



Empowering the Hydrogen Economy

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Hydrogen Technologies

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We support our customers from the microscale up to global energy systems: We develop, model and analyze materials, components, production processes and infrastructure systems. In addition, we carry out techno-economic and life cycle assessments.

As a sustainable energy carrier, hydrogen offers enormous potential for the global energy system of the future: It stores renewable energies and makes them globally tradable. Since the early 1990s, our research into hydrogen technologies has been supporting the development of climate-neutral industrial processes and sustainable mobility. With our expertise, we support our customers from industry, politics and society in the development of efficient technologies and processes along the entire value chain: from hydrogen production via water electrolysis using renewable energies, to hydrogen conversion in fuel cells, to further processing into sustainable synthesis products and their reforming. Our core competence lies in the development, production and characterization of catalytically active components. In addition, we carry out life cycle and techno-economic analyses to evaluate the sustainability and costs of various processes and products.

Electrolysis and Hydrogen Infrastructure

Hydrogen production in water electrolyzers is a clean and efficient process to convert and store large quantities of renewable electricity. Our R&D focuses on membrane water electrolysis and involves fundamental research on single cell components such as the membrane electrode assembly (MEA), the porous transport layers, coatings and bipolar plates. We are investigating the influence of various stressors on cell and

stack performance and aging mechanisms. Furthermore, we are increasingly focusing on low-cost cell concepts and MEA production. In-house developed laboratory cells, stacks and automated test stands form the backbone of our R&D projects. In addition, we have developed a comprehensive system level understanding, including the operation of our own hydrogen injection station and hydrogen fueling station with several fuel cell vehicles and related research on field test systems. We apply this knowledge in techno-economic analyses, supporting companies in setting up various hydrogen installations and optimizing their business models. Multi-criteria optimization tasks are solved with our own toolbox "H2ProSim" , which allows us to perform dynamic system modeling.

Our services include:

- scientific investigations of performance and degradation mechanisms of cell and stack components for membrane water electrolysis using state-of-the-art electrochemical characterization and ex situ analysis
- research on manufacturing processes for cell and stack components, such as catalyst-coated membranes and protective coatings
- technological evaluation and accompanying research for power-to-gas plants and hydrogen infrastructure
- techno-economic modeling and simulation of electrolysis and hydrogen installations for the optimization of system concepts, business models and infrastructure development

Institute's own hydrogen injection station into the local natural gas grid.



*Laboratory for fuel cell and electrolysis production research.
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Mini plant for developing industrial scale methanol synthesis.

Hydrogen-Based Energy Carriers, Fuels and Chemicals

We investigate the synthesis of sustainable fuels and chemical platform molecules (power-to-liquid PtL and power-to-chemicals PtX), as well as solutions in process and emission reduction technologies, e. g. our fuel processing technology CATVAP®. We cover the entire process chain of sustainable synthesis products: from green hydrogen, the direct air capture of CO₂ and the synthesis of PtX products (e. g. ammonia, dimethyl ether DME, methanol) to reforming processes and end applications. We develop and optimize processes and reactor concepts for the production of PtX products and for thermochemical hydrogen production from PtX products. We develop, test and characterize tailor-made catalysts. We offer sophisticated characterization of materials, such as innovative X-ray photoelectron spectroscopy (HT-NAP-XPS). We complement our research services with economic feasibility studies and life cycle assessments along the value chain for renewable energies, generation of hydrogen and hydrogen derivatives, transport, distribution and usage.

Our services include:

- reactor and process development of efficient synthesis based on N₂ or CO₂ and H₂ feeds, e. g. clean OME and DME technology including a powerful simulation platform
- design, test and characterization of tailor-made catalyst systems
- in-house design, construction, programming and operation of fully automated, remote-operated mini and pilot plants
- development of tailor-made reactors for fuel processing and reforming (e.g. NH₃ and DME reforming) using computational fluid dynamics simulations
- simulations, techno-economic and ecological evaluation of complete processes (life cycle analysis), assessments and experimental investigations of direct air capture processes, reactors and materials using our test and simulation platform

Fuel Cells

Membrane fuel cells are recommended for applications such as zero-emission mobility, small traction vehicles, off-road vehicles, stationary combined heat and power plants, and back-up power. Especially, the electrochemically active components, like the membrane electrode assembly, must operate reliably and efficiently under extreme conditions with high stability. We support and advise customers with our interdisciplinary know-how and comprehensive services, ranging from basic R&D to product commercialization. Our research encompasses the development, simulation, production and ex-situ analysis as well as in-operando characterization of components, single cells and stacks.

Our services include:

- in-situ characterization of components, cells and stacks with regard to performance and degradation, using state-of-the-art electrochemical measurement techniques
- ex-situ analysis of fuel cell components
- production research along the value chain from catalyst ink formulation to membrane electrode assembly – with processes from lab scale up to roll-to-roll industrial series production
- characterization at extreme climatic conditions
- modeling and simulation performed from the microscale up to the system level

Our Mission

- We support global efforts to defossilize the future energy economy and contribute to the mitigation of climate change by enabling hydrogen technologies.
- We conduct applied research in an international context for the benefit of our customers.
- With more than three decades of technological experience and advanced equipment, we offer scientifically sound analysis and testing services.
- By developing technological innovations and novel system solutions, we help to strengthen the competitiveness of our customers in Germany and around the world.
- Our research activities aim to promote the utilization of hydrogen and its derivatives as energy storage media, as fuel for zero-emission mobility and as a chemical feedstock.

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Further
information

Cover image:

AEM electrolysis test bench with a 4 cm² electrolysis cell developed by Fraunhofer ISE for characterizing new non-precious metal catalyst materials under industry-relevant conditions.

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