Bern University
of Applied Sciences

BFH Energy Storage Research Centre

What sets us apart

The BFH Energy Storage Research Centre develops solutions for the energy production of tomorrow. These solutions make it possible for renewable energies from decentralised production to be integrated into the supply grid, and to replace fossil fuels for transportation. The objective is to better exploit the potential of sustainable energy sources such as photovoltaic and wind power.

The BFH Energy Storage Research Centre unites several research groups of the Bern University of Applied Sciences (BFH) and works closely with the battery specialists at the "Centre Suisse d'Electronique et de Microtechnique SA" (CSEM, Swiss Centre for Electronics and Microtechnology, Neuenburg). The researchers address the challenges of electrical energy storage for energy production and mobility.

Multidisciplinary and good networking

The combination of skills from energy research, business and IT-assisted management provides the foundation for a holistic approach to the energy storage question all under the same roof. In this way the BFH Energy Storage Research Centre promotes interdisciplinary cooperation, advances the development of skills, strengthens the transfer of knowledge and technology, and opens up new areas of energy research.

The commitment of the BFH to the Swiss Competence Centres for Energy Research (SCCER) "Storage", "Mobility" and "Grids" is highly beneficial. This collaboration ensures access to the most important national and international research networks in the field of energy storage and its applications. This is particularly valuable for the external partners of the BFH Energy Storage Research Centre.

Comprehensive consultancy skills

In their work the researchers at the BFH Energy Storage Research Centre aim to provide competent and comprehensive advice to the decision-makers in administration and industry in three main areas:

- the selection, development and use of electrical storage systems for energy and mobility applications;
- the operational management of such storage systems based on needs and optimised for their cost-effectiveness and benefits; and
- when assessing investments in storage systems and facilities as well as their business models. Electricity supply and demand as well as the expected innovations and falling costs of storage systems are taken into account here.

To achieve this goal the BFH has joined with its laboratory infrastructure partner CSEM one of the most modern laboratory facilities for the research of electrical energy storage in Switzerland. The test equipment for batteries and fuel cells enables the researchers to measure and determine the characteristics of cells and modules in a wide range of different environmental conditions, for applications in energy production and mobility. What is more, the Prosumer-Lab allows to test all the components of a "Smart building" up to a connected load of 50 kW and optimise their interactions by means of an energy manager system.

Research applications via partnerships

The BFH Energy Storage Research Centre is situated in the buildings of the Switzerland Innovation Park Biel/Bienne – in direct proximity to Biel railway station and the planned BFH campus.

The Innovation Park promotes the networking of industry, research and specialists, and with its highly modern infrastructure creates an appealing environment for innovation. Thanks to the Switzerland Innovation Park Biel/Bienne and the proximity to industry, the research results of the BFH Energy Storage Research Centre can be implemented in practical applications directly and through partnerships.

Our goal is to nurture discoveries and develop technologies that contribute to ensuring the sustainability of the Swiss energy system.

A challenge for society

Efficient technologies for the storage of electricity are of great importance in the energy and mobility sectors. They are essential to achieve tomorrow's energy requirements.

The reliable production of electrical energy and a high degree of mobility are important factors for the high quality of life of the populace and for an effective economy. The dominant role of nuclear energy and fossil energy carriers is, however, being increasingly called into question by politics and society. An increasing number of people consider the risks that these entail to be unacceptable: nuclear accidents, long-term storage of nuclear waste, the burden on the environment caused by combustion engines in terms of noise, emissions, global warming.

The transition to renewable energy carriers, and the replacement of fossil fuels by the CO_2-free production of electrical power, present great challenges. Of central importance here is the use of electrical energy storage systems to balance out the fluctuating availability of wind and solar energy.

Expertise in the service of Energy Strategy 2050

Investments in renewable energies are capital-intensive, and they only become profitable in the long run. This forces investors to make their decisions on the basis of assumptions about the effect that innovations will have in future and possible scenarios of how costs and prices will develop. Uncertainties concerning the speed of innovation, technical development, market growth, decreasing costs, and the demand-related sensitivity of pricing, lead to delayed investment decisions and a tendency to cling on to existing systems. All this stands in the way of achieving the targets of the Swiss Federal Council's Energy Strategy 2050.

And this is precisely where the BFH Energy

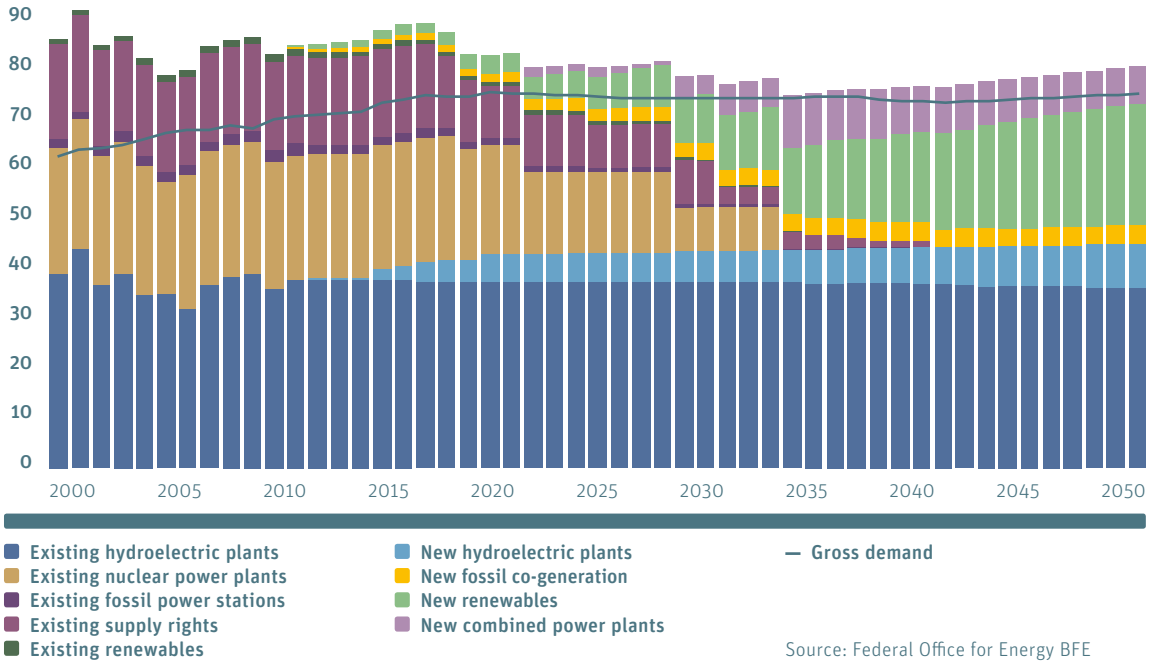
Storage Research Centre comes in. With its interdisciplinary approach it adopts a strategy of combining the skills that already exist in the relevant disciplines. The combination and interplay of expertise in information processing, a profound knowledge of the energy market, and skills in social and economic sciences, provide the conditions needed to master the challenges.

Great tasks, great ambitions

The BFH Energy Storage Research Centre has set itself the goal of achieving a leading position in the field of electrical storage technologies in national energy research. To achieve this, the site is to be developed so that it becomes a unique centre in Switzerland for competencies at the interface between energy management and mobility. The cooperation with the CSEM in Neuenburg and the BKW technology centre in Nidau are visible signs of how well the research work of the BFH Energy Storage Research Centre is being recognised and received.

The replacement of nuclear energy: the prognosis for 2050

in TWh



Storage technologies are needed first, to make possible the effective use of renewable energies in the energy sector and in mobility – this makes them a key element in a future sustainable energy policy.

Source: Federal Office for Energy BFE

Electrochemical energy storage systems

Modelling and determining the characteristics of electrochemical storage cells is essential for the successful use of electrical storage systems. It is also necessary to develop and test complete battery and energy systems.

The industry is increasingly using electrochemical storage systems, and in this respect there is currently a major focus on lithium-ion batteries for mobile and stationary applications. With electrochemical energy storage, researchers want to contribute towards the successful implementation and optimal use of these applications. For this, various technical aspects of batteries such as capacity, reliability and length of useful life present great challenges. One of the goals is to determine the optimum parameters to incorporate electrochemical storage systems in a wide range of different applications. Many different methods of testing and determining characteristics are used for this.

Sophisticated battery management

The safe and correct use of electrical storage systems is ensured by battery and energy management systems (BMS and EMS). Among the most important functions of these systems are the monitoring of temperature, voltages and current, maintenance scheduling, optimisation of battery capacity, failure prediction and / or avoidance, as well as the collection and analysis of battery data.

The researchers specialising in battery management systems are also developing efficient and reliable hardware and software for the BMS and EMS. For this they test, develop and validate model-based software algorithms and hardware modules for a wide range of battery applications.

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We test and determine the characteristics of batteries and our circuits and software make storage systems safe and reliable.

The experimental determination of the characteristics of storage systems is the basis for developing battery systems for home storage units and electromobility.

Manufacturing technologies

The manufacturing of batteries is one of the key technologies for achieving the goals of the “energy turnaround” or transformation (Energiewende). The specialists in manufacturing techniques optimise the production process in combination with the development of more efficient and robust devices.

High-performance, safe and inexpensive energy storage systems are essential for emission-free mobility and day/night storage for the energy turnaround. For this technology to succeed, new and more efficient production methods must be developed. This means that for each line, a complete battery cell must come off the production line every 30 seconds. These production methods must enable mass production of batteries with a high capacity and top quality with minimum waste.

The specialists in manufacturing technology are developing production methods for battery cells that make the process more robust and efficient. Virtual depictions are created and optimised holistically for planned and existing lines. This goes way beyond standard materials flow planning. The entire production process can also be mapped. Smart sensors automatically check the virtual or real performance and product quality. They autonomously intervene during the manufacturing process in order to achieve a better result.

“Industry 4.0” manufacturing environment

Only the combination of different disciplines – automation and control systems, data communication and data management, and mechanical engineering – can pave the way to an “Industry 4.0” manufacturing environment. The work focuses on integrating the individual steps within the overall, optimised manufacturing process, and developing production methods and machines to manufacture large-format battery cells. Additionally the researchers are developing versatile cutting technologies to process and form the structure of electrodes using lasers.

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The team makes its knowledge of the construction and optimisation of production plants directly available to the Swiss mechanical engineering industry and the battery manufacturers.

Laser-formed current collector: Laser automation is fully parameter-based and allows a flexible geometry of design.

Hydrogen systems

The specialists have the comprehensive knowledge for an optimal design of hydrogen-based energy systems and how to operate them safely and efficiently. Their fuel cell systems are tested in numerous projects for mobile applications.

Hydrogen is the purest form of energy and is set to replace fossil fuels in the long term. Electrolysers and fuel cells are the energy converters needed for the use of hydrogen energy. These systems feature a high energy efficiency, are relatively simple in design, and have a minimal impact on the environment.

Expert knowledge for construction and operation

The laboratory staff develop and build fuel cells based on their award-winning design, IHPoS (Independent Hydrogen Power System). For this they assemble a cost-optimised gas peripheral system and incorporate the fuel cells in a compact manner, taking into account the heat flow. The way in which a fuel cell is operated is important for its high efficiency and long life. The deep expertise in how fuel cells should be started, operated and shut down is based on many years' experience and extended field tests. The functions provided by the management systems enable an optimum integration of the fuel cells within complex energy systems.

The precondition for market penetration of hydrogen systems and their storage systems is a manufacturing method that is suitable for low-cost mass production. Electrical storage is used to adapt the systems to the individual energy and performance requirements and to the environmental conditions of each application. The modern infrastructure of the H_2-Lab can handle capacities from a few hundred watts up to several kilowatts. These systems are ideally suitable for portable and mobile electrical power supplies.

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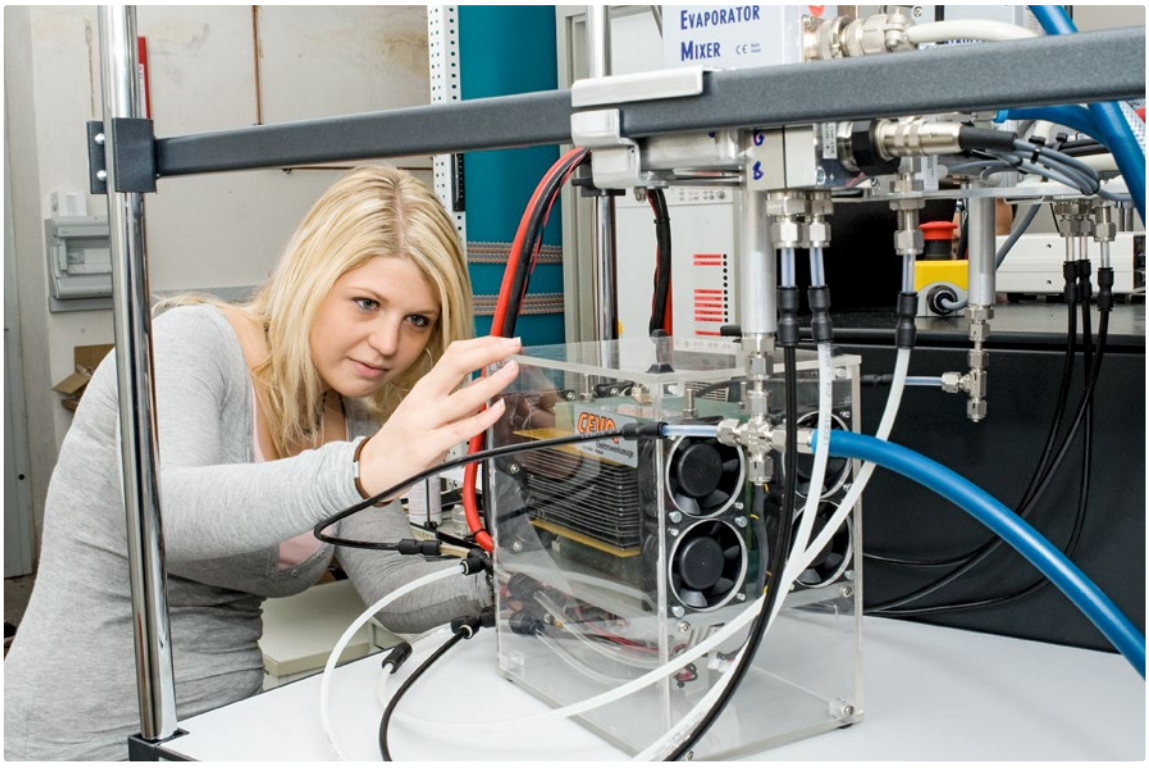
We develop fuel cells and electrolysers and combine them with storage units to modern hydrogen systems.



A stack of IHPoS modules is connected to the test stand for PEM fuel cells, to study the effects of various operating conditions on their long-term behaviour.

Power Grids

Increasing fluctuations in energy production and consumers' needs call for a better knowledge of the electricity grids. Wide-area measurement campaigns provide the information required to build up accurate grid models and to analyse future scenarios.

Electrical power production is in a phase of great transformation. The growing share of fluctuating renewable energies such as wind and solar power as sources of electricity is leading to greater production-related fluctuations in the electrical system. At the same time the grid components are charged with higher dynamic loads, and the behaviour of the connected devices is becoming more multi-layered and complex. This brings the electricity supply systems to the limit of their capacity. To ensure reliable operation, the grid disturbing effects from the customers' installations have to be known and their interaction via the distribution grid decoded.

A detailed view of the networks

With their diversified equipment the BFH engineers measure and model the power quality in the distribution grids and power plant networks, particularly those with a concentration of decentralised electrical power production. In this way they get an overview of the load profiles, the voltage quality, and the oscillatory behaviour of the distribution grids of their partners. For modelling and analysing the grids, powerful simulation tools are used. With the help of validated models of the network components and customers' installations robust scenario analyses are carried out.

From these the researchers can derive their recommendations, which help to ensure that electrical grids are operated reliably and used to their full capacity. This in turn reduces the network costs.

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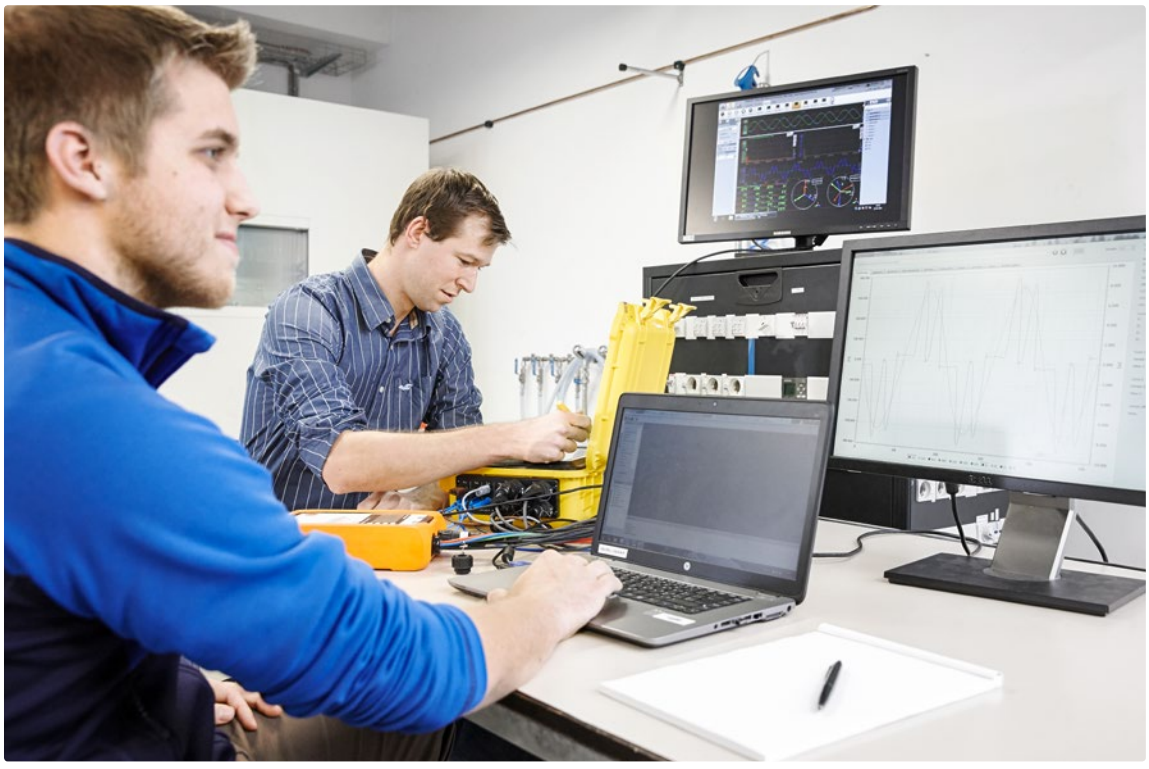
We measure and model power grids so that we can assess their static and dynamic behaviour and their voltage quality.



The power quality simulator is used to analyse the sensitivity of small devices to network disturbances, and their effects on the power grid.

The BFH photovoltaic laboratory has been carrying out research in the field of photovoltaic systems for almost 30 years. Solar modules are the most important new source of electrical power for the Energy Strategy 2050 of the Swiss Federal Council.

Photovoltaics

The laboratory for photovoltaic systems at the BFH in Burgdorf has been conducting successful research in the area of PV systems technology for over 30 years. This expertise is the ideal complement for what the BFH Energy Storage Research Centre already has to offer. The lab's extensive infrastructure is made available to Swiss industry as well.

Photovoltaics (PV) is the most important new source of electrical power in Switzerland within the framework of the Energy Strategy 2050. The researchers at the PV laboratory focus upon four professional competency areas:

- PV long-term measurement and quality control
- PV power inverters and storage tests
- PV-oriented buildings (PVOBs): Building skins with photovoltaics
- PV2X / EV2X: PV coupled with "smart consumers" such as electric vehicles

Infrastructure and know-how

The extensive test laboratories, the PV installations and one of the few high-voltage test laboratories in Switzerland, together with the entire infrastructure, are made available to Swiss industry and users for measurements and development products (KTI / Swissinnovation etc.). The employees offer support with analyses, advice, studies, lectures and training.

We test solar inverters with batteries and develop the necessary measurement infrastructure for this purpose.

PV long-term measurement and quality control

The long-term measurement of PV installations should document how reliable and productive PV installations are during operation. For this purpose, the researchers perform long-term measurements of 1 kWp to 2.1 MWp on more than 40 installations in three climate regions. Installations and components of third parties are also analysed. Infrastructure, activities and services:

- Operation of own PV installations from 2.5 to 60 kWp on school premises and the roof of the school building
- Safety (incl. fire prevention) of PV installations
- Storage in off-grid PV installations
- IR monitoring of PV installations by drone
- Electroluminescence and PV module test installations

PV power inverters and storage tests

The PV power inverter competence group has 30 years of testing experience. The PV power inverter test laboratory has been accredited with the Swiss Accreditation Service (SAS) since September 2017.

Infrastructure, activities and services:

- Measurements on diverse components of PV systems
- Testing of insulation strength as well as the lightning current sensitivity of solar modules
- PV power inverter test of single- and multi-string inverters
- Measurements and research on PV storage systems

PV-oriented buildings (PVOBs): Building skins with photovoltaics

In this new competency group, the engineers focus on PV building skins and the associated planning. Previously completed projects, some undertaken as Bachelor theses, include the 60 m-high residential tower in Sihlweid, Zurich, the preliminary planning of the world's largest PV stadium installation in Biel, and the "All-round solar skin" project. In cooperation with Gebäudeversicherung Bern, this project focuses upon the planning of PV façades and PV fire prevention. Infrastructure, activities and services:

- Planning of PV skins and calculation of PV revenues (PV-oriented buildings – PVOBs)
- Development of PV building components
- Measurement of coloured and neutral PV façades and PV roof elements
- Analysis of fires with PV installations

PV2X / EV2X: PV coupled with "smart consumers" such as electric vehicles

Today these are primarily the generators who consume the PV electricity themselves (PV2X). Electricity is increasingly entering local temporary storage, very often by means of electric vehicles (EV2X). Infrastructure, activities and services:

- Integration of smart grid components for PV installations
- Matching of PV revenue to PV consumption (KTI / Innosuisse projects etc.)
- Private consumption optimisation of PV installations
- Integration of storage systems / bi-directional electric cars
- PV and electric cars/charging procedure for electric cars

The list of activities and services is not exhaustive and is intended as a reference.

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Mobility

The development of high-performance and economic energy storage systems is the biggest challenge on the path to creating electric vehicles that are suitable for mass production. The design and integration of the traction battery is of central importance in the design of such applications.

Whether by road, rail, in the air or on water: thanks to high-performance lithium cells one finds that electric vehicles are penetrating the market more and more. In view of the present challenges faced by environmental policy, the advantages of electrical drives are evident. Electrical power, the fuel for electric vehicles, can be obtained from practically any primary energy source. Renewable energy from water, wind and solar installations is also available in sufficient quantities in Switzerland, and can be used in a sustainable way.

Expertise in business solutions

The limited options for storing electrical energy pose the greatest obstacle, this is especially true of mobile applications. Yet today in many cases chemical energy storage can provide economical solutions, provided the battery is optimally designed for the particular application.

With their broad-based expertise in batteries, the researchers at the BFH Energy Storage Research Centre are making an important contribution to the design of optimum energy storage systems for mobility applications of industrial partners. They record data and analyse characteristic vehicle parameters, produce models of vehicle operations, and determine application-typical load profiles, and derive the optimum battery parameters. This allows them to electrify vehicles in accordance with the standards and regulations.

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We determine the requirements for batteries in vehicles and incorporate them in accordance with the current regulations.

For vehicles to be electrified in an economically viable way, the energy requirement of the drive and ancillary modules has to be precisely determined. Students in the automobile section are analysing a small hybrid tractor.

Innovation management, business administration

The work on business and societal questions is a necessity for achieving the energy turnaround. In customer projects with clients from industry and public administration, organisational and system-theoretical methods as well as the tools of energy informatics are used.

The specialists for company and business model development and the IT-supported management of the BFH Energy Storage Research Centre analyse complex economic issues for their customers and develop innovative business models. In addition, they design management systems for energy storage and energy management.

We make the energy turnaround tangible and manageable.

Wide-ranging expertise

The skills of the researchers encompass a number of activities in the fields of management research and IT. The integrative analysis of innovative ecosystems to distribute battery storage technologies and manufacturing methods more widely is carried out using system simulations. The specialists also analyse how instruments designed to optimise energy consumption, such as taxes, tariffs and various technologies, can be made acceptable for specific target groups. Existing business models related to energy storage will have to undergo changes. They must be evaluated and enhanced.

Together with government and private business contractors, the specialists specify guidelines for the strategic target-setting and implementation. Questions concerning the protection of the privacy of the individual in “smart” energy distribution networks also need to be addressed. The protection of communication and management infrastructures using IT procedures is an important area of activity as well.

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Businesses prosper when they recognise the complexities of their innovative ecosystems at an early stage and purposefully align them with their business model. This is where we can help with concrete management methods.

Discussion about a digital prototype of a business model that can be represented by a simulation. To penetrate complex configurations requires a combination of expert knowledge from business and technology.

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