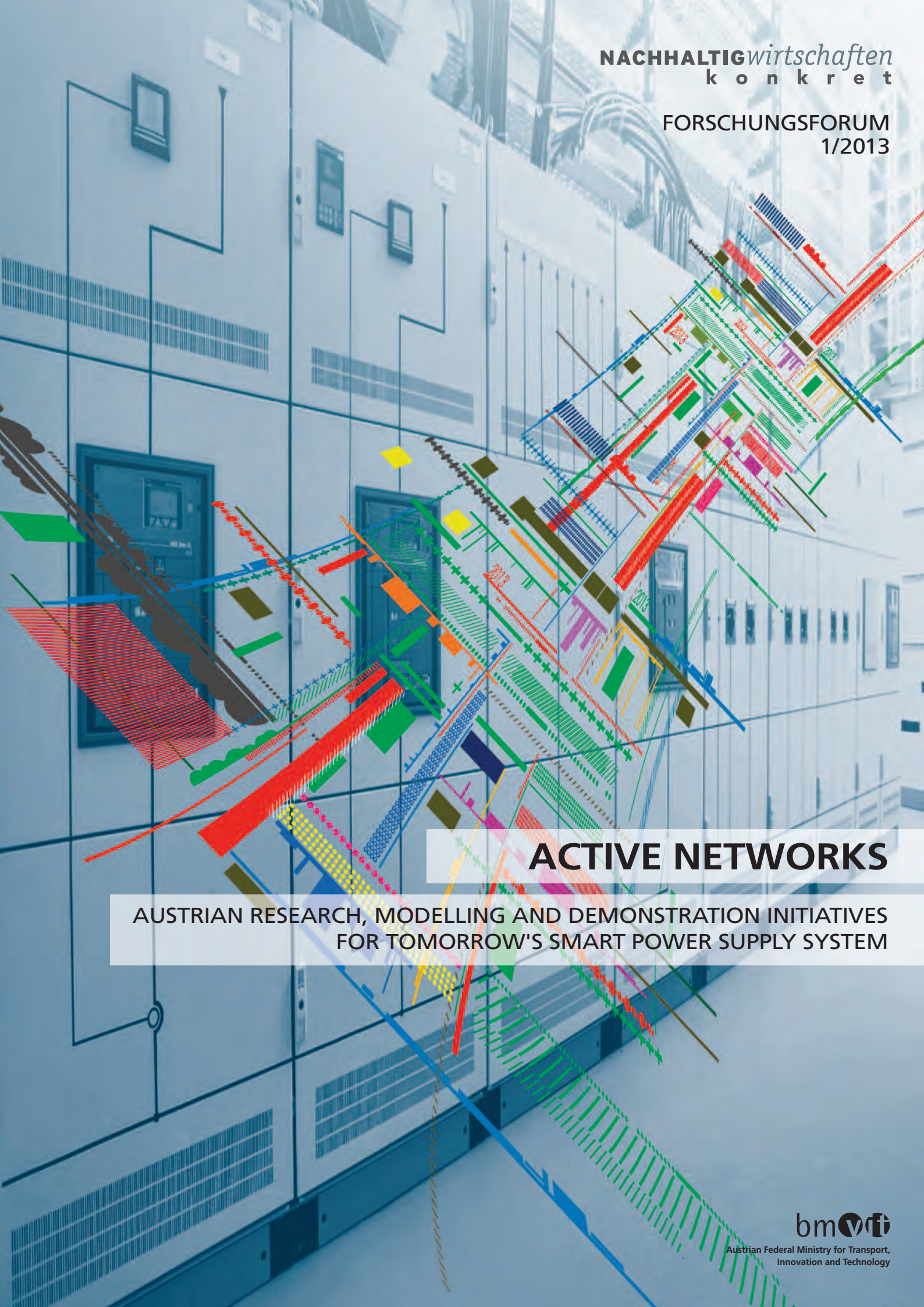

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ACTIVE NETWORKS

AUSTRIAN RESEARCH, MODELLING AND DEMONSTRATION INITIATIVES FOR TOMORROW'S SMART POWER SUPPLY SYSTEM

bmvit
Austrian Federal Ministry for Transport,
Innovation and Technology

THE ACTIVE NETWORK – INFRASTRUCTURE INNOVATIONS FOR A SUSTAINABLE POWER SUPPLY SYSTEM

National and international energy policy targets (the EU 20-20-20 goals) entail a considerable increase in renewables' share of future power supply. Making more use of energy from distributed, local energy resources such as sun, wind or biomass, is a real challenge for grid operators. All over Europe power distribution networks are more and more driven to their limits.

Traditionally, electricity was generated in large scale central power plants and fed in only in one direction from the high voltage transmission network to the distribution networks. In future, as an effect of the recent change in energy policies, increasing numbers of local generators will feed fluctuating power into the networks. Innovative solutions will be needed in order to develop existing networks to the point where voltage fluctuations are limited according to the operational standards for electricity networks even in pre - sence of a high amount of distributed generators.

Quelle: Projektfabrik Waldhör KG

A solution to the challenge of how to operate grids in future is the smart grid approach. "Active" distribution networks feature bidirectional communication between suppliers, consumers and storage facilities, making intelligent power management feasible, so that existing grids can be more effectively utilised. Whereas network operation used to be based on the strategy that generation must follow load, the smart grid approach partly reverses this: loads are forced to match the current availability of generation by means of intelligent control systems (load follows generation).

In this way reliable operation without inconvenience for the consumers should be guaranteed even with local fluctuating generation, and renewable energy sources exploited to the full extent at the same time. New types of storage facilities play a vital part here, involving (for instance) heat pumps (buffer storage) or using the batteries in electric vehicles to store electricity.

AUSTRIA'S CONTRIBUTION TO THE EUROPEAN SMART GRIDS INITIATIVE (EEGI)

The implementation of smart grids is a complex long-term project that – given the extent to which the power supply system is interlinked across borders – can be developed and implemented only internationally. In the "European Strategic Energy Technology Plan" (SET Plan) integration of renewables into tomorrow's power grids is a central issue that is being tackled at the international level in the "European Electricity Grid Initiative" (EEGI).

Austria has marked out its contribution to implement the pan-European targets: the strategic focus is on researching, modelling and demonstrating smart, sustainable solutions for planning and operating the distribution networks. The goal is to integrate a large proportion of renewables in the existing networks, and to link electric vehicles, buildings and consumers together in a smart energy management system.

DG DEMONET – TECHNICAL DEVELOPMENT CHAIN FOR ACTIVE DISTRIBUTION NETWORKS

As part of the "DG DemoNet"-project chain, experts at AIT (Austrian Institute of Technology, Energy Department) and its partner institutions at Austrian universities have been working for several years on developing and implementing smart control strategies for tailor made voltage management. In collaboration with Austrian distribution network operators they are continuously developing, validating and demonstrating innovative technical solutions. Some of these approaches are currently very successfully under test in practice in the smart grid model regions (Salzburg, Upper Austria, Vorarlberg), in order to solve problems specific for the individual regions. The work receives financial support from the Federal Ministry for Transport, Innovation and Technology (BMVIT) and from the Austrian Climate and Energy Fund.

Within Europe Austria is thus setting an example of how to close the gap between theoretical approaches and suitable solutions for the real network, and helping to implement the necessary transition of the power grid. The key factor of success is intensive collaboration between applied research and network operators.

BUILDING BLOCKS FOR THE ACTIVE DISTRIBUTION GRID

As part of research and demonstration projects undertaken by AIT and its project partners, tentative solutions to the problem of implementing a smart, sustainable power supply system are being developed and tested in Austria. Here we present **four building blocks** for active distribution grids, together with the relevant demonstration projects:

Source: Dieter Schütz, pixelio.de

Source: Stadtwerke Murau

INTEGRATING RENEWABLE SOURCES OF ENERGY AT THE MEDIUM-VOLTAGE LEVEL

In Austria the number of medium scale local generators feeding power from hydro, wind, biomass and photovoltaic plants into the grid at medium-voltage level has been increasing for years. While this group of generators delivers power surpluses to the grid at certain times of year (e.g. in summer), it generates less at other times (e.g. in winter). As the overall rate of power from renewable sources is strongly changing over time, while the demand for power also varies, voltage fluctuates are the consequence. Up to now, because monitoring and control possibilities were very limited, medium-voltage grids had to be oversized, so as to be able to cope with all possible situations (worst case planning).

With the approaches to voltage management developed as part of the **DG DemoNet projects**, extended reserves can be utilized more effectively, and voltage can be kept within the defined limits at all times. This is achieved by means of new control methods which enable to integrate many more distributed generation units into the existing network infrastructure without any need of grid reinforcement.

At the medium-voltage level the focus has been on the following approaches:

- Analysing the interaction between distributed generation and the electricity system
- Extended numerical power-flow simulations
- Developing methods to increase the hosting capacity of the existing electricity network
- Developing approaches for planning and analysing power grids with a high share of distributed generation

Initially the new approaches were tested in the laboratory, where the controllers were placed in a simulation environment and confronted with different states of the grid; here it was shown that these approaches for voltage control are technical and economical feasible.

Implementation is now in progress in two medium-voltage networks in Salzburg and Vorarlberg. The researchers involved anticipate that both grid areas will be able to host more than 50 % additional distributed generation from biomass, wind and hydro power as a result.

AIT RESEARCH APPROACHES TO THE ACTIVE DISTRIBUTION GRID

When the "DG DemoNet"-project chain was launched, the initial focus was on medium-voltage level; where local electricity generators (wind parks, large Photovoltaic arrays, hydropower plants) increasingly feed power into the grid. Research activities have then also been extended to the low-voltage sector.

In particular, Photovoltaic equipment in households and electric vehicles are connected to the local low-voltage grid that distributes power from substation to socket. If generation and consumption are not matched in this complex system, the voltage will soon drift outside the limits permitted; so smart control systems are needed here, too.

To develop appropriate control solutions, simulations based on real-time data reflecting the actual state of the power grid are essential; "smart meters" are used to gather these data.

Going further, the ultimate aim is to better balance supply and consumption side by integrating electric vehicles, buildings and customers, who become interactive participants in the grid with the support of automated control systems.

DG DEMONET FIELD TEST VORARLBERG / VORARLBERGER ENERGIENETZE GMBH

On-load tap changer (OLTC) transformers using measurements from critical nodes in the network (CVCU Central Voltage Control Unit)

www.vorarlbergnetz.at

Source: VKW

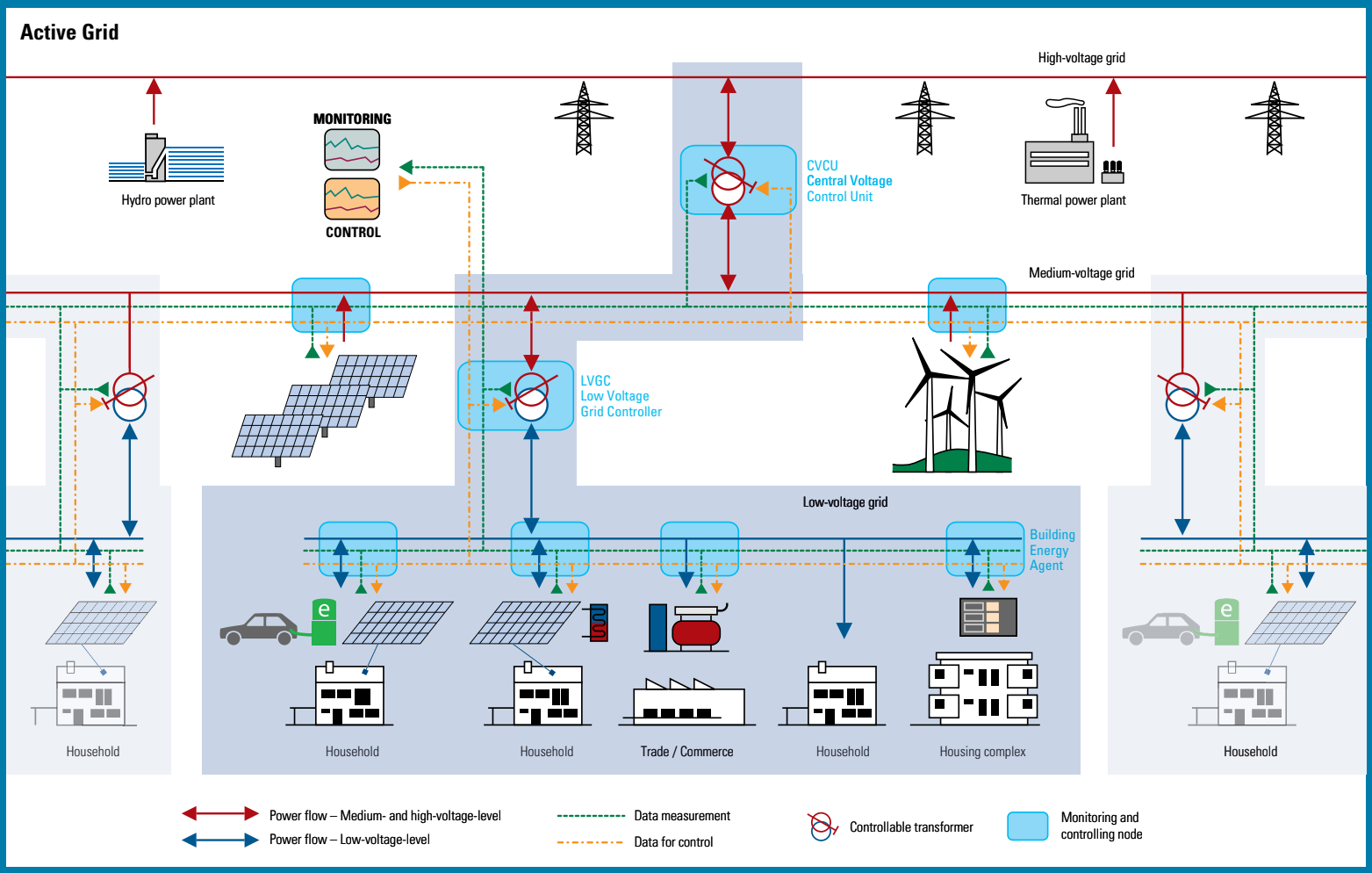
DG DEMONET FIELD TEST LUNGAU / SALZBURG AG

Comparison between two approaches:

- Distributed solution with controller (CVCU) at substation level
- Central solution using a network control system with on-line grid state estimation (project ZUQDE)

www.smartgridssalzburg.at

Source: Salzburg AG



Graphic: Projektfabrik Waldhör KG

BUILDING INTEGRATED PHOTOVOLTAIC – LOW VOLTAGE GRID MONITORING

Solar power in the building sector has a major impact in various energy scenarios. In the future, "energy-plus-buildings" using photovoltaic systems integrated in roofs or façades, will generate more power than they consume, and will feed the surplus power into the grid at low voltage level.
If photovoltaic (PV) systems were installed on all suitable buildings, the hosting capacity of the existing low voltage network would be exceeded. Thus, also in the low voltage network intelligent control strategies are required. They are based on simulation models, delivering an almost real image of the voltage situation in the system.

In the **ISOLVES:PSSA-M (Power Snap-Shot Analysis by Meters)** project a method has been developed to take instantaneous images of the network, making it possible to map voltage and load conditions in low voltage networks. The "eyes" in the grid are adapted "smart meters", which not only measure consumption but also parameters such as voltage, active and reactive power. Results from data analysis contribute to model low voltage networks more precisely which leads to an essential improvement of network planning and operation in distribution networks. These data simulations often are a starting-point for smart control strategies like those developed in the project "DG DemoNet LV Grid" (see next page).

"EYES IN GRID" FIELD TEST EBERSTALLZELL / ENERGIE AG

Source: Energie AG

"Snap-shots" in the power grid: all meters in the local low voltage networks are synchronized so that a snap-shot of the measurement data can be retrieved from every single meter simultaneously at any time. The snap-shots are transmitted from the secondary substations to the grid operator's server and analysed scientifically. With these data the simulation models can exactly be adapted to the real world.
www.energieag.at

ISOLVES:PSSA-M Animation:
www.ait.ac.at/press/ait-youtube-channel/?L=1

INTELLIGENT INTEGRATION OF ELECTRIC VEHICLES AND PHOTOVOLTAIC

Besides the expansion of renewable energies, supplying many electric vehicles with power is an additional challenge for low voltage networks. A large number of electric vehicles plugged into the grid and randomly recharged may cause extraordinary peaks in demand. Thus, innovative concepts involve smart linking of demand and supply side measures. The project **DG DemoNet Smart LV Grid** aims to enable an efficient and cost effective use of existing infrastructure based on intelligent planning, on-line monitoring and active grid management. Objective is to utilize synergies between distributed generation (photovoltaic units) and flexible loads (electric vehicle). Voltage fluctuations should be balanced, for instance, by intelligently controlled charging of electric vehicles while taking in account the characteristics of PV generation.

At the low voltage level the focus has been on the following approaches:

> Voltage control in secondary substations (on-load tap changer)
> Monitoring based on smart metering systems
> Active and reactive power control in generation units
> Controlled charging for electric vehicles

MODEL COMMUNITY KÖSTENDORF / SALZBURG AG

Source: Klimafonds/Ringhofer

A futuristic scenario with fluctuating distributed generation (local PV) accounting for 50 % of total supply and electric cars accounting for 50 % of private cars has been set up for test purposes in selected low voltage network areas. Not feasible for the existing grid; the developed control strategies enable supply and demand matching without interfering customer needs.
www.smartgridssalzburg.at

Source: Semen Grinberg, pixelio.de

Source: Andreas Morlok, pixelio.de

MAKING POWER CONSUMPTION MORE FLEXIBLE – BUILDINGS AS INTERACTIVE PARTICIPANTS IN A SMART GRID

To reduce demand peaks and to improve energy efficiency, another approach combines buildings and consumers into a smart grid.
The aim is to use automatic building control services to provide more flexibility in consumer demand.

The project **Building2Grid** investigates the load shifting potential of buildings as active grid components. All required information is gathered within the building and then exchanged with the grid en bloc.

LIGHTHOUSE PROJECT HiT / SALZBURG AG

In the lighthouse project HiT (houses as interactive participants in a smart grid, Rosa-Hofmann-Straße housing complex) all smart grid elements relevant to the low-voltage level are combined into a revolutionary strategy for buildings. The project involves planning, construction, operation and monitoring a housing complex with 130 flats (rented or owneroccupied) for various different groups of residents.

A "Building energy agent" developed by Siemens in collaboration with AIT is used to investigate issues regarding PV, electric vehicles, buildings and storage:

> Local power generation (CHP, PV)
> Electricity storage

Source: www.rosazukunft.at, rendering: thalmeier architekten

> Automatic load shifting (controlled heat pumps, controlled charging for electric vehicles, home automation)
> Energy feedback, user interaction
> Energy concept and load profiles

www.smartgridssalzburg.at

EXPERTS

AIT AUSTRIAN INSTITUTE OF TECHNOLOGY – RESEARCH FOR TOMMORROW`S POWER NETWORKS

The AIT, Austria's largest non-university research institute, is among the European research institutes a specialist in the key infrastructure issues of the future. AIT provides research and technological development to realize basic innovations for the next generation of infrastructure related technologies in the fields of health & environment, energy, mobility and safety & security. These technological research areas are supplemented by the competence in foresight & policy development. With the applied research, the provision of excellent
research infrastructure and the strong international network AIT takes over a leading role in Austria and Europe.

AIT ENERGY DEPARTMENT

The Energy Department favours a holistic approach to the environmentally friendly electricity supply, heating and climate control of the buildings and cities of tomorrow. Key expertise ranges from the development and optimisation of individual components and the integration of innovative technologies and control strategies at system level to the creation of comprehensive energy concepts for buildings and regions. In the research field smart grid the focus is on:

> Management, planning and simulation of electricity networks
> Interaction between power systems and specific network components
> Method development for design, validation and diagnosis of power system components

SmartEST Labor, Source: AIT

AIT SMARTEST LABORATORY FOR SMART GRIDS

The new SmartEST (Smart Electricity Systems and Technologies) Laboratory, established by AIT, provides a unique research and simulation infrastructure to analyse the interactions between components and the grid under realistic conditions. Potential candidates for testing range from inverters, storage units, grid controllers and CHP units to charging stations for electric vehicles. The laboratory infrastructure includes freely configurable low-voltage networks, flexible high-bandwidth grid simulators, high-performance PV simulators and an environmental chamber for tests at full power under extreme temperature and humidity conditions. The AIT SmartEST Laboratory additionally offers the opportunity to simulate complex electrical grids in real time and connect them to the lab networks. This power hardware-in-the-loop (P-HIL) configuration allows real components to be integrated into a virtual grid environment and tested under realistic conditions in interaction with the grid. The combination of state-of-the-art testing infrastructure and simulations provides cutting-edge testing capabilities for component manufacturers and network operators. This infrastructure is also the basis for collaboration with research pioneers, e.g. within the framework of the "International Smart Grid Action Network" (ISGAN).

Source: AIT

FIGURES/DATA/FACTS

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www.energiesystemederzukunft.at/highlights/smartgrids

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