel.kraft@

umsicht.fraunhofer.de

PROCESS TECHNOLOGY

"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. Grge 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.

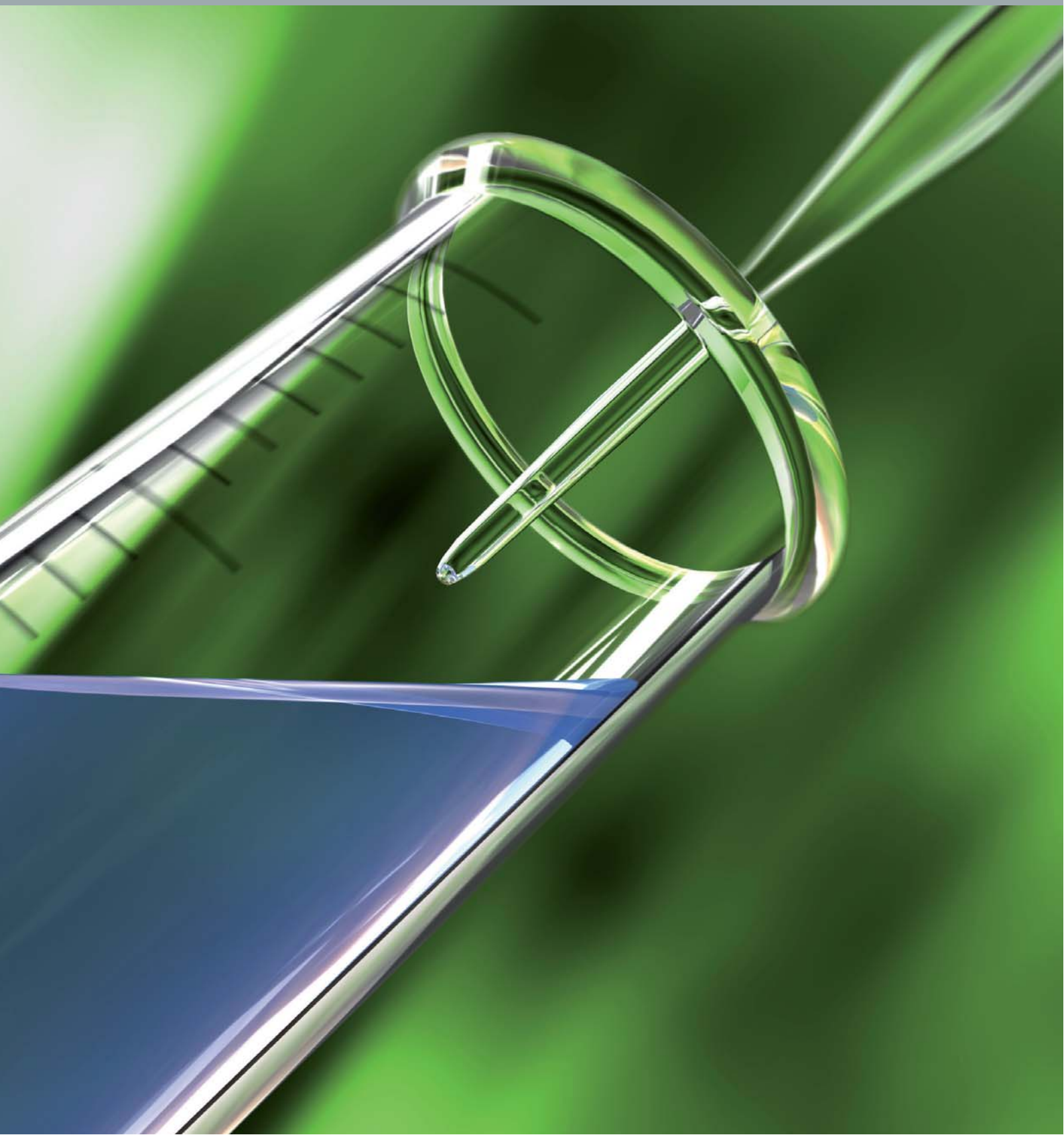
OPTIMIZED ADSORPTION PROCESSES

DSP – DOWNSTREAM PROCESSING

USE OF ENZYMES FOR THE CONSERVATION OF RENEWABLE RESOURCES

FINE PARTICULATE FILTERS FOR WOOD COMBUSTION

PROCESS TECHNOLOGY



OPTIMIZED ADSORPTION PROCESSES

The selective deposition of the gas molecules on the inner surface of adsorbents is a classical separation process in process technology. The application range for this process continues to broaden based on the development of more selective adsorbents and the possibility to simulate the main process steps.

Fraunhofer UMSICHT offers its customers an extensive service spectrum for researching adsorbents and adsorption processes:

- Measurement of adsorption parameters (e.g. adsorption isotherms, porosities) in the lab
- Interpretation and critical evaluation of existing data
- Development support for innovative adsorbents
- Development of process-based calculation models and their use for the prognosis and optimization of processes
- Planning and construction of pilot plants for research on adsorption processes

During the reporting year, several industrial contract research projects were successfully completed. These included, among others, the storage of natural gas in tanks which were filled with a new type of adsorbent. After developing a simulation model, a test plant was conceptualized and erected, which allows investigating the process on a semi-technical scale. The work aims at precise thermal control of the adsorption process during filling and, as a result, will deliver important data for the planned market introduction of the storage material.

In the field of publically funded research, the execution of the EU-Project COALSWAD has commenced. The goal of the research is the collection of data about the swelling behavior of coals from German and Czech mines during the adsorption of CO₂. The backdrop to this work is the feasibility of utilizing abandoned (or inactive) coal seams for the storage of anthropogenic CO₂. Another focus is on research activities for the optimization of gas vapor containment (or capture) systems for the use of biofuels.

Contact:

Dr.-Ing. Stefan Schlüter

Phone: +49 208 8598-1126

E-mail: stefan.schlueter@

umsicht.fraunhofer.de

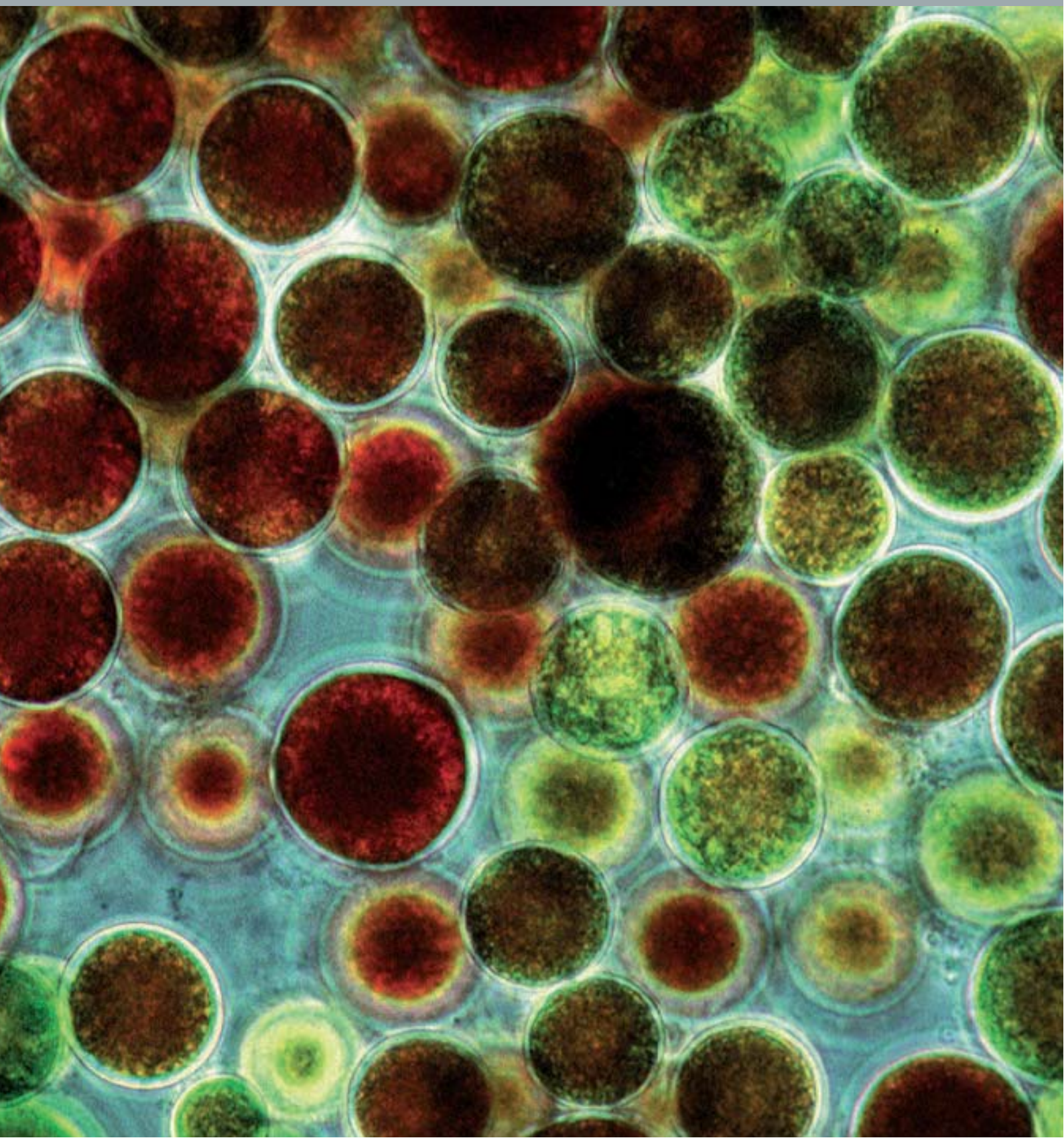
Dr. rer. nat. Eva Schieferstein

Phone: +49 208 8598-1328

E-mail: eva.schieferstein@

umsicht.fraunhofer.de

PROCESS TECHNOLOGY



DSP – DOWNSTREAM PROCESSING

Industrial white biotechnology encompasses the use of renewable resources for the manufacturing of chemical and pharmaceutical products. In addition to the conversion step, the success of the processes is largely determined by the processes of product isolation and cleaning (downstream processing, DSP). Mechanical, thermal, or chemical separation technologies have to be optimally tailored to the upstream bio-conversion and subsequent processing.

Fraunhofer UMSICHT develops efficient processes for synthesis building blocks, pharmaceuticals, food additives, or plant based natural materials. The development to downstream processing is accomplished largely

- through the integration of up and downstream processes for the increase of yield and for the improvement of economics,
- through specific process screening under economic aspects,
- through the utilization of simulation tools
- through accompanying economic feasibility studies.

Based on given boundary conditions, this is how the optimum process sequence was developed and evaluated for various projects. Special examples include the production of 1,3-propanediol and 1,18-octadecadienoic acid from the respective fermentation solutions as part of the MAVO¹ BioProChem.

In both cases, a multi-stage process was developed in which various concentration and cleaning steps were performed after the biomass separation. The production of amino acids and carbohydrate fractions through nanofiltration and crystallization represents another research focus (patent: EP 1113861 B1). Additionally, resource recovery from algae is another research concentration. Investigations have shown that the use of supercritical carbon dioxide enables the decomposition of the algae and extraction of the valuable constituents in a single process step.

Contact:

Dipl.-Ing. Hans-Jürgen Körner

Phone: +49 208 8598-1272

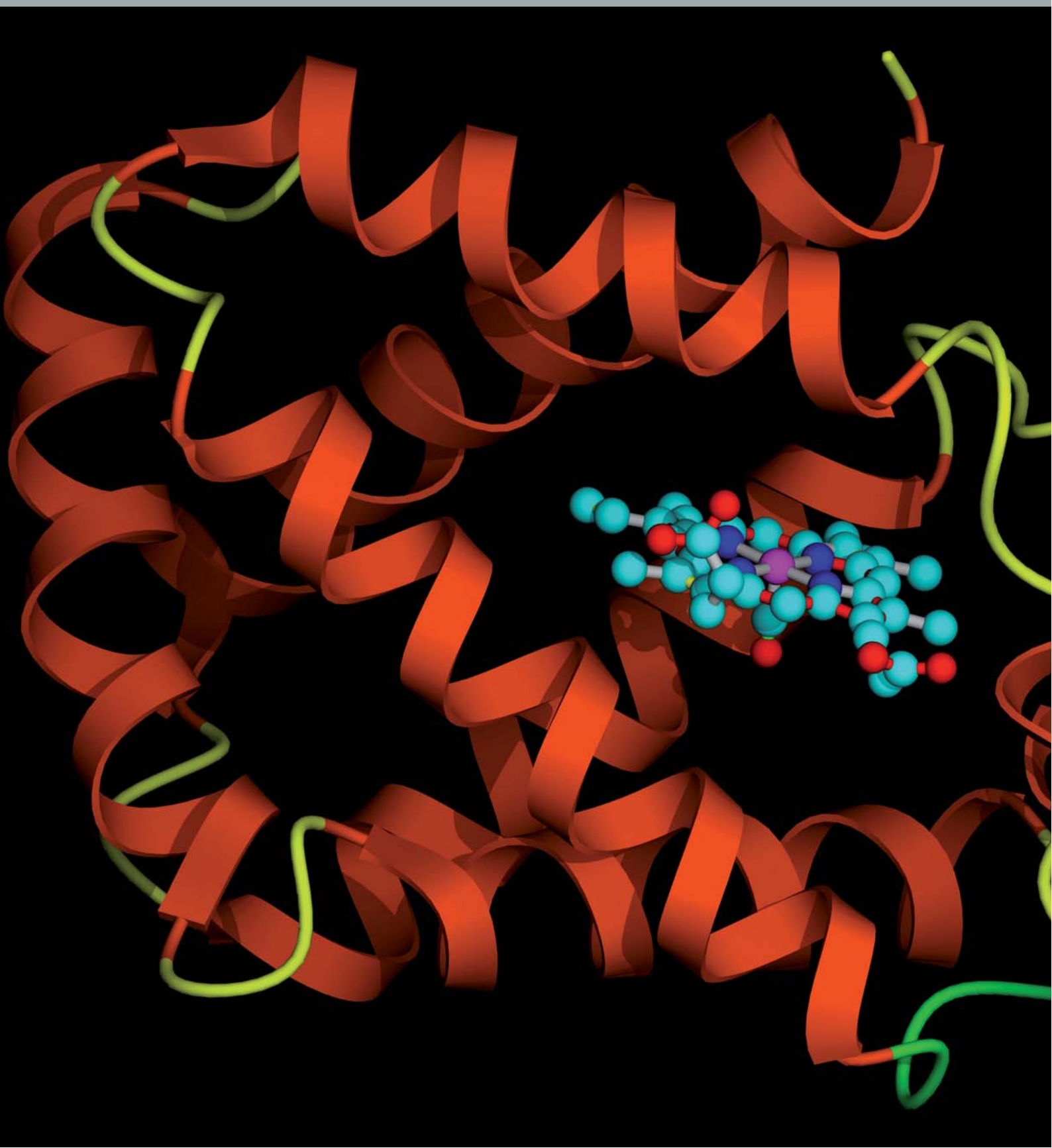
E-mail: hans-juergen.koerner@umsicht.fraunhofer.de

Dipl.-Ing. Josef Robert

Phone: +49 208 8598-1150

E-mail: josef.robert@umsicht.fraunhofer.de

*¹market-oriented strategic
research internal Fraunhofer-program*



USE OF ENZYMES FOR THE CONVERSION OF RENEWABLE RESOURCES

The market for biotechnologically manufactured products will exhibit stronger growth in the future than the overall chemical industry. The reasons for that are, on the one hand, associated with the increasing number of successful biotechnological processes in traditional areas of industrial production, while, on the other hand, also in quantifiable advantages such as new reaction possibilities and products, a reduced number of production steps, a lower energy consumption, and the reduction of pollutant emissions.

Fraunhofer UMSICHT develops and optimizes enzymatic processes for the production of valuable materials from natural materials. The process development pays special attention to

- processing of raw materials,
- selection and screening of enzymes under process technological aspects,
- development of reversible immobilization techniques,
- development of new processing technologies and strategies as well as
- optimization of process control.

Since enzyme costs can represent a significant cost factor, the recovery and, thus, multiple use of the enzymes are of essential importance. The goals of various projects are the development of immobilization technologies and selective separation. As part of the project "Matrifix", a mechanically stable immobilization matrix consisting of a hydrogel and a flexible material in which the bio-catalyst is reversibly immobilized. In addition, the utilization of immobilized enzymes in supercritical fluids was researched during another project. The advantage of such a process lies in the coupling of the conversion and production steps. Another possibility for enzyme recovery is the enzyme-membrane reactor in which the enzyme and the educt (or reactant) are separated from the product in an external separation step and reintroduced into the reactor. Aside from the multiple use of the enzymes, this process technology also enables continuous operation.

Contact:

Dipl.-Ing. Josef Robert

Phone: +49 208 8598-1150

E-mail: josef.robert@

umsicht.fraunhofer.de

Dipl.-Ing. Hans-Jürgen Körner

Phone: +49 208 8598-1272

E-mail: hans-juergen.koerner@

umsicht.fraunhofer.de

PROCESS TECHNOLOGY



PARTICULATE FILTERS FOR WOOD COMBUSTION

The reduction of fine particulate emissions from wood combustion is currently a central topic in the fields of environmental protection and air quality control. It is likely that the emission limits for particulates will be lowered significantly through the planned changes of the regulatory requirements (Amendment 1. BImSchV, Federal Emission Control Act). Almost all installed biomass fired systems (from fireplaces to centralized heating) will have to comply with the new regulations after coming into force. For older existing plants, transition regulations are provided starting in 2015. Currently, a plant inventory of 14 to 15 million small combustion plants is estimated to exist in Germany for which emission reduction solutions are sought. According to the amendment of 1. BImSchV, the emission limits for fine particulate emissions are to be based on the total particulate matter mass, although it is known that the health risks associated with fine particulates are especially linked to the polycyclic aromatic hydrocarbon fine particles ($< 1 \mu\text{m}$) and aerosols. This decision represents potential for conflict which can be countered today through the development of appropriate filtering technologies.

The goal of the research is the minimization of human toxicological risks through reliable fine particulate and tar separation, the development of technologies for the compliance of future emission limits, and the retrofitability of older plants with low investment and operating costs.

In this context, Fraunhofer UMSICHT is developing several potential solutions. One project encompasses the two-step filtration/cleaning of the flue gas from small combustion plants with a heating capacity of 30 to 500 kW (funded by BMELV/FNR¹, funding reference 220-211-06). Among others, metallic microsieves are implemented in this project. Another approach is the utilization adsorption and absorption technologies for the removal of tars from the flue gas stream.

Several pilot plants and comprehensive measurement technology are available for practical tests.

Contact:

Dipl.-Ing. Josef Robert

Phone: +49 208 8598-1150

E-mail: josef.robert@

umsicht.fraunhofer.de

Dipl.-Ing. Esther Stahl

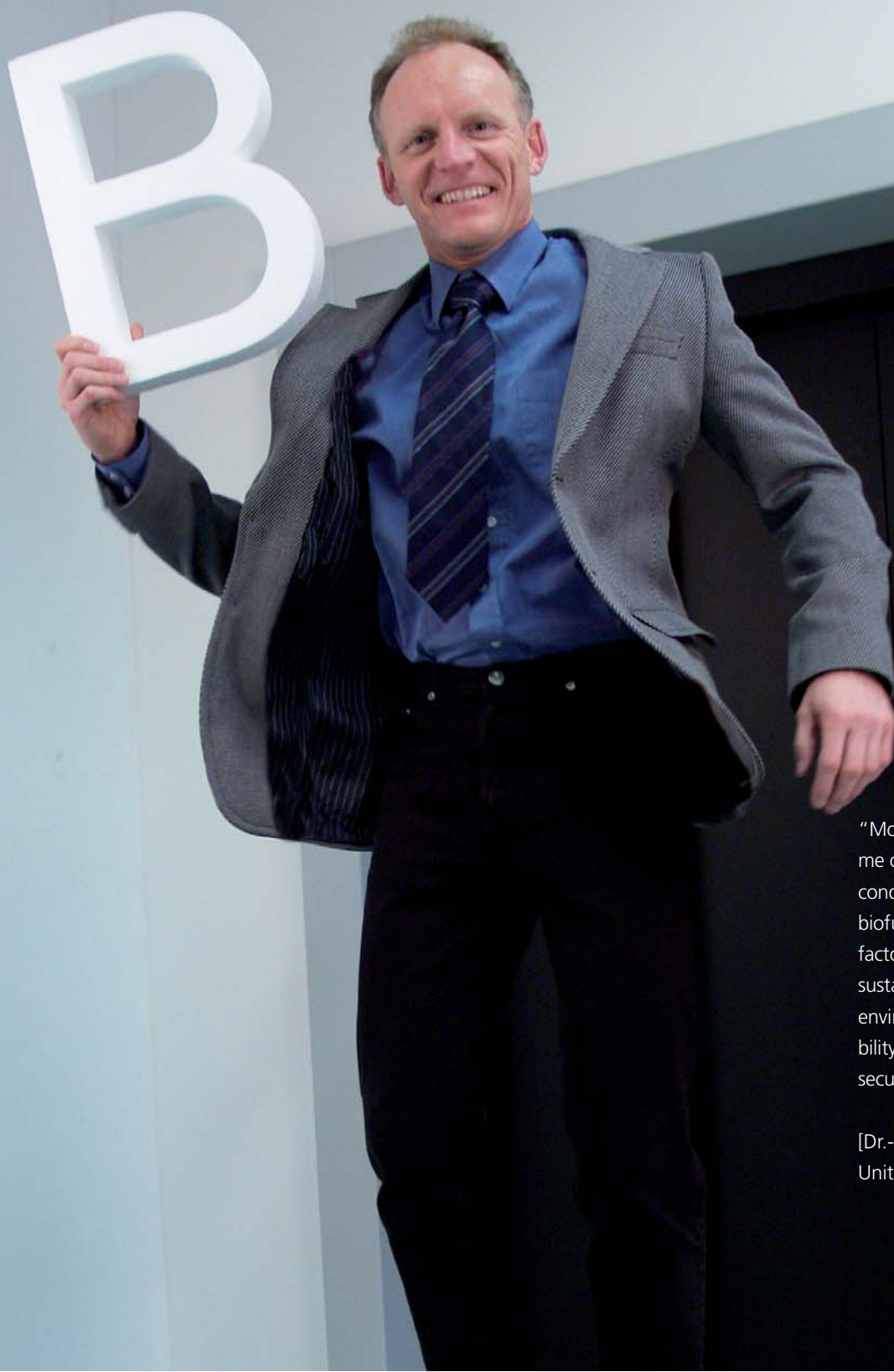
Phone: +49 208 8598-1158

E-mail: esther.stahl@

umsicht.fraunhofer.de

¹Federal Ministry of Food,
Agriculture and Consumer
Protection/Agency for Renewable
Resources

BIOFUELS



"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.

AUTOMATED PROCESS DEVELOPMENT FOR BIOFUELS AND BIO-REFINERIES

THE WASTE-TO-FUELS-PROCESS GREASOLINE®

BIOFUELS



AUTOMATED PROCESS DEVELOPMENT FOR BIOFUELS AND BIO-REFINERIES

The Business Unit "Biofuels" develops and optimizes chemical-catalytic processes and catalysts for the conversion of renewable resources in biofuels and bio-based chemicals in the framework of biorefineries.

Automated small scale plants, so-called "Mini-Plants", play an important role in the technological development and ecological optimization of processes.

This Business Unit conceptualizes and installs Mini-Plants for specific requirements.

These Mini-Plants represent many advantages for customers since they eliminate the need for complex and expensive infrastructure and specially trained personnel.

The advantages of Mini-Plants are, among other,

- the quick, safe and economic process development (including sample taking),
- reproducible results and automated, comprehensive documentation,
- simple execution of sample production on a kilogram-scale for market research,
- quick generation of data for economic feasibility studies,
- simple realization of catalyst life tests,
- the possible enrichment of byproducts and their processing.

The Business Unit currently has the following Mini-Plants at its disposal:

- Pilot plant for catalytic gas phase reactions
1,5 bar, 450 °C, multiple stream feeding up to 3 kg/h
- Continuous distillation with heating
1,5 bar, up to 350 °C head temperature, capacity up to 2 kg/h
- Laboratory plant for the catalytic gas phase pyrolysis with online-GC (FID/TCD),
1 bar, up to 600 °C, multiple stream feeding up to 60 g/h
- Catalytic fixed bed reactor with online-GC-MS
up to 5 bar, up to 550 °C, capacity 0,001 - 1 kg/h
- Liquid phase de-hydrogenation in a Mettler-RC1
(semi-)batch, 2-l-reactor, up to 50 bar, 230 °C, multiple stream feeding up to 0,5 kg/h
- Catalytic fixed bed reactor (gas/liquid),
Inconel, 100 bar, up to 350 °C, multiple stream feeding up to 1,2 kg/h
- Continuous stirred reactor cascade with dosing lines,
feed heater, phase separator, glass, 2 liter reactors, 1 bar,
up to 150 °C, multiple stream feeding up to 0,5 kg/h (see figure)
- High pressure autoclave (hastelloy C / titanium / steel)
0,1 l, 300 bar, up to 350 °C, batch

Contact:

Dr. Jürgen Grän-Heedfeld

Phone: +49 208 8598-1274

E-mail:

juergen.graen-heedfeld@

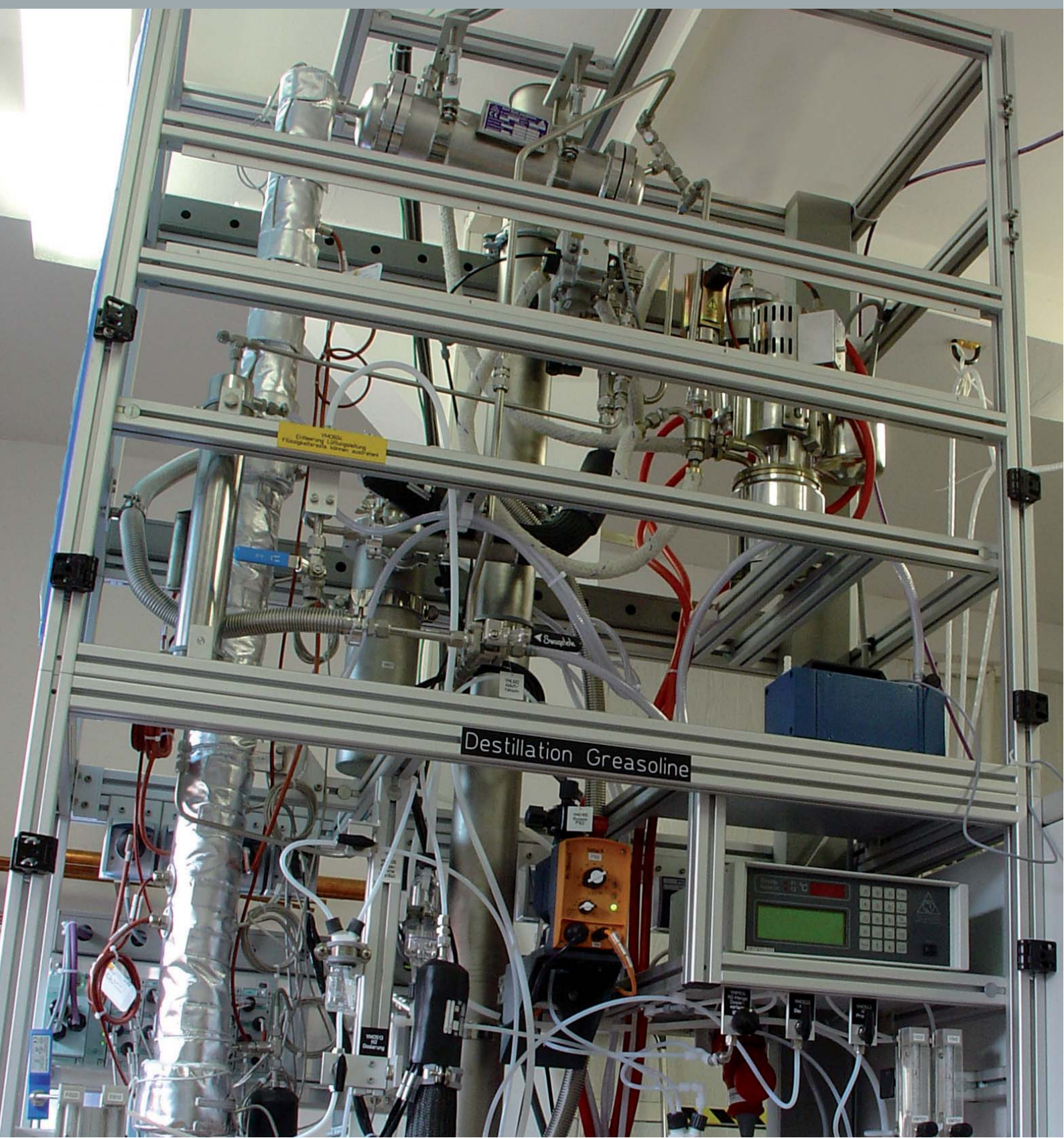
umsicht.fraunhofer.de

Dipl.-Ing. Karl Meller

Phone: +49 208 8598-1279

E-mail: karl.meller@

umsicht.fraunhofer.de



THE WASTE-TO-FUELS-PROCESS GREASOLINE®

CRACKING WASTE OILS AND FATS INTO BIOFUELS

Processing high-quality vegetable waste oils and fats such as used frying oils from restaurants into biodiesel is state of the art – only, the free fatty acids generated during the frying process have to be removed first, or else require special treatment. Even while producing biodiesel from rapeseed oil and palm oil, up to 10 wt-% of the fresh oil is separated as waste streams rich of free fatty acids. Currently, these waste streams are mostly combusted – a utilization that does not at all take full advantage of the free fatty acids' chemical potential.

Using the greasoline® technology, these waste materials were successfully converted into long-chained hydrocarbons known from high-quality fossil diesel fuels. Activated carbon serves as a "green" catalyst. Quite in contrast to biodiesel, the resulting fuel is engine-compatible without any restriction. The main primary products are the oils' and fats' free and bound fatty acids, shortened by one carbon atom. When processing Western European mixed waste grease, the arising hydrocarbons are predominantly n-pentadecane and n-heptadecane (cetane numbers 96 and 105). Current developments aim at producing an additive that upgrades conventional diesel fuel to designer diesel with higher cetane numbers.

Alternatively, greasoline® can selectively produce gaseous hydrocarbons like ethylene, propane, and butane. Here, even waste glycerol from biodiesel production with a considerable residual amount of water can also be used as feedstock.

Moreover, applying the greasoline® technology to algae oil processing has a great potential, too.

Milestones in 2008 were the granting of a European patent (EP14891S7A1), the production of photo-stable, distilled product, the successful completion of a co-operation project funded by the European Commission (Project no. 018109, "GREASOLINE"), as well as the completion of a pilot plant for converting 3 kg of waste grease per hour.

Contact:

Dr.-Ing. Volker Heil

Phone: +49 208 8598-1163

E-mail: volker.heil@umsicht.

fraunhofer.de

Dr.-Ing. Axel Kraft

Phone: +49 208 8598-1167

E-mail: axel.kraft@umsicht.

fraunhofer.de

*The European Commission
is in no way responsible for
the content of this publica-
tion. The parties responsible
are solely the authors.*

ADVANCED MATERIALS



„For us the development of innovative materials and applications is a holistic task. For this purpose we combine the research on functional and adaptive materials with aspects of sustainability. And – what is of special importance to us – we do not just revert to mere physical-chemical investigations but in the future we also want to gain a better understanding of the sensory perceptions evoked by the material during its utilization.“

[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 modification 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 specimens or prototypes we use intelligent simulation and testing procedures to examine the appropriateness of the respective materials for their special applications. The sensory design under application and utilization specific aspects is an integral research topic in our R&D work.

WOOD THROUGH MODIFICATION – FIT FOR THE FUTURE

LEATHER TANNING UNDER THE INFLUENCE OF COMPRESSED CARBON DIOXIDE

MICROENCAPSULATION: SMALL CAPSULES WITH A LARGE EFFECT

NEW THERMOPLASTIC COATINGS

ADVANCED MATERIALS



WOOD TROUGH MODIFICATION – FIT FOR THE FUTURE

Indigenous woods play an important role as a renewable resource in the construction industry but are often replaced by tropical woods or other materials (such as plastics or metals) when characteristics such as dimensional stability and durability do not meet the requirements.

The impregnation of wood with silica nanosols or silicones represents an opportunity for the fulfillment of these requirements, because their insertion into lumina and cell walls should result in a positive modification of the wood characteristics. Using conventional impregnation processes which use water or solvents as carrier medium, a complete penetration can usually not be achieved and the solvents have to be strenuously removed subsequently.

Therefore, alternative processes for the impregnation and modification of wood through supercritical carbon dioxide (scCO_2 , $T_{\text{crit}} = 31\text{ °C}$, $p_{\text{crit}} = 74\text{ bar}$) is currently being investigated. Carbon dioxide as a carrier medium penetrates deeper into the material to be impregnated and can be removed from the material by reducing the pressure without subjecting the material to any thermal load. Despite the high pressure, damage of the wood structure can be avoided entirely through accurate control of the process parameters, especially pressure increase and decrease. In addition, it was demonstrated that a complete penetration of the wood object can be achieved. Furthermore, research has shown that the nanosols are dispersed within the wood without agglomerations.

In the future, it will be possible to individually modify wood to meet the requirements of the market with the help of supercritical impregnation and modification. The findings can also be transferred to additional cellulosic materials such as silencers, leather, paper, and textiles.

Contact:

Dipl.-Ing. Erich Jelen

Phone: +49 208 8598-1277

E-mail: erich.jelen@

umsicht.fraunhofer.de

ADVANCED MATERIALS



LEATHER TANNING UNDER THE INFLUENCE OF COMPRESSED CARBON DIOXIDE

Tanning is a time, cost, and work intensive process. The goal is to turn hide that is fragile and has a short shelf life into a sturdy, durable, and decorative material. This is achieved by soaking the pretreated skin in a solution of water and tanning in rotating tannery vats. 90 % of all leathers are tanned with chrome-III-salts. On an industrial scale, this means that several tons of rawhide are exposed to twice the amount of chrome containing liquid and turned in the tannery vats for 24 to 30 hours. After this step, the hide is tanned and will become leather through subsequent processing. Fraunhofer UMSICHT pursues the goal of accelerating the tanning process and of reducing the environmental impact through the avoidance of problematic waste waters. This is achieved by utilizing compressed carbon dioxide (CO₂).

Based on laboratory tests, it was shown that the tanning process duration can be shortened by a factor of 6 (see figure below). For every dot shown in the diagram, two tests were performed. The quality of the leather is closely correlated to the Cr content.

At 3% by weight, the quality is optimal. The transfer of the results from a laboratory to pilot scale has been proven successfully. The pilot scale tests were performed in a CO₂ plant with a 20 liter capacity (or volume). Leather pieces produced under CO₂ influence (approximately 0,5 m²) exhibited high quality with time savings by a factor of 10.

Currently, the next goal is the reduction of water consumption. This is accomplished through the reduction of process steps, which conventionally involve various water baths which are now substituted through the use of CO₂. The project is being performed in cooperation with UHDE hpt and Pelzveredelung Geihlsler and funded by the BMBF¹. Market introduction of the technology is planned for 2010.

Contact:

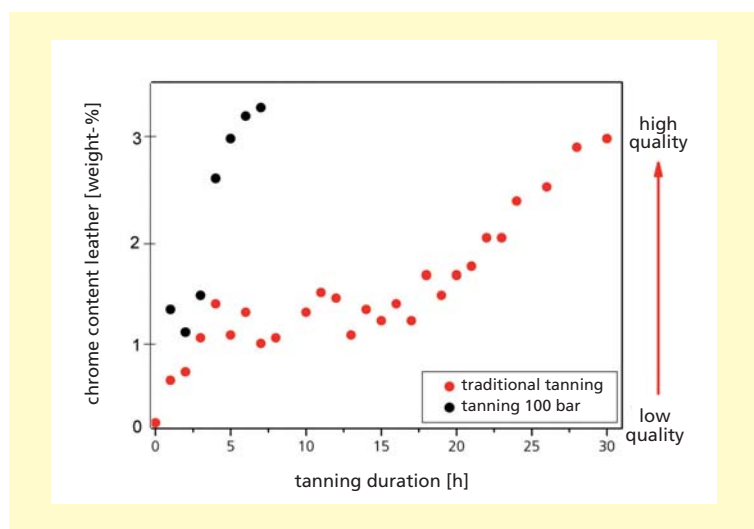
Dipl.-Ing. Manfred Renner

Phone: +49 208 8598-1411

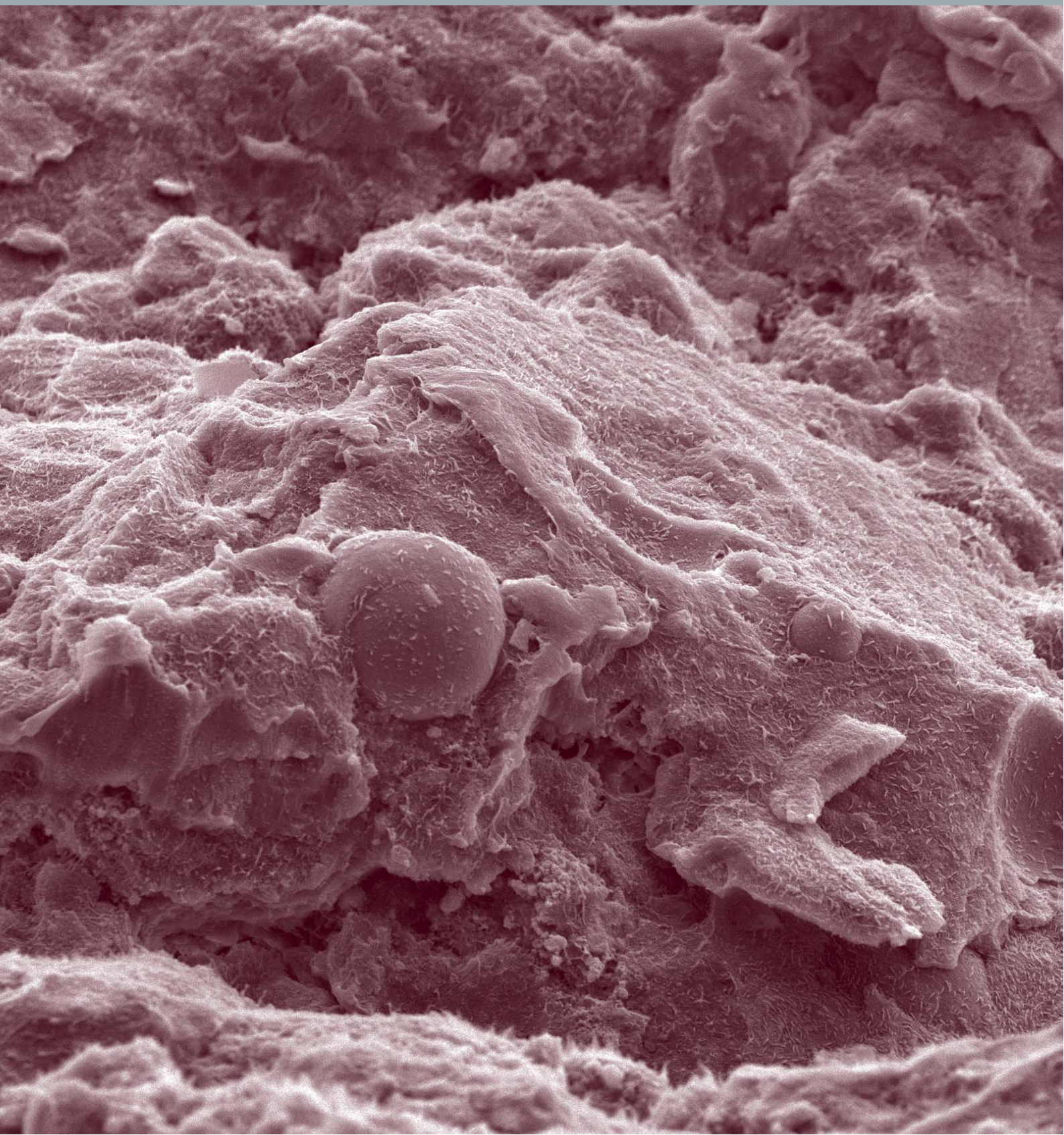
E-mail: manfred.renner@

umsicht.fraunhofer.de

¹Federal Ministry of Education
and Research



ADVANCED MATERIALS



MICROENCAPSULATION: SMALL CAPSULES WITH A LARGE EFFECT

Today, microencapsulation is a widely used process, which has its origins as far back as the 1930s. Liquid, solid, and even gaseous substances are encapsulated with polymeric or inorganic wall materials in which the materials of the shell and core are advantageously combined. Based on the multiple combination possibilities, many objectives and a broad application spectrum are feasible for micro capsules:

- separation of reaction components, indicators, etc.
- long-term stabilization of active substances flame retardants etc.
- compatilization of different materials
- optimization of flow behavior
- avoidance of agglomeration
- "conversion" of liquids into solids
- improvements of dosing behavior
- protection from environment
- taste and odor masking

The skilled material combination, adaptation of new materials, or multiple encapsulation opens new application fields for microencapsulation.

For the first time, the Business Unit Advanced Materials succeeded in 2008 in developing liquid filled micro capsules, which are stable in the processing environment of thermoplastic materials. These capsules represent another functionilization of thermoplastic materials such as, for example, lubricants for polymeric bearings, the processing of fragrances close to the boiling point for hygiene products, or the utilization of phase change materials in thermoplastics.

Aside from the encapsulation of lipophilic materials, the application of aqueous capsule systems is moving to the forefront. Thus, the business unit is currently actively developing micro capsule systems that can cope with the high diffusion potential of water. The various capsulation methods such as stirred vessel processes, spray drying, and dropping technology are combined to achieve that.

Contact:

Dipl.-Ing. Andreas Sengespeick

Phone: +49 208 8598-1157

E-mail: andreas.sengespeick@umsicht.fraunhofer.de

Dr. rer. nat. Anke Nellesen

Phone: +49 208 8598-1147

E-mail: anke.nellesen@umsicht.fraunhofer.de

ADVANCED MATERIALS



NEW THERMOPLASTIC COATINGS

Electrostatic coating with powder paints is of great economic importance. The simple handling, the recovery of unused powders, and the avoidance of solvents are significant advantages compared to wet painting. Duromers are used almost exclusively, which are materials that crosslink during the heating process. The use of thermoplastic materials is currently limited to niche applications. Due to the higher chemical resistance of thermoplastics compared to conventional powder coatings, applications for the coating of dish washer baskets are one example. However, the performance spectrum of thermoplastic materials offers far more.

In 2008, the Business Unit Advanced Materials, in cooperation with industry partners, expanded the material selection of functional coating powders for electrostatic processing. Tribologic surfaces were the focus with materials optimized for lubrication and friction depending on the application. A material based on polyamide was developed for an application in which optimum grip was required. The material exhibits long-term elasticity with coating thicknesses as low as 0,2 mm which prevents the slipping of safety relevant components during use.

Through the modification of polyoxymethylen (POM) surfaces were realized that are characterized by extremely low friction values. The skid number of the coating is comparable with those of fluor polymers but without losing the significantly higher wear resistance of POM.

The development of powder production is of great significance for all of them. Aside from the classic use of mechanical size reduction at low temperatures, high pressure spraying of the molten polymers with the PGSS®-process was performed. A PGSS® production plant built at the institute offers new possibilities for the future (compare figure in the left).

Contact:

Dipl.-Ing. Marcus Rechberger

Phone: +49 208 8598-1405

E-mail: marcus.rechberger@umsicht.fraunhofer.de

umsicht.fraunhofer.de



*Elasticity guarantee
coating with grip!*

INFORMATION TECHNOLOGY IN PROCESS ENGINEERING



"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 Infor-
mation 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.

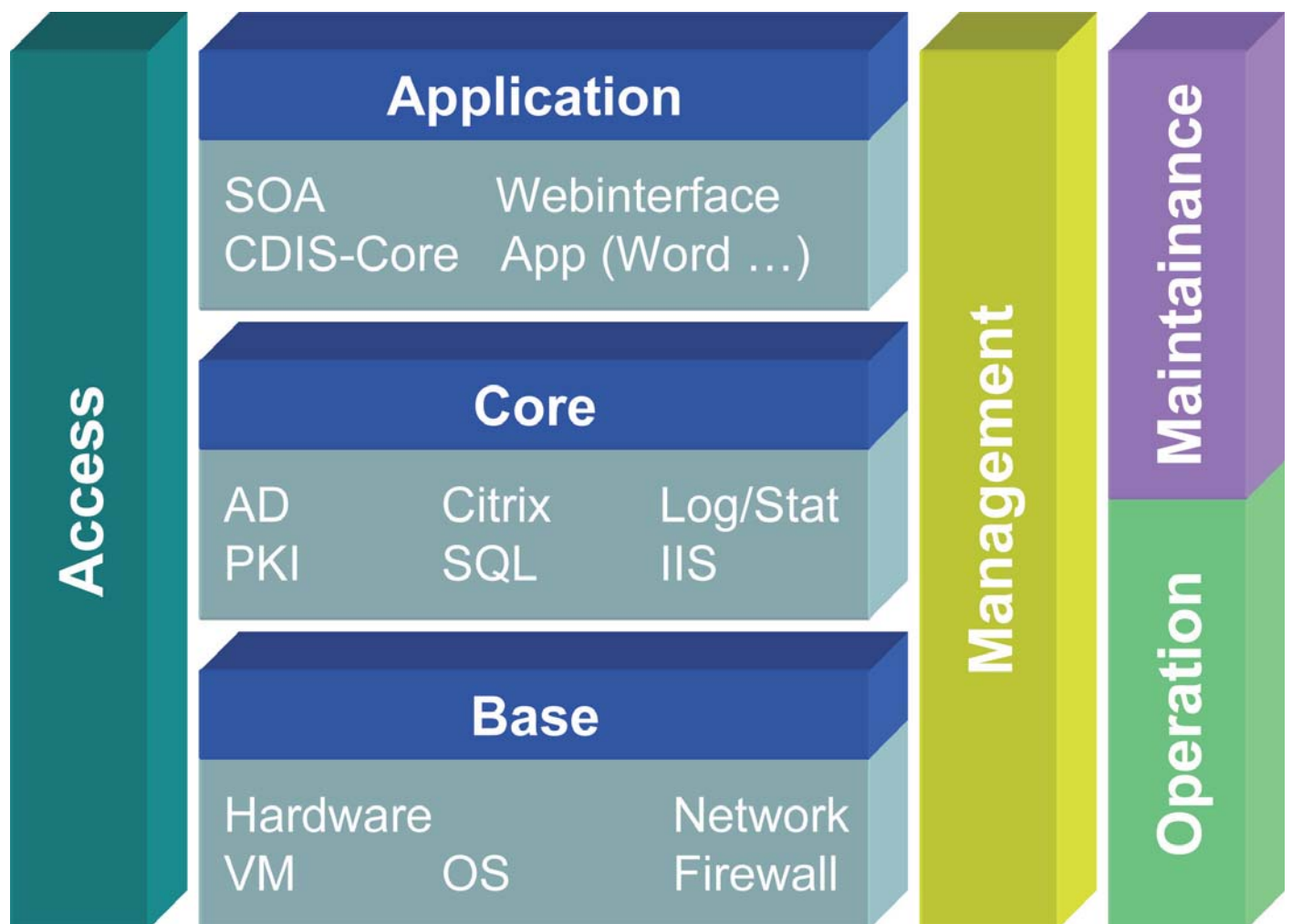
Value added chains in companies are closely connected to the supply of information. Often, optimizations cannot be realized without a sufficient data pool.

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.

CDIS (COLLABORATIVE DOCUMENTATION AND INFORMATION SYSTEM)

WORKFLOW EXPANSION IN GEVIS II

SMOKE CONTROL DURING FIRES – HELP WITH TESTING AND EVALUATION



CDIS (COLLABORATIVE DOCUMENTATION AND INFORMATION SYSTEM)

The technical documentation in machinery and plant construction has always been a point of contention between contractor and contractee and is often viewed as necessary evil and thus neglected. Often it is generated under time pressure. Internal documentation is gaining importance especially in the context of know-how and information management. The German and international regulations place specific requirements on technical documentation. EU norms, product liability, and CE certifications force businesses to deliver safety-documentation as a part of the product.

The collaborative documentation and information platform CDIS currently under development by Fraunhofer UMSICHT forms the entire lifecycle of a complex technical plant from its planning to its permitting all the way to its construction, commissioning, and operation. Prerequisite for this is the fusion of all processes in an integrated management system. The selection of the necessary components for the IT operation follows a basic economic approach. The operating environment is built on the results of the Fraunhofer study "Ecological comparison of the climate relevance of PC and Thin Client Workstations 2008".

A central, fail-safe server based computing architecture, which provides a client accessible presentation layer without creating an increased installation and maintenance effort for the process participant, is used for the general display and documentation of the above described phase. They are granted access through an ergonomic and intuitive user guidance via a web-frontend which significantly simplifies access to the relevant documents. Portable thin clients also enable mobile access to all relevant data during field work.

The total concept is to be evaluated on the example of a new biomass gasification plant for the generation of heat and power to be built in 2009.

Contact:

Dipl.-Phys. Thorsten Wack

Phone: +49 208 8598-1278

E-mail: thorsten.wack@

umsicht.fraunhofer.de

Dipl.-Ing. Andreas Schröder

Phone: +49 208 8598-1131

E-mail: andreas.schroeder@

umsicht.fraunhofer.de



S29/35

6/27/28

WORKFLOW EXPANSION IN GEVIS II

When dealing with hazardous materials, many things have to be paid attention to. The hazardous material management and information system (GEVIS II) developed by Fraunhofer UMSICHT offers help. For example, which material should be categorized as hazardous material and what has to be paid attention to for potential hazards during storage, transport, or handling?

The software system contains certain process steps which always recur, and can, therefore, be represented in a workflow. The checking, teaching, and renewal of instructions is such a workflow. Employees who have received instructions with certain hazardous materials have to renew these instructions within certain time durations. The goal is an automated information flow to simplify the process.

Workflows can be represented as fixed (business) processes with pre-defined activities. Such a combination of activities can be shown as a sequential workflow similar to a flow diagram. Individual steps are defined and logically connected within it such that an optimized workflow and information model is generated. An activity forms a logical unit in which special work steps are performed. When such activities are sequentially connected, a workflow is formed. The order in which it is located within the sequential workflow is of great importance because it is the order in which they will be performed.

During the development of such digital workflows, Windows® Workflow Foundation (WF) provides the necessary infrastructure. The Workflow designer delivered by Microsoft® can be integrated into GEVIS II and can be used to develop workflows. In this manner, different activities and regulations can be summarized into a workflow. Such graphically represented program sequences can be followed and even modified more easily by other users.

Contact:

B. ICT André Reinecke

Phone: +49 208 8598-1318

E-mail: andre.reinecke@

umsicht.fraunhofer.de

Dipl.-Phys. Thorsten Wack

Phone: +49 208 8598-1278

E-mail: thorsten.wack@

umsicht.fraunhofer.de

INFORMATION TECHNOLOGY IN PROCESS ENGINEERING



SMOKE CONTROL DURING FIRES

HELP WITH TESTING AND EVALUATION

Protecting people from the dangers of building fires in many cases means to control and constrain the spreading of fire smoke. The question of the effectiveness of such measures becomes especially important when extraordinary circumstances regarding the escape and rescue exist (such as a penitentiary for example) and when technical systems (e.g. pressurized ventilation systems, smoke curtains) are used for smoke control.

For over a decade, Fraunhofer UMSICHT has been performing practical tests of smoke distribution and discharge (or exhausting) in buildings with its hot smoke test facilities. Tailored to the requirements in each case, the available measurement technology enables making dependable statements about the distribution and concentration of smoke during fires and provides the necessary safety to perform tests with hot gases even in sensitive objects.

The detection of leaks in the smoke protection installations represents a focus of the research in 2008. Thus, the protective effect of cell doors against smoke penetration were proven and confirmed on the basis of concentration measurements during a test at a penitentiary. In another public building, the effectiveness of smoke curtains for keeping smoke out of escape routes was tested. The results gave reason for retrofitting measures.

Installed smoke protection doors were tested for leaks with a special testing apparatus. Thus far, findings from various objects showed that smoke penetration can be much higher than the testing norm of the door would lead to expect even when smoke protection doors appear to be correctly installed visually. A closer investigation of this topic should offer more clarity in the future.

Contact:

Dr.-Ing. Ulrich Seifert

Phone: +49 208 8598-1127

E-mail: [ulrich.seifert@](mailto:ulrich.seifert@umsicht.fraunhofer.de)

umsicht.fraunhofer.de

Dipl.-Ing. Jürgen Stein

Phone: +49 208 8598-1128

E-mail: [juergen.stein@](mailto:juergen.stein@umsicht.fraunhofer.de)

umsicht.fraunhofer.de

ENERGY TECHNOLOGY



"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.

DEVELOPMENT OF A RAPID TEST FOR REFUSE-DERIVED FUELS

USING LEAN GASES IN MICRO GAS TURBINES

BIOGAS FEED-IN INTO THE NATURAL GAS GRID



DEVELOPMENT OF A RAPID TEST FOR REFUSE-DERIVED FUELS

The quality of refuse-derived fuels (RDF) is subject to wide variations, which is mainly attributed to their heterogeneous composition as waste-derived materials. This problem has been the starting point for quality control measures as suggested by the Gütegemeinschaft Sekundär-brennstoffe und Recyclingholz e.V. (BGS) – Quality Association for Solid Recovered Fuels and Recycling Wood. Special consideration is given to the content of chlorine as measuring parameter, since chlorine compounds cause corrosion damage or may detrimentally affect the product quality in cement kilns. Due to their heterogeneous composition, apparently precise analytical results yielded for refuse-derived fuels have to undergo a further critical investigation. The key question is whether the sample analyzed may be considered representative for the entire product. A rapid testing method which allows the fast determination of the most important quality parameters for a large number of samples, would deliver better information on the “genuine” composition of a sample and thus present a significant instrument for quality control.

In the framework of a collaborative project, supported by AiF¹/Zutech, Fraunhofer UMSICHT co-operates with the Institute for Waste Management and Contaminated Site Treatment of the Dresden University of Technology and the Department for Waste Management of the Berlin University of Technology on a project targeted at the development of technological equipment suitable for the rapid testing of refuse-derived fuels. The objective of the rapid test is the determination of the calorific value and the water, ash, and chlorine contents. The investigations will cover the development of a sampling and sample-preparation concept, the development of a method and the layout of a demonstration plant. This plant will be equipped with a furnace system, a gas management unit, various measurement units and an evaluation module. When analyzing the combustible, the sample will be oxidized, the combustion gas/flue gas absorbed and the dissolved chlorides will be identified using a photometric rapid testing method. The amount of combustion water and carbon dioxide can be identified using specific sensors or absorbing agents. As a result, the content of carbon and hydrogen and the heating value may be calculated via an evaluation module. During the development of the method significant differences in the behavior of organic and inorganic chlorine compounds became evident, which finally are responsible for the lower results using DIN analytical methods.

Contact:

Dr. Thomas Marzi

Phone: +49 208 8598-1230

E-mail: thomas.marzi@

umsicht.fraunhofer.de

Dr.-Ing. Edda Möhle

Phone: +49 208 8598-1231

E-mail: edda.moehle@

umsicht.fraunhofer.de

*¹German Federation
of Industrial Research
Associations*

ENERGY TECHNOLOGY



USING LEAN GASES IN MICRO GAS TURBINES

The Renewable Energy Sources Act (EEG, as of April 2000) in Germany and equivalent rules and regulations in the neighboring European countries governing the compensation of electricity produced from biogases, has led to a dynamic development in the utilization of lean gases in combined heat and power generation (CHP) plants. Nevertheless, lean gases with low calorific values ($H_i < 14 \text{ MJ/Nm}^3$) are still used to a minor extent, since gas engines and also micro gas turbines using conventional combustion techniques cannot utilize these gases without cost-consuming upgrading (calorific increase through propane or natural gas admixture). This is why a novel burner concept was developed and tested during a three-year collaborative project, in collaboration with several partners. This novel burner concept allows the utilization of low-calorific-value lean gases without upgrading.

The COSTAIR burner¹ developed by the Gaswärme-Institut was adjusted to the geometry of a commercial micro gas turbine, type T 100 manufactured by the company Turbec, and tested at an atmospheric test rig in a first step. Results yielded that a stable operation with various gas compounds including CH_4 , N_2 , H_2 , CO und CO_2 is possible. The mixture yielding the lowest calorific value needed for stable operation, was composed of 15 Vol.-% CH_4 in N_2 ($H_i = 5.4 \text{ MJ/Nm}^3$).

After these successful pre-investigations, the COSTAIR burner was installed in the micro gas turbine type T100 and tested under real operating conditions (integrated in the electricity and heat grid) using a synthetic lean gas mixture containing natural gas type L and nitrogen. The stability limit of the unit consisting of combustion chamber and turbine was reached at a fuel gas with a calorific value of $H_i = 5.6 \text{ MJ/Nm}^3$. Above this methane content, the CO -emissions were lower than 50 ppm and the NO_x -emissions lower than 20 ppm (each related to the 15 % O_2 share in the flue gas). At a calorific value of $H_i = 4.7 \text{ MJ/Nm}^3$, operation is still possible, however, the combustion was no longer stable, which was also indicated by the fluctuating CO measuring values ranging between 20 and 300 ppm.

This research project was supported by AiF² funds under reference no. 14472.

Contact:

Dipl.-Ing. Tim Schulzke

Phone: +49 208 8598-1155

E-mail: [tim.schulzke@](mailto:tim.schulzke@umsicht.fraunhofer.de)

umsicht.fraunhofer.de

The partner-institutes are:

Gaswärme-Institut e.V., Essen

(Project coordinator); Fraunhofer

Institute for Environmental,

Safety, and Energy Technology

UMSICHT, Oberhausen; the

Chair of Energy Systems and

Process Engineering of the

Bochum Ruhr University;

Nowum Energy Institute of

the Aachen University of

Applied Sciences, Research

Center Jülich; Research Unit

Waste Management and

Technology of the University

of Duisburg-Essen

¹COSTAIR = COntinued

STaged AIR, patented by

Gaswärme-Institut e.V., Essen,

EP 0834040 B1,

US 6,419,480 B2

²German Federation of Industrial Research Associations

ENERGY TECHNOLOGY



BIOGAS FEED-IN INTO THE NATURAL GAS GRID

The BMBF¹ funded collaborative project “Biogaseinspeisung – Biogas feed-in into the natural gas grid” undertakes the approach of a realistic evaluation of possibilities and potentials of the biogas feed-in into the natural gas grid, also taking into account restraints regarding the generation, conditioning and feed-in of biogas and working out solutions to overcome these challenges. The central objective of the project is the set-up of a geographic information system (GIS). Using GIS, planning actors are able to combine (geographic) data on biomass potentials, site planning details and data on biomass transport logistics via analysis tools for the planning of biogas installations, considering also the current land use, specific spatial planning aspects and infrastructural factors. Project work is conducted interdisciplinarily among economists, ecologists, engineers, legal practitioners and geographers.

The project partners work investigate for selected model regions:

- natural biomass potentials for the sustainable cultivation of energy plants
- optimization of biomass plants sites, biomass transport logistics and potential feed-in points
- the impacts of biogas feed-in on the natural gas grid
- the political, legal and socio-economic frame conditions of a sustainable biogas utilization
- the technologies required for the generation, conditioning and feed-in of biogas into the grid

For the first time, the determination of biomass potentials is made on the basis of natural conditions, real locations, under consideration of land use competition as well as of legal, socio-economic, economic and ecological factors. Geographic information tools facilitate the location planning and optimization for biogas plants and entry points including infrastructural factors such as traffic and gas grid.

As a result, instruments for an integrative view of scenarios and assessment of various biomass utilization options related to climate change, regional added value and economic efficiency are made available for future application.

Detailed project results may be found at: www.biogaseinspeisung.de

Contact:

Dipl.-Ing. Wolfgang Urban

Phone: +49 208 8598-1124

E-mail: [wolfgang.urban@](mailto:wolfgang.urban@umsicht.fraunhofer.de)

umsicht.fraunhofer.de

*¹Federal Ministry of Education
and Research*

ENERGY SYSTEMS



"Industrial societies need energy. In order to guarantee a sustainable and economic supply of more efficient energy 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“.

RELIABLE ELECTRICITY FROM SUN AND WIND

ENERGY IS NOT ONE-DIMENSIONAL – THE EXERGYFINGERPRINT

ABSORPTION CHILLERS USING MEMBRANE TECHNOLOGY

INNOVATIVE RECOVERY OF WASTE HEAT WITH SMALL-SCALE ORC-APPLICATIONS

ENERGY SYSTEMS



RELIABLE ELECTRICITY FROM SUN AND WIND

Electricity generated from wind power plants has become a sustainable pillar of Germany's energy supply. Due to the fluctuating energy output of wind plants, however, a further extension would require considerable input regarding the grid management, reserve capacity and balancing measures via conventional auxiliary peak load power stations. A promising approach to address this problem is the intermediate storage of electric power. In this field, Fraunhofer UMSICHT is working on two different storage techniques: compressed air and redox flow energy storage.

Compressed air energy storage – CAES – represents an inexpensive option of storage, however, limited to large-scale installations and thus to specific sites (caverns). Smaller plants in the performance range of 5 to 50 MW_{el}, on the other hand, are entirely independent of geological formations and may be effectively employed for district energy supply. Fraunhofer UMSICHT works on novel, dynamic design methods for flexible CAES. In collaboration with the Bochum Ruhr University, simulations of different air compressors and expanders on the basis of performance curves are worked out, and temporal and spatially high-resolved models of stratified heat storage systems are developed and combined. Thus, the development of novel, efficient CAES plant concepts may be performed more accurately and cost-efficient.

Redox-flow batteries are one of the most important options for the storage of electrical power up to the MW range. In an internal project, redox-flow concepts already developed have been analyzed. In future, new redox couples, electrolyte, electrode and membrane materials for redox-flow batteries are planned to be investigated. The objective is to increase the energy output and performance range of current systems at a high efficiency rate and to develop new systems with improved properties finally aiming at the integration into the energy supply grid. Another current topic at Fraunhofer UMSICHT is the simulation of redox-flow batteries with special regard to the layout, the construction and the system management of this new storage technology.

Contact:

Dr.-Ing. Christian Dötsch

Phone: +49 208 8598-1195

E-mail: christian.doetsch@

umsicht.fraunhofer.de

Dipl.-Ing. Daniel Wolf

Phone: +49 208 8598-1422

E-mail: daniel.wolf@

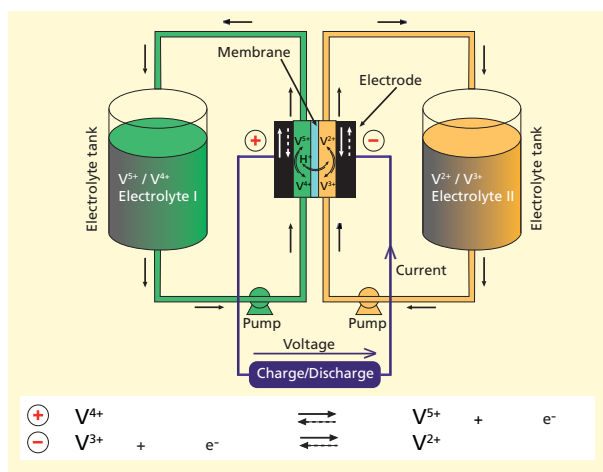
umsicht.fraunhofer.de

Dipl.-Ing. Sascha Berthold

Phone: +49 208 8598-1421

E-mail: sascha.berthold@

umsicht.fraunhofer.de





ENERGY IS NOT ONE-DIMENSIONAL – THE EXERGYFINGERPRINT

How to save primary energy? This question is being discussed intensively in politics and society. A promising approach that allows a comprehensive and scientifically correct identification and assessment of saving potentials is exergy analysis. Exergy is defined as the maximum work capacity associated with mass or energy flows in relation to a reference environment. It provides information not only regarding “size” but also regarding “quality” associated with the considered flows.

For many, the saving of primary energy is regarded equivalent to cutting energy consumption. Yet, this point of view neglects the fact that primary energy may also be saved by adjusting the quality level of energy production to the quality demand of the consumer. A novel exergy-based approach developed at Fraunhofer UMSICHT allows the separate evaluation of quantitative and qualitative effects by splitting exergy into quantity (transformation energy) and quality (transformability) thus increasing the transparency of exergy-based assessment. Using this so-called transformability concept in combination with a consistent approach for comparative evaluation, it is for example possible to show that the utilization of low temperature heat from high-efficiency cogeneration plants may yield savings comparable to those provided by high-quality insulation in a fundamentally different way.

The advantages of the partition of exergy into quantity and quality become apparent in the ExergyFingerprint for energy supply scenarios. This newly developed graphical assessment tool allows a precise and highly specific characterization of energy supply scenarios and makes it possible to identify and communicate optimization potentials in a convenient and yet strictly scientific way. For any given supply scenario the ExergyFingerprint can clearly show whether the largest potential for primary energy savings is found on the quantitative or on the qualitative scale.

Contact:

Dipl.-Ing. Andrej Jentsch

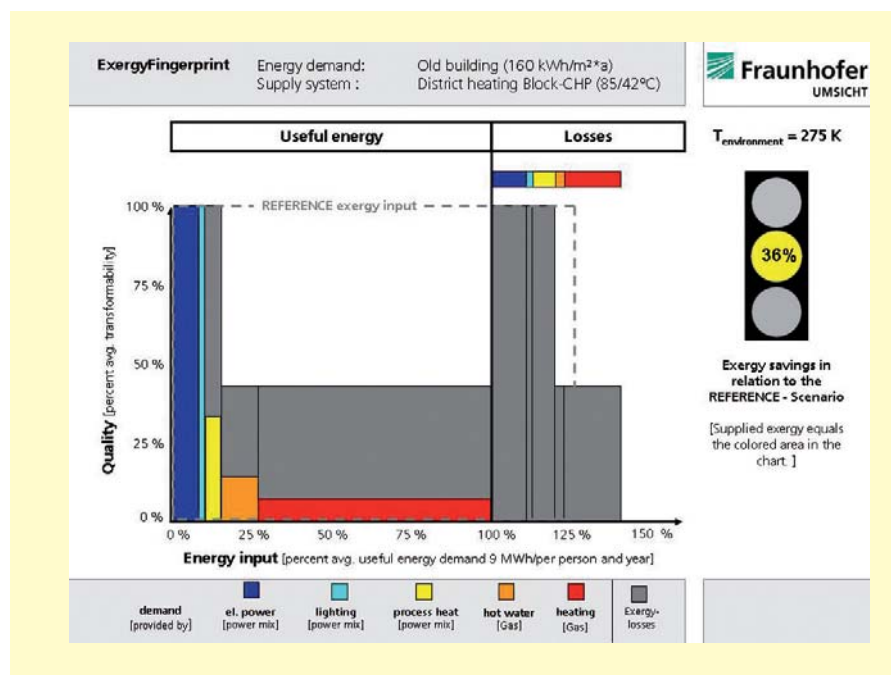
Phone: +49 208 8598-1146

E-mail: andrej.jentsch@umsicht.fraunhofer.de

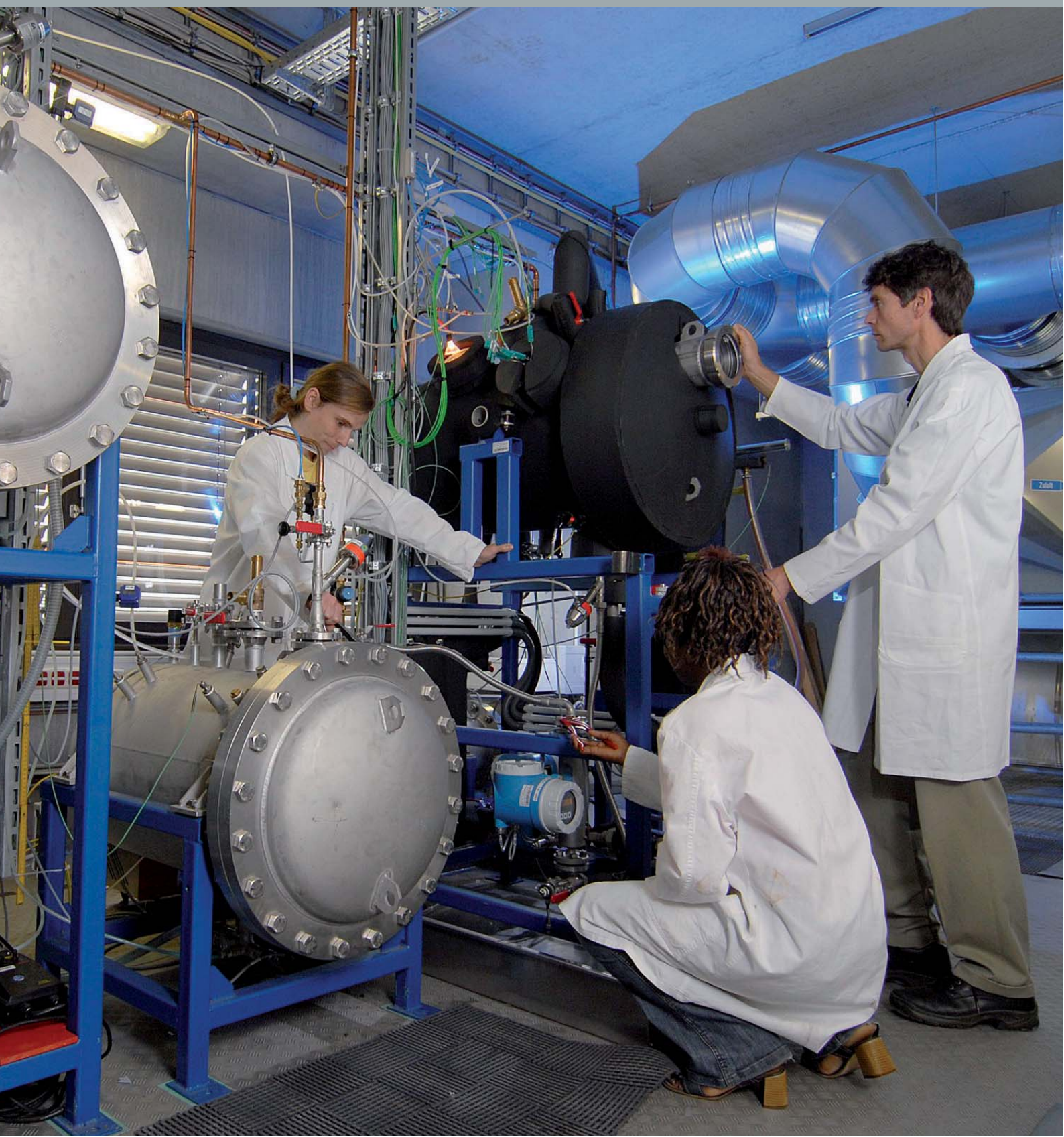
Dipl.-Phys. Stefan Bargel

Phone: +49 208 8598-1276

E-mail: stefan.bargel@umsicht.fraunhofer.de



ENERGY SYSTEMS



ABSORPTION CHILLERS USING MEMBRANE TECHNOLOGY

Across the world, an increasing number of buildings are being equipped with small, electrically driven chillers. This leads to peak loads in summer months and thus to seasonal overloads of the power grid and sometimes to severe grid failures. Alternatives to electrically driven compressor cooling machines become more and more urgently required, addressing the dwindling fossil energy resources for energy production, responding to requirements of climate protection and a more efficient building energy supply.

An ecologically effective alternative for air-conditioning systems are in particular thermally driven cooling processes, operated with solar heat, district heat or waste heat from small CHP plants. Large-scale absorption chillers have been well established over the last decades, however, in the range of 5 to 10 kW there are hardly any competitive products.

Fraunhofer UMSICHT is working on an innovative approach for the development of a small-scale solar-driven absorption chiller. Through integrating elements from membrane and nano-technologies, the heat and mass transfer in the individual system components are going to be enormously increased and thus a higher energy efficiency at a smaller construction size may be attained. The objective is to deliver an absorption chiller, driven e.g. by solar energy, in the size of a domestic refrigerator to the end consumer.

In the first stages, the appropriate membranes were determined and experimentally analyzed. A prototype of a membrane absorber module as well as a spray desorber were manufactured and measured in a chiller test facility at Fraunhofer UMSICHT. In further steps, detailed work packages concerning sealing techniques, the media supply and the design of a cost-effective production are addressed.

A special research focus is on the development of the hybrid cooling tower for waste heat dissipation, in order to combine high cooling performance of wet cooling towers with the hygienic advantages of a dry operation mode, using special nanoscaled surface coatings.

E.ON Research Award

This project has been awarded with the E.ON Research Award 2009 and supports outstanding achievements regarding the "use of nanotechnology in the energy sector". The award was presented by Professor Andreas Pinkwart, North Rhine-Westphalian Minister for Innovation, Science, Research and Technology.

Contact:

Dipl.-Ing. Peter Schwerdt

Phone: +49 208 8598-1173

E-mail: peter.schwerdt@

umsicht.fraunhofer.de

Dr.-Ing. Clemens Pollerberg

Phone: +49 208 8598-1418

E-mail: clemens.pollerberg@

umsicht.fraunhofer.de

ENERGY SYSTEMS



INNOVATIVE RECOVERY OF WASTE HEAT WITH SMALL-SCALE ORC-APPLICATIONS

Power generation by waste heat recovery

Novel energy efficiency methods which convert heat/waste heat at relatively low temperature into high-quality usable energies, are of special interest for the energy efficiency market. For power generation from waste heat in the small-scale range, the ORC process technology, a rankine cycle with an organic working fluid, is a competitive option.

Like commercial ORC applications for biomass fired CHP plants, geothermal and industrial heat, small ORC applications enjoy particularly high demand on the market, yet commercial systems below the range of 200 kW_{el} are hardly to be found. Fraunhofer UMSICHT is among the cutting edge developers of this small scale ORC processes.

ORC product range for utilization of waste heat

One ORC process system was already put into full automatic operation in a collaborative project with Cyplan Ltd. The plant is based on the utilization of waste heat generated by two biogas engines of the agri.capital GmbH at the site Wasmerslage. In spring 2009, the plant already achieved 10,000 fully automatic operating hours with only few, unforeseen failures, and has meanwhile received a CE certificate and was commissioned by the client. Building upon this first successful project, Fraunhofer UMSICHT has taken upon to develop a full product range and also is going to start field testing in order to optimize the processes and successively improve the efficiency, reliability and production price of the systems developed.

Development of further applications

Modifications of these small-scale ORC processes for further applications such as cogeneration of heat and power based on small wood incinerations, energetic utilization of exhaust heat of high temperature fuel cells (MCFC³) or micro gas turbines and further solutions for solar-thermal power production and industrial utilization of exhaust heat (e.g. in the non-ferrous metal, paper, glass and ceramics industries) are under way.

Contact:

Dr.-Ing. Wilhelm Althaus

Phone: +49 208 8598-1186

E-mail: wilhelm.althaus@

umsicht.fraunhofer.de

¹ORC = Organic Rankine Cycle

²Organic working fluids, e. g. aliphatic and aromatic hydrocarbons, alcohols, silicone oils; suitable to the temperature regime of heat source and thermal power cycle

³MCFC = Molten Carbonate Fuel Cell – a high temperature fuel cell

RESOURCES MANAGEMENT



"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 infrastructure processes and procedures can be optimized.

APPLICATION POTENTIALS OF INDUSTRIAL BIOTECHNOLOGY IN NORTH RHINE-WESTPHALIA

CO₂-BALANCES IN THE RECYCLING INDUSTRY

SUSTAINABILITY IN RESEARCH

SOCIO-ECONOMIC ASPECTS IN THE WASTE MANAGEMENT SECTOR



APPLICATION POTENTIALS OF INDUSTRIAL BIOTECHNOLOGY IN NORTH RHINE-WESTPHALIA

A study on the "Application potentials of bioengineering (white biotechnology) in North Rhine-Westphalia (NRW)", has taken on to identify IBT¹ applications that have already penetrated the market or are presently prepared for market introduction and to assign them to NRW relevant application branches of the producing industries (food, paper, textile, metal processing), with particular consideration of small and medium-sized enterprises (SME).

The analyses have yielded that no technological leaps for IBT application innovation in the fields considered in this report have been reported over the last five to seven years. In those sectors where IBT has been proven suitable, it has become a standard method, (e.g. food and textile industries), however, in fields where this has not been achieved yet (e.g. in the paper and metal processing industries), IBT is used to a minor extent or still unknown.

Basically, knowledge and public attention to this field is lacking. On the other hand, there are only few successful and innovative examples of IBT applications to be reported on, in particular with respect to the objective of a production-integrated environmental protection (PIUS).

There are hardly any detailed data on environmental impacts published so far and the little material that is available is hardly comparable due to different operational frame conditions. A better basis could be provided via projects that focus on the ecological comparison of conventional and IBT based processes (e.g. benchmarking based on ecological indicators). Only a significant data compilation as basis for IBT applications, including the assessment of environmental effects, may provide the basis for reliable conclusions on the increased application of IBT in SMEs aiming at environmental relief.

The suggested two-step action concept includes project approaches with the following key measures as a first step:

- Set-up of a network node
- Transfer of IBT know-how
- Initiative projects in the relevant industries

Contact:

Dr.-Ing. Hartmut Pflaum

Phone: +49 208 8598-1171

E-mail: hartmut.pflaum@

umsicht.fraunhofer.de

Dr.-Ing. Stephan Kabasci

Phone: +49 208 8598-1164

E-mail: stephan.kabasci@

umsicht.fraunhofer.de

*Commissioned by the Ministry
of the Environment and
Conservation, Agriculture and
Consumer Protection of North
Rhine-Westphalia*

Ministerium für Umwelt und Naturschutz,
Landwirtschaft und Verbraucherschutz
des Landes Nordrhein-Westfalen



*In collaboration with
Fraunhofer ISI*

¹IBT = Industrial Biotechnology



CO₂-BALANCES IN THE RECYCLING INDUSTRY

In the framework of a research study for the INTERSEROH SE, a stock market listed business group, the contribution of the company to climate protection was calculated and assessed. Interseroh is a lead player in the field of recovery of secondary raw materials in the waste management sector. The study encompassed the material flows of iron, aluminium, copper, wood, paper, polyethylene (PE) and polyethylene terephthalate (PET).

In the study, the production of a product from recycled raw materials and the production of a comparable product from primary raw materials were compared and balanced against each other. The entire process chain was considered, the system limits were defined as the points of time when a primary material is extracted or the secondary material is collected by the recycling company, and on the other hand, the point of time when a comparable product is finished. For the calculation of the carbon dioxide savings, details from environmental data bases and literature as well as data gathered by INTERSEROH SE directly on real recycling sites were incorporated. An agreement was made to always use the most conservative calculations so that in reality the savings may be even higher.

Emission reductions were observed with all materials in the recycling process compared to the production from primary raw materials. Aluminium recycling yielded the highest savings, amounting to 9.87 tonnes of CO₂ per tonne of material, followed by copper with 3.52 t CO₂ per tonne of material and PET with 2.54 t CO₂ per tonne. In 2007 the savings per tonne totaled at 0.86 t CO₂ for recycling steel production, at 0.77 t CO₂ for wood, at 1.19 t CO₂ for PE and at 94 kg.

The emissions of primary and secondary processes are mainly affected by the composition of the electricity mix, the share of contraries, the logistic processes and of course the production and treatment processes involved. These aspects were investigated in sensitivity analyses, the results being validated against other studies.

Interseroh's business helped to save about 5.2 million tonnes of carbon dioxide in 2007. This corresponds to 0.6 percent of the total carbon dioxide emissions in Germany. This reduction corresponds to the CO₂-emissions of a German city with about 500 000 inhabitants (such as Duisburg).

Contact:

Dr.-Ing. Markus Hiebel MSc

Phone: +49 208 8598-1181

E-mail: markus.hiebel@

umsicht.fraunhofer.de

Dr.-Ing. Hartmut Pflaum

Phone: +49 208 8598-1171

E-mail: hartmut.pflaum@

umsicht.fraunhofer.de



SUSTAINABILITY IN RESEARCH

There is a public consensus on the fact that a sustainable development is needed. However, complex interdependencies and dynamic frame conditions lead to controversial discussions with the result that necessary measures and prioritizations are severely contested. Here, the research community has to take on an important, pioneering and disseminating role.

Fraunhofer UMSICHT has undertaken to develop and to test a method for an early and comprehensive assessment of R&D projects with regard to their sustainability. In contrast to conventional approaches such as life cycle analysis or indicator calculation, the novel method is not designed to prioritize any single approach (economic, ecological, social, institutionally). Furthermore, this method will not only cover processes and products as such, but also the assessment of ideas, concepts and guiding principles.

The basis for this new method is adopted from present integrative concepts for sustainability. The catalogue of principles worked out starting from these concepts will be the assessment basis. In a first project phase, potential contributions to single principles are identified and opportunities and risks of their activation are analyzed. Subsequently, reference areas are defined where the project objectives are effective and their references with which they have to compete. This is the foundation for the definition, calculation and assessment of specific target-related indicators and parameters and for the derivation of action options to be made. The procedure described is planned to be multi-step, thus permitting project-accompanying, increasingly detailed analysis.

Fraunhofer UMSICHT currently uses this concept for the assessment of projects for biomimetic innovations (under the BIONA scheme supported by the German Ministry for Education and Research). The large heterogeneity of biomimetic approaches and the adoption of biological models, which is controversially discussed at the present moment, allows for an interesting and comprehensive way of evaluating the assessment approach.

Contact:

Dipl.-Ing. Jürgen Bertling

Phone: +49 208 8598-1168

E-mail: juergen.bertling@

umsicht.fraunhofer.de

Dipl.-Biol.

Volker Knappertsbusch

Phone: +49 208 8598-1232

E-mail: volker.knappertsbusch@

umsicht.fraunhofer.de



SOCIO-ECONOMIC ASPECTS IN THE WASTE MANAGEMENT SECTOR

Cost-benefit analyses are used, among other, as instruments to prepare political decisions. In the revised EU Waste Framework Directive, cost-benefit analyses play an important role: a five-step waste hierarchy is being introduced:

- Prevention
- Preparing for Re-Use
- Recycling
- Other recovery, (e. g. energy recovery)
- Disposal

The waste hierarchy is to be re-instated as a general rule but deviations will be possible if life-cycle assessments (LCA) and cost-benefit analyses (CBA) are clearly in favor of another treatment option. Further aspects to be considered in the case of deviation are the transparency of the decision-making processes and the participation of citizens and the parties concerned.

Beside the net investment and operational costs, cost-benefit analyses also include the monetization of ecological impacts of waste treatment methods. However, there are no standardized rules for the monetization of environmental costs.

The study on “Socio-economic aspects in the waste management sector”, commissioned by the German Federal Environment Agency (Umweltbundesamt – UBA), demonstrates that both for the assessment as well as the underlying frame conditions and methods, different procedures are currently being used.

Against this background, the current state of activities for the standardization of cost-benefit analyses in European and Anglo-American countries and the derivation and discounting of monetization factors for the assessment of environmental effects are investigated. A decision support guide in order to delineate and assess local and global effects and a survey on data formats and data stocks which are available for life cycle assessments were set up.

The results were presented to a large number of participants from politics and industry at a workshop organized in Berlin on 19 June, 2008. In the discussion subsequently moderated by Fraunhofer UMSICHT, recommendations for policy makers and business players were worked out.

Contact:

Dr.-Ing. Markus Hiebel MSc

Phone: +49 208 8598-1181

E-mail: markus.hiebel@

umsicht.fraunhofer.de

Dr.-Ing. Asja Mrotzek

Phone: +49 208 8598-1154

E-mail: asja.mrotzek@

umsicht.fraunhofer.de

*Commissioned by the German
Federal Environment Agency*



NAMES, DATA, EVENTS

A person is shown from the chest up, holding a large, thick red book in front of their face. They are wearing a white long-sleeved top. The background is a solid red color with a subtle pattern of concentric circles. The lighting is soft, highlighting the person's hands and the texture of the book.

"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.

You may search for Fraunhofer publications and patents online at:
<http://publica.fraunhofer.de/starweb/publica/index.htm>

PUBLICATIONS
SELECTED CLIENTS AND CONTACTS
PATENTS
SPIN-OFFS
HOW TO FIND US
THE FRAUNHOFER-GESELLSCHAFT
BOARD OF TRUSTEES
IMPRINT

Publications

The following survey only includes lectures and publications which were written and/or delivered in English.

For a complete bibliography, see the German version of our annual report.

Ali, A. H.; Noeres, P.; Pollerberg, C.:
Performance assessment of an integrated free cooling and solar powered single-effect lithium bromide-water absorption chiller for the duration of five years
In: Solar energy 82 (2008) 11, p. 1021-1030

Ali, A. H.; Noeres, P.; Pollerberg, C.; Dötsch, C.:
Operational experiences of a solar cooling plant
(International Conference on Solar Heating, Cooling and Buildings <1, 2008, Lisbon>)
In: EuroSun 2008: 1st International Conference on Solar Heating, Cooling and Buildings: Lisbon, 7-10 October 2008
Freiburg/Breisgau: International Solar Energy Society -ISES-/Europe, 2008, 8 p.

Ali, A. H.; Schwerdt, P.:
Characteristics of the membrane utilized in a compact absorber for lithium bromide/water absorption chillers
(International Energy Agency Heat Pump Conference <9, 2008, Zürich>)
In: 9th International Energy Agency Heat Pump Conference 2008: advances and prospects in technology, applications and markets; Zürich, Switzerland, 20-22 May 2008; conference proceedings Zürich: International Energy Agency -IEA-, 2008

Bechthold, I.; Bretz, K.; Kabasci, S.; Kopitzky, R.; Springer, A.:
Succinic acid: A new platform chemical for biobased polymers from renewable resources
In: Chemical Engineering & Technology 31 (2008) 5, p. 647-654

Deerberg, G.:
German environmental technology – strengths and opportunities
(BMBF-Forum für Nachhaltigkeit (FONA) <5, 2008, Berlin>)
In: Bundesministerium für Bildung und Forschung -BMBF-, Forschung für Nachhaltigkeit -FONA-, Bad Godesberg:
5. BMBF-Forum für Nachhaltigkeit: Forschung für Nachhaltigkeit – Treiber für Innovationen; mit dem 12. European Roundtable on Sustainable Consumption and Production (erscp2008); 23-25 September 2008, ewerk, Berlin
Bad Godesberg: Bundesministerium für Bildung und Forschung -BMBF-, Forschung für Nachhaltigkeit -FONA-, 2008, 14 p.

Dötsch, C.; Berthold, S.; Wolf, D.; Tübke, J.; Smolinka, T.; Bretschneider, P.; Radgen, P.:
Electrical energy storage from 100 kW – state of the art technologies, realisations, fields of use
(International Renewable Energy Storage Con-

ference (IRES) <2, 2007, Bonn>)
In: World Council for Renewable Energy -WCRE-; EUROSOLAR, Europäische Vereinigung für Erneuerbare Energien e. V., Bonn: Energy storage and the case of energy autonomy, decentralization and efficiency: Second International Renewable Energy Storage Conference (IRES II); Bonn: EUROSOLAR, Europäische Vereinigung für Erneuerbare Energien e.V., 2008

Dudlik, A.; Prasser, H.; Apostolidis, A.; Bergant, A.:
Water hammer induced by fast-acting valves: Experimental studies at pilot plant pipework
In: Multiphase science and technology 20 (2008) 3-4, p. 239-263

Gleis, M.; Hiebel, M.; Mrotzek, A.:
Ensuring comparability of cost-benefit analyses in the waste management sector
(Annual International Conference on Thermal Treatment Technologies (IT3) <27, 2008, Montreal>)
In: Air & Waste Management Association -A&WMA-, Pittsburgh/Pa.: 27th Annual International Conference on Thermal Treatment Technologies 2008: [IT3] ; May 12-16, 2008, Montreal, Quebec, Canada
Red Hook/NY.: Curran, 2008

Huang, L.; Pollerberg, C.; Dötsch, C.:
Paraffin O/W emulsion for cold storage and distribution applications
(Gustav Lorentzen Conference on Natural Working Fluids <8, 2008, Copenhagen>)
In: 8th IIR Gustav Lorentzen Conference on Natural Working Fluids: Copenhagen, September 7-10, 2008, Paris: International Institute of Refrigeration -IIR-, 2008, 11 Bl.

Jentsch, A.:
The rural district heating (RDH) handbook: A guide to economic and eco-friendly heat supply in rural regions
(Decentralised Generation in Germany – Workshop <2008, Karlsruhe>)
In: DG Workshop; 25 November 2008 Karlsruhe: European Institute of Energy Research -EIFER-, 2008, 17 p.

Keuter, V.; Engelhart, M.; Knerr, H.; Krystkiewicz, D.:
First experience report with the water recycling system KOMPLETT from the operator's point of view
(Bremer Colloquium Production Integrated Water/Wastewater Technology <12, 2008, Bremen>)
In: Wastewater technology of the future - sustainable solutions: Bremer Colloquium Production Integrated Water/Wastewater Technology 2008; 22.-23. September 2008; preprints Bremen: Institut für Umweltverfahrenstechnik -IUV-, 2008

Lohmann, H.; Urban, W.; Salazar, G. J. I.:
Trace components in biogenic gases
(BioFuels Met <2008, Strasbourg>)
In: BioFuels Met 2008: biofuels and metrology;

First European Meeting on the Metrology of Biofuels; 6-7 November 2008 in Strasbourg, France
Paris: Laboratoire National de Métrologie et d'Essais -LNE-, 2008, 6 p.

Marzi, T.; Danz, P.; Mrotzek, A.; Di Matteo, L.; Marotz, G.:
Flight characteristics and combustion behaviour of refused derived fuels (RDF) in a cement kiln
(International Symposium on Energy from Biomass and Waste <2, 2008, Venice>)
In: Venice 2008: Second International Symposium on Energy from Biomass and Waste: Fondazione Cini, Venice, Italy 17-20 November, 2008
Padua: International Waste Working Group -IWWG-, 2008, 8 Bl.

Mrotzek, A.; Marzi, T.; Hiebel, M.:
Model-based material flow analysis of RDF-production
(International Symposium on Energy from Biomass and Waste <2, 2008, Venice>)
In: Venice 2008: Second International Symposium on Energy from Biomass and Waste: Fondazione Cini, Venice, Italy 17- 20 November, 2008
Padua: International Waste Working Group -IWWG-, 2008, 8 Bl.

Nellesen, A.:
Self-healing polymers based on novel biomimetic materials
(BMBF-Forum für Nachhaltigkeit (FONA) <5, 2008, Berlin>)
In: 5. BMBF-Forum für Nachhaltigkeit: Forschung für Nachhaltigkeit – Treiber für Innovationen; mit dem 12. European Roundtable on Sustainable Consumption and Production (erscp2008); 23-25 September 2008, ewerk, Berlin
Bad Godesberg: Bundesministerium für Bildung und Forschung -BMBF-, Forschung für Nachhaltigkeit -FONA-, 2008, 22 p.

Pfeifer, C.; Huettler, H.; Hofbauer, H.; Schulzke, T.; Unger, C.:
Catalytic tar decomposition in a slip stream of an 8 MV dual fluidised bed biomass steam gasifier
(International Symposium on Gas Cleaning at High Temperatures (GCHT) <7, 2008, Newcastle>)
In: 7th International Symposium on Gas Cleaning at High Temperatures: GCHT-7; proceedings; June 23rd-25th, 2008, Shoal Bay Resort, Newcastle, Australia
Newcastle: University of Newcastle, 2008, 10 p.

Pollerberg, C.:
Thermal-driven cooling plants
(Decentralised Generation in Germany – Workshop <2008, Karlsruhe>)
In: DG Workshop; 25 November 2008
Karlsruhe: European Institute of Energy Research -EIFER-, 2008, 12 p.

Pollerberg, C.; Ali, A. H.; Dötsch, C.:
Experimental study on the performance of a

Publications

solar driven steam jet ejector chiller

(International Conference on Thermal Engineering: Theory and Applications (ICTEA) <3, 2007, Amman>)

In: 3rd International Conference on Thermal Engineering: Theory and Applications (2008), p. 3318-3325

Pollerberg, C.; Ali, A. H.; Dötsch, C.:

Solar driven steam jet ejector chiller

In: Applied thermal engineering (2008), 8 p.

Unger, C.; Schulzke, T.:

Comparison of different routes from lignocellulose to ethanol

(European Biomass Conference & Exhibition (EBCE) <16, 2008, Valencia>)

In: 16th European Biomass Conference & Exhibition: proceedings of the international conference held in Valencia, Spain, 2 - 6 June 2008

Florence: ETA-Renewable Energies, 2008, p. 2079-2083

Unger, C.; Schulzke, T.:

Process analysis of downdraft fixed bed biomass gasifiers – a tool to increase operational availability

(European Biomass Conference & Exhibition (EBCE) <16, 2008, Valencia>)

In: 16th European Biomass Conference & Exhibition: proceedings of the international conference held in Valencia, Spain, 2 - 6 June 2008

Florence: ETA-Renewable Energies, 2008, p. 813-815

Urban, W.:

Biogas upgrading to pipeline quality – technology and costs

(International "Conference Connecting Clean Mobility" <2007, Arnhem>)

In: International Conference "Connecting Clean Mobility": 14-15 November 2007, Arnhem, 2008, 15 p.

Urban, W.; Salazar, G. J. I.; Lohmann, H.:

Catalytically upgraded landfill gas as a cost-effective alternative for fuel cells

(Conference „Fuel Cells Science & Technology“ <4, 2008, Copenhagen>)

In: Journal of power sources (2008), 8 p.

Wolf, D.; Berthold, S.; Smolinka, T.; Tübke, J.; Bretschneider, P.; Radgen, P.; Dötsch, C.:

Electrical energy storage - state of the art technologies, fields of use and costs for large scale application

(Electricity Storage Association Annual Meeting (ESA Annual Meeting) <18, 2008, Anaheim/Calif.>)

In: Electricity Storage Association Annual Meeting ESA 08: proceedings; CD-ROM; May 20-21, 2008, Anaheim, Orange County, California, 2008

Morgan Hill/Calif.: Electricity Storage Association -ESA-, 2008, 34 p.

Selected Clients and Contacts

Selected Clients and Contacts

Since its foundation Fraunhofer UMSICHT has successfully been co-operating with customers from all industrial sectors and with companies of all sizes. The following extract of the institute's reference lists is an overview on project and co-operation partners and customers:

A. & E. Lindenberg GmbH & Co.KG, Bergisch-Gladbach
 Abfallentsorgungsanlage Linkenbach, Linkenbach
 Abfallwirtschaftsgesellschaft mbH Wuppertal, Wuppertal
 ACCESS e.V., Aachen
 agri.capital GmbH, Münster
 Air Products GmbH, Hattingen
 alta4 Geoinformatik AG Trier, Trier
 Aqua Society GmbH, Herten
 ARI Armaturen Albert Richter GmbH & Co. KG, Schloss Holte-Stukenbrock
 A.R.I. Flow Control Accessoires Kfar Charuv, Israel
 A-TEC Anlagentechnik GmbH, Duisburg
 Aufbereitungstechnologie Noll GmbH, Bobingen
 Aufwind Schmack GmbH Neue Energien, Regensburg
 BASF SE Aktiengesellschaft, Ludwigshafen
 Bau- und Liegenschaftsbetrieb NRW, Düsseldorf, Bielefeld
 Bayer CropScience AG, Frankfurt a. M.
 Bernd Josef Wenning, Rhede
 Berufsgenossenschaft der chemischen Industrie, Cologne
 BETEC Beschichtungstechnik GmbH, Karlsruhe
 BHC Gummi-Metall GmbH, Meckenheim
 BKV Beteiligungs- und Kunststoffverwertungsgesellschaft mbH, Frankfurt a. M.
 BKW FMB Energie AG, Bern, Switzerland
 Bopp&Reuther Sicherheits- und Regelarmaturen GmbH, Mannheim
 BP Gelsenkirchen GmbH, Gelsenkirchen
 Bundesministerium für Bildung und Forschung, Berlin
 Bundesministerium für Wirtschaft und Technologie, Berlin
 BWS Technologie GmbH, Grevenbroich
 BYK Chemie GmbH, Wesel
 CHEMION Logistik GmbH, Leverkusen
 Claas Selbstfahrende Erntemaschinen GmbH, Harsewinkel
 Cognis GmbH, Düsseldorf
 Colortec Farbpasten GmbH, Mannheim
 Coperion Waeschle GmbH & Co. KG, Weingarten
 Cornpack GmbH & Co. KG, Teterow
 Cyplan Ltd., Osnabrück
 Daimler AG, Ulm
 DBU - Deutsche Bundesstiftung Umwelt, Osnabrück
 Degussa AG, Hanau
 DELU AG - Deutsche Leckageortungs- und Umwelttechnik AG, Gladbeck
 Deutsches BiomasseForschungsZentrum gGmbH Leipzig, Leipzig
 DiMatteo Förderanlagen GmbH & Co. KG, Beckum

Dinnissen BV, Sevenum, Netherlands
 EBRO ARMATUREN Gebr. Bröer GmbH, Hagen
 ecoprogram GmbH, Cologne
 Ecowest Entsorgungsverbund Westfalen GmbH, Ennigerloh
 Elastogran GmbH, Lemförde
 EnD-I Loick Bioenergy GmbH, Dorsten
 Enrichment Technology Company Limited (ETC), Jülich
 EntwicklungsAgentur Wirtschaft EAW Wesel, Wesel
 E.ON Avacon Netz GmbH, Braunschweig
 E.ON Energy from Waste GmbH, Hanover
 E.ON Ruhrgas AG, Essen
 European Commission/DG Information Society, Luxembourg
 Evonik Degussa GmbH, Hanau
 Evonik Degussa GmbH, Science to Business Center, Marl
 Fachagentur Nachwachsende Rohstoffe e.V. (FNR), Gülzow
 FerroDuo GmbH, Duisburg
 FH Münster - Labor für Abfallwirtschaft, Siedlungswasserwirtschaft, Umweltchemie LASU, Münster
 FKur Kunststoff GmbH, Willich
 Fluent Deutschland GmbH, Darmstadt
 Forschungszentrum Jülich GmbH, Jülich
 Fraunhofer-Gesellschaft, Munich
 Fraunhofer IFF, Magdeburg
 Fraunhofer IGD, Darmstadt
 Fraunhofer ITWM, Kaiserslautern
 Fraunhofer Venture Group, Munich
 Fraunhofer-Zentrum für Mittel- und Osteuropa MOEZ, Leipzig
 GASAG Berliner Gaswerke AG, Berlin
 Gaswärme-Institut e.V., Essen
 GE Bayer Silicones GmbH & Co. KG, Leverkusen
 GE Jenbacher GmbH & Co OHG, Jenbach
 GE Sensing GmbH, Bad Nauheim
 Gesellschaft zur Förderung von Medizin-, Bio- und Umwelttechnologien e.V., Halle/Saale
 GfEM Biogas GmbH & Co. KG, Finsterwalde
 GKT Gummi- und Kunststofftechnik Fürstenwalde GmbH, Fürstenwalde
 Hahl Filaments GmbH, Munderkingen
 Hitachi Power Europe GmbH, Duisburg
 Hochtief Aktiengesellschaft, Essen
 Hochtief Construction AG, Leipzig
 Humana GmbH, Herford
 Hydac-Accessories GmbH, Sulzbach/Saar
 iaks Ingenieurbüro für Abfluss-, Kläranlagen-, Steuerung GmbH, Sonthofen
 imat-uve GmbH, Mönchengladbach
 Inde Plastik Betriebsgesellschaft m.b.H. Aldenhoven
 Impreglon AG, Lüneburg
 INFRA-Institut für Abfall, Abwasser und Infrastrukturmanagement GmbH, Ahlen
 INFRACOR GmbH, Marl
 infra fürth gmbh, Fürth
 Ingenieurbüro r.efkes GbR, Willich
 Innovene Deutschland GmbH Köln, Cologne
 Internationales Büro DLR, Bonn
 INTERSEHROH SE, Cologne
 IoLiTec Ionic Liquids Technologies GmbH & Co. KG, Denzlingen
 I'REE, Daegu, Korea
 ITE International Tunneling Equipment GmbH, Alsdorf

ITProtect GmbH & Co. KG, Gevelsberg
 IZEG Informationszentrum Entwässerungstechnik Guss e.V., Bonn
 Johnson Controls Interieurs GmbH & Co KG, Greifarth
 Jowat AG, Detmold
 KB Ökoenergie GmbH & Co KG, Schmallingenberg
 Kelman Ltd., Lisburn
 Kernkraftwerk Leibstadt AG, Leibstadt, Switzerland
 KEYNES Planungsgesellschaft mbH, Neuss
 KHT Fahrzeugteile GmbH & Co. KG, Grevenbroich
 Knoll Maschinenbau GmbH, Bad Saulgau
 Krohne Messtechnik GmbH und Co. KG, Duisburg
 Krones AG, Neutraubling
 Landratsamt Bamberg, Bamberg
 Linck Holzverarbeitungstechnik GmbH, Oberkirch
 MATINO GMBH, Kyritz
 Ministerium für Umwelt und Naturschutz, Landwirtschaft und Verbraucherschutz des Landes NRW, Düsseldorf
 MNT-Systeme GmbH, Oberhausen
 Mommertz GmbH Wasser- und Wärmetechnik, Oberhausen
 Neumann Krex & Partner, Ingenieurbüro für Brandschutz und Bauwesen GmbH, Niestetal
 Newtec GmbH, Dortmund
 nova Institut GmbH, Hürth
 Novoplastic GmbH, Mannheim
 NuTech Solutions GmbH, Dortmund
 Osram GmbH, Augsburg
 OXEA Deutschland GmbH, Oberhausen
 Pantreon GmbH, Gmund, Austria
 Pera Innovation Ltd., Melton Mowbray, Great Britain
 Polysius AG, Beckum
 Privatbrauerei Moritz Fiege GmbH & Co. KG, Bochum
 PUR Technologie Hegemann, Essen
 Pyramid Bioplastics Guben GmbH, Guben
 RAG Aktiengesellschaft, Herne
 Ralf Hacker Edelstahl, Hüllhorst
 Renolit AG, Salzgitter
 rpm rapid prototyping and manufacturing, rpm GmbH, Helmstedt
 Ruhr-Universität Bochum, Institut für Energie- und Bergrecht, Bochum
 Ruhr-Universität Bochum, Lehrstuhl für Energieanlagen und Energieprozesstechnik LEAT, Bochum
 RWE Innogy Cogen GmbH, Dortmund
 Ritter-Pen GmbH, Brensbach
 S+B Industrial Minerals GmbH, Marl
 Schaumburger Privat-Brauerei GmbH, Stadthagen
 Siemens AG, Erlangen
 Silcarbon Aktivkohle GmbH, Kirchhundem
 Soldesa Hydrogen B.V., Den Haag, Netherlands
 Solex Thermal Science Inc., Arnhem, Netherlands
 SOLID Composites GmbH, Voerde
 Solvay Fluor GmbH, Frankfurt
 Stadtwerke Duisburg AG, Duisburg
 Stadtwerke Gronau GmbH, Gronau
 Stadtwerke Strausberg GmbH, Strausberg
 Südwestdeutsche Salzwerke AG, Heilbronn
 swb-Gruppe, Bremen

Selected Clients and Contacts

Thermoprozess GmbH, Essen
Thyssen Krupp Bilstein Suspension GmbH,
Ennepetal
ThyssenKrupp Real Estate GmbH, Essen
Thyssen Krupp Xervon Energy GmbH, Duisburg
TÜV NORD Systems GmbH & Co. KG, Essen
TÜV NORD Systems GmbH & Co. KG, Hamburg
TÜV SÜD Industrie Service GmbH, Munich
UBE Engineering Plastics S.A., Düsseldorf
Uhde GmbH, Dortmund
Uhde High Pressure Technologies GmbH,
Hagen
Umweltbundesamt Dessau, Dessau
UNIQEMA GmbH & Co. KG, Emmerich
Universität Duisburg-Essen, Fachgebiet Abfall-
wirtschaft und Abfalltechnik, Essen
Universität Duisburg-Essen, Institut für Energie-
und Umweltverfahrenstechnik, Duisburg
University College Dublin, School of Agricul-
ture, Food Science and Veterinary Medicine,
Dublin, Ireland
Verein zur Förderung der Energie- und Umwelt-
technik e.V. (VEU e.V.), Duisburg
Vertum GmbH, Markkleeberg
Viking GmbH, Langkampfen/Kufstein, Austria
Voith Siemens, Heidenheim
Volkswagen AG, Wolfsburg
Wacker Chemie AG, Werk Burghausen,
Burghausen
WAGRO Systemdichtungen GmbH, Dortmund
WEKO-Werkzeuge Kolks GmbH, Bocholt
Werner Evers e.K., Wassertechnik und Anthra-
zitveredelung, Hopsten
Westfalia Separator Food Tec GmbH, Oelde
WETEC Elektrotechnik GmbH, Moers
Windwärts Energie GmbH, Hanover
Wirtschaftsbetriebe Duisburg AöR, Duisburg
WRH Walter Reist Holding AG, Hinwil,
Switzerland
Wuppertal Institut für Klima, Umwelt, Energie
GmbH, Wuppertal
Worlee Chemie GmbH, Lauenburg
Zukunft Emden GmbH, Emden
Zwiesel Kristallglas AG, Zwiesel

Patents

Patents 2008

Iussed Patents:

Process for continuous or partly continuous conversion of fat- or oil-containing raw and waste materials into mixtures having a high hydrocarbon content, products obtained by this process and their use (Heil, Jelen, Keldenich, Unger) – Germany

Detachable high-pressure connection between a pressure reservoir and/or pressure distributor and a pressure line (Dudlik, *Wickl, Apostolidis, Schlüter) – Germany

Use of hydrophobized silica gel as a selective sorbent for removing organic silicon compounds (Urban, Unger) – Germany

Process for converting of raw materials and waste materials containing oil or fat in a composition containing hydrocarbons (Cinquemani, Heil, Jakob, Weber) – Europe

* = external inventors

Registered trademarks:

european center for elastomeric powders (European word trademark/figurative trademark)

Spin-offs

AIROX GmbH, Alpen

Systems for oxygenation
www.airox.de

Andreas Schröder IT-Consulting GmbH, Schermbeck

Counseling and service in the area of information and telecommunication technologies

A-TEC Anlagentechnik GmbH, Duisburg

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

Carbon-TF B.V., Venlo, Netherlands

Emissions trading

DataPool Engineering GmbH, Oberhausen

Software development, system analyses, EDP-consulting
www.dp-e.de

Emissions-Trader ET GmbH, Alpen

Emissions trading
www.emissions-trader.de

FKuR Kunststoff GmbH, Willich

Innovative solutions concerning plastics and recycling; comminution technology; extrusion, injection molding; elastomer recycling; material analyses; test technology; recycling concepts
www.fkur.de

SOLid Composites GmbH, Voerde

Plastic powder at its finest!
Thermoplastic coating powders, laser sinter powders, functional filler systems
www.solidcomposites.de

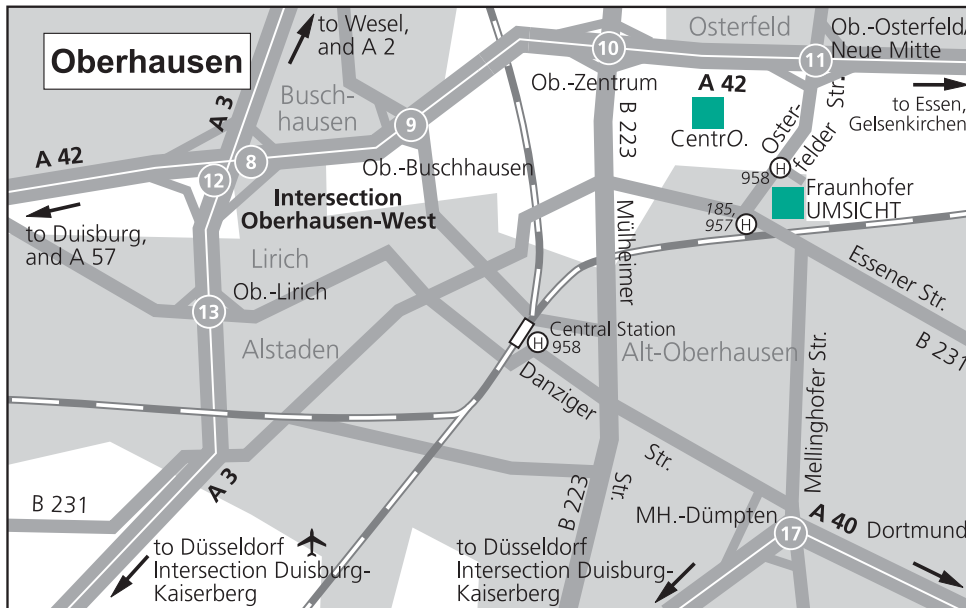
VENTAX Big-Bag Network GmbH & Co. KG, Willich

Big-Bag cleaning facilities, reusable Big-Bag, packaging systems
www.ventax.de

WAGRO Systemdichtungen GmbH, Dortmund

Swellable polymere seals; sewer and building refurbishment; consultation, planning, and implementation; development and production of sealing systems (area of application: engineering and pipeline construction)
www.wagro-systemdichtungen.de

How to Find us



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

By car

Freeway A42

coming from Dortmund:

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

coming from Duisburg:

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

Freeway A40

coming from Dortmund:

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

coming from Duisburg:

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

By Train

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

Flugzeug und Bahn/Auto

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 A44 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:

Prof. Dr.-Ing. Eckhard Weidner

Deputy Director:

Dr.-Ing. Görges Deerberg

Osterfelder Strasse 3
46047 Oberhausen
Germany

Phone: + 49 208 8598-0
Fax: + 49 208 8598-12 90

Website: www.umsicht.fraunhofer.de
E-mail: info@umsicht.fraunhofer.de

Your way to us online:
www.umsicht.fhg.de/profil/anfahrt/index.php

The Fraunhofer-Gesellschaft

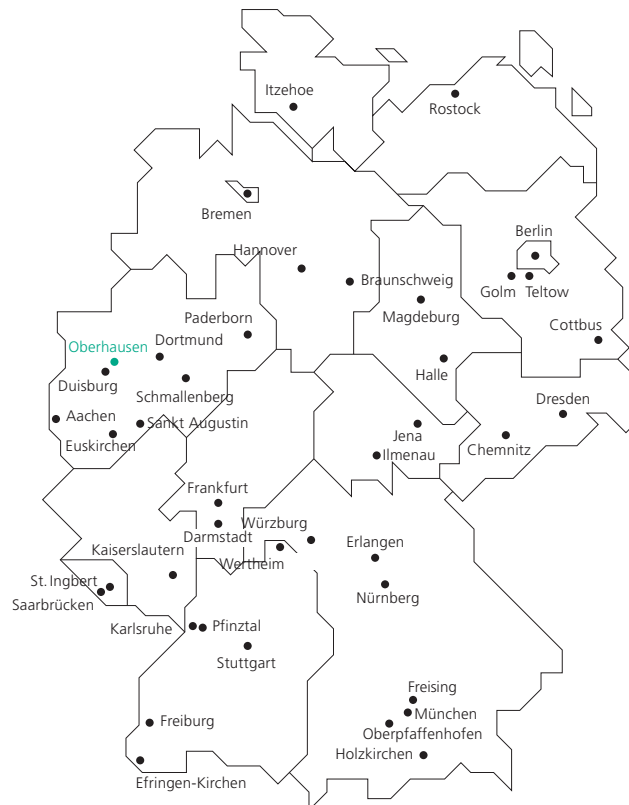
The Fraunhofer-Gesellschaft

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.

At present, the Fraunhofer-Gesellschaft maintains more than 80 research units in Germany, including 60 Fraunhofer Institutes. The majority of the 14,000 staff are qualified scientists and engineers, who work with an annual research budget of €1.4 billion. Of this sum, more than €1.2 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 German federal and Länder governments in the form of base funding, enabling the institutes to work ahead on solutions to problems that will not become acutely relevant to industry and society until five or ten years from now.

Affiliated 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.

With its clearly defined mission of application-oriented research and its focus on key technologies of relevance to the future, the Fraunhofer-Gesellschaft plays a prominent role in the German and European innovation process. Applied re-



search has a knock-on effect that extends beyond the direct benefits perceived by the customer: Through their research and development work, the Fraunhofer Institutes help to reinforce the competitive strength of the economy in their local region, and throughout Germany and Europe. They do so by promoting innovation, strengthening the technological base, improving the acceptance of new technologies, and helping to train the urgently needed future generation of scientists and engineers.

As an employer, the Fraunhofer-Gesellschaft offers its staff the opportunity to

develop the professional and personal skills that will allow them to take up positions of responsibility within their institute, at universities, in industry and in society. Students who choose to work on projects at the Fraunhofer Institutes have excellent prospects of starting and developing a career in industry by virtue of the practical training and experience they have acquired.

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

Board of Trustees –
Fraunhofer UMSICHT

The 7th meeting of the Board of Trustees of Fraunhofer UMSICHT

24 October 2008 in Oberhausen

Trustees:



1. Ernst Gerlach, Chairman
(NRW.BANK, Member of the Board)



9. Prof. Dr.-Ing. Volker Pilz
(Director a. D. of Bayer AG)



2. Hubert Loick, deputy chairman
(Loick AG, Managing board Loick
Bioenergie GmbH)



10. Dr. Franz-Josef Renneke
(Bayer Schering Pharma AG,
Plantmanager)



3. Burkhard Drescher



11. Prof. Dr.-Ing. Viktor Scherer
(Ruhr-University of Bochum, Chair
of Energy Systems and Energy and
Process Technology)



4. Dr. Jochen Hamatschek
(Westfalia Separator Food Tec GmbH,
Managing Director)



12. Dr.-Ing. Andreas Schütte
(Agency of Renewable Resources
e. V. [FNR], Managing Director)



5. Prof. Dr.-Ing. Helmut Hoyer
(FernUniversität in Hagen, Rector)



13. Ernst Schwanhold
(BASF SE, Head of the Competence
Center Environment, Energy and
Safety Technology until 2008, in
retirement)



6. Dr.-Ing. Gerd Jäger
(RWE Power AG, Member of the
board)



14. Dr. Dipl.-Ing. Gunnar Still
(ThyssenKrupp Steel AG Direktions-
bereich Umweltschutz, Senior Vice
President)



7. Dr.-Ing. Thomas Mathenia
(Energieversorgung Oberhausen AG,
Member of the Board)



15. Udo Völker
(MAN Ferrostaal AG, Chief
Representative)



8. Prof. Dr.-Ing. Thomas Melin
(RWTH Aachen, Head of Chair I and
the Institute of Process Engineering of
RWTH Aachen, Aachen)



16. Dr.-Ing. Wilhelm Wick
(RWTÜV AG, Chairman of the
Board)

Imprint

THE DIRECTORATE



Director:

Prof. Dr.-Ing. Eckhard Weidner

Deputy Director:

Dr.-Ing. Gorge Deerberg
(from left)

Editing and Publishing:

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

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

www.umsicht.fraunhofer.de
info@umsicht.fraunhofer.de

Editing:

Dipl.-Chem. Iris Kumpmann
(responsible)
Dr.-Ing. Hartmut Pflaum

Proof-reading:

Dr. Joachim Danzig
Alexandra Dumont

Typesetting:

Dipl.-Des. Barbara Vatter

Printed by:

ZELLE, Der Printspezialist, Dusseldorf

Sources of photographs:

C3 Prozess- und Analystechnik GmbH
(official agent of Fa. BuchiGlasUster AG,
Switzerland): p. 32
ILS Integrated Lab Solutions GmbH: p. 38
 Fraunhofer Institute for Interfacial Engi-
neering and Biotechnology IGB, Stuttgart:
p. 44
www.turbec.com: p. 78
Joachim Schumacher: p. 88

www.photocase.com
p. 8, p. 14, p. 16, p. 24-29, p. 34,
p. 80, p. 98, p. 100, p. 102

www.shutterstock.com
p. 42, p. 46, p. 96

www.mev.de
p. 94

all other photographs:
Fraunhofer UMSICHT

 Fraunhofer UMSICHT

Use of photographs, graphics
and texts in any form – even in
extracts – only by previous written
permission by Fraunhofer UMSICHT.