Fraunhofer
ISE

FRAUNHOFER INSTITUTE FOR SOLAR ENERGY SYSTEMS ISE

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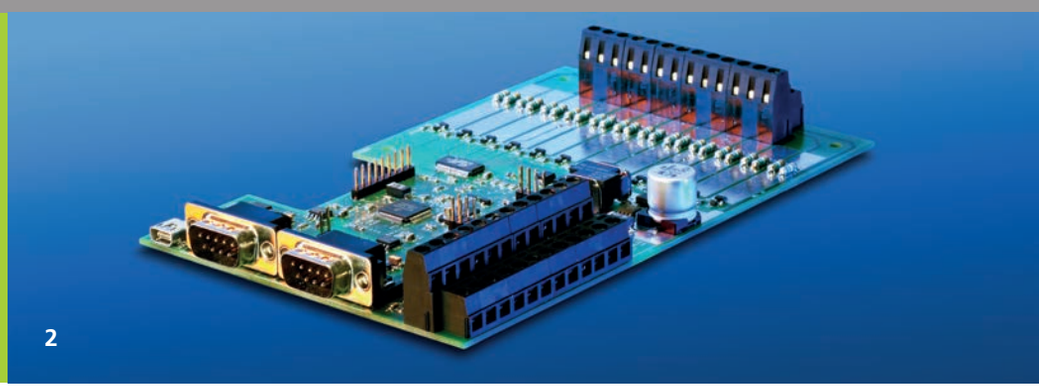

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1 *Home battery storage for photovoltaic systems.*
2 *Battery management system.*

BATTERY SYSTEMS

Developing powerful energy storage systems is essential for the efficient use of renewable energy. Reliability, safety, efficiency and a long-life cycle are key for any battery system.

Fraunhofer ISE has made the optimization of battery systems along the entire value chain – from the cell to the complete system – a priority.

Depending on the application and load profile, the requirements for future battery systems will be tremendous. They will have to be safe and able to withstand dramatically fluctuating ambient temperatures; they must have long service lives in terms of both time and the number of cycles, and they must be able to be charged quickly while also remaining affordable.

Our combination of extensive technical knowledge, many years of experience, innovative thinking and a high-quality laboratory environment allows us to competently support our clients in developing competitive products. Every step of the way, we help our customers by choosing the smallest cell, developing the final system and integrating it into the application.

We offer a wide range of services, including tests and characterizations of battery cells, modules, and systems up to 250 kilowatts; developing optimized, application-specific system solutions for stationary and mobile applications as well as modeling and simulation at different scales.

In modern battery systems, battery and energy management are particularly important. Here too, we can share our comprehensive expertise. Our specialties include lifetime prediction algorithms and a precise determination of the state of charge and state of health. We rely on our system and aging models developed using the latest simulation tools and validated with measurement data from our laboratory.

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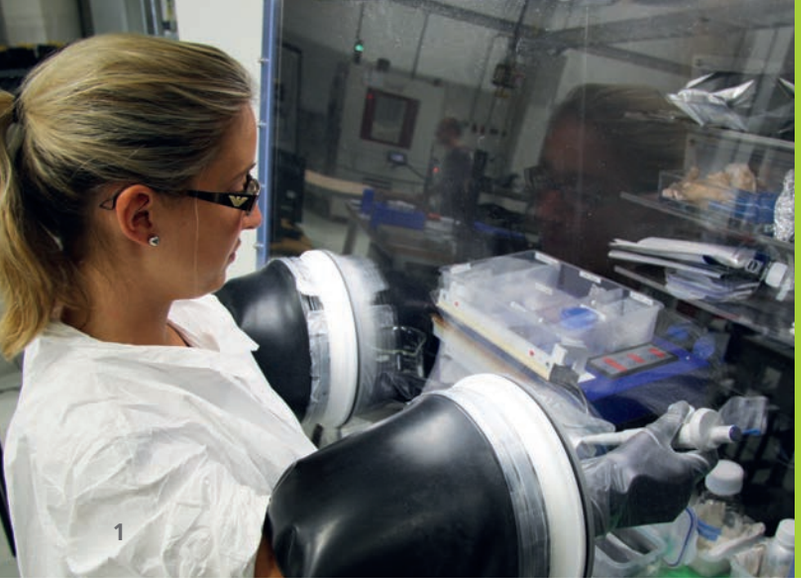

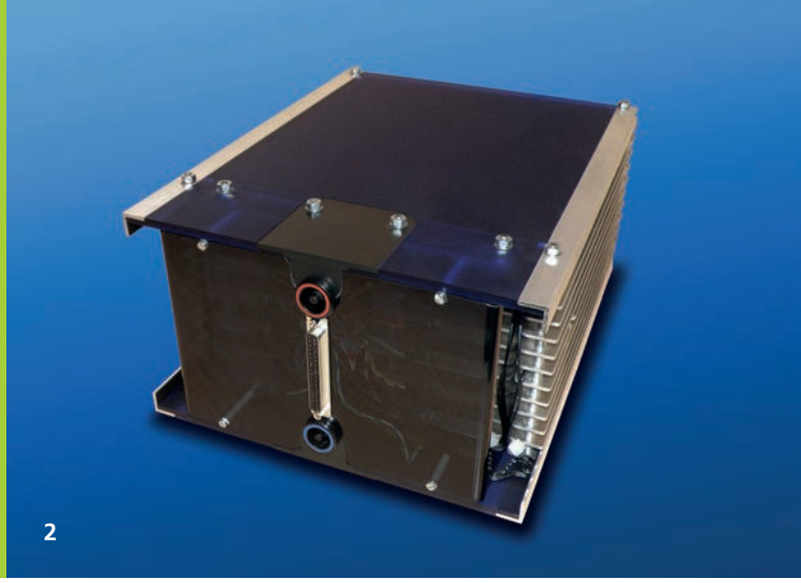

Cells

The starting point for developing battery systems is the individual cell. In order to achieve the best possible results for a specific application, Fraunhofer ISE provides the following R&D services for a variety of different cell types (lithium-ion batteries, lead-acid batteries, nickel-based batteries, etc.):

- cell characterization
- electrical performance tests
- thermal studies
- aging studies
- modeling and simulation (time and space-resolved)

Formation

For lithium-ion cells, we also work to optimize formation processes using both experimental and simulative approaches. Not only do these processes have a decisive impact on performance and lifecycle, but they are also a significant cost factor in cell production.

Modules

Modern battery systems have modular structures for easy integration in a variety of system solutions, with a module typically consisting of a certain number of serially connected cells. The work of Fraunhofer ISE in this field focuses on the following areas:

- development of application-specific modules
- structure design and cell contacts
- thermal management
- safety concepts
- modeling and simulation (time and space-resolved)

Systems

Battery systems are used in a wide variety of applications: e-mobility, home storage and large-scale storage (one or more megawatts). We develop optimized system solutions for all of these applications, from a few watts upwards (including hybrid storage with multiple kinds of cells) to connected loads of 100 kilowatts and above and DC voltages of 1000 volts. In this area, Fraunhofer ISE offers the following services:

- development of application-specific system solutions
- cooling system design
- development and implementation of safety concepts
- interface specification
- integration in energy systems
- modeling and simulation

Battery Management Systems

Every modern battery system has its own battery management system that performs a number of functions to ensure optimized, safe and reliable operation and therefore serves as the control center. Here, we provide:

- application-specific hardware design
- precise algorithms to determine state of charge and state of health
- aging and lifetime prediction methods
- optimized charging and operation strategies
- cell balancing

System Concepts and Analyses

Fraunhofer ISE has detailed models (system theory approaches, space-resolved approaches, descriptions of aging processes) for a wide range of battery technologies. With the help of simulation tools, these models are used to provide the following services related to system analysis and system concept development:

- simulation-based design and evaluation of battery-coupled systems
- selection of suitable technologies for different applications
- lifetime predictions for different technologies and applications
- cost analyses (levelized cost of electricity of PV battery systems, etc.)
- design of optimized stationary hybrid storage systems
- design of optimized (hybrid) battery-coupled drive trains
- reuse of old batteries (e. g. from electric cars)

1 *Studying lithium-ion batteries in a glove box in the ServiceLab Batteries of Fraunhofer ISE.*

2 *Lithium-ion battery module with high energy density for stationary applications.*