Fraunhofer
UMSICHT

Pioneering the way to a sustainable world

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Pioneering the way to a sustainable world

Head of Institute:
Prof. Dr.- Ing. Christian Doetsch (l.) and
Prof. Dr.-Ing. Manfred Renner (r.)

The interaction of our focus topics as a whole is particularly relevant for our industrial customers.«

What are the technological challenges of the future and how is Fraunhofer UMSICHT focusing on them?

As a country poor in energy and raw materials, Germany is facing particular challenges. In order to strengthen Germany's position as an industrial and high-tech location and achieve technological leadership in key technologies, the supply of energy and raw materials must be reliable, cost-effective and sustainable.

Technologies for the industrial location of the future

Circular Economy

The circular economy offers immense advantages in terms of saving raw materials. This means recovering raw materials from residual and waste materials and supporting new products, services and business models. Example: In the medium term, petroleum-based plastics are to be replaced by recyclate from mechanical-chemical recycling of plastic waste and bio-based plastics. Critical materials such as rare earths for energy storage or wind power plants can be recovered from old plants or scrap, as can phosphorus for fertilizer production from sewage sludge. This increases value creation in Germany and Europe and reduces dependence on critical resources.

Green Hydrogen

In the future, energy will mainly be provided by renewable energy sources such as photovoltaics and wind power. As electricity cannot always be used directly, we need green chemical energy sources for applications such as aviation fuels or high-temperature heat in glassworks. The production of green hydrogen, storage in chemical form (e. g. ammonia) and the production of green synthesis gas for sustainable chemistry are central themes of the Green Hydrogen focus topic.

Carbon Management

Carbon will become scarce in the future, as the use of fossil raw materials will decline sharply. The focus is on technologies that recover carbon from residual materials and waste or capture it directly from carbon-containing exhaust gases emitted by steel and cement plants, including waste incineration plants or from the air. These technologies and the conversion of the recovered carbon into high-value chemicals such as methanol are central themes of the Carbon Management focus topic.

Local Energy Systems

The defossilization of energy supply, a successful heating transition in the residential and industrial sectors and the cross-linking of electricity, heating, cooling and mobility are milestones of our future energy supply. In the Local Energy Systems focus topic we develop concepts and technologies for a cross-sectoral, efficient and future-oriented energy supply and implement them in residential districts and industrial plants.

Fraunhofer UMSICHT, Oberhausen site

Interview

What are the technological challenges of the future and how is Fraunhofer UMSICHT focusing on them?

Our four focus topics are closely interlinked – both through technologies and material flows as well as through the diverse interdisciplinary expertise of our researchers. This interaction as a whole is particularly relevant for our industrial customers.

In short, the Circular Economy focus topic enables us to recover important raw and basic materials from residual materials and make resources available. To ensure this works sustainably, renewable energy is essential, which is why the Local Energy Systems focus topic is crucial.

Within the Green Hydrogen focus topic, we produce green energy sources, fuels and green synthesis gas for new products from renewable energies. As part of the Circular Economy, we we develop alternative water sources for hydrogen production that do not compete with drinking water production and irrigation. The production of green synthesis gas requires sustainable or recycled carbon based on technologies developed within the Carbon Management focus topic.

How do expertise and teams connect with each other in the focus topics?

We live in a highly complex world. Solving the tasks ahead of us requires intensive cooperation both within the institute and beyond its borders. Our principle is: Everything is geared towards the topics and challenges of industry, society and politics.

Our scientific departments have aligned themselves behind the four focus topics and work closely together, often on two interrelated focus topics at the same time. This allows us to pool expertise and use synergies.

Processing of the tasks developed based on the focus topics is organized via "management boards". Their members, the department heads, the research management and the institute management, jointly make strategic decisions and plan, organize and control activities and resources. This enables a targeted focusing of expertise on the most important tasks and avoids rigid departmental structures or boundaries.

This type of cooperation strengthens our expertise in the focus topics, increases our visibility in the outside world and ensures that the project goals are achieved with a very high degree of reliability.

How are technologies, processes and material development implemented on the market together with companies?

There is no one-and-only answer but rather there are two important ways to develop marketable technologies.

Firstly, we promote close and trusting cooperation with companies, both when being directly commissioned by companies and in publicly funded consortia. We openly discuss relevant technological issues and jointly define the company's impact and priorities. The aim is to quickly achieve a validated technological readiness level (TRL) that enables the technology to be implemented on a prototype scale.

We accompany the company during commissioning and offer support during operation to ensure monitoring and further optimization. We can often build up a patent portfolio that protects the technology and can be exclusively licensed by the company to protect its investment.

Secondly, we develop technologies based on our own ideas, market observations and pre-competitive research. As in the first way, we address technological solutions with a high impact and the highest possible application potential.

However, in this case we involve companies at a later stage, either through direct orders or publicly funded projects. The focus here is also on the early validation of results on existing technologies or the assessment of the potential of completely new products, processes and services. Our experience in scaling up process and materials developments to an industrial scale and the applicability of our digital solutions is one of our teams' key areas of expertise.

Head of Institute:
Prof. Dr.-Ing. Manfred Renner (l.) and
Prof. Dr.- Ing. Christian Doetsch (r.)

Our principle is that everything is geared towards the topics and challenges of industry, society and politics.«

How do you support politics and society?

Credibility, independence and openness to solutions are at the heart of our cooperation with companies, politics and society. In the light of major challenges such as climate change, biodiversity loss and limited use of resources, our aim is to develop consistent systems in large networks. We interlink these systems together instead of presenting individual technologies developed by us as single solutions. We contribute important building blocks, know the national and international environment and provide independent advice to support corporate goals as well as technological and long-term political agendas in Germany and Europe.

Our topics are closely interrelated, enabling a comprehensive perspective on solutions. This has been clearly demonstrated in recent years. One example is the implementation of the circular economy, which in many areas only makes sense in terms of energy if the energy system is taken into account – heating networks, geothermal systems and renewable energies play an important role here. Regarding the plastics industry of the future, the question arises as to how carbon is made available. Here, the different carbon sources such as recycling, biomass and Carbon Capture and Utilization (CCU) must be given equal consideration.

One of the main pillars of our work is our close collaboration with universities, colleges and research institutions, in particular the Ruhr University Bochum, with which we have a long-standing and trusting relationship.

Best regards,

Manfred Renner
Head of Institute

Christian Doetsch
Head of Institute

Facts and figures

Fraunhofer UMSICHT 2023/24

776
Projects

151
Customers
from industry

195
Publications

69 million €
Total budget

> 600
Employees

37 %
Proportion of women

12
Patents
registered

12
Doctoral awards
completed

33
Teaching activities

127
Theses
of which 70% are Master's theses

125
Lectures

3
Science awards

27
Countries
from 5 continents represented in the staff

»We have our main site in Oberhausen (NRW), an institute branch in Sulzbach-Rosenberg (Bavaria) and a plastics technology center in Willich (NRW).«

Our focus topics

Sustainable transformation of the economy and society: circular, climate-neutral, economical

Circular Economy

Materials and processes for the circular use of resources: from laboratory to industrial scale

Carbon Management

Technology and material development for the sustainable use of carbon

Green Hydrogen

Materials and processes for the electrochemical production, use and storage of green hydrogen

Local Energy Systems

Concepts and technologies for transforming the energy supply of districts and industry

The iCycle® pyrolysis process efficiently converts packaging waste and composite materials into high-quality basic chemicals.«

Circular Economy

Development of materials and processes for the circular use of resources

Increasing use of resources, high emissions and short product life cycles characterize our economic system and our society. The consequences for people and the environment are becoming increasingly serious. Climate neutrality and resource efficiency can be achieved with a system change to a circular economy.

The transition to a circular economy requires the development of new materials, products and services, innovative value chains and tailored business models. We support your company as a reliable and competent partner on the path to a circular economy.

Take advantage of our expertise on your path to the circular economy.

Circular materials: plastics

- Development of bio-based plastics and recycled plastics for a variety of applications from films, fibers and injection-molded parts
- Biodegradation of polymers and plastic products

Chemical recycling: pyrolysis

- Pyrolysis of plastics and composite materials
- Pyrolysis products as a basis for chemicals, fuels or plastics

Water management: process and wastewater

- Treatment and recycling of process water while optimizing impact, costs, reliability and sustainability
- Recovery of materials and nutrients from wastewater

Sustainability assessment

- Systemic evaluation of processes and products
- Circular design of materials and products

www.umsicht.fraunhofer.de/en/circulareconomy

We produce methanol from steel production gases. Next step: scaling up the plant to industrial scale.«

Carbon Management

Sustainable use of carbon

The current economy produces goods that emit carbon dioxide during their production (e. g. steel, cement) or that are mostly incinerated after use, which also leads to carbon dioxide emissions. A climate-neutral economy requires rethinking: We need to recycle carbon, use it sustainably and develop alternative sources. This is the only way to meet the necessary carbon requirements for existing and future value chains.

Based on our expertise in chemistry, energy, production and plant engineering already demonstrated in major projects such as Carbon2Chem®, we support you in recycling carbon and refining it into chemicals and materials. Even for processes where carbon dioxide (CO_2) continues to be produced – such as in the cement and lime industry or in waste incineration – we develop, together with you, customized solutions that enable defossilized cycles.

Use our expertise to close your carbon cycle.

Technology and material development for the carbon cycle

- CO_2 separation, CO_2 storage and gas purification
- Processes for the production of chemicals, fuels and materials from CO_2, CO and H_2
- Catalyst development, testing and upscaling
- CO_2 electrolysis
- Pyrolysis and carbonization of carbonated residues
- Modeling, simulation and optimization of power-to-x and CCU processes

www.umsicht.fraunhofer.de/en/carbonmanagement

We develop and manufacture components and stacks for electrolysers and fuel cells.«

Green Hydrogen

Electrochemical production, use and storage of green hydrogen

As a storage medium for renewable energies, as a raw material for industrial processes and as a substitute for fossil fuels green hydrogen plays a decisive role in making our economy climate-neutral. The development of reliable and efficient technologies for the production of hydrogen and the infrastructure for its storage, distribution and use pose major challenges for companies.

We are working on the industrialization of electrolysis, focusing on materials and processes for the electrochemical production, use and storage of green hydrogen: On the one hand, we design and build electrolysers and fuel cells. On the other hand, we develop processes for the conversion and reconversion of hydrogen into chemical energy storage systems such as ammonia and methanol. We also provide support in the evaluation of systems and locations where hydrogen is to be used.

Use our expertise for your hydrogen strategy.

Electrolyzers and fuel cells

- Design, development, characterization and construction of electrochemical reactors
- Complete development chain, manufacturing and testing of materials and components through the entire system

Bipolar plates for mobile fuel cell applications

- Ultra-thin, thermally and electrically conductive composite bipolar plates that are cost-efficient and durable

Chemical storage of hydrogen

- Development of processes for the conversion and reconversion of hydrogen into chemical storage mediums such as ammonia and methanol

Development of regional and sustainable hydrogen concepts

- to transform the energy supply of districts and industry (local energy systems)

www.umsicht.fraunhofer.de/en/greenhydrogen

We develop concepts for transforming the energy supply of industrial sites with high process heat and process steam requirements.«

Local Energy Systems

Transforming the energy supply for districts and industry

Ensuring energy security for your production site or achieving energy and CO_2 savings targets to maintain your company's competitiveness: There are many reasons to switch the energy supply of districts and industrial sites to renewable energies and low-carbon systems and to improve their energy efficiency.

Anyone who wants to transform a local energy system must face several challenges: The integration of renewable energy often requires the adaptation, conversion or redesign of existing infrastructures as well as the development and integration of new solutions for energy storage and distribution. A multitude of local and operational requirements, framework parameters and technological options make a holistic analysis and planning necessary in order to reduce investment costs and maximize benefits. At the same time, it is important to gain the support and acceptance of all stakeholders – be they affected communities, residents, local companies or employees.

Take advantage of our expertise in the transformation of your energy supply.

Energy concepts

- for climate-neutral commercial and industrial sites and residential areas
- Modeling of local energy systems with regard to the generation, storage, distribution and use of electricity, gas, heat, cooling, steam and compressed air

Management of all players

- Actor analysis, participatory stakeholder involvement and network development

Development/Implementation of technologies

- for thermochemical conversion of biogenic residues
- for industrial high-temperature heat pumps
- for latent heat and battery storage
- to supplement the measures of the sponge city principle

www.umsicht.fraunhofer.de/en/localenergysystems

Our projects are as individual as your technological challenges. Let's talk.«

Contact
businessdevelopment@umsicht.fraunhofer.de

Selected projects

Our focus topics form the backbone of our business. Every year, we work on several hundred research projects that pave the way to a sustainable and climate-neutral future. Be inspired by selected projects that we have realized for the public sector and companies of all sizes.

Take advantage of our expertise to develop sustainable solutions for your company.

EU project To-Syn-Fuel

Demonstration plant sets research benchmarks in carbon conversion

In the EU project To-Syn-Fuel, a large-scale plant significantly contributing to the defossilization of industry was developed at the Hohenburg location. Fossil raw materials are replaced by sustainable carbon sources such as biogenic residues and waste containing plastics.

These feedstocks can be processed on a large scale via thermochemical conversion processes (pyrolysis) into basic materials for the (petro-)chemical industry and serve as the basis for sustainable fuels, chemical or plastic products.

Hohenburg large-scale research facility

- Develops three basic material branches from waste biomass: synthesis gas, carbonisate (biochar), pyrolysis oil (bio-oil).
- Uses thermo-catalytic reforming (TCR®), a technology developed by Fraunhofer UMSICHT that achieves a high bio-oil quality, as the core process.
- Improves the carbon footprint of companies by carbon sequestration.

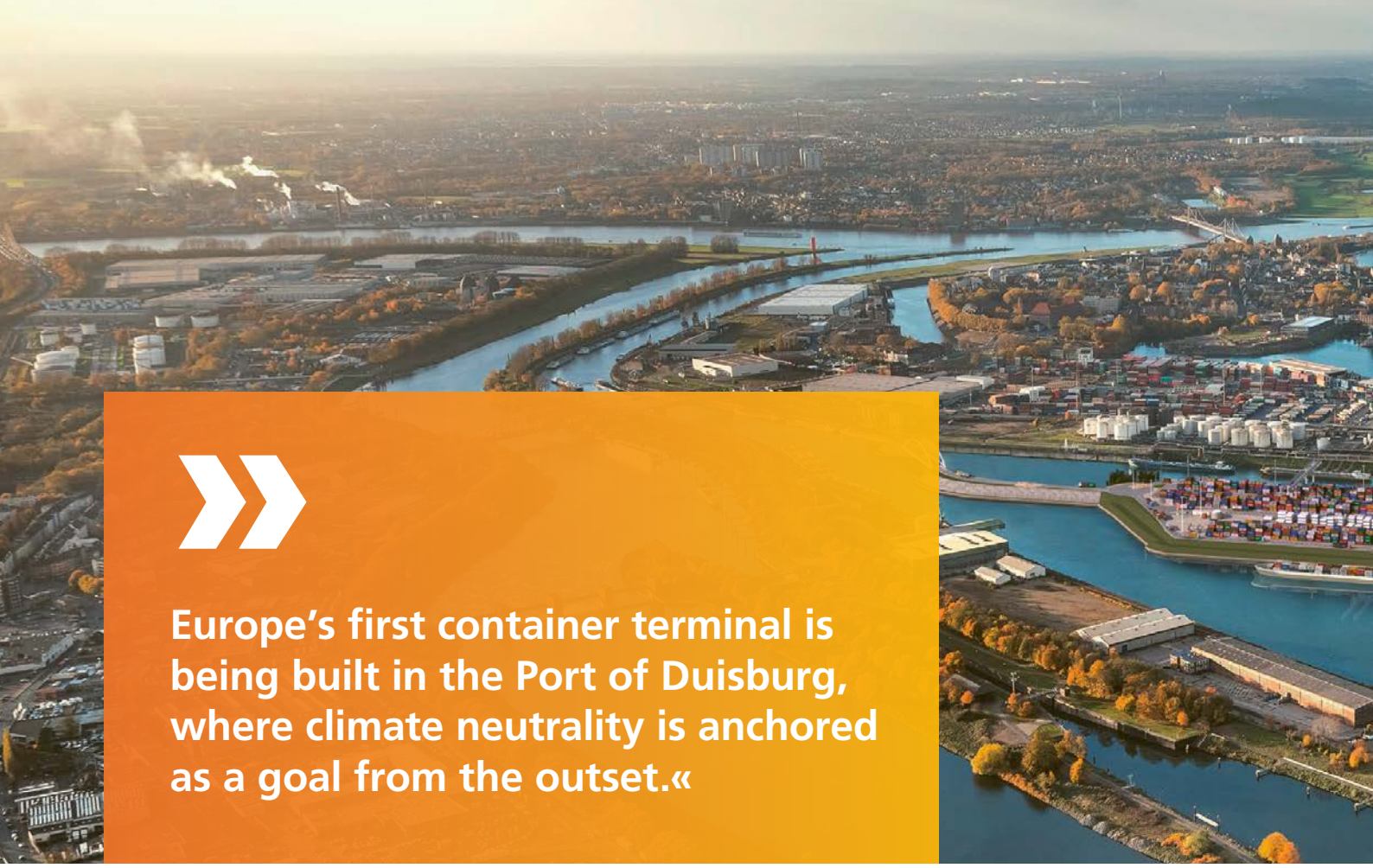
Pyrolysis opens up new sources of raw materials

In Hohenburg, biomass and biogenic residues such as sewage sludge are converted into bio-oil, biochar and synthesis gas. The outstanding development progress achieved in this process is the quality of the bio-oil produced. It is similar to fossil crude oil, is more climate-friendly than the latter and is suitable for processing into petrochemical products thanks to the thermal stability of the specially developed thermochemical conversion process. Initially designed for biogenic residues and waste materials, the thermochemical conversion technology was adapted for waste containing plastics in order to tap into another important source of carbon and keep it in the cycle.

Outstanding production capacity throughout Europe

- Over 1500 operating hours
- 500 tonnes of sewage sludge converted into 50,000 liters of bio-oil
- Over 200 tonnes of carbonates produced
- Several tonnes of green hydrogen produced

Project information / Funding provider:
s.fhg.de/to-syn-fuel-en



Europe's first container terminal is being built in the Port of Duisburg, where climate neutrality is anchored as a goal from the outset.«

enerPort II

Sustainable energy supply for a container terminal at the Port of Duisburg

The largest container terminal in the European hinterland is being built in the Port of Duisburg on 149,200 m². Operation shall be as greenhouse gas neutral as possible with the help of hydrogen. It is also being investigated whether and how neighboring districts can be supplied with energy from the terminal. The duisport (overall project management) and Fraunhofer UMSICHT (scientific management) are working on the implementation of these goals with the support of other partners in the "enerPort II" project funded by the Federal Ministry for Economic Affairs and Climate Action. The foundations for this collaboration were laid in the predecessor "enerPort" project.

Our research focuses on linking different technologies to create an intelligently operated system. The technologies include photovoltaics, hydrogen-powered fuel cells and combined heat and power plants as well as electricity and hydrogen storage systems. The team develops mathematical models that make it possible to optimally coordinate the dimensions and operating modes of the individual components. Optimized operation ensures that far-reaching sustainability goals can be achieved and thus prepare for the targeted climate neutrality.

In addition, the researchers accompany monitoring during the commissioning of the energy system and during pilot operation.

Important milestones reached

Key milestones have been reached since the start of the project at the end of 2021: The optimal sizes of the technologies have been determined and ensure that the electricity requirements of the buildings and crane systems at the terminal can be fully met on site, even at full load. The majority of the plants have already been delivered and the next steps will be the completion and commissioning of the energy system. In addition to the technical development, a suitable operator structure has also been defined and an operating strategy developed for commissioning. At the opening of the Duisburg Gateway Terminal in September 2024 attended by NRW Minister-President Hendrik Wüst, "enerPort II" was also presented and the plants of the energy system were inspected by the participants at the project location.

Project information / Funding provider:
www.green-terminal.ruhr/en

Visualization of the enerPort II model site Duisburg Gateway Terminal

Carbon2Chem®

Industrial process gases as a carbon source for the synthesis of chemical products

Using industrial process gases as a carbon source for the synthesis of chemical products – this is the objective of the Carbon2Chem® project funded by the German Federal Ministry of Education and Research. The contents relevant in phase 2 for the example of the steel and lime industry as well as thermal waste treatment include the following:

- Development of methods/tools for the industry- and location-based development and evaluation of concepts for CCU applications (Carbon Capture and Utilization)
- Proof of suitability of commercially available catalysts
- Transfer of important findings from CO_2 separation and treatment
- Development of principles and methods for the systemic analysis of CCU processes and products
- Plant construction/operation on a laboratory and pilot plant scale including process scaling

Project information/Funding provider:
www.umsicht.fraunhofer.de/en/carbon-cycle

Green ammonia will play an important role in securing the energy supply, especially in decentralized applications.«

Fraunhofer flagship project AmmonVektor

Green ammonia as a decentralized, cross-sectoral energy vector for the energy transition

The industrial demand for electricity and process heat, for example in Germany as an industrial location, is immense and will not be met without imports of sustainably produced energy carriers. Hydrogen is such an energy carrier of the future. However, its transportation over long distances, under high pressure or cryogenically liquefied, is very costly compared to the transportation of oil and is not yet feasible due to the lack of suitable ships.

Solutions for these logistics challenges are being developed as part of the "AmmonVektor" project: The flagship project coordinated by Fraunhofer UMSICHT focuses on ammonia as an energy vector, which can be easily transported in its liquid form without requiring a great deal of energy. Another advantage is that ammonia already has a global transport infrastructure due to fertilizer production.

Over the next three years, new technologies and concepts for the development, storage, distribution and direct use of renewable energies based on ammonia will be developed. Researchers from a total of eight Fraunhofer Institutes are working on the entire value chain: reactors and catalysts for flexible, energy-efficient ammonia synthesis as well as technologies for splitting ammonia and using it to generate electricity, heat and motion are being developed. Storage and logistics concepts are also being created and business models developed. Everything is aimed at making hydrogen available decentrally and as cheaply as possible in the future.

Project information / Funding provider:
www.ammonvektor.fraunhofer.de/en

AmmonVektor Keyvisual

aerogel2industry

Building insulation with aerogels receives multiple awards: 2024 Innovation Award of the State of NRW

Building insulation makes a significant contribution to saving CO_2 emissions. Conventional insulating materials such as polystyrene are mostly based on petrochemical sources. Fraunhofer UMSICHT has succeeded in the production of a sustainable, cost-effective mineral insulation material that is based on aerogels and suitable for mass production. In just six years, the team developed a novel production process for aerogels that does not require any environmentally hazardous chemicals – from the laboratory to pre-industrial scale. Manufacturing costs were reduced by 70 percent and the production time from more than ten to four hours.

The development team received the Joseph von Fraunhofer Prize 2023, the Innovation Award 2023 from the European Association of Research and Technology Organizations (EARTO) and the Innovation Award 2024 from the State of North Rhine-Westphalia, the second most prestigious award of its kind in Germany.

Project information / Funding provider:
s.fhg.de/nrw-innovation-award-aerogels

NuKoS

A new process enables the production of climate-positive bricks from steel slag hitherto dumped in landfills

Steel production in Germany generates around 14 million tonnes of steel slag every year. Around 35 percent of this remains unused – there is a lack of highly specialized methods to make these types of slag usable as materials.

In the joint research project "NuKoS", Fraunhofer UMSICHT has now succeeded in replacing the binding agent calcium oxide (CaO) with steel slag and in making the brick production process less energy-intensive. The fine fraction of the steel slag is ground up and mixed with sand and water. This mixture can be pressed into any shape and the bricks thus produced are then set out for curing – using CO_2. Test results achieved so far with the slag-based bricks are very promising. The compressive strength values are comparable to those of concrete and twice as high as required for wall bricks.

Project information / Funding provider:
s.fhg.de/NuKoS-en

Innovativeness

Shaping a sustainable future together

We are doing pioneering work for sustainable chemistry.«

Dr. rer. nat. Kevinjeorjios Pellumbi
Senior Scientist

We develop customized value propositions that are relevant to our customers' business models.«

Dr.-Ing. Jochen Nühlen
Business Development

We work in interdisciplinary teams.

Science meets the market: We develop solutions that work!

Based on our many years of experience in synthesis gas chemistry, we have implemented a process for the sustainable production of methanol from metallurgical gases in the joint research project Carbon2Chem®.«

Dipl.-Ing. Tim Schulzke
Senior Applied Researcher

Become part of our network!

I am in close contact with partners from industry and research as well as our operational departments to initiate strategic projects focusing on our Green Hydrogen and Local Energy Systems topics.«

Dr.-Ing. Esther Stahl
Strategic Project Development

Flexibility instead of standard solutions

We have a large-scale, specialized laboratory infrastructure for product and applied research, which we use to offer customized solutions.«

Dr.-Ing. Edda Möhle
Head of Analytics

We are well positioned internationally.

The realization of sustainable raw material cycles requires a high degree of interdisciplinary, long-term collaboration. In many of our projects, we also work internationally on this topic.«

Dipl.-Ing. Katharina Reh
Head of Department
Secondary Resources and Assessment

Science meets teaching: We shape the future through collaboration.

Since 2010, I have been teaching at the Ruhr University Bochum. Students get to know the latest developments in Fraunhofer research, and I contribute to the excellent vocational training of tomorrow's scientists.«

Prof. Dr.-Ing. Anna Grevé
Head of Department
Electrochemical Energy Storage

In the mechanical and electrical workshops, we offer short decision-making paths and customized solutions for projects.«

Markus Gläßer B. Eng.
Head of Mechanical Workshop

In interviews, our employees provide deeper insights into their work. Scan the QR code!«

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Contact / How to reach us

Fraunhofer UMSICHT
Main site

Osterfelder Strasse 3
46047 Oberhausen, Germany

Phone +49 208 8598-0
E-Mail info@umsicht.fraunhofer.de
Internet www.umsicht.fraunhofer.de/en.html

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

Fraunhofer UMSICHT
Institute branch Sulzbach-Rosenberg

An der Maxhütte 1
92237 Sulzbach-Rosenberg, Germany

Phone +49 9661 8155-40
E-Mail info-suro@umsicht.fraunhofer.de
Internet www.umsicht-suro.fraunhofer.de/en.html

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

Fraunhofer UMSICHT
Willich branch

Siemensring 53
47877 Willich
Phone +49 208 8598-1122, Germany

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

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

Phone +49 208 8598-0
E-Mail info@umsicht.fraunhofer.de
Internet www.umsicht.fraunhofer.de

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Fraunhofer-Gesellschaft
for the Promotion of Applied Research e. V.
Hansastraße 27 c
80686 Munich, Germany

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Contact

Fraunhofer UMSICHT
Osterfelder Strasse 3
46047 Oberhausen, Germany

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