ZSW

1 A Brief Introduction

The Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (ZSW), or the Centre for Solar Energy and Hydrogen Research Baden-Württemberg as it is known in English, is a leading institute for applied research in photovoltaics and battery and fuel cell technology. ZSW also investigates the production of renewable fuels and hydrogen and conducts economic analyses of energy systems.

The institute engages in alliances with universities, research institutions and businesses at home and abroad.

2 Mission

Established in 1988 by the state of Baden-Württemberg, the universities of Stuttgart and Ulm, the German Aerospace Centre, and several business enterprises, ZSW is a non-profit foundation under the German civil code.

Its purpose is:

"to conduct and promote research and development in the field of renewable energies, energy efficiency, energy conversion and storage, with a focus on solar energy and hydrogen technology, in co-operation with universitary and non-universitary research and by transferring the results into industrial application."

ZSW has been accomplishing this mission with great success since its inception. For example, the institute bridged the divide between fundamental research and industrial manufacturing by developing CIGS thin-film technology for solar power generation that is now manufactured commercially.

3 USPs

- A leader in CIGS thin-film photovoltaics and multiple efficiency world record holder
- The leading testing centre (Solab) for photovoltaic modules of every technology
- The ability to correlate the results of field and laboratory measurements to test solar modules
- A frontrunner in application-oriented fuel cell technology spanning the entire value chain from material development to system testing
- Europe's largest development and testing centre for batteries with capabilities ranging from active materials and cell manufacturing technology to safety testing
- At the vanguard when it comes to developing manufacturing processes for lithium-ion battery cells in the lab, in pilot projects, and on an industry-like scale
- An aptitude for achieving the highest hydrogen content with thermo-chemical conversions of renewable resources
- The pacesetter in using hydrogen and methane to store to electricity (power-to-gas, P2G®)
- A preeminent policy consultancy and source of studies on energy economics in its specialty field
- A forerunner in renewable energy monitoring
- A leader in wind and photovoltaic power forecasting and site assessments
- The capabilities needed to simulate and optimize regenerative combined cycle power plants
- A diversified skill-set covering the full value chain from materials development to system testing
- Synergies achieved with advances in different but related fields

4 Research and Development Topics

ZSW's R&D efforts currently focus on:

- **Photovoltaics: Materials research**
  - Optimising semiconductors for absorbing solar radiation
  - Developing new types of solar modules
  - Developing manufacturing processes for conventional thin-film photovoltaic modules and for variants on flexible carrier foils
  - Developing solar cells with organic or inorganic absorbers using non-vacuum methods

- **Photovoltaics: Systems engineering**
  - Characterising solar modules of every technology in the Solab photovoltaic test laboratory
  - Taking field measurements of modules and systems at solar testing facilities in Widderstall, Baden-Württemberg, Germany, and Girona, Spain
  - Measuring and optimising solar power plants' yield
  - Conducting site and technology assessments
  - Calculating the local consumption of solar power in combination with storage systems and heat pumps, and the effects on the grid's load

- **Renewable fuels / hydrogen technology**
  - Developing electrolysis systems and operating and safety concepts
  - Developing different methods of producing hydrogen or synthetic fuels from renewable resources (e.g. electrolysis / power-to-gas technology / thermo-chemical conversion)
  - Reforming fuels for the operation of fuel cells

- **Fuel cells**
  - Modelling, designing and implementing PEM fuel cell stacks and fuel cell systems ranging from 5 W to 100 kW
  - Testing components, stacks and subsystems ranging up 120 kW_{el} using application-oriented methods
  - Optimising and characterising
  - Conducting failure and post-mortem analyses
  - Investigating automotive system technology

- **Energy storage in batteries and supercapacitors**
  - Synthesising new active materials and designing, characterising and building lithium-ion batteries
  - Operating an entire cell production line for cells in 18650 format, for pouch cells, and for cells in PHEV-1 format
  - Developing, validating and optimising production processes for (large) lithium-ion cells under factory-like conditions
  - Verifying advanced cell chemistries and optimised cell designs in large-format standard cells
  - Investigating all production-related issues from plant design to quality assurance processes
  - Providing consulting expertise on manufacturing technology and costing
  - Opening cells and carrying out post-mortem analyses
  - Optimising lead battery systems
  - Analysing aging mechanisms
  - Conducting battery system and safety tests

- **Economic analyses of energy systems**
  - Preparing strategic studies
  - Assessing energy systems and their prospects for development
  - Implementing innovative energy technologies in specific real-world applications
  - Providing policy advice at the federal and state levels
  - Forecasting wind and photovoltaic power using machine learning techniques
  - Simulating and optimizing virtual power plants based on renewable energies for municipalities and regions

5 Target Groups

Industrial enterprises, SMEs, power companies, the public sector, policymakers

6 Laboratory and Testing Facilities

Photovoltaics: Cleanroom with a pilot line for manufacturing CIGS thin-film solar cells on glass up to a size of 30 cm x 30 cm; roll-to-roll pilot line for manufacturing flexible solar cells; cleanroom for developing organic solar cells; a full analytical toolset for characterising solar cells, layers and modules; the Solab photovoltaic test laboratory; outdoor solar testing facility at Widderstall, Baden-Württemberg, Germany.

Renewable fuels: Several labs and test bays for developing and checking electrolysers and electrolysis blocks in the power range up to several 100 kW; various labs for converting biogenic residuals, producing hydrogen and analysing materials; a chemistry lab; various reactors for studying absorption-enhanced reforming / gasification of fuels (AER process) and for developing methods of storing surplus electricity as renewable methane by way of electrolysis and methanation (power-to-gas)

Fuel cells: An extensive equipment pool for fundamental electrochemical research, for fuel cell manufacturing and for post-mortem analysis; pilot plants for automated manufacturing of fuel cell stacks; simulation and modelling software; fuel cell test field with 20 fully automated and flexibly adaptable test bays for up to 120 kW

Battery storage: Lab equipment for synthesising and characterizing functional materials for energy storage; cell manufacturing technology; extensive battery test field with bays for small and large batteries; temperature chambers; impedance spectrometers and ancillary devices; extensive battery safety testing equipment; wet chemistry lab for battery analysis; a research production line for researching and developing the entire manufacturing process, from slurry production to cell formation, for automotive grade lithium-ion batteries under factory-like conditions

7 Workforce & Revenue

The three ZSW sites are currently staffed with around 230 employees and some 70 student assistants. The institute's scientists specialise in physics, chemistry, materials science, mineralogy, meteorology and economics as well as in chemical, environmental and electrical engineering. They are assisted by technicians who perform the physics and chemistry lab work and by industrial mechanics tasked to support prototype manufacturing.

Most recently, revenue came to around €34 million, around 85% of which is attributable to third-party funding.

8 The Organisation

ZSW consists of the *Photovoltaics* and *Electrochemical Energy Technologies* business divisions and the cross-divisional units *Energy Policy* and *Energy Carriers*.

Board of Directors:

- Prof. Dr. Frithjof Staiß – Managing Director (Energy Policy and Energy Carriers)
- Prof. Dr. Michael Powalla – Head of Photovoltaics
- Prof. Dr. Werner Tillmetz – Head of Electrochemical Energy Technologies

A list of the institute's departments follows. Each is staffed with experts in the given field and equipped with highly specialised laboratory infrastructure.

• Systems Analysis	Dipl.-Wirt.-Ing. Maike Schmidt
• Photovoltaics: Materials Research	Dr. Wiltraud Wischmann
• Photovoltaics: Modules Systems Applications	Dr. Jann Binder
• Renewable Fuels and Processes	Dr. Michael Specht
• Accumulators	Dr. Harry Döring
• Accumulator Materials Research	Dr. Margret Wohlfahrt-Mehrens
• Accumulators Manufacturing Research	N.N.
• Fuel Cell Fundamentals	Dr. Ludwig Jörissen
• Fuel Cell Stacks	Dr. Joachim Scholta
• Fuel Cell Systems	Dr. Alexander Kabza

The **Board of Trustees** serves in an advisory and policy-making capacity. It monitors the foundation's development for compliance with the articles of association and supervises the work of the Board of Directors. This Board is chaired by Dr. Christian Mohrdieck who presides over 20 members drawn from ministries, universities, research institutes and businesses.

9 Locations

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89081 Ulm, Laboratory for Battery Technology (eLaB), Lise-Meitner-Str. 24	Phone: +49 (0)731 95 30-500, Fax: +49 (0)731 95 30-599

For directions to all locations, visit www.zsw-bw.de.

10 Press Relations

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11 Public Relations at ZSW

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12 Further Information

- Internet: www.zsw-bw.de
- Annual reports
- Press releases and articles
- Scientific publications
- Flyers
- High-definition images (source to be acknowledged)