SMART GRIDS IN AUSTRIA

Integrating distributed renewable energy generating systems, particularly photovoltaics (PV), into the grid poses a significant challenge at present. As a result, a variety of opinions on the subject have already been aired. There has been much discussion about and numerous papers published on the topics of feed-in management, including the power station characteristics of the systems and the benefits of conventional grid expansion (additional resources) as opposed to “intelligent” grid expansion (Smart Grid).

The following article examines Austrian experiences and perspectives. Due to its natural geography, the bulk of Austria's electricity demand has for decades been met by hydroelectric power, with small to medium-sized hydroelectric power stations making a sizeable contribution. These have for a considerable time been in the form of distributed generation systems and even today are continuing to expand within their segment. This expansion has in the past exhausted the medium-voltage capacity of some parts of the distribution network. To solve this problem, active distribution network strategies, in addition to conventional grid expansion, have been examined and implemented in conjunction with the power station operators.

Background to the DG DemoNet – Smart LV Grid pilot project

Compared with the operational implications for the grid of the traditional use of hydro-electricity and the more recent expansion of wind power, the surge in the number of photovoltaic systems in Austria has only now started to place a considerable strain on the country's grids. If we look at the situation in Germany at the end of 2010, there was already 17,320 MWpeak of photovoltaic output installed [BMU, 2012], whereas in Austria, the figure at that time was a comparatively meagre 154 MWpeak [E-Control, 2012]. Despite these figures, and in anticipation of higher PV system numbers in the years ahead, 2010 saw the launch of the broad-based research project DG DemoNet – Smart LV Grid (time frame 2011 to 2014) [Einfalt et al., 2012]. Distributed generation systems and electric vehicles present a number of associated challenges for low-voltage (LV) grids. Grid operators, technology companies and research institutes both within and outside universities hoped to identify these as early as possible and work together on solutions, which they would then make available at the appropriate time: initially, there was no problem that couldn't be solved. That covers the historical aspects.

The need for smart low voltage grids

A lot has happened in the meantime. On the one hand, installed PV output in Austria has quadrupled over the last three years and now stands at more than 600 MWpeak. On the other, the first “smart low-voltage grids” have appeared in Austria in the course of the aforementioned research project. To meet the need to implement these in real grids, an exceptionally high density, by Austrian standards, of small PV installations was installed in three field test regions of three grid operators. For this purpose, individual local grids were provided with a distributed PV output of approximately the same level as the transformer output[1]. In total, around 700 kVA of inverter output was installed in 136 PV systems, giving an average system size of about 5 kVA. In addition, wide-area telecontrol[2] – of various types depending on the test region and the application being investigated – and a large number of electric vehicles (approx. the same number as PV systems) were introduced.

Install test regions to study and solve problems in a controlled manner

A special feature of the test regions is that practically all the new elements of the energy and communication infrastructure were developed especially for the project. On the one hand this has produced the local concentration of generating systems, while on the other has ensured the targeted utilisation of all the systems involved for project purposes (above all access to this mode of operation). For this special case, federal and local government funding was obtained and advantage taken of the readiness of the system operators to invest and cooperate. All the systems involved are newly installed self-consumption systems. These parameters are the benchmarks, so to speak, of a project that deviates from a greenfield policy.

Firstly, the project team began the necessary construction works in the field test regions and were consequently the first to create the problematic voltage situations that had to be solved. Secondly, the project consortium worked on innovative grid planning and monitoring designs and above all the “intelligent” control of distributed generating systems and electric vehicles as encountered during active grid operation. The main focus of the project as a whole was to provide a technical and cost-effective assessment of the alternatives to conventional grid expansion.

Intelligent control systems

The “intelligent” control systems are based on the one hand on local autonomy, e.g. PQ(U) control, and, on the other, on coordinated optimisation using a higher-level Siemens computer (Smart LV Grid Controller). To implement these approaches, inverters – in this case exclusively devices from the Austrian manufacturer Fronius – and electric vehicles were upgraded to cope with control conditions. This necessitated the development of a series of new inverter features to implement local control functions and to provide a bidirectional interface to the remote control system. The interface to the control system and consequently the networking of the entire system (Smart Grid) was carried out by Siemens, one of the project partners. Depending on the test region, this was either achieved using the rolled-out Smart Metering infrastructure (PLC) or via a secure internet connection for each individual PV system (HFC).

Smart local grids

The combination of individual components, including controllable inverters and electric vehicle charging stations, each with a telecontrol interface, smart metering, controllable local grid transformers and grid controllers, resulted in the creation of fully configured “smart” local grids in every test region. Their differing configurations reflect the range of applications under investigation (grid planning, grid monitoring and grid control). Commissioning of the corresponding functions and control loops in the field took place in each case following comprehensive simulation (of the electrical grid and communication facilities) and laboratory tests. All the individual components are currently in operation and the execution of the individual field test scenarios has begun. The declared objective is to provide quantitative statements with regard to the functionality and effectiveness of the various applications, particularly with respect to the voltage range that can be achieved. In parallel, an economic assessment of the admittedly complex “smart” measures was carried out and compared with conventional grid expansion. The intention here is to enable concrete statements to be made concerning the measures and costs involved in increasing the capacity of an existing grid infrastructure for distributed feed-in providers, and the extent to which this capacity can be increased.

Optimisation potential gradually exhausted

With respect to the scenarios being studied in the field test regions, the perspective of the grid operator was placed firmly in the foreground. Put simply, a distinction can be made between two stages of active grid operation as far as complexity and optimisation potential are concerned. As mentioned above, the first stage involves the exclusively local control of the active grid components (inverters, charging station, local grid transformer). This means that local autonomous controllers react according to their degree of flexibility to the variables that can be measured locally (especially voltage and output). The inverter can then adapt its generating behaviour (effective and reactive power), the charging station its charging behaviour and the controllable local grid transformer its transformation ratio (tap position) as the situation demands.

Together with the protection functions, which remain unaffected, adherence to the grid operating limits is ensured, meaning that this first (lowest) stage is also the fallback level should no further optimisation be possible. The second stage involves networking the individual local control loops in the grid to produce a higher-level overall system that can then be optimised. In this scenario, a central controller determines the current status of the respective local grid and, depending on the optimisation priority (e.g. minimising the affected voltage band or balancing the reactive power budget of the local grid), generates set values for the active components in the grid. Their operating points are corrected accordingly. The degree of optimisation that can be achieved in this stage is largely dependent on the quality of the grid status image (e.g. detection of a change in the switching state and hence the grid topology) and the performance of the grid controller and communication infrastructure.

First results promising – tested features already in production

The first results of the analysis of local control systems are promising. A smaller pilot field test demonstrated that even in a modern, pre-cabled local grid – despite its lower electrical sensitivity to reactive power (due to the low inductive share of the grid impedance) – the capacity for distributed PV systems can typically be increased by at least one third using local autonomous reactive power control. Moreover, the voltage increase resulting from the decentralised feed-in could safely be restricted to a maximum permitted value by employing voltage-dependent effective power control. Apart from their deployment in the field test regions, some specific inverter features, whose proven stability and effectiveness have already been introduced into the Fronius inverter series, are therefore now available for general use.

Among these features are, for example, the ability to reconfigure operating parameters dynamically (using communication facilities, during ongoing operation), or the grid-optimised combination of voltage-dependent effective and reactive power control PQ(U). This means that the underlying functionality (e.g. stable, local control functions of inverters when working alongside neighbouring systems) has been developed, tested and is now available. How these functions can now be optimised is currently being examined by way of a comparative quantitative analysis of the effectiveness of individual operating modes.

Technical challenges posed by grid integration now often considered to be mastered

To summarise, we can see that we are already in a position to implement suitable solutions using the functionality already at our disposal of distributed generating systems. This will in many cases enable us to overcome the technical restrictions imposed on the grid by the expansion of small, distributed generating systems. The purely technical challenges posed by grid integration are thus largely considered to be mastered. Against this, we have to face up now and in the future to the organisational challenge of how to make targeted and commercially viable use of grid-supporting features. This category includes, for example, the standard factory settings of inverters, the legal-regulatory aspects of the measures associated with yield losses, or the standardisation of communication parameters and interfaces. To satisfy this integration requirement will probably necessitate a certain change in the cultural mindset as far as the interaction between the various players in the energy sector is concerned. In any event, Austria is well positioned, both in terms of the availability of technological solutions (see above) and in matters relating to their application. Another point worth noting is that those involved are often located in close proximity to one another, both in a geographical and often an organisational sense as well. This all plays a significant role in the success of joint research projects and particularly fosters mutual understanding among the heterogeneous stakeholders within the energy system. As a technology company, Fronius sees its home advantage as the key to unlock opportunities on an international scale.

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[1] Every local grid has a transformer station with a particular transformer output. The ratio between transformer output and the PV output associated with the lower-level grid is characteristic.

[2] Remote monitoring and remote control using communication.

Characters: 11,138 (without spaces)
Words: 1,437

References:

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“DG DemoNet – Smart LV Grid” project partners:

- AIT Austrian Institute of Technology (consortium leader)
- Siemens AG, Austria
- Fronius International GmbH
- Energie AG Oberösterreich Netz GmbH (now known as Netz Oberösterreich GmbH)
- Salzburg Netz GmbH
- Linz Strom Netz GmbH

- TU Wien – Institut für Elektrische Anlagen und Energiewirtschaft [University of Vienna – Institute for Electrical Systems and the Energy Industry]
- TU Wien – Institut für Computertechnik [University of Vienna – Institute of Information Technology]
- BEWAG Netz GmbH

Illustrations - overview:

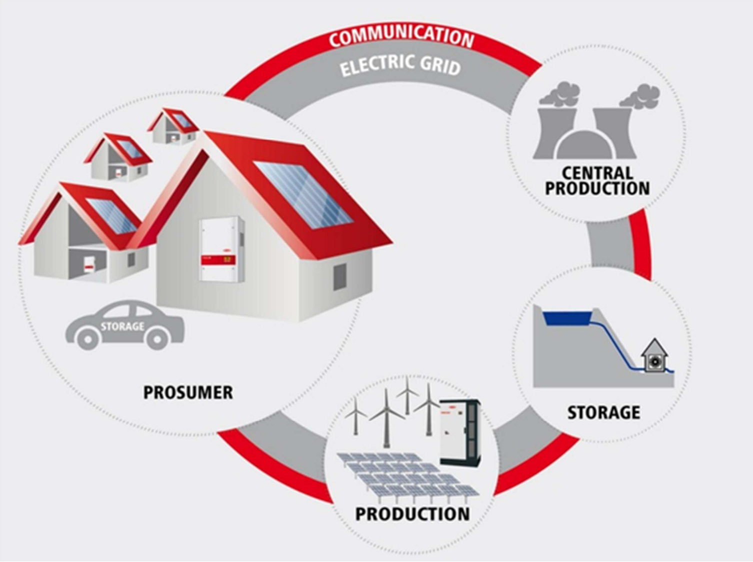

Fig. 1: In a Smart Grid, smart devices are networked in a grid so they can communicate with one another.

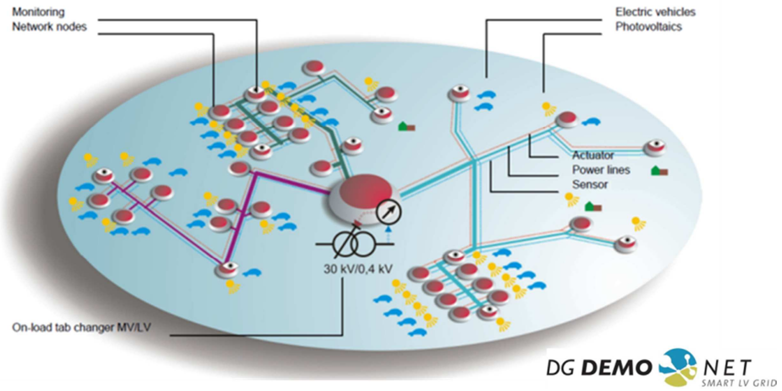

Fig. 2: Low-voltage grid configuration in the field test. Intelligent control of effective and reactive power on Fronius inverters (☀), monitoring with smart meters to improve grid design (👁), management of the controllable local grid transformer (⦶) and controllable loads, such as electric vehicles (🚗).

Figure 1 Fronius International GmbH, Figure 2: Energie AG Upper Austria

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About Fronius International GmbH
Fronius International GmbH is an Austrian company with headquarters in Pettenbach and other sites in Wels, Thalheim, Steinhaus and Sattledt. With 3,239 employees worldwide, the company is active in the fields of battery charging systems, welding technology and solar electronics. Around 93% of its products are exported through 19 international Fronius subsidiaries and sales partners/representatives in over 60 countries. With its innovative products and services and 864 active patents, Fronius is the global technology leader.

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