

// Gas processing technology: reforming and synthesis gas upgrade



ZSW is proud of its comprehensive and long-standing expertise in gas processing technology, which is demonstrated by the development and implementation of synthesis gas generation and its Power-to-Gas (P2G[®]) technology. This expertise can also be deployed in related areas and is offered as a service to interested parties. For example, reforming is used to generate hydrogen from methane for electricity and heat generation by means of fuel-cell combined heat and power (CHP) units. P2G[®] is the reverse process. If there is excess electricity, then electrolytic hydrogen (H₂) is generated, which is either used immediately (e.g. for mobility) or converted to methane in a further conversion step using CO₂. The range of services encompasses the development, dimensioning and qualification of individual process steps and also the basic engineering of entire process chains right up to the construction of demonstration systems.

Range of services

- > Basic engineering, consultation on process technology
- > Development, characterisation and qualification of process steps, components and overall processes
- > Demonstration system construction
- > Process simulation and monitoring
- > System integration
- > Process automation

Facilities

- > Test facilities suitable for endurance testing
- > Various reactor types
- > Gas analysis systems (IR, FT-IR, WLD, FID, GC and MS)
- > Volume flow measurement systems
- > Thermogravimetric analysis

// Contact

Dr Ulrich Zuberbuehler
ulrich.zuberbuehler@zsw-bw.de
+49 (0)711 78 70-239

// Gas treatment using membrane



Gas treatment by means of membrane technology makes use of the different material transport speeds (permeation rates) of individual gas components passing through a membrane. The engineering investment required for membrane technology is relatively low in comparison with other gas treatment methods. Membrane technology has a modular structure allowing it to be quickly adapted to changing operating conditions and a wide range of loads. The technology can be used for various separating tasks, such as the treatment of biogas to produce biomethane, and it is also suitable for smaller plants.

Range of services

- > Test facility for the characterisation of membrane modules
- > Investigation of dynamic long-term properties of gas by-products
- > Dimensioning gas treatment systems

Facilities

Versatile test bench:

- > Operating pressure: 0–16 bar
- > Operating temperature: 5–60°C
- > Volume flow: 0–20 m³_{STP}/h
- > Variable gas compositions, e.g. H₂, CH₄, CO₂, CO, N₂, H₂O, air
- > Gas analytics and quantity measurement

// Contact

Dipl.-Ing. (FH) Bernd Stürmer
bernd.stuermer@zsw-bw.de
+49(0)711 7870-249

// Renewable Fuels and Processes



Services for research and industry:

- > Conception
- > Basic Engineering
- > Demonstration plant construction
- > Test operation
- > Monitoring

Center for Solar Energy and Hydrogen
Research Baden-Württemberg (ZSW)

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// Water electrolysis and system concepts



ZSW benefits from its many years of experience in the design, dimensioning, installation, commissioning and pilot operation of electrolysis plants and also has expertise in data evaluation for these plants. The department currently operates an alkaline pressure electrolysis system and a PEM pressure electrolyser that uses either direct gas application or a pressure buffer. A new test bench also provides even more methods to test electrolysis blocks and individual system components.

Range of services

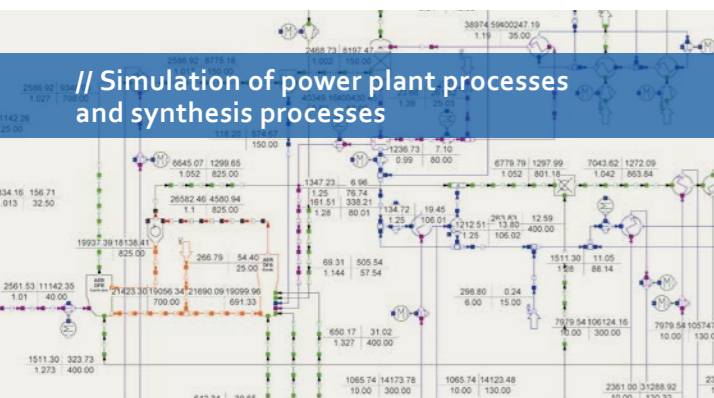
- > Development of our own electrolysis block concepts and the corresponding manufacturing processes
- > Development of electrolysis systems and concepts for operation and safety
- > Development of concepts for the installation and integration of electrolysis systems
- > Development of specifications for tendering
- > Performance and evaluation of measurements using electrolysis components on our own test benches
- > Performance and evaluation of measurements on electrolysis systems
- > Identification of the potential for optimisation
- > Supervision of the construction and commissioning of electrolysis systems

Facilities

- > Alkaline pressure electrolysis system, 320 kW_N, 6–11 bar
- > PEM pressure electrolyser 1.8 kW_N, 1–30 bar at P_N
- > Alkaline block test bench, 1 cell, 2–20 cell blocks, max. 6,000 cm² electrode area, 3–16/ 25 bar, 0–5,000 A_{DC}, 1–50 V_{DC} max.

// Contact

Dipl.-Ing. Andreas Brinner
andreas.brinner@zsw-bw.de
+49 (0)711 78 70-338



// Simulation of power plant processes and synthesis processes

The modelling and simulation of power plants and renewables-based synthesis processes are an essential factor in the expansion of renewable energy sources. The process efficiency and the profitability of planned plants must be quantified under variable conditions before recommendations regarding engineering and subsequent operation can be made. Simulation combined with technology monitoring can also be used to determine the potential for optimisation in regard to existing systems. To do this, ZSW uses the IPSEpro software (Integrated Process Simulation Environment). This software focuses on the simulation of detailed overall process chains, including the necessary peripheral systems, for example, the methane and hydrogen generation processes.

Range of services

- > Identification of detailed mass and energy balances for plant engineering
- > Simulation-based development of innovative process combinations for power plant processes and synthesis processes
- > Process optimisation by means of simulating alternative plant configurations
- > Recommendation of favourable operating conditions via sensitivity analysis
- > Monitoring and analysis of existing plants by means of process simulation

Facilities

- > IPSEpro process simulation software
- > Commercial and own model libraries

// Contact
Dr Jochen Brellochs
jochen.brellochs@zsw-bw.de
+49 (0)711 78 70-211



// Technical monitoring

ZSW has extensive expertise in the field of technical monitoring, which encompasses monitoring of many decentralised energy systems with low power outputs (e.g. combined heat and power in the domestic energy supply) and centrally-installed power systems with industrial megawatt outputs. Some of the highlights of this work include scientific supervision of the flagship Callux project in terms of the preparation of fuel cell combined heat and power (CHP) units for market launch and also the technical monitoring of Audi's 6 MW Power-to-Gas plant in Werlte. As part of the monitoring process, ZSW provides technical expertise in the development of concepts, supports the production of basic calculations, defines the required measurement points and creates data transfer concepts. ZSW has a comprehensive IT infrastructure that ensures the efficient collection and processing of data. As part of the reporting process, the data is analysed, and this analysis forms the basis of recommendations for process optimisation.

Range of services

- > Development of concepts for plant monitoring
- > Recording existing data and measurements
- > Data processing and evaluation
- > Reporting and analysis of recommendations for process optimisation

Facilities

- > IT expertise for data transmission

// Contact
Dipl.-Ing. Stefan Steiert
stefan.steiert@zsw-bw.de
+49 (0)711 78 70-257



// Conversion of biogenic residues

Since 2001, ZSW has been active in the field of thermochemical biomass conversion in fluidised bed reactors. Making use of its high-quality laboratory infrastructure, ZSW has focused on developing innovative processes to convert mineral-rich substitute fuels, such as biogenic residues. Selecting the right fluidised bed material is the key to successful commercial implementation. ZSW's expertise in this area covers the selection, testing and application of reactive fluidised bed materials on a MW_{th} scale.

Range of services

- > Research on the applicability of substitute fuels in the fluidised bed process
- > Selection, development and recommendation of reactive fluidised bed materials

Facilities

- > Fluidised bed test platform up to 20 kW_{th} fuel thermal input
- > High-temperature rheometer test bench with proRheo R180 rotational viscosimeter
- > Ball mill for identifying the resistance of fluidised bed materials
- > High-temperature furnaces for fuel treatment and the preparation of fluidised bed materials
- > Analysis of the particle size distribution

// Contact
Dr Jochen Brellochs
jochen.brellochs@zsw-bw.de
+49 (0)711 78 70-211



// Thermogravimetric analysis

Thermogravimetric analysis (TGA) measures the mass change in a sample based on temperature and time. Therefore, the conversion in the gas-solid reactions can be broken down into periods of time and the influence of individual parameters (temperature, pressure and gas composition) can be determined by changing the reaction environment. TGA makes it possible to study the individual steps of gas generation, gas conditioning and gas purification and it also allows materials like sorbents and catalysts to be characterised.

Range of services

- > Identification of favourable reaction conditions for catalysts
- > Studying deactivation mechanisms
- > Kinetics measurements
- > Screening of catalytic activity
- > Cycle stability tests
- > Identification of sample composition
- > Research on biomass conversion properties during pyrolysis or gasification

Facilities

- > Netzsch STA 409 CD atmospheric thermobalance
- > Rubotherm DynTherm high-pressure thermobalance (pressure-operated to 40 bar) linked to IPI GAM 400 mass spectrometer

// Contact
Dipl.-Ing. (FH) Peter Sichler
peter.sichler@zsw-bw.de
+49 (0)711 78 70-149