2/2018

energy innovation austria

Current Developments and Examples of Sustainable Energy Technologies

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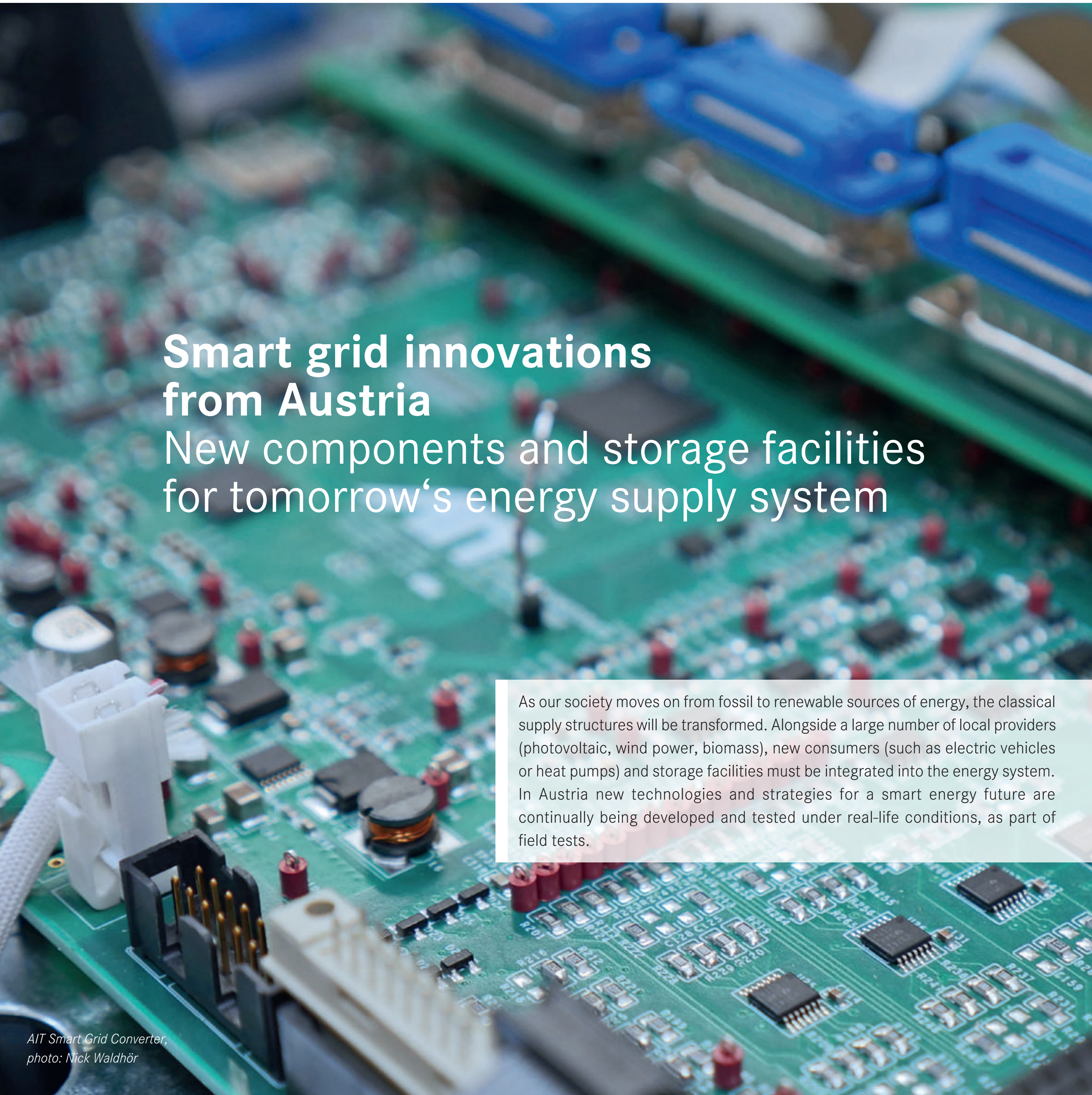
Smart grid innovations from Austria

New components and storage facilities for tomorrow‘s energy supply system

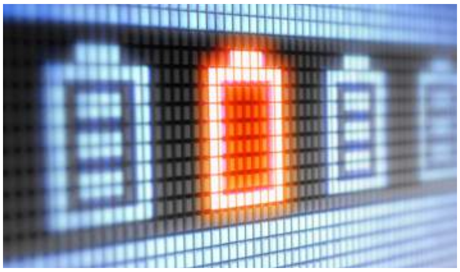
As our society moves on from fossil to renewable sources of energy, the classical supply structures will be transformed. Alongside a large number of local providers (photovoltaic, wind power, biomass), new consumers (such as electric vehicles or heat pumps) and storage facilities must be integrated into the energy system. In Austria new technologies and strategies for a smart energy future are continually being developed and tested under real-life conditions, as part of field tests.



AIT Smart Grid Converter, photo: Nick Waldhör

Innovations for sustainable energy supply systems
National and international activities

photos: phaisarnwong2517, Pavel Ignatov, franz12; all: fotolia.de


The energy transition will involve major changes to energy infrastructure. As renewable sources of energy are increasingly integrated into the system, energy consumers are coming to play an active part in the energy market. In the future smart grids will make it possible to coordinate providers, consumers and storage facilities in real time, with the aim of using the system's capacities to the full and manage energy intelligently. With pioneering smart grid technologies cross-sector coupling (linking electricity, heat and transport systems together efficiently and reliably) should be feasible.

To fulfil the new demands on our electricity grids, smart, flexible components will be needed. This applies not only to high- and medium-voltage networks, but also to low-voltage networks, all the way down to secondary circuits in industry and small-scale manufacturing.

Storage systems count as a vital element in implementing the energy transition. While storage systems will be used to ensure grid stability as renewables' share of supply increases (so that the rate of supply tends to fluctuate more), for various stakeholders in the energy system electrochemical storage systems may be interesting from an economic point of view in future. For instance, storage systems in owner-occupied dwellings make it possible to increase the extent to which electricity from, say, local photovoltaic (PV) facilities is used on the premises, yielding financial benefits.

From research to actual practice

For many years new technologies and strategies for a smart energy future have been developed and tested under real-life conditions in Austria, as part of demonstration projects and field tests in the smart grid model regions. In this issue we present some current research projects focussed on novel components for efficient energy management and on control strategies for storing electricity from renewables locally. Some of these pioneering solutions have already been tested under real-life conditions in Austrian communities in collaboration with local stakeholders, making it possible to evaluate and develop them further. ◘

SET-PLAN Action 4

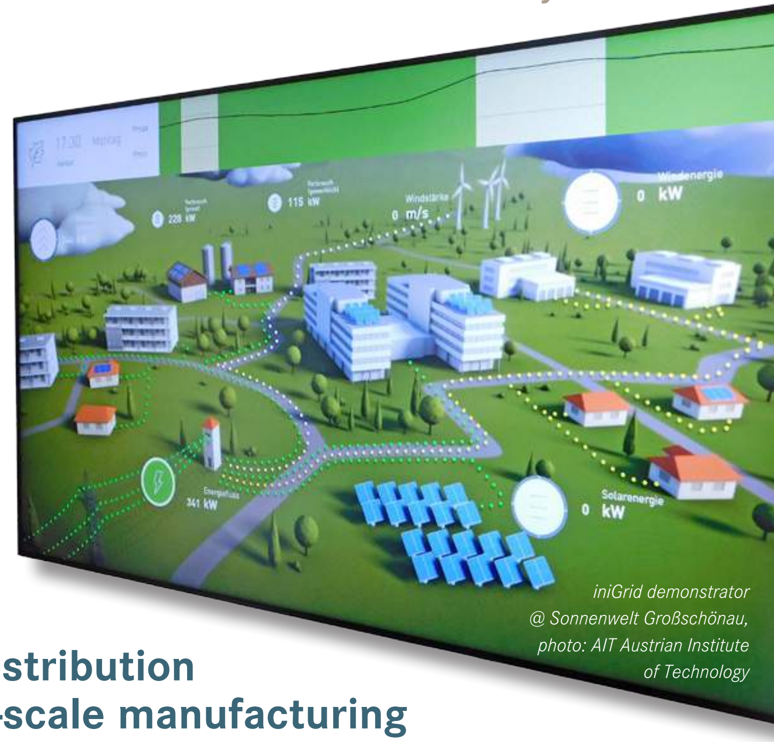
Austrian research and technological development in the field of smart energy systems is tied into the EU's strategies for a sustainable energy supply system. The European Strategic Energy Technology Plan (SET-Plan) is the technological mainstay of the European Energy Union. In the implementation plan SET-Plan Action 4 "Increase the resilience and security of the energy system" (published in January 2018), two new flagship initiatives were formulated.

One of these requires technologies for fine-tuned, reliable, efficient power grids in Europe to be developed further. Here the focus is on tying in electricity from renewables (fed in at fluctuating rates) by making the system flexible, increasing customer participation, plus storage facilities and coupling different sectors together. The other initiative is focussed on developing integrated local and regional energy systems, addressing not only the electricity sector but also other research topics such as flexible heat grids. Special emphasis will be placed on the fields of digitalization and smart services.
www.nachhaltigwirtschaften.at/en/news/2018/implementation-plan-of-set-plan-action-4.php englisch

ERA-Net Smart Energy Systems

The ERA-Net Smart Energy Systems contributes the implementation of the SET-Plan strategies. The programme platform for funding transnational RDD projects supports the development of integrated regional and local energy systems based on up to 100 % renewable sources of energy. Tying need-owners into co-creation processes at an early stage is vital.
www.eranet-smartenergysystems.eu

Digital showcase with Smart Breaker @ Ars Electronica Festival 2016, photo: Ars Electronica Solutions / Garamantis



iniGrid demonstrator @ Sonnenwelt Großschönau, photo: AIT Austrian Institute of Technology

iniGrid
Smart components for active distribution networks in industry and small-scale manufacturing

To integrate renewable sources of energy into our power grids, we need smart, flexible components for efficient network management. In the iniGrid project (Integration of innovative Distribution Sensors and Actuators in Smart Grids) AIT Austrian Institute of Technology is developing pioneering sensor and actuator technology for smart distribution networks, in collaboration with partners in industry and research institutes[1]. A keystone here is the so-called "Smart Breaker", a semiconductor switch for low-voltage applications. It not only provides switching and protective functions, but also allows for monitoring and remote control, thus opening up entirely new options for energy management within firms. As part of iniGrid the consortium is also developing a new voltage sensor for air-insulated medium-voltage facilities.

In conjunction with other technologies already on hand, such as smart metering and other existing sensor technology, the new components are being integrated into a secure, comprehensive automatization infrastructure supported by intelligent algorithms in the energy management system. How the new components interact with existing technology has been comprehensively validated in AIT's SmartEST laboratory by Hardware-in-the-Loop tests. From summer 2017 to spring 2018 the concept was tested successfully in a fieldtest at parts of the "Sonnenwelt Großschönau" exhibition in Lower Austria. Here the ventilation system, the lighting and the screens were automatically controlled, depending on the air quality and the movement of the visitors.

Low-cost all-in-one solution

The Smart Breaker is particularly suitable for use in industry and small-scale manufacturing. Every manufacturing plant has separate circuits for e. g. machines, lighting or ventilation. If the MCB's (Miniature Circuit Breaker) are replaced by the new Smart Breaker, various measuring and control functions are obtained in addition to circuit-breaking. All the power flows within the company can be made visible by means of Smart Breakers. An energy management system developed in the course of the project collects the data profiles and controls producers and consumers to meet given power and voltage limits as well as to minimize energy costs. With semiconductor technology this new-generation device can be built compact and produced at low cost. With conventional designs several elements (a measuring device, a remote trip, protective components and a communication unit) would be needed to achieve the Smart Breaker's functionality – involving much greater expense.

The iniGrid demonstrator

The specially developed iniGrid demonstrator models a virtual power grid in which electricity consumption and generation from renewables, are defined over time; a simulation shows how infrastructure capacity utilization varies with the time of year and time of day selected.

Visitors to the exhibition can test the range of functions provided by the new technology and intervene interactively in generation and consumption so as to create or avoid awkward situations, or deal with these automatically by means of the Smart Breaker and iniGrid algorithms. The iniGrid approach was also presented at ars electronica in Linz and in the Welios Science Center in Wels in 2017. ◘

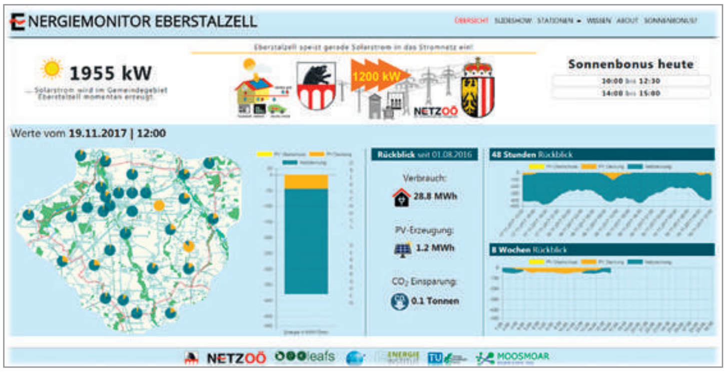
[1] *Commercial and research partners: AIT Austrian Institute of Technology GmbH, Eaton Industries (Austria) GmbH, Infineon Technologies Austria AG, Zelisko GmbH, Sprecher Automation GmbH, TU Wien (University of Technology Vienna) – Institute of Computer Technology (ICT), University of Applied Sciences Upper Austria – F&E GesmbH, Linz Strom Netz GmbH, MOOSMOAR Energies OG*

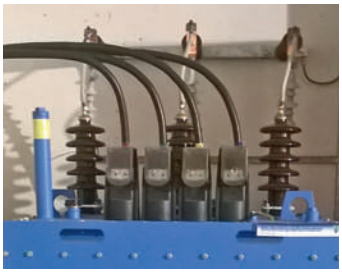
photo: Simon Kraus/fotolia.de

LEAFS
Integrating local storage systems and variable loading into low-voltage networks

With renewables' share of power generation steadily increasing, major challenges result, affecting not only high-voltage and medium-voltage networks but also low-voltage networks. This is due to the growing numbers of PV facilities and of additional consumers such as heat pumps or electric vehicles.

Today private PV facilities are operating in large numbers of Austrian households (about 60,000). Recently technologies for storing PV-generated electricity on the spot have been launched on an increasing scale. With compact electrochemical power storage units households can store the electricity they generate on the spot, and consume it themselves later. Up to now the grids have been dimensioned on the basis of statistical assumptions about consumers and producers. With new technologies such as on-the-spot storage and flexible loading, it is less and less feasible to obtain load profiles by purely statistical means. Instead, we get market-oriented load profiles with potentially great simultaneity in a node. If the new technologies spread widely enough, we may get thermal overloading and voltage problems in distribution networks.





above: energy monitor in Eberstalzell; below: control unit and step-down transformer in Köstendorf; all photos: AIT Austrian Institute of Technology

In LEAFS (Integration of Loads and Electric Storage Systems into Advanced Flexibility Schemes for LV Networks) an energy research flagship project, which AIT Austrian Institute of Technology is implementing in collaboration with commercial and research partners[1], technologies and operating strategies for active, network- and market-driven control of local storage systems and variable loading are being developed and tested in field trials. In addition, financial incentives are being evaluated and the cost-effectiveness of local storage systems analysed and assessed.

Simulation and technological development

Initially the researchers used simulations with representative model networks to investigate possible effects of market-driven storage utilization and load variability in distribution networks. They then developed new control strategies for various requirements: direct control of central (e.g. large-scale power storage) and local elements (e.g. household storage systems) as well as indirect control of local elements such as heat pumps or local storage systems on customers' premises via an energy management system.

Field trials

The various different methods of storage and control are being investigated and compared in network field trials in three communities: Köstendorf in Salzburg, Eberstalzell in Upper Austria and Heimschuh in Styria. In all three networks infrastructure from previous projects could be utilized to some extent, which saved expense and effort. For the various cases under consideration legal, economic and regulatory analyses were carried out, which will later be helpful when the new solutions are investigated for transferability and scalability.

Köstendorf (Salzburg Netz GmbH)

In the Smart Grid Model Community Köstendorf storage systems have been installed in five households with PV facilities, and integrated into the local control system, i.e. tied in with the Building Energy Agent (BEA), the regulated distribution transformer and the local electric vehicles. The Smart Control unit regulates the various elements indirectly. The grid operator acts as an aggregator, transmitting market signals.

[1] Commercial and research partners: AIT Austrian Institute of Technology GmbH (Project management), Fronius International GmbH, Siemens AG Österreich, Salzburg Netz GmbH, Netz Oberösterreich GmbH, Energienetze Steiermark GmbH, TU Wien (University of Technology Vienna) - Energy Economics Group, Energy Institute at the Johannes Kepler University (JKU) Linz, MOOSMOAR Energies OG

Central storage sytem in Heimschuh
photo: Energie Steiermark/Symbol

Eberstalzell / Littring (Energie AG/Netz OÖ GmbH)

Here three household storage systems have been installed in a single network segment. Based on weather forecasts the grid operator transmits network constraints, which the storage system must comply with, via the power line every day. As the need arises, an aggregator (in this case Fronius International GmbH) transmits a market signal directly to the device via the internet. This approach models a crucial scenario for the future.

"Sonnenbonus" involves a second field trial. Here financial incentives are to be tested in relation to the rate of local PV generation. The aim is to motivate households to consume the electricity generated on the spot in specific timeframes. The customers receive 10 cents per kilowatt hour if they consume as much power as possible when plenty of power is being fed into the grid. Via an application one can find out whether and when on the following day the "Sonnenbonus" will be available. More than 200 households are taking part in this field trial, which is now in progress.

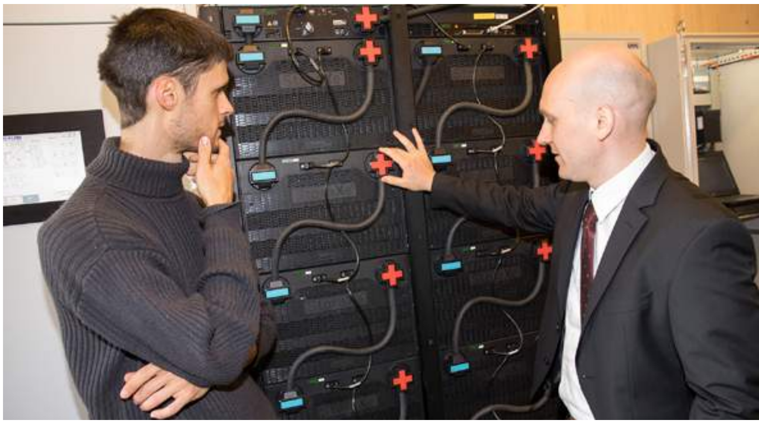
Heimschuh (Energienetze Steiermark GmbH)

In Heimschuh, a community in the south of Styria, nine households feed green power from their PV facilities into a central storage system, and withdraw it as the need arises. Usually the electricity from a household PV facility covers only about 30 % of an average household's power consumption, because demand often occurs when the sun is not shining. With a household storage system this figure can go up to as much as 70 %.

photo: Energie Steiermark / Christian Jungwirth

„One of the central challenges we face is making our power grid even more efficient, more flexible and technically smarter, so that – in spite of thousands of local generators making the situation more complicated – we can keep charges to customers as low as possible. The LEAFS project is an important contribution to this."

Christian Purrer and Martin Graf,
Directors of Energie Steiermark



above: storage block,
below: control unit in Heimschuh
all photos: Energie Steiermark/Symbol

Up till now PV electricity generated on the spot normally is stored in a household storage system. For the field trial a battery with a storage capacity of 100 kWh has been installed – equivalent to 20 household storage systems. The battery is rated at 100 kW, which means that the new storage system can be used by several households simultaneously. As a result the cost of installation and maintenance is reduced, and the various households need no space for a separate storage facility indoors.

The trial, which will run till march of 2019, is intended to show how this central power storage unit can benefit the local power network, the customers and the market. The storage system is under the direct control of the grid operator. In addition it can deliver market services such as participation in the spot market. The expectation is that costs for the network customers will go down, while power consumption will be reduced and the power grid will be relieved and stabilized. ◘

FACDS
Network services by means of local storage systems

The FACDS (Flexible AC Distribution Systems) research project, headed by Wiener Netze GmbH, is investigating how network storage systems can be utilized to improve distribution networks. For distribution network operators local storage systems are a new facility that can be put to work flexibly and actively, and regulated dynamically. With these network storage systems numerous options result for network services designed to improve network stability and quality and to ensure a reliable power supply as more power is generated and fed in locally and a large number of new consumers (e.g. electric vehicles) appear on the scene.

Demonstration trial in Aspern, Vienna‘s Urban Lakeside

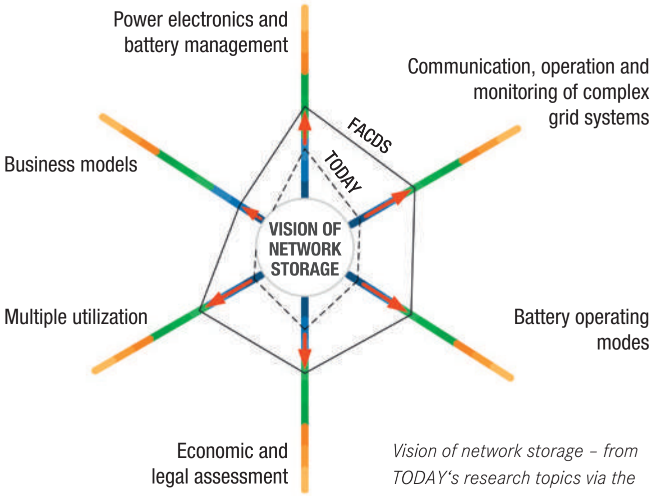
The pioneering approach is being investigated under real-life conditions in the ASCR (Aspern Smart City Research) testbed in Aspern, Vienna‘s Urban Lakeside. Apart from simulations and laboratory operation, a full-scale network storage system has been implemented, with five battery storage units installed in Aspern‘s smart transformer stations. The system consists of a lithium iron phosphate battery with a power rating of 100 kW and a capacity of 120 kWh, plus an inverter. Here dimensioning storage capacity, and various operating modes in the distribution network, are to be tested.

Strategies for cost-effective operation

How various different stakeholders can use network storage jointly is also being investigated. Apart from utilization by the distribution network operator, the storage system can also help the operators of local facilities to improve their own power consumption; and power providers could store electricity here when wholesale prices are low, and supply it to customers later at the market price.

photo: Wiener Netze GmbH

With suitable strategies for multiple utilization, operating electrochemical storage systems are to become more cost-effective. The key aspect here is using storage capacity and inverter power for network services; only residual potential should be employed to improve cost-benefit ratios. Alongside technological and economic aspects, the project will also spotlight the legal framework applying. ◘



Vision of network storage – from TODAY‘s research topics via the innovation hub to the project target, image: Wiener Netze GmbH

photo: Wiener Netze GmbH

„The new challenges in the energy sector are the goals of decarbonization, digitalization and decentralization. Influences at work in Austria and internationally encourage a definite trend toward energy self-sufficiency, electric-powered transport and cross-linking. Apart from expanding distribution grids, the energy transition requires that use can be made of network storage systems. Our research project is investigating a smart grid strategy to cope with several forthcoming network and market challenges. Electricity storage and flexible control of a smart grid, both relevant today, will be an essential issue tomorrow!“

Thomas Maderbacher
CEO Wiener Netze GmbH

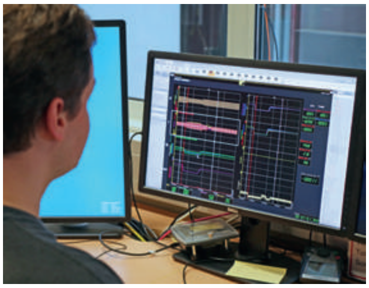


photo left: AIT Austrian Institute of Technology; upper photos: Nick Waldhör

AIT SmartEST Laboratory
Technical infrastructure for smart power systems

Implementing smart grids necessarily brings up the question of how new components and control strategies will affect the networks. Safety considerations preclude testing different scenarios in actual network operation. With the SmartEST Laboratory AIT Austrian Institute of Technology provides a unique test and research infrastructure for tomorrow's smart grids.

The laboratory offers researchers, grid operators and manufacturers of components for local electrical facilities an ideal experimental environment for development work. Here the interactions between equipment and the upper levels of the grid can be analysed and products like inverters, storage systems and smart meters as well as control strategies can be tested and developed further. The entire range of local power technology components, from PV inverters via power storage systems such as accumulators or fuel cells all the way to cogeneration units or charging points for electric vehicles, are candidates for testing.

With 400 m^2 of floor space, the laboratory has indoor and outdoor testing areas with many different functions. The infrastructure features three configurable laboratory networks that can be operated at a constant output of up to 1000 kW. The equipment includes network simulators, PV simulators, a facility for setting up stand-alone networks, facilities for Power-Hardware-in-the-Loop simulation, plus an environmental test chamber for extreme temperature and humidity conditions.

FUNCTIONS of the SmartEST Laboratory

> Accredited testing components and systems for local generation with simulated networks and primary energy sources (e.g. PV inverters)
> Electrical tests for switching, functions and performance as per standard
> Simultaneous testing of components' power and communication interfaces
> Performance and durability tests under controlled ambient conditions
> Simulation and testing of individual components and entire systems and facilities
> P-HIL tests using real-time simulation and multi-domain co-simulation
> Simulation of smart grid scenarios

In so-called Power-Hardware-in-the-Loop (P-HIL) simulations a node is simulated in real time and the components to be tested are tied into the virtual network environment as hardware. The simulations indicate how compatible the components in question are with the higher-level network structure and with other devices on hand. ◘

DC LAB – DC networks at medium- and low-voltage level

PV facilities, power storage systems, and accumulators for electric vehicles will play a key part in the power system of the future. All these elements operate with direct current; if they were tied directly into a DC network, the power losses resulting from inverting from Direct Current (DC) to Alternating Current (AC) could be diminished. Even today power from offshore wind parks is transmitted to the mainland over considerable distances as high-voltage DC, with a minimum of loss. In future DC networks could be employed at medium and low-voltage levels, too.

In the Austrian DC Labs project AIT Austrian Institute of Technology together with the Nikola Tesla Laboratory at Graz University of Technology is developing new methods of testing and certifying elements for these grids. This is intended to strengthen the hand of Austrian developers and manufacturers of power electronic components in global competition.

photo: Nick Waldhör

Wolfgang Hribernik
Head of Competence Unit Electric Energy Systems
AIT Austrian Institute of Technology

AIT's SmartEST laboratory is a front-runner worldwide in researching smart grids. Will the lab make Austria a pioneer internationally in this research field?
AIT's SmartEST laboratory is a unique development platform for smart grid technologies and system architecture: both solutions and products developed by partners in industry and AIT inhouse developments that will reach the market later. In this way AIT assists development processes within Austrian stakeholders, thus providing a competitive advantage, while also making AIT technologies more visible internationally.

What were the highlights so far among the poineering technologies tested here?
Power storage systems and their current and future jobs in the overall energy system are the dominant issues at the moment. With the aid of Hardware-in-the-Loop (HIL) methods, AIT supports system operators and manufacturers in virtually all the significant demonstration projects for utility-scale battery systems. Among the technologies developed by AIT, the AIT Smart Grid Converter (ASGC) is the centrepiece of power electronics systems.

The AIT Center for Energy collaborates with other top European laboratories in international networks. What specific goals are involved here?
For many years AIT has been an internationally active hub in smart grid research. It is a founding member of DERlab (European Distributed Energy Resources Laboratories), is active in the European Energy Research Alliance (EERA) and in the technology platforms involved in implementing the SET Plan. Going beyond Europe, AIT plays an active part in Implementing Agreement ISGAN (International Smart Grid Action Network), in which we also handle the operative business. The goals of these activities are: jointly setting research proirities at the European level, using and developing research infrastructure efficiently, and also promoting the mobility of researchers into smart grids. This last concern helps to make the research location more attractive, and gives us a cutting edge as regards competition for the best people.

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