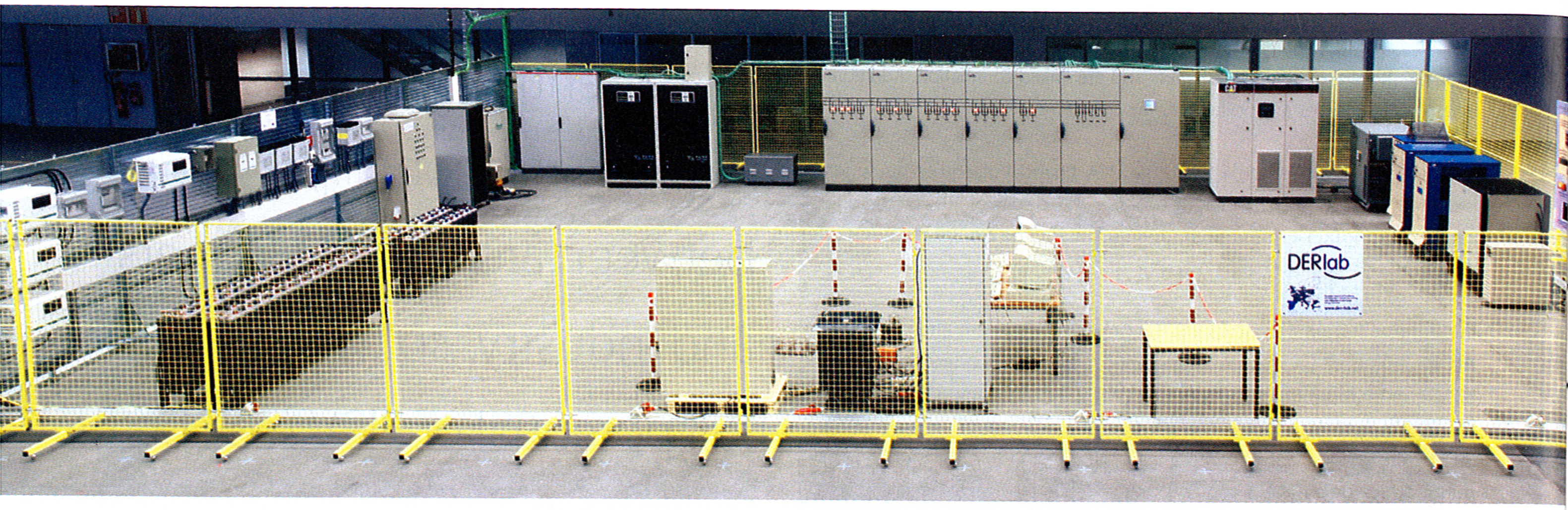

Renewables: making the grid work

MORE RENEWABLES IN THE BUILT ENVIRONMENT MEANS MORE PRESSURE ON GRIDS. SO WHAT'S THE WAY FORWARD? LEADING EUROPEAN RESEARCH INSTITUTES HAVE FOUNDED A NEW ASSOCIATION – **DERLAB** – WHICH WILL RESEARCH DISTRIBUTED POWER GENERATION.

Iris Krampitz

Currently, distributed power generators (DG) such as solar power plants and wind turbines feed their electricity – unregulated for the most part – into the public grid at a low-voltage or medium-voltage level. The increasing number of distributed sources creates new challenges; and there are neither harmonised standards nor harmonised interconnection requirements or test procedures for grid feed-in, in Europe.

Recent targets for the penetration of renewable energy sources in the European Union demand that the share of energy consumption covered by renewable energy sources should be raised to 20% by 2020. This target actually requires a considerably higher renewable electricity share (over 30% by 2020), and if the growing DG output is not properly controlled, the reliability and the security of the energy supply could decrease.

Technical needs for DG integration

Transmission systems need clear interfaces with the downstream distributed system. Distribution system operators should consider active power flow management. For a complete integration of DG into the system both technically as well as economically, at least a part of the DG units should also provide ancillary services. Furthermore, the development and improvement of cost-effective and coordinated high-power energy storage systems, based on different technologies, could play a key role in facilitating a larger penetration of DG resources. Innovative network controlling devices should be inserted and used both by transmission – as well as by distribution system operators.

Today, DG units have to be equipped with voltage and frequency protection systems that automatically disconnect from the network when the local voltage at the connection point (or the system frequency) are out of a predefined range. But with the increasing numbers of DG they have to contribute to system services ranging from congestion management to support in the event of network faults. The interconnection requirements and grid codes currently under revision account for these issues.

Impact of DG on distribution systems

Distribution networks have mainly been designed and operated to distribute power from the upstream generation and transmission system to the final customers. However, with an increasing number of generators connected to the distribution network, power can be also transferred reversely. Such bi-directional power flows mean new challenges for the distribution networks, which have not been designed to account for power input from generators and reverse power flows.

The connection of DG to the distribution system can cause an increase in the level of short circuit currents. This rise can create problems to the operation of distribution components like line conductors, breakers and switches. For this reason, it is crucial to verify the level of short circuit currents against the components' limits before physically connecting the DG unit to the grid.

In addition, one should consider how robust the network at the connection point is, as dispersed generation and large consumers can cause relatively large changes in the voltage levels on a weak network.

Connecting a DG unit to the distribution system leads to a modification of the voltage profiles on the distribution network with a possible increase of the voltage along the connection line. This voltage modification depends on the DG unit's power rating and location, on the power factor as well as on the local network structure. There might be situations, in which in the presence of DG, the voltage regulators cannot bring the voltage profiles inside the due range. For these cases, a solution may be the direct involvement of the DG units interfaced via synchronous machines or converter systems, in the line voltage and reactive power control.

For smooth and reliable power system operation, both active and reactive power must be in balance. In this way, the power produced must instantaneously equal the sum of the power consumed and the power loss. As well as the active power deviations, uncontrolled reactive power may also represent an issue as it may heavily affect voltage levels, especially in emergency conditions.

The grid of the future

Active networks can be structured and operated similarly as transmission systems. They manage bidirectional power flows. The active distribution network may deliver power to users and/or transfer it to the transmission system as well. This big transformation is already ongoing in some European countries.

The **European SmartGrids Technology Platform** defines **Microgrids** as low voltage networks with DG sources, together with local storage devices and controllable loads. The unique feature of Microgrids is that, although they operate mostly connected to the distribution network, they can be automatically transferred to islanded mode in case of faults in the upstream network. After a fault has been resolved and the upstream network operation restored, they can be resynchronised to the rest of the system. Microgrids generally have a total installed capacity in the range of between a few hundred kW and tens of MW. Microgrids pilot projects are present in Greece, Germany, Netherlands, Italy, Portugal, Spain, and in Denmark.

The **Virtual Power Plant (VPP)** is an energy management system tasked to aggregate different decentralised small generators either for the purpose of energy trading or to provide system support services. The plants are not physically connected, but instead interlinked via soft technologies. For a grid operator or energy trader, buying energy or ancillary services from a VPP is equivalent to purchasing from a conventional station.

"We need smart, active grids", says Wolfram Heckmann from the German research institute **ISET**. "Active Networks, Microgrids, and Virtual Power Plants may represent a possibility for the future."

New system control and communication approach

Decentrally organised control of power plants and loads is more robust than centralised management, as well as being less complex and with fewer communication requirements – features which are particularly important in view of the huge numbers of distributed energy resources (DER) and controllable loads. The decisions are made by decentralised energy management systems capable of optimising the power generation (and connecting or disconnecting loads). These optimisation decisions are controlled using key information – such as feed-in and reference tariffs that optimise the entire system.

For largely automated, decentralised energy management the customers need corresponding hard- and software to switch controllable loads and generators. Some field tests are already running that involve small private network users. In these projects a new approach is tested for using variable energy prices in order to give incentives to participate with decentralised energy management. The real-time access for smart electricity grids is easily set up at regions equipped with broadband power line infrastructure, and other communication channels like internet can also be used.

Customers select the quantity, price and origin of their energy at their own discretion in real time, and drive energy efficiency and the energy market through their own behavioural patterns. The new "E-Energy marketplaces" will, above all, facilitate the efficient supply and use of renewable energy and efficient domestic power systems with combined heat and power generation.

DERlab partners develop harmonised standards for solar power plants and wind turbines

For all the different approaches that aim to integrate distributed generators actively into the power system, an overall systems approach is necessary. It is evident that all participating generators and system devices have to act in concert with each other. This means that testing laboratories need to use well defined and harmonised testing procedures on a high-quality level to achieve comparability and confidence.

In the **Network of Excellence DERlab**, supported by the **European Commission**, 11 research institutes have been developing joint requirements and quality criteria for the interconnection and operation of distributed energy resources since the end of 2005. They are also preparing testing and certification methods as well as standards valid all over Europe for decentralised power generation.

DERlab will continue to use and provide laboratory infrastructure, as well as exchange research results, personnel and know how. "With our collaboration, we want to ensure the quality of decentralised power generators and co-ordinate future test procedures at an early stage", Philipp Strauss, chairman of the board said at the recent **Kassel Symposium on Energy Systems Technology**.

The DERlab approach is to conduct and evaluate round-robin tests between the laboratories involved. The availability of appropriate and well-defined testing routines is a basic prerequisite for the following certification of DER products.

"We must define common standards", says Thomas Degner, coordinator of the DERlab network. Even if a standard exists, it has many exceptions and variations. An example: The European standard called *Requirements for the connection of micro-generators in parallel with public low-voltage distribution networks* includes default values for the interface protection. "Of all 27 EU countries, 18 have added tables with exceptions and variations", Degner says.

Harmonising standards is one of the major aims of the DERlab partners. The Network of Excellence has, for example, prepared an international white paper about standardising grid inverters. These devices are increasingly being used to integrate distributed power generation and adapt the voltage and frequency of a solar power plant, for example, to grid conditions. To date, global standards do not exist in this area, and a draft concept devised by the DERlab partners will be discussed at the framework of the third DERlab inverter workshop in Nice, France on 9 December 2008.