Systems Analysis and Technology Assessment

Decisions in the energy industry, energy policies and energy research always have far-reaching and long-lasting consequences. By foresighted action, the opportunities of new technologies can be recognized in time and possible negative effects on the environment and society can be minimized.

The department outlines the various technical and structural options that can serve as a framework for a sustainable energy supply system, analyzes technologies and their potentials and assesses their advantages and disadvantages. On this basis, scenarios showing the way to an affordable, reliable and environmentally sound energy future are developed. Furthermore, the department develops new methodologies, evaluates instruments, and compiles recommendations for action that allow for efficient implementation of the indicated goals.

The department's key areas of work are:
- Energy system modelling and scenarios: development of scenarios with large shares of renewable energy, taking into account the spatio-temporal variability of renewable resources in a least-cost approach
- Resources and potentials: modelling and analysis of the available renewable resources
- Incentive programs and economic aspects: evaluation of incentive programs and legal regulations, as well as determination of employment market effects of expanding renewable sources of energy in Germany
- Market strategies for solar-thermal power plant: integration of solar thermal power plant technology into systems, grids and markets

Thermal Process Technology

The overall objective of the Thermal Process Technology Department is to increase the efficiency of energy conversion and storage processes as a key element in reducing fuel consumption and protecting the climate. The department's work includes the development of advanced components, processes and system technologies in the field of thermal and chemical energy storage, heat management and fuel processing.

The focal points of the department's work are:
- High-temperature heat storage (up to 1000 °C) for solar thermal and conventional power plant technologies, cogeneration (combined heat and power) and industrial process heat
- Thermo-chemical storage of high-temperature heat for stationary and mobile applications
- High-performance heat exchangers for gas-turbine processes and heat recovery and heat exchangers with increased power density for vaporization and condensation
- Hydrogen generation and storage for decentralized and mobile applications

The department possesses a unique research infrastructure for the development of heat storage systems, heat exchangers and chemical storage systems up to the hundred-kilowatt range.

Electrochemical Energy Technology

The Electrochemical Energy Technology Department works on development of efficient electrochemical energy converters, mainly batteries, fuel cells and electrolysers; their importance for future power systems, both in stationary power supply and in electro mobility, increases continuously. The department's activities range from cell design, manufacturing processes, and diagnosis to system optimization and demonstration. The scientific and engineering challenges of electrochemical storage technology and energy conversion consist of handling the conflicting goals of efficiency, operating life, convenience, safety and costs.

The focal points of the department's work are:
- Development of polymer-electrolyte fuel cells (PEFC) and solid-oxide (ceramic) fuel cells (SOFC)
- Advanced cell concepts for higher power density, reduced-materials and manufacturing costs and greater ruggedness
- Future lithium batteries, especially the development of lithium-air and lithium-sulphur batteries
- Identification of the degradation mechanisms in fuel cells and batteries and strategies for preventing degradation
- On-site and off-site examinations of fuel cells and batteries-by means of innovative measurement methods, such as spatially resolved current density
- Modelling or simulation of complex systems
- Optimized system technology for fuel cells, batteries and electrolysers
- Highly-integrated electrochemical systems for aerospace applications

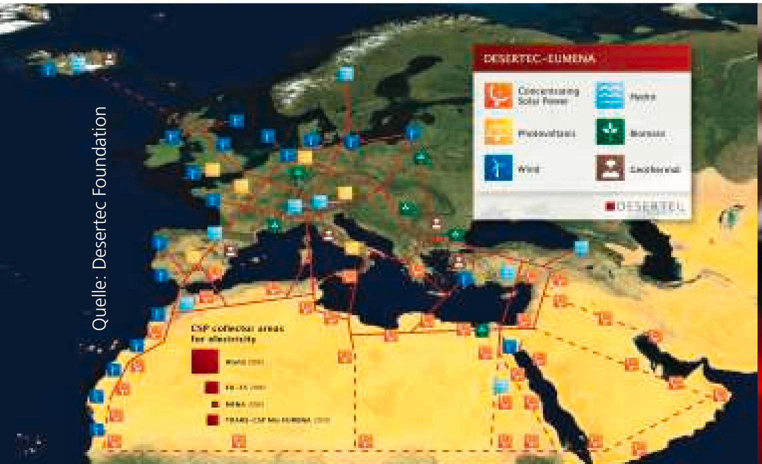
Computational Electrochemistry

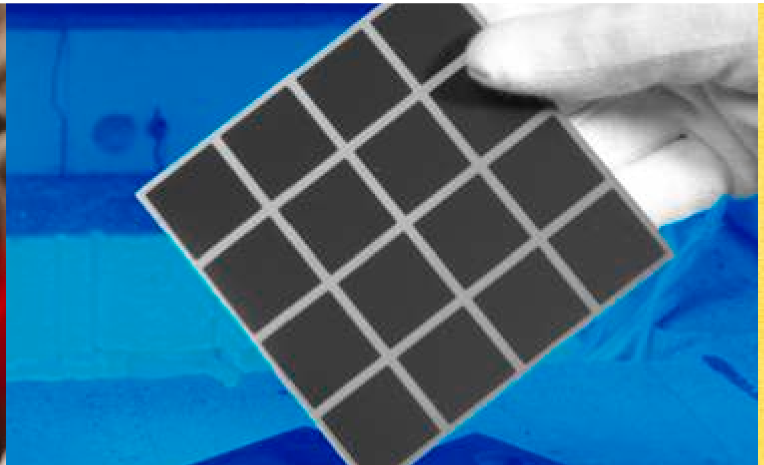
The objective of the department Computational Electrochemistry is the development of mathematical models for the chemical and physical processes in batteries and fuel cells with the purpose to investigate them with the help of computer simulations and mathematical analysis. The deeper understanding of the complex electrochemical multiphysics processes facilitates the conception of model based optimization strategies for design, power density and life time of batteries and fuel cells. The research is performed at the two locations of the DLR in Stuttgart and the Helmholtz-Institute for Electrochemical Energy Storage in Ulm.

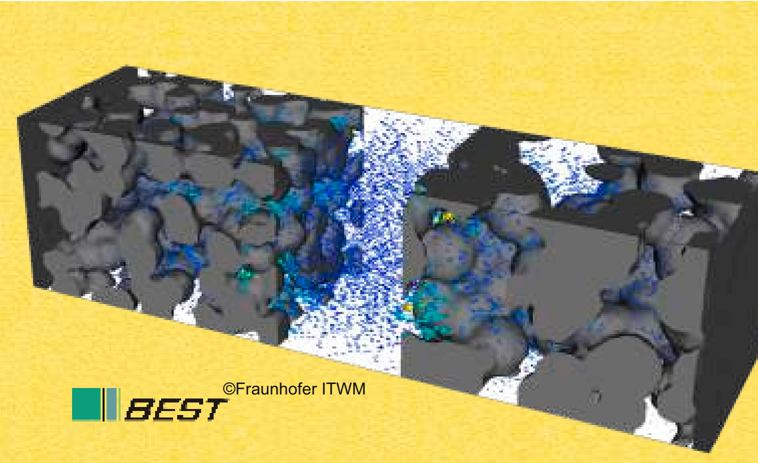
The activities are focused on three main topics
- Investigations of structure – function relations in batteries and fuel cells by microstructure simulation
- Research and applications of theoretical concepts for the coupling of processes on different time and length scales
- Modeling and simulation of degradation mechanisms in batteries and fuel cells

Modeling of fuel cells covers the main types of fuel cells as PEFC, SOFC and DMFC. Important research topics are the kinetics of electrochemical processes and reactions leading to degradation on the nanometer scale, as well as the investigation of multi phase flow and charge transport in porous electrodes on the micrometer up to centimeter scale.

Modeling of battery is concerned with established lithium ion intercalation batteries as well as more experimental concepts like lithium sulfur and lithium air batteries. Rigorous thermodynamic methods and three dimensional simulations techniques are used to study the influence of electrochemical processes as well micro – and nanostructured electrodes and the macroscopic cell design on the life time and power density of batteries.







Battery test bed

Due to the fields in which it researches, the institute acts as a bridge between basic research and industrial development, and thus often plays a key role in the introduction of new technologies. In addition to research and development, other important functions are advising political and business decision-makers and advanced training of young scientists.

With its strategic, long-term research and developmental work in the field of energy engineering, the institute makes a major contribution to ensuring power supplies that conserve natural resources and thus to sustainable development for our society.

Studying high-temperature ceramic components

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 7,400 people are employed at sixteen locations in Germany: Cologne (headquarters), Augsburg, Berlin, Bonn, Braunschweig, Bremen, Goettingen, Hamburg, Juelich, Lampoldshausen, Neustrelitz, Oberpfaffenhofen, Stade, Stuttgart, Trauen, and Weilheim. DLR also operates offices in Brussels, Paris, Tokyo, and Washington D.C.

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Knowledge for Tomorrow

Wissen für Morgen

Institute of Technical Thermodynamics

DLR

An Overview of the Institute

The Institute of Technical Thermodynamics at the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt - DLR) does research in the field of efficient energy storage systems that conserve natural resources and next generation energy conversion technologies with a staff of 160 scientific and technical employees, engineers and doctoral candidates.

The spectrum of activities ranges from theoretical studies to laboratory work for basic research and to the operation of pilot plants.

These experimental and theoretical studies are accompanied by systems analysis studies to analyse the associated technological, environmental and economic potential and situate it in a larger overall context of the energy economy by means of scenarios. In addition to these core activities in the DLR field *Energy,* the Institute of Technical Thermodynamics also works on selected subjects from the fields of *Aviation* and *Transportation,* thus contributing to other focal points of the DLR. These include developments to the use of fuel cells in aircraft and ground vehicles and to the generation and storage of hydrogen.

A major characteristic is the interdisciplinary collaboration of the departments, so that skills and synergies are utilized to the full extent of project work. The institute and its activities are very well integrated in national and international research networks.

Developing power supply concepts