



Fraunhofer Institute for Micro-
engineering and Microsystems IMM

Hydrogen-based energy supply

**Applied research & development in microsystems
and microtechnology**



Microengineering solutions for energy supply

Clean solutions
for your challenges

The transition of the global energy sector from fossil fuels to carbon-free energy sources is a challenge for many companies in many branches of industry. They are not able to completely eliminate carbon dioxide emissions, and the storage and transport of hydrogen is proving difficult.

We help you to reform your energy production and make it clean, efficient and suitable for all conventional and renewable fuels.



Your solution is our business!«

Benefit from our expertise

Core competencies

Materials

We develop catalysts and catalytic coatings for microstructures that are optimized for the specific fuel, the application and the scaling of your process.

Technologies

Based on many years of experience in micro-machining and laser shaping/welding, we offer the realization of technological feasibility studies, the creation of functional samples and pilot series production.

Process Modeling

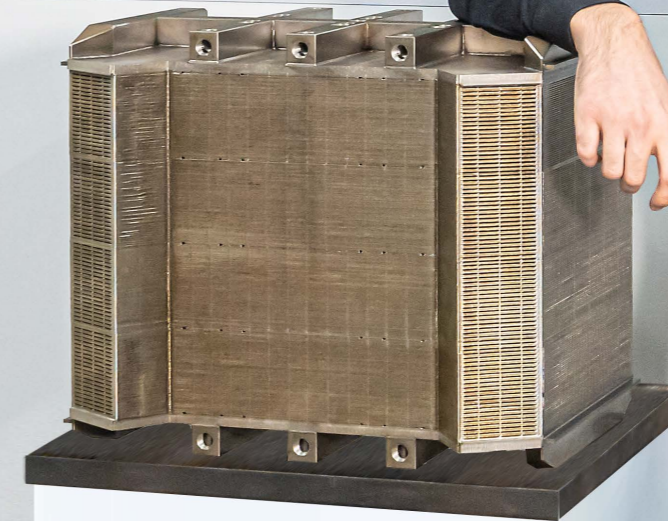
We have the know-how to translate concepts into optimized solutions and – and from there to complete automated prototypes.

Development

Our system development services cover the entire chain from process and fluidic simulation, basic and detailed engineering, CAD design, through to component procurement, assembly and commissioning.

Unique IMM technology

- Our patented unique methanol reforming catalyst technology holds world-record in activity – for more than a decade.
- Our ammonia cracking catalyst technology also holds world record in activity – and is stable under practical conditions (presence of water).
- Our reactor technology allows highest compactness – 90 percent size reduction compared to conventional technology. This is especially crucial for all applications with limited space availability.
- Thanks to their unique heat integration, our methanol reformers and ammonia crackers have maximum efficiency levels in the region of 90 percent.



Our portfolio – Technologies

Catalysis

In addition to tailor-made catalysts, the Energy division's developmental efforts encompass system design, process optimization, reactor design, the advancement of cost-effective manufacturing technologies, system control, integration, and testing.

We provide a comprehensive one-stop service covering the entire technology chain. This starts with process simulation, catalyst and reactor development, and extends to the construction and testing of fully automated plants for power generation or chemical production.

When it comes to catalytic materials, you can rely on our diverse portfolio of long-term stable catalyst formulations and on our comprehensive expertise in catalyst preparation, testing and coating.

Areas of application

- Fine chemistry
- Cosmetics
- Active Ingredients
- Mobile energy supply
- Sustainable fuels
- Energy conversion
- Photochemistry
- Hydrogen from hydrogen carriers



We optimize your material and energy conversion systems.«

Our portfolio – Technologies

Reformer development

Fuel cell systems are currently at the edge to market introduction in the automotive and marine sectors but also for stationary power supply. Fuel processors are required for the production of hydrogen out of fossil and regenerative fuels.

The integration of the individual components into a completely thermally integrated fuel processor is a critical step on the road to a marketable product. Compactness, maximum efficiency and short start-up times are important goals during the development process.

In the field of fuel synthesis we develop for our customers and partners complete solutions from the lab to pilot scale and even further to production scale.

Benefit from 20 years experience in fuel processor development for stationary, mobile (aviation, maritime, ground transport) and portable applications.



We optimize the design of the fuel processor for your specific application.«



Areas of application

- Land vehicles
- Maritime applications
- Stationary application

Power Range

- 5-200 kW

Fuels

- Methanol
- Ethanol
- Ammonia
- Hydrocarbons
(e.g. Biogas, synthetic diesel)

Our portfolio – Technologies

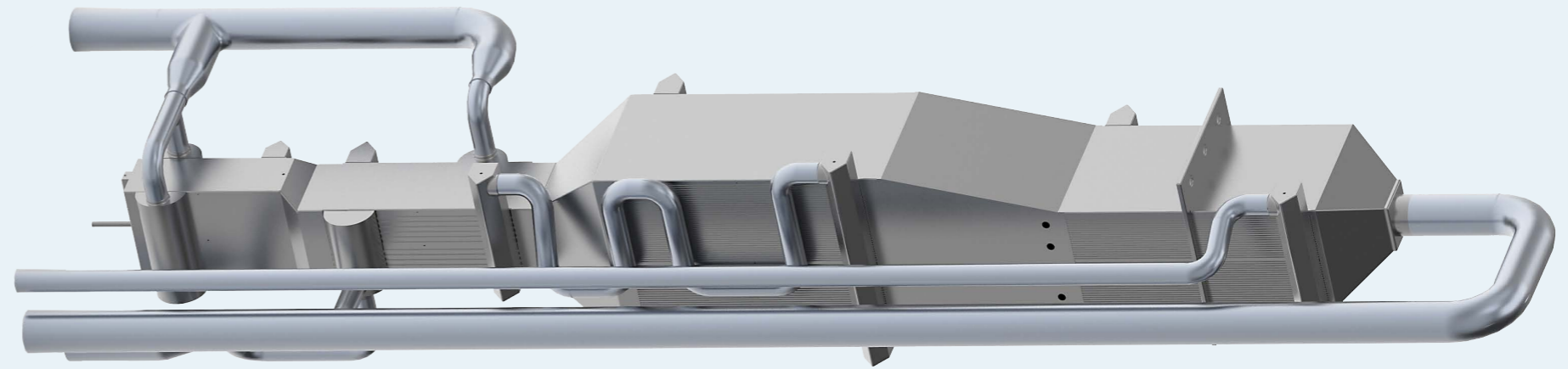
Hydrogen from hydrogen carriers: Ammonia and methanol

Significant challenges must be overcome in the areas of transport and storage in order for hydrogen to be widely used as an energy source. These challenges are accompanied by either a significant space requirement for hydrogen storage or unfavorable conditions in case of liquefied hydrogen. Hydrogen carriers such as ammonia and methanol, which enable easy storage and transport of the required hydrogen, prove to be viable alternatives.

Our current development efforts focus on the areas of transport, logistics and manufacturing. We use our extensive expertise in system design, process simulation, catalyst development, reactor design, system control, integration and testing and address various aspects and application scenarios. This includes reactor development and the construction of system prototypes.

We work actually in three areas of applications:

- **Infrastructure of gas stations - decentralized hydrogen supply:** Developing a hydrogen refueling module based on innovative catalyst technology and microstructured reactor technology.
- **Transport sector:** As part of an international consortium we are developing an ammonia and methanol based propulsion systems for large vessels.
- **Innovative combustion engine concepts based upon ammonia:** Working on the utilization of sustainable “Spaltgas” as a flammable gas mixture for combustion engines.



Power-to-Gas: Methanation of carbon dioxide

The methanation process, involving the conversion of carbon dioxide contained in biogas with hydrogen into synthetic methane, encounters technical challenges that demand careful consideration, including:

- Eliminating the need for separating carbon dioxide from biogas
- Ensuring a rapid response for the highly dynamic operation required when utilizing renewable energy sources
- Implementing efficient heat management for the strongly exothermic methanation reaction
- Development of sulfur-resistant and highly selective catalysts

Our innovative IMM methanation process addresses these challenges through the utilization of monolithic reactors coated with a high-temperature resistant catalyst, coupled with intercooling between the reactors. This unique configuration results in a decreasing temperature profile across the reactors, achieving a remarkable degree of conversion. This level of conversion is crucial in a decentralized gas injection scenario, leveraging both the existing natural gas distribution infrastructure and local carbon dioxide sources.

Your benefits

- Practically tested, exceptionally robust plate heat exchanger reactor technology
- Cost-efficient production of our reactor technology
- Technology suitable for the construction of modular plants
- High efficiency through heat integration
- Optimum compactness through microchannel technology



We optimize the design of the fuel processor for your specific application.«

What are you benefit from

- Use of ProSIM as established simulation and optimization software
- Life Cycle Aanalysis applying UMBERTO®.
- Experience in cost estimations including balance-of-plant

Our portfolio – Services

Process simulation

The development and optimization of technical processes for the conversion of hydrogen carriers such as ammonia or methanol requires model-based tools on the way to the optimized process and final plant.

The design and modeling of single reactors and assembled fuel processors is a prerequisite for the functionality of the developed systems. Life Cycle Analysis (LCA) gets increasingly important to proof the sustainability of novel technology and processes. Reliable cost prediction helps to guarantee the success of your future product.

To develop a process optimally adapted to your requirements, we use a range of professional simulation tools in addition to our broad hardware portfolio, our development experience and our manufacturing expertise.

In addition, our expertise in the field of exhaust gas purification enables us to consider questions about the resulting emissions in advance.

Our offer for you

Analysis

Together we analyze your requirements for the implementation of your ideas and goals.

Conception

We design models and concepts according to your ideas.

Manufacturing

We also produce reactors, catalytic converters and reformers in larger quantities for field testing.

Integration

We implement the developed systems and technologies together with you.

Testing

We check and test the correct functioning of our installed systems and technologies over the long term.



Your benefit

All-in-one

You receive all R&D services, including the entire system along with the fuel cells, from a single source.

Cost efficiency

We provide a reliable manufacturing technology for the cost efficient production of a large number of systems.



Benefit from our 20 years of experience in catalyst and reactor development for decentralized and mobile hydrogen supply.«



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