

DLR at a glance

DLR is Germany's national research centre for aeronautics and space. Its extensive research and development work in Aeronautics, Space, Energy, Transport and Security is integrated into national and international cooperative ventures. As Germany's space agency, DLR has been given responsibility for the forward planning and the implementation of the German space programme by the German federal government as well as for the international representation of German interests. Furthermore, Germany's largest project-management agency is also part of DLR.

Approximately 6,900 people are employed at thirteen locations in Germany: Cologne (headquarters), Berlin, Bonn, Braunschweig, Bremen, Goettingen, Hamburg, Lampoldshausen, Neustrelitz, Oberpfaffenhofen, Stuttgart, Trauen, and Weilheim. DLR also operates offices in Brussels, Paris, and Washington D.C.

DLR's mission comprises the exploration of the Earth and the Solar System, research for protecting the environment, for environmentally-compatible technologies, and for promoting mobility, communication, and security. DLR's research portfolio ranges from basic research to innovative applications and products of tomorrow. In that way DLR contributes the scientific and technical know-how that it has gained to enhancing Germany's industrial and technological reputation. DLR operates large-scale research facilities for DLR's own projects and as a service provider for its clients and partners. It also promotes the next generation of scientists, provides competent advisory services to government, and is a driving force in the local regions of its field centers.



**Deutsches Zentrum
für Luft- und Raumfahrt e.V.**
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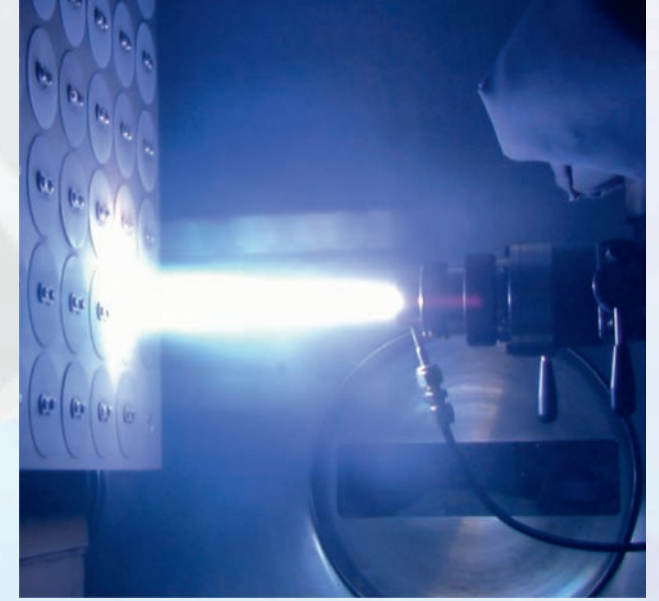
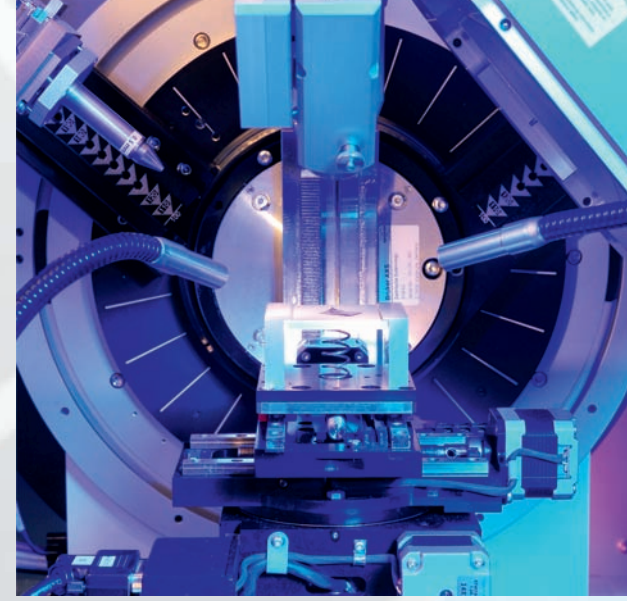
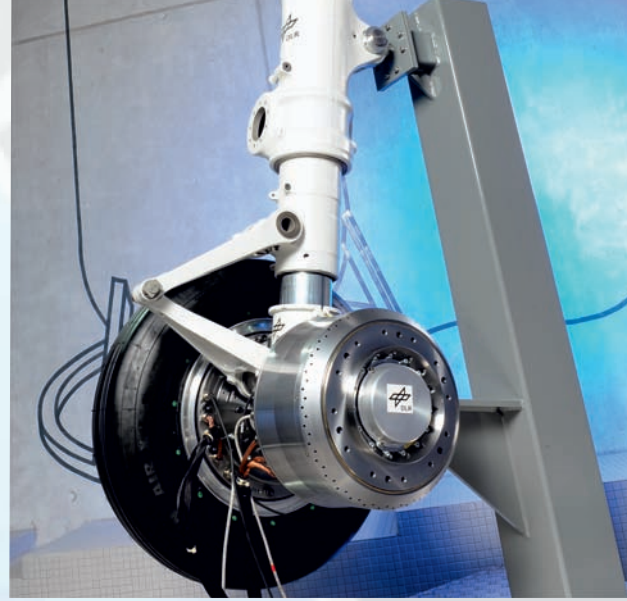
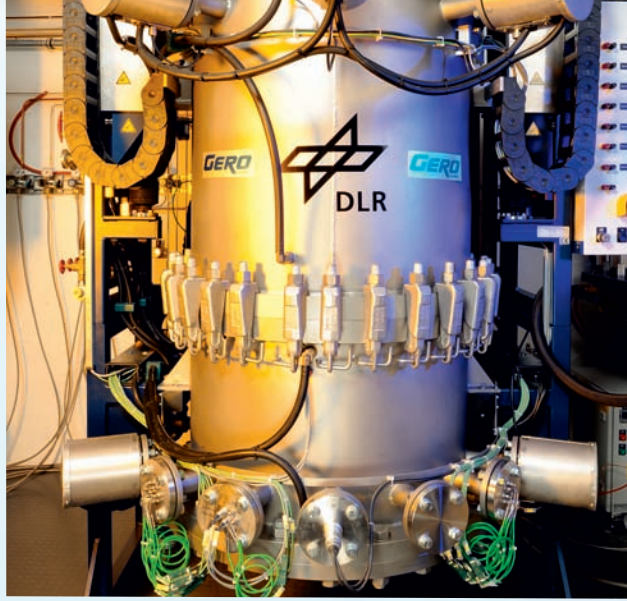
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Department Electrochemical Energy Technology





Tasks and Aims

The research and development topics of the department Electrochemical Energy Technology are efficient electrochemical energy storage and conversion especially with batteries, fuel cells and electrolysers.

These devices are key technologies for future energy systems both for stationary power supply and for electric mobility. The activities include the design of fuel cells, manufacturing technology, diagnostics of cells and stacks as well as system optimisation and demonstration.

An important aspect of the development is the balancing of the conflicting aims between efficiency, operating time, comfort, security and costs.

Lithium Metal and Lithium Ion Batteries (LIB)

Electrochemical energy storage is the basis for advanced and efficient vehicle power trains, namely battery hybrid cars, pure battery cars but also hybridized hydrogen and fuel cells based drives. The key technology for the realisation of a wide electric mobility is an efficient, affordable and customer-friendly battery. Battery systems such as lithium sulphur and lithium air batteries have the potential for highest capacity (energy density). These systems still face many challenges, which have to be answered by fundamental research and by fundamental solutions.

Security and reliability of high-energy and high-performance batteries are very important for general acceptance of the technology and require a reliable determination of the battery state as well as the implementation of inherently safe materials.

Key activities:

- Development of lithium sulphur and lithium air batteries by new nano- and micro-structured electrodes
- Analysis of degradation phenomena and development of mitigation strategies
- Development of electrodes with enhanced safety by cost-effective manufacturing technologies
- State diagnostics (state of charge (SOC), state of health (SOH)) for battery cells and systems with in-situ diagnostics and frequency analysis

Solid Oxide Fuel Cells (SOFC)

The main advantages of SOFC are their high electrical efficiency and tolerance for different fuels. SOFC can be operated with natural gas or diesel, which qualifies their use for both auxiliary power units (APU) and stationary power supply applications.

Key activities:

- Realisation of durable, powerful and cost effective SOFC-stacks
- Lower operating temperature in SOFC-stacks for simplification of system technology
- Modern methods of analysis and diagnostics for high temperature fuel cells
- Accelerated aging and degradation processes, non-invasive characterisation

Polymer Electrolyte Fuel Cells (PEFC)

PEFC are characterised by their high dynamic and flexible operating conditions. For that reason, this technology is well suited both for electric mobility with hydrogen fuel and residential power supply with natural gas.

Key activities:

- Use of the internal dry spraying technology for gas diffusion electrodes and gas diffusion stacks
- Development of in-situ diagnostics using frequency analysis, segmentation and spectroscopy

- Adaption and further development of fuel cells to realise the operating between -30 and 120 degrees Celsius
- Analysis of degradation and aging, development of strategies and operating methods to improve the longevity and reliability of fuel cells

Electrochemical Production of Hydrogen

The German Aerospace Center has developed highly-efficient alkaline water electrolysers for intermittent operating in the course of the HYSOLAR and HYCO-projects. The expertise includes both the production of specialised electrodes with extended stability and low losses and an efficient system design. An intermittent electrolysis operating is essential for coupling with photovoltaic or solar thermal electricity generation or with the operation of electrolysers with local wind power stations. Sophisticated electrolysers with high power density and efficiency for the dynamic operation have been developed up to power ratings of 350 KW in prototypes.

The existing expertises include:

- Activated electrodes with degradation prevention without voltage maintenance during idling
- Optimised system technology regarding technical and economic aspects as well as safety
- Extended experience in the operating of electrolysis facilities
- Reliable simulation of the system performance

Electrochemical Systems

The main focus of the electrochemical system group is an overall efficient system which includes battery systems, multifunctional fuel cells systems and optimised components for stationary and mobile applications.

The selection of appropriate components as well as a system design based on detailed modelling and simulation calculations is performed.

The requirements of the system depend on the specific application and its specifications, e.g. for the auxiliary power units (APU) for aeronautical applications.

Key activities:

- Development of multifunctional systems of fuel cells for aeronautical applications
- Development of coupled systems with hydrogen power generating unit and fuel cells system
- Analysis and development of SOFC generators in combination with gas turbines for hybrid power stations
- Operating strategies with charging management and quick charging of battery systems
- Hybrid systems, e.g. range-extendors for batteries and plug-in battery systems

Modelling and Simulation

Prerequisite for the further improvement of the efficiency factor, longevity and costs of fuel cells and batteries is a very good understanding of the underlying physical, chemical and mass transport processes.

Models as well as modern numerical methods are developed and used in the group modelling and simulation.

An important part of the activities is the close collaboration with experimental groups. This combination allows the development of validated and predictive models, which are used regarding two central aspects:

1. **model-based interpretation** of experimental observations including the understanding of the elementary processes in fuel cells and batteries
2. **model-based optimisation** of design, capacity and longevity

Aim of the activities is the support of a knowledge-based development of electrochemical energy converters at the German Aerospace Center.