Fraunhofer ISE

Fraunhofer Institute for Solar Energy Systems ISE

Empowering the Hydrogen Economy

Hydrogen Technologies

www.ise.fraunhofer.de/hydrogen-technologies

Hydrogen Technologies

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.

Institute's own hydrogen injection station into the local natural gas grid. We analyze, develop and optimize hydrogen infrastructures and supply chains.

Distillation column with a total height of 7.5 meters for developing an industrial scale synthesis of dimethyl ether and other sustainable energy carriers.

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.

Our Mission

- We support global efforts to defossilize the energy, chemical and mobility economy and contribute to the mitigation of climate change by enabling hydrogen technologies.
- 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.

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

Laboratory for fuel cell and electrolysis production research. We support our customers to scale up fuel cell and electrolyzer MEA production. © Fraunhofer ISE / Photo Dirk Mahler

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 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. Based on our operational experience with field test facilities, we offer services for condition monitoring and targeted measurement programs under real conditions. We apply this knowledge in techno-economic analyses, supporting companies in setting up electrolysis plants and hydrogen filling stations and investigate operational management strategies. 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 electrolysis 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

Sustainable Synthesis Products

The synthesis of sustainable fuels and chemical platform molecules (power-to-liquid, PtL and power-to-X, PtX), as well as efficient processes and emission reduction technologies are crucial for a climate-neutral future. From green hydrogen, the direct air capture of CO_2 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. The application-focused testing and characterization of tailor-made catalyst solutions, respectively their implementation as, e.g. our fuel processing technology CATVAP®, is part of our core expertise. 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 N_2 or CO_2 and H_2 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. NH_3 and DME reforming) using computational fluid dynamics simulations
- simulations, techno-economic and ecological evaluation (life cycle analysis), assessments and experimental investigations of direct air capture
- processes, reactors and materials using our test and simulation platform

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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.
Images: © Fraunhofer ISE / Photo Joscha Feuerstein

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