HYDROGEN AS AN ESSENTIAL COMPONENT OF THE ENERGY TRANSITION

Germany and the European Union aim to be climate-neutral by 2050. This should be achieved while ensuring that the population has a reliable energy supply and that industry remains competitive. To ensure Germany achieves its energy transition goals, Helmholtz centers for production, energy, distributing, and using hydrogen (H₂) need to be developed and made commercially available on a large scale. The research for this is as follows:

- Hydrogen technologies can close the gap between the fluctuating generation of energy from renewable energy sources and actual demand. This applies to grids that would otherwise operate for hours, days, weeks, or even months. Hydrogen technologies can also cover the entire energy spectrum.

- Hydrogen technologies enable the coupling and comprehensive optimization of energy sectors (electricity, heating), industry, and transport, which are thus considered separately. For example, if there is a surplus of renewable energy, hydrogen can be used to electrolyze water to produce hydrogen, which can in turn be used to power fuel cells or be stored for later use. If there is a shortage of renewable energy, hydrogen can be used to produce electricity through electrolysis.

- Production of hydrogen from the reformation of carbon dioxide (CO₂) is sustainable, and industry can capture these emissions and use hydrogen to convert them into usable substances such as synthetic fuels or chemicals.

The Helmholtz Association aims to strengthen its role in innovation processes in future, particularly in regions of structural change. Examples of projects include the Helmholtz cluster for a sustainable and infrastructure-compatible hydrogen economy in Jülich, the DLR innovation center for sustainable electrochemical value chains, and the new DLR institute Future Solar Fuels. Furthermore, the Helmholtz Association is proposing to establish a center of excellence for hydrogen mobility in view of the structural change in the automotive industry.

RESEARCH FOR INNOVATIONS
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Scientists at the Helmholtz Association believe that cross-program and interdisciplinary research funding initiatives are necessary to strengthen and make better use of synergies resulting from interdisciplinarily collaboration as part of a holistic approach to complex research topics. An example of this is sector coupling with hydrogen. Such initiatives also enable the synergistic organization of expertise for developing, producing, characterizing, and installing materials as well as the acceleration of developments across the value chain. The scientists also see the need for increased use of supercomputing and artificial intelligence through collaborations between the research fields of information and energy.

Furthermore, the Helmholtz Association aims to take over the largest, internationally competitive European industrial facilities for research on carbon capture and utilization as well as the acceleration of developments across the value chain. This includes the building for the energy transition as well as demonstration projects and pilot systems to ensure that hydrogen technologies can be used in industrial applications and brought to market as soon as possible.

An additional focus is on education and training, which the Helmholtz Association aims to expand and push forward together with universities and chambers of industry and commerce.

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Helmholtz Association’s research hydrogen so important for the energy transition?
Cost-effective and sustainable

There are numerous possibilities for producing hydrogen. Scientists at the Helmholtz Association are working on ensuring that established production processes, for example electrolysis, are more cost-effective, more sustainable, and more reliable. One focus of their work is to transfer laboratory results to demonstration plants on an industrial scale. The Helmholtz scientists also research new, not yet mature technologies such as the biocatalytic production of hydrogen.

HIGHLIGHTS

• Dynamic operation of 400 kW high-temperature electrolyzer (FZJ)
• 20,000 h operation of a high-temperature electrolyzer stack (FZJ)
• Development of the world’s largest solar reactor for hydrogen production (FZJ)
• Development of membrane purifiers and reforming in subcritical water for CO₂-free hydrogen production (KIT)
• Development of photocollaboration schemes that can release hydrogen directly from water (KIT)
• Efficient record for artificial photosynthesis using silicon solar cells (KIT)
• Demonstration of a 50 cm² artificial leaf for producing hydrogen using solar power based on metal oxides (HZB)
• Characterization of the spintronics reduction source of novel catalysts for splitting water (DESY)

Fuel cells and synthetic fuels

Helmholtz scientists are working on improving the efficiency, durability, and performance of fuel cells. Fuel cells convert hydrogen directly into electrical energy and are of interest for many different uses. These include for electric drive on the on-board power supply of trucks, buses, ships, forklifts, and passenger cars, as well as for combined heat and power units and for supplying electricity to dressers on the grid. Various cell types are ideal for different applications due to their properties and operating conditions. Hydrogen can also be used to produce synthetic liquid fuels and base chemicals. Helmholtz researchers are developing corresponding methods right up to industrial scale.

HIGHLIGHTS

• 190,000 h continuous operation of a solid oxide fuel cell stack (FZJ)
• Compact fuel cell module for on-board power supply of mobile applications (FZJ)
• World’s first hydrogen-powered ferry (DLR)
• Development of burners for gas turbines in which pure hydrogen is burned (DLR)
• Development of chemical reactor technologies that can be used to convert hydrogen and CO₂ locally into synthetic fuel and base chemicals (FZJ, KIT)

The energy system of the future

Decisions made with respect to the energy sector, energy policy, and research funding have long-lasting impacts and are of relevance for almost all areas of society. Knowledge of systems analysis is needed to act with foresight, to identify the opportunities offered by new technologies, and to reduce the risks posed to the environment and the economy. Helmholtz scientists are therefore developing system models of the German, European, and global energy system that integrate hydrogen technologies. They evaluate these technologies and take aspects related to safety, the economy, social acceptance into account. The scientists also design concepts to decarbonize energy-intensive industrial sectors by using hydrogen, i.e. switching to low-carbon or carbon-free production processes. Furthermore, they analyze hydrogen supply systems and analyze industrial-scale storage options.

HIGHLIGHTS

• Study: Pathways for the German energy transition by 2050 (FZJ)
• Living labs for intelligent networked energy systems based on renewable energy sources (FZJ, KIT, DLR)