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SMART GRID TEST RUN IN VORARLBERG - BYTES NOT EXCAVATORS INSIDE THE BIOSPHERE PARK GROSSES WALSERTAL

APPROACHES TO A RESOURCE-CONSERVING AND SMART INTEGRATION OF RENEWABLE ENERGY SOURCES IN RURAL AREAS

bmvit
Austrian Federal Ministry for Transport, Innovation and Technology

ENERGY SELF-SUFFICIENCY BASED ON RENEWABLE ENERGY SOURCES AND SMART GRIDS

As early as 2009 Austria's westernmost province, Vorarlberg, had set itself an ambitious target: achieving energy self-sufficiency based on renewable energy sources by 2050 and so becoming independent of price rises and supply shortfalls affecting oil and natural gas.

The process "Vorarlberg's Energy Future" is intended to implement a sustainable energy supply system step by step and make a valuable contribution to climate protection. This long-term strategy relies upon energy saving and energy efficiency, increased employment of renewable energy, new mobility strategies and investment in research, development and education.

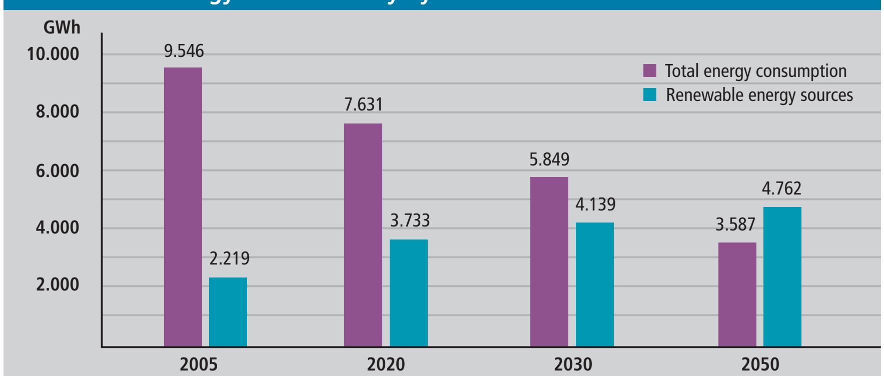
In the near future, by 2020, Vorarlberg wants to achieve at least the energy policy goals set by the EU (20-20-20). An extensive portfolio of measures far more ambitious than that was adopted in 2011, the so-called "101 measures for our grandchildren".
www.energiezukunft-vorarlberg.at

Electricity has a special role in the energy system of the future. A key element in supplying energy in the future involves a drastic expansion of tapping renewable energy from sunlight, water and biomass.

Even today over 30 % of Vorarlberg's energy consumption is covered by renewable energy sources, via 18 large hydro power stations, about 240 small hydro power stations, around 13,000 solar thermal installations, 1,500 photovoltaic installations, 5,000 heat pumps and around 35 biogas facilities.

Within the framework of research projects the province of Vorarlberg has investigated the potential of various possible energy scenarios in depth, in order to find out whether energy self-sufficiency by 2050 is feasible in principle. The diagram below shows the path toward energy self-sufficiency in 2050 resulting from the scenarios investigated. Firm commitments and measures are already in place for the first stage. By 2020 the province of Vorarlberg aims to achieve a reduction of electricity demand from small consumers by 17%.

Path toward energy self-sufficiency by 2050



Source: www.energiezukunft-vorarlberg.at

For a sustainable economy a secure, efficient energy supply chain able to deliver essential and convenience-increasing services and products is a central issue. The aim of the subprogram "Energy Systems of Tomorrow" initiated by the Austrian Federal Ministry for Transport, Innovation and Technology (BMVIT) is to develop technologies and strategies for an efficient, flexible energy supply system based on exploiting renewable sources of energy and capable of meeting our energy needs indefinitely.

Deploying a wide range of technology-related modules and concomitant activities is intended to provide impetus to this sector, and thus open up new opportunities for Austrian business.

The province of Vorarlberg plans to increase the number of photovoltaic installations fivefold by 2020. Hydro power will be expanded considerably through a range of large and small power stations and the number of biogas facilities is to almost double.

It is to be expected that the future energy supply of households and industry will increasingly be based on electricity. We are moving towards an "electricity society", i. e. other sources of energy will progressively be supplanted by electricity (e. g. by using heat pumps or moving into electro-mobility). The demand for electricity will therefore rise in these areas.
To still be able to meet the set goals by 2050 it is necessary to realize the full potential available for saving energy and increasing energy efficiency systematically.

Due to geographical factors some regions of Vorarlberg face particular problems which have to be taken into account for an expansion of renewable energy. In order to integrate a large number of local energy suppliers without costly grid upgrading, innovative, intelligent strategies are needed for the distribution grids and network management.

Together with numerous partners, and with support from BMVIT and the Climate and Energy Fund, the province of Vorarlberg is developing (within the framework of various research projects) new approaches to smart network management, and testing the technical and economic feasibility of these ideas in a regional context.

INTELLIGENT VOLTAGE CONTROL WITHIN THE DISTRIBUTED-GENERATION TEST GRID OF THE GROSSES WALSERTAL BIOSPHERE RESERVE

■ As their facilities are usually medium-sized, local suppliers feed into the medium and low-voltage grid. Decentralized feed-in can lead to impermissible local rises in mains voltage. To avoid these rises the conductors in the affected parts of the grid have been reinforced. However, the resulting high grid access costs make it uneconomical to erect some of the generating facilities projected.

In rural areas with low population density and little demand for electricity connecting a large number of local power stations to the conventional distribution grid soon runs into difficulties. Electricity from renewable sources is mostly generated right at the source. The feed-in points are distributed all over the grid region, including remote areas on the fringes of the grids, where their performance is more limited.

In some regions of Vorarlberg no more power stations can be hooked up to the grid without costly enhancement measures. A new approach here is a bidirectional, so-called “active” distribution grid. In future the lowest grid levels connected to consumers are increasingly to accept and distribute electricity fed in from local generators and to transmit surplus power on to higher grid levels.

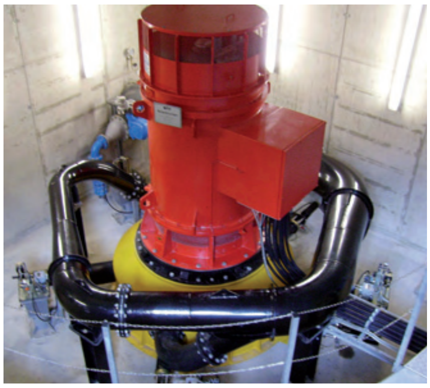
ENERGY PRODUCTION AND CONSUMPTION IN THE REGION OF THE GROSSES WALSERTAL BIOSPHERE RESERVE

A typical situation involving seasonal cycles is to be found in the Großes Walsertal Biosphere Reserve, which is 20 km long. During the winter power consumption in the valley is comparatively high, due to the winter tourism industry with its ski lifts and hotels. At the same time the yields from hydroelectric plants are low, because there is not much run-off. In spring, however, during the thawing period and in summer after rain the small hydropower stations with a total current nameplate capacity of around 3 MW deliver a lot more energy than is needed in the valley. This surplus electricity has to be transmitted out of the long valley.

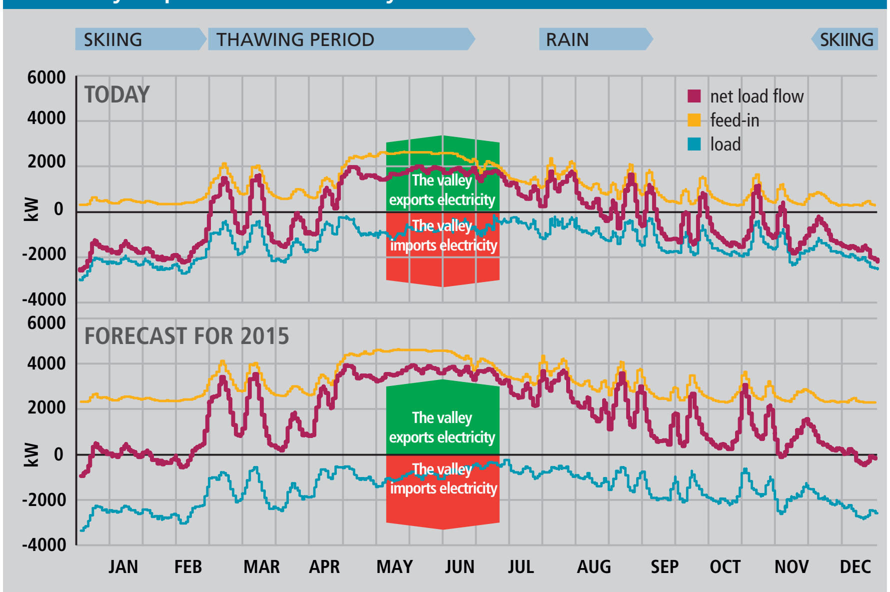
Every additional power station and the increasing contrast between summer and winter add to the problem. Under the present conditions connecting an additional small hydroelectric plant to the Großes Walsertal grid is not possible. The generating potential worth exploiting and currently untapped amounts to about 10 MW.

STRATEGIES FOR INTELLIGENT VOLTAGE CONTROL

In future the distribution grid should be able to transmit electricity in both directions, with the control system ensuring that the grid voltage stays within the target range at all locations (so that electrical equipment/devices function reliably). If power consumption and generation are not entirely in



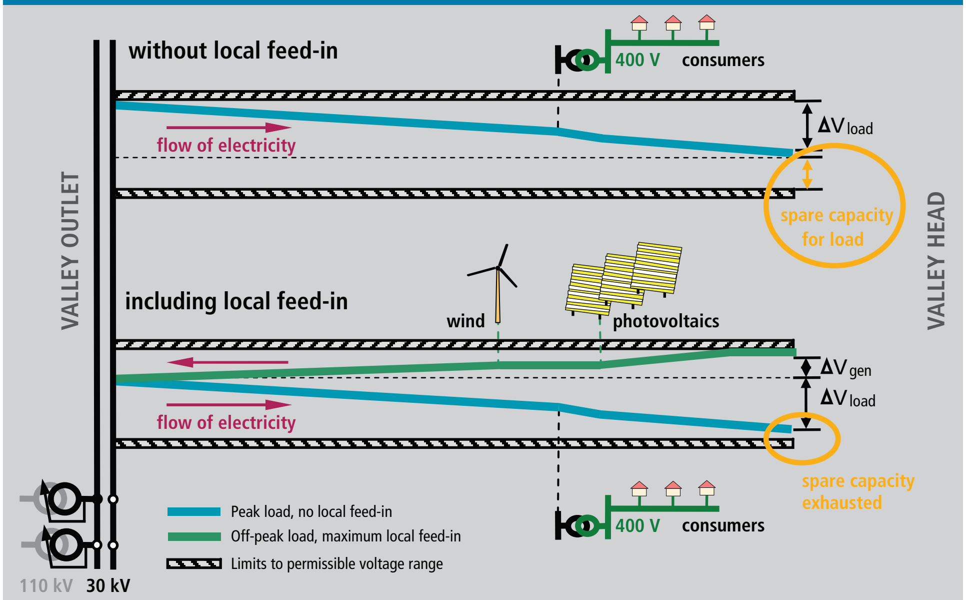
Electricity surplus/deficit over the year



Source: Vorarlberg Netz

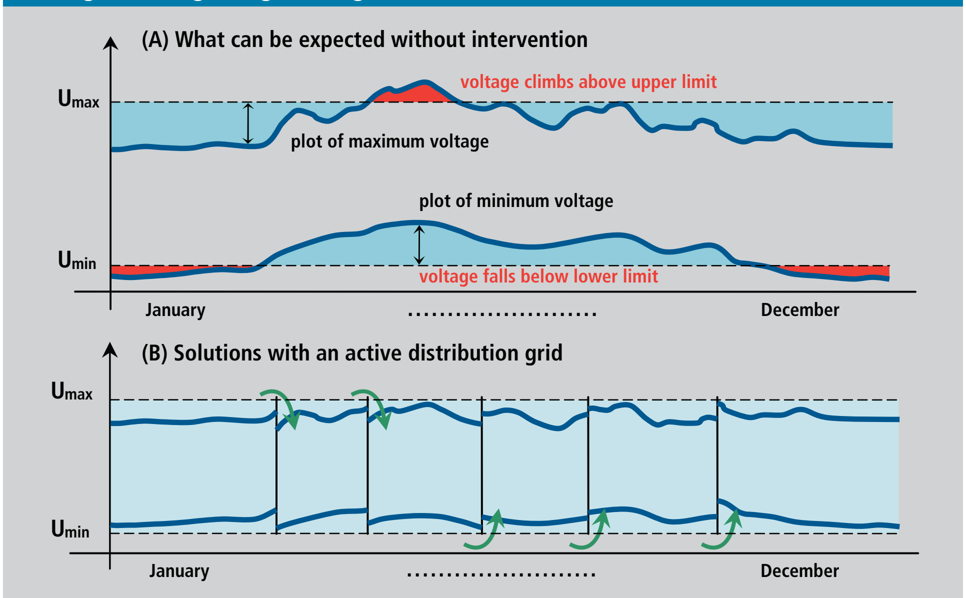
Source: DG DemoNet – Concept

Voltage increase caused by local producers



Source: DG DemoNet – Concept

Intelligent voltage range management



A shows that without intervention the actual voltage strays outside the permissible limits.
B shows how the voltage range is adjusted as the need arises – made possible through active intervention influencing the actual voltage in real time.

Strategies for intelligent voltage control

> *Remote Control*
Measuring the voltage levels in the grids and processing the data in a local intelligence unit to calculate a changeable, moving controller setpoint for the substation. With voltage values at the critical grid nodes known, the setpoint to make optimal use of the voltage range is continually optimized by the CVCU (Central Voltage Control Unit, housed in the central control station) and adjusted in the substation.

> *Local Q-Control*
Influencing voltages by modifying the reactive power Q of power stations, i. e. the voltage levels in power stations larger than 100 kW are monitored locally, so as to be able to modulate the voltage in the grid segment to be regulated. Thus each power station can contribute locally by adjusting the voltage level in the desired direction within the thermal limitations of the generators even if communications with the control centre break down.

> *Coordinated Voltage Control*
Combination of Remote Control and Q-Control, controlling via the intelligent CVCU (Central Voltage Control Unit), increased efficiency as the CVCU also modulates power stations' reactive power, which still lies within the permissible limits but could help to reduce stress in critical areas. Should the options detailed above be combined with a view to the entire grid, this makes it possible to take fuller advantage of the voltage range, which results in definite cost savings (see diagram above right: power input increased by about a third at lower costs than Remote Control, or fourfold power input at almost the same cost compared with the Local Q-Control).

phase, additional feeders-in take up part of the slack in the voltage range - and thus “occupy” grid reserves that would otherwise be available to additional consumers. As a result, the system reaches the range limits earlier.

Active distribution grids take a new approach. With the aid of ***control mechanisms*** which actively regulate voltages while the grid is running, spare capacities in grid infrastructure can be better exploited. This involves include grid participants and grid components in the control mechanism (by recording, linking and analysing data from the grid in real time). In the course of the multi-phase research project “DG DemoNet – Concept”, together with numerous partners, different approaches for active distribution grids have been investigated and their capability evaluated.

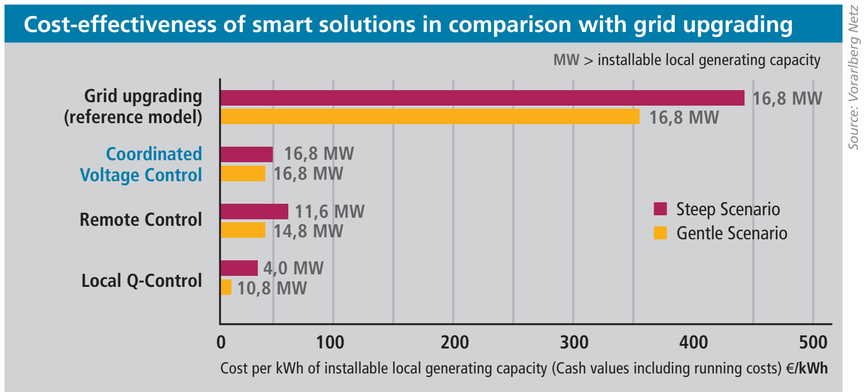
VORARLBERG'S FIRST SMART GRID IN THE GROSSES WALSERTAL BIOSPHERE RESERVE

Building on the results of the project “DG DemoNet – Concept” the concept of “coordinated voltage control“ is now being implemented and tested in Großes Walsertal. Should this strategy prove its worth, the new technology is to be deployed in other regions, too.

At the heart of the system is the “brain”, the CVCU (Central Voltage Control Unit), which is housed in the central control station in Bregenz. Distributed across the test network 16 measuring points are installed at “critical nodes“, forwarding their data continuously to the central control station. The critical nodes include (in particular) major consumers and power stations on the fringes of the grid. Those are the points which provide a representative picture of the entire grid with the most extreme voltage values (outliers). The 16 critical nodes will be identified in a so-called input matrix.

Here the effect of every single feed-in or load on the entire system is calculated. The 16 measuring points transmit the current voltage levels continuously to the CVCU via various modes of communication (MS power line carrier, radio data transmission, optical fibre, copper wire). The CVCU processes the data from the network and fits the operating voltage into the permissible range so that the upper and lower limits are not infringed.

The CVCU supplies the control transformers in the Nenzing substation (at the valley outlet) with optimized set-points for voltage control. This way the operating voltage throughout the grid system is maintained within the permissible range. In addition, the CVCU sends control commands to the power stations in order to reduce the feed-in of reactive power; this helps to relieve pressure on the grid in the case of local feed-in.



Power station addition scenarios were examined with varying sequences of action. The "steep" scenarios involve additions in an unsuitable order, such as building further powerful electricity plants on the fringes of the grid first. The "gentle" scenarios involve a more suitable order (i.e. powerful electricity plants are added on the fringes of the grid last).

The scenarios described above were analysed with respect to both technical and economic aspects, so as to assess the profitability of intelligent voltage control. It turned out that the cost of upgrading the grid in the conventional way is significantly higher in all scenarios. By means of coordinated voltage control it is possible to incorporate the same volume of additional local capacity at much lower cost.

INTERNATIONAL LINKS

VORARLBERG'S PUMPED-STORAGE POWER STATIONS EMPLOYED TO INTEGRATE FLUCTUATING LEVELS OF RENEWABLE ENERGY

■ To push generating electricity from renewable sources of energy does not just require new solutions for operating the distribution grid. This development is also leading to massive upheavals in the European electricity markets. The storage of electricity plays a central role in this context. The point is to tide over periods with little wind or sun, and to avoid shutting down feed-in facilities in times of surplus supply. Inevitable forecasting errors have to be corrected quickly and occasional violent swings in feed-in supply smoothed over.

Vorarlberg makes use of the favourable topography of the region in terms of the energy economy within the international network. The pumped-storage power stations in Vorarlberg help to iron out fluctuations in the supply of electricity from wind and solar energy.

In Germany the share of renewable energy in electricity production rose to about 20 % in 2011 and is intended to reach 80 % by 2050.

When the Vorarlberger Illwerke were founded, more than 80 years ago, cooperation with partners from Germany was the basis for starting interconnected operation, with important transmission links to Germany. This cooperation continues today with the EnBW Energie Baden-Württemberg.

The Illwerke provide high-grade balancing energy and can make use of the flexibility of their equipment for short-term intraday trading and the capacity of their all-year storage to tackle seasonal fluctuations. With the commissioning of Kopswerk II in 2008, the refitting of Rodundwerk II in 2011 and the planned construction of

Obervermuntwerk II further steps are to be taken to sustainably advance the integration and continued expansion of renewable energy in Europe.

VEHICLE TO GRID – ELECTRO MOBILITY MODEL TRIAL IN THE VORARLBERG RHINE VALLEY

■ A further keystone of Vorarlberg's long-term energy strategy is electromobility. Energy self-sufficiency scenarios involve a complete transition to electric power trains by 2050, at least as far as private transport is concerned. The mass-market introduction of electromobility will have a great impact on the operation of the distribution grid; bidirectional load and energy management will play an important role in this area, too, in future.

Since 2008 the province of Vorarlberg has been conducting one of Europe's biggest electromobility tests, the project VLOTTE, in which 357 electric cars running on electricity from renewable energy sources have already travelled 2.5 million kilometres.

As part of the project Continental's "AutoLinQ™ for Electric Vehicles" system is being tested as a strategy for intelligent energy management on the road. The focus is on data transmission between vehicles and the grid (VehicletoGrid).

Currently smart approaches to recharging vehicle accumulators are being tested, in order to avoid uncoordinated simultaneous recharging of a large number of vehicles (e.g. in the evening) in future. The focus of interest is on how the grid operator can influence recharging.

The "AutoLinQ™ for Electric Vehicles" system consists of a communications box built into the vehicle, maintaining a constant mobile data connection with the "Gateway and Service Delivery Platform", which provides a connection to the electricity provider's energy management systems. The new system allows "Smart Charging" via ordinary power plugs. This means that the grid operator receives information about plugged-in vehicles' state of charge and energy requirements, and can control recharging depending on the current availability of electricity from wind power or solar energy.

In the summer of 2011 VLOTTE's first 20 electric vehicles were equipped with the new system in Bregenz. During a 2-year test phase the system's functionality in load management is to be tested on the road and experience with delaying recharging is to be gathered.

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FIGURES / DATA / FACTS

CONTACTS

Vorarlberg Netz
Prok. DI Werner Friesenecker
werner.friesenecker@vorarlbergnetz.at
DI (FH) Frank Herb
frank.herb@vorarlbergnetz.at
Dipl.-HTL-Ing. Reinhard Nenning
reinhard.nenning@vorarlbergnetz.at
www.vorarlbergnetz.at

VLOTTE Electromobility
DI (FH) Christian Eugster
christian.eugster@vkw.at
www.vlotte.at
DI Herbert Halamek
Herbert.Halamek@continental-corporation.com
www.continental-corporation.com

Office of the Provincial Government of Vorarlberg
adolf.gross@vorarlberg.at
www.vorarlberg.at

INFORMATION / PUBLICATIONS

DG DemoNet – Concept
H. Brunner, A. Lugmaier, B. Bletterie, H. Fechner, R. Bründlinger; arsenal research, Vienna 2008; as part of "Energiesysteme der Zukunft", BMVIT

Active Demand-Side Management via feed-in forecasting (aDSM)
Vienna University of Technology, Institute of Energy Systems and Electrical Drives; partners: ZAMG, Vlotte, APG; as part of "Neue Energien 2020", Klima- und Energiefonds

Optimized cross-system local hybrid energy storage facility "Symbiose"
Vienna University of Technology, Institute of Energy Systems and Electrical Drives; partners: ENRAG GmbH, Vorarlberger Kraftwerke AG; as part of "Neue Energien 2020", Klima- und Energiefonds

VLOTTE
Vorarlberger Elektroautomobil Planungs- und Beratungs GmbH, project manager: DI (FH) Christian Eugster; as part of "Modellregionen der E-Mobilität", Klima- und Energiefonds

Final reports on individual research projects are published by BMVIT in the series "Berichte aus Energie- und Umweltforschung" ("Reports from Energy and Environment Research"). (DG DemoNet – Report 12/2010, in german) A full list of these reports, and facilities for downloading them, are to be found on the website: www.NachhaltigWirtschaften.at

Further information on smart grids in Austria at: www.ENERGIESYSTEMEderZukunft.at/highlights/smartgrids

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