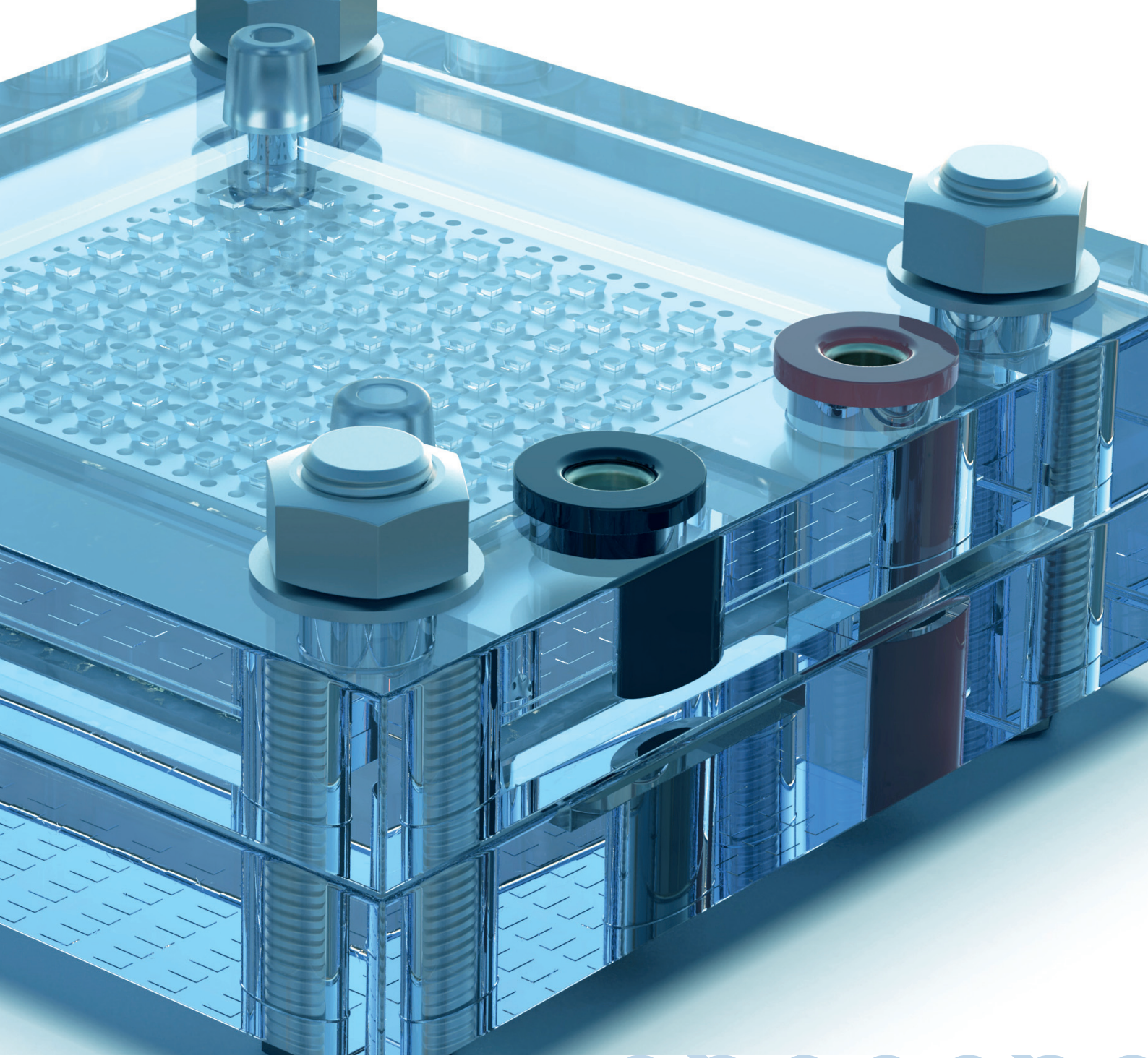


Services along the hydrogen value chain

Usage/application:

Fuel cell system

HydroHub

H_2 competence @ HydroHub

Our services run along the entire value chain in the hydrogen industry – from generation through transport and storage to use in various fields of application.

Energy generation

Renewables (e.g. wind, solar)

Conventional power plants

Geothermal

H_2 generation

Electrolysis

Seawater desalination plants

Reforming processes

Methane pyrolysis

Distribution/transport

Electrical grid

Pipelines

District heating

Intelligent networks

Refuelling stations/ filling systems

Tankers (lorry, train, ship)

Storage

Battery storage

Gas tanks

Cavern storage (H_2 and CO_2)

Pressure vessels

H_2 hydride storage

Consumption/use

Fuel cell system

Methanol synthesis unit

Carbon capture and utilisation

Mobility (e.g. e-fuels)

Reconversion to electricity

Power to gas (gas, heat, liquid)

Industrial applications (e.g. refinery)

H_2 competence @ HydroHub

We give comprehensive support to hydrogen projects and offer a broad spectrum of services in the concept/planning, production, operation and decommissioning/disposal phases.

Concept/planning

We support you from the start with research and project planning measures and specific tasks. Already at the conception phase, we are there at your side with feasibility studies, strategic and financial consultation and a broad range of organisational and technical services. Alongside concept creation with consideration for legal, technical and economic conditions, we take on the task of analysing the requirements and support you in the process of determining feasibility through basic and design planning all the way to the approval process.

Production

For over 150 years, it has been one of our tasks to analyse and manage technical sources of risk. With our wide range of specific services, we are thus able to offer you competent help in the integration of hydrogen technologies into the industrial value chain. Our range of services runs from fact-finding and construction through project management, administering documentation and operator's obligations, basic and detailed process engineering all the way to project support through geological, environmental and engineering services during the production process.

Operation

We support frictionless operation with our extensive range of services and our primary goal of optimising operational reliability and preventing damage. Our services support you in the implementation of your operating strategies and in the accompanying optimisation, maintenance and upkeep concepts. Our safety-oriented process with operational monitoring and the creation of damage-limitation concepts contributes, in the final account, to establishing hydrogen in the popular conception as a safe and controllable technology.

Decommissioning/disposal

Just as we are there for you in the first concept phase, we are also at your side at the decommissioning phase, providing all the required services for dismantling and disposal – including project management and comprehensive services to handle your operational obligations. We create concepts to the current legal requirements, standards and regulations and support you in identifying, analysing and avoiding the potential risks of your intervention.

Fuel cells: the motors of the hydrogen economy

Fuel cells are required to generate electricity from hydrogen. By converting chemical energy directly into electrical energy and heat, they have a significantly higher level of efficiency than conventional power plants. In combination with a fuel storage tank and water recycling facility, fuel cell systems can achieve energy generation that is fully free from pollutants. The range of power in fuel cells runs from the sub-kW range for individual cells to the MW range in the form of virtual power plants. They are used, among other things, to generate heat and electricity in buildings, provide remote solutions outside the grid and to drive vehicles, aeroplanes and ships.

We are your partner for the research, development and market deployment of fuel cell technologies – giving special attention to municipal and industrial actors aiming to make use of hydrogen. With the most modern analytical methods and competent specialists, we are at your side to carry out your project safely and successfully, and to help you benefit from subsidies as available. Do get in touch.

Fuel cell technologies

Currently, 6 types of fuel cells are used. They run on various gases, use different electrolytes and are classified depending on their operating temperature as either low, medium or high-temperature fuel cells.

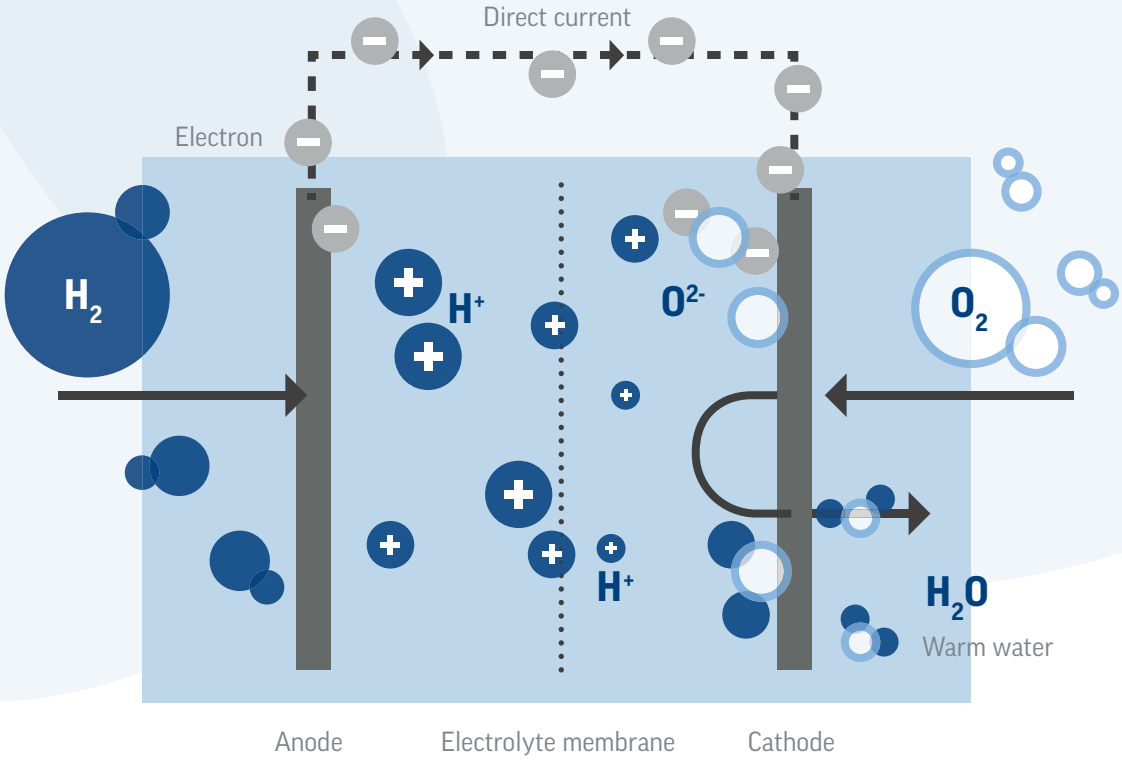
Type	Anode gas	Cathode gas	Electrolyte	Working temperature	Range of services	Cell efficiency
Alkaline fuel cell AFC	Hydrogen	Oxygen	Aqueous potash	20 °C–90 °C	up to 100 kW	60 %–70 %
Proton exchange membrane fuel cell PEMFC	Hydrogen	Atmospheric oxygen	Polymer membrane	20 °C–80 °C	up to 500 kW	50 %–70 %
Direct methanol fuel cell DMFC	Methanol	Atmospheric oxygen	Polymer membrane	20 °C–130 °C	up to 100 kW	20 %–30 %
Phosphoric acid fuel cell PAFC	Hydrogen, natural or biogas	Atmospheric oxygen	Phosphoric acid	160 °C–220 °C	up to 10 MW	55 %
Molten carbonate fuel cell MCFC	Natural, coal, biogas	Atmospheric oxygen	Molten carbonate salts	620 °C–660 °C	up to 100 MW	65 %
Solid oxide fuel cell SOFC	Natural, coal, biogas	Atmospheric oxygen	Yttrium-stabilised zirconium oxide	800 °C–1000 °C	up to 100 MW	60 %–65 %

Principle of construction and functioning

A fuel cell consists of an array of several cells divided by separators and arranged into a stack. They are set up in planar layers or, in the case of solid oxide cells, as tubular systems.

The core of an individual cell is a liquid or solid electrolyte, surrounded on two sides by bipolar electrode plates (anode and cathode). The plates have a porous GDL (gas diffusion layer) that transports the reactive gases past a noble-metal-coated catalyst (low and medium-temperature range) or a nickel, ceramic or steel catalyst (high-temperature range).

In this way, in most fuel cell types, the hydrogen is split at the anode and the electrons diverted to the electrical load. The hydrogen protons migrate through the electrolyte to the cathode side and combine with the oxygen provided there to form water.



Areas of use and usage

The range of uses for fuel cells is large and constantly growing as they are reliable to use, low-maintenance and environmentally friendly. While all fuel cell types are suitable for stationary applications, portable and mobile uses largely rely on membrane fuel cells and direct methanol fuel cells.

LOW-TEMPERATURE FUEL CELLS

Alkaline fuel cells (AFC)
This fuel cell type is setting benchmarks in the development of the technology, above all in space and submarine travel. The first fuel cell passenger boat in the world was also driven by alkaline fuel cells.

Despite its robust system, this type of fuel cell nevertheless has a low service life and does not achieve the high power density of today's widespread membrane fuel cells.

Proton exchange membrane fuel cells (PEMFC)
No other fuel cell type is so versatile. Because of the high dynamism of their power output, membrane fuel cells are often deployed in mobile use, e.g. in cars, small vans and buses, alongside aerospace and nautical applications.

A further use is in emergency power supplies, say, for railway transport and in telecommunications and to secure critical industrial infrastructures or data centres. Smaller fuel cell systems are used e.g. in portable generators or, in stationary use, for domestic energy supply from cogeneration plants. Larger systems are found e.g. in hospitals, swimming pools and other communal utilities.

Direct methanol fuel cell (DMFC)
Thanks to its uncomplicated handling, this fuel cell technology finds widespread use. Stationary uses include remote electricity supply for metering stations, monitoring systems or communications facilities. They can be portable e.g. for leisure use (while camping, say) and mobile, where they are often used as range extenders for electric vehicles, for which they provide excellent, environmentally friendly mobility thanks to their high storage density.

Through the reaction of methanol with oxygen, a small amount of CO_2 alongside water vapour is generated in direct methanol technology.

MEDIUM- AND HIGH-TEMPERATURE FUEL CELLS

Phosphoric acid fuel cells (PAFC)

As medium-temperature fuel cells, this cell type not only has a higher working temperature than the low-temperature fuel cells, but also has a certain CO and CO_2 tolerance, meaning they can largely be operated with reformed natural gas. Because of their aggressive, acidic electrolytes, however, they have a comparatively low service life. They are used in the field of cogeneration, e.g. in stationary energy supply for industrial plants, shopping centres, hospitals and residential estates.

Molten carbonate fuel cells (MCFC)

As high-temperature fuel cells, molten carbonate fuel cells have the advantage of being insensitive to CO and able to use natural, coal, bio- and synthetic gas directly, without reforming. However, their internal CO_2 cycle requires additional electrolyte and CO_2 management. As with the medium-temperature fuel cell, heat production is the focus here rather than electricity production. As they have a longer start-up phase and their service life is decisively influenced by the number of start-stop cycles, they are ideally used in power plants and cogeneration plants ideally in base-load operation.

Solid oxide fuel cells (SOFC)

In comparison with molten carbonate fuel cells, solid oxide fuel cells have a comparatively simple system, high service life and high efficiency. Their working temperature of up to 1,000 °C predetermines these powerful high-temperature fuel cells for the decoupling of process heat and thus for stationary use in power plants, cogeneration plants, and also heating facilities in detached and semi-detached houses. In combination with gas turbines, solid oxide fuel cells are also used in smaller communal cogeneration plants and larger facilities for electricity generation.

Our services

Fuel cells and fuel cell systems have great market potential in nearly all areas of emissions-free energy supply. With comprehensive services in the fields of consulting, engineering and training, we support manufacturers and operators in the following phases:

	Concept/ Planning	Production	Operation	Decommissioning/ Disposal
Creation of concepts to current legal requirements, standards and regulations	●			●
Creating requirements specifications	●			●
Creating technical specifications	●			●
Creating commissioning and periodic inspection concepts	●			
Weak-point analysis, identification and analysis of potential risks	●			●
Creation, consultation on staggered power system protection plans, protection tests	●			●
Conception and consultation (commissioning, periodic inspection) of isolated networks including the incorporation of e.g. decentralised generator units, electrolysers and any necessary storage facilities (on and offshore)	●			
Creation of risk analyses to determine the potential risk of intervention	●			●
Creation of safeguarding concepts	●			●
Consultation, evaluation of electrical and mechanical safeguarding systems	●			●
Consultation, evaluation on installation and operation of alarm receiving stations	●			●
Consultation, evaluation on determination of intervention measures by guarding/security company or police	●			●

	Concept/ Planning	Production	Operation	Decommissioning/ Disposal
Consultation, evaluation on determination of administrative security measures	●			●
Technical advisory services	●			
Project management and document administration	●	●	●	●
Damage assessments and analyses of the causes of damage, creation of avoidance concepts			●	
Analysis and evaluation of damages and measures to prevent comparable faults			●	
Maintenance of breakdown statistics to assess operational reliability in comparable plants/components			●	
Analysis of electrical grids: e.g. short circuit, load flow calculations, efficiency and optimisation assessments			●	

HydroHub

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