Summary of Dissertation: „Influence of the Frequency Behaviour of Small Generators and Loads on Power Grids in Consideration of Large Grid Disturbances" by Philipp Strauß

This dissertation demonstrates that the frequency behaviour of small generators in the distribution grids considerably influences the grid stability of interconnected power systems. In case when big distortions occur as well as under normal operation conditions, small generators and loads can actively support the frequency control.

The boundary conditions of the European interconnected electrical power supply system have considerably changed in the past decade. At the distribution level, decentralised power production and strongly fluctuating power have attained a relevant and continuously increasing share. Additionally, a growing number of wind parks are feeding large amounts of fluctuating power at the transmission level. The resulting energy transport is super-imposed on the power flow that is caused by the international electrical energy trade. As the tie-lines between many European countries are still relatively weak, the regularly large power exchange raises the probability of big disturbances.

For a closer investigation of the power system stability, depending on the power-frequency control and on the parameterisation concerning the frequency limits of decentralised power generators, a dynamic model of the interconnected power system was developed. Using two examples of severe grid disturbances it was shown that the sum of relatively small decentralised generators considerably influences both stability and security of the European interconnected power system.

The disturbances under investigation caused load steps which were well above the primary reserve of the whole interconnected grid. This was due to the fact that grid parts became separated whilst they were in the process of exchanging large amounts of energy. In both cases huge numbers of decentralised power units were separated from the grid at a frequency deviation of 0.5 Hertz, thereby causing an additional lack of power. The dissertation justifies the recommendation to harmonise the lower frequency limit of such units European-wide to 47.5 Hertz, in order to avoid unnecessary loss of load in the future.

According to the rules for normal operation conditions of the European transmission grid, the secondary control should only be activated in control areas or control blocks in which the imbalances occur. The study analyses the influence of this rule on major disturbances with grid separation. The simulation showed that without blocking the secondary control during grid separation, large control reserves could have been activated for power balancing. Under the assumption of avoiding too high horizontal balancing currents, the nominal frequency value could have been reestablished much faster. Consequently, this approach would also accelerate resynchronisation and reconnection of the control areas and would hereby allow the power from the grid parts with excess power to be rapidly reactivated.

Also during normal operation conditions considerably high shares of primary and secondary control power can be delivered by decentralised generators and controllable loads. The influence that active-power contributions can have on the voltage in different grid levels was quantified. It was analysed how such decentralised power units could participate actively in the frequency control. Furthermore, new approaches for the frequency control of island grids were investigated. With monitoring data from field tests it was shown that decentralised generators can be controlled by applying the grid frequency as the only medium of communication.

The frequency control in static-converter dominated island grids is not only suitable for fast power control with power-frequency droops but also for energy management by using the grid frequency as an information carrier. On the Greek island of Kythnos, the first static-converter dominated grids with distributed photovoltaic generators, which were controlled via the grid frequency, were set up. Evaluation of the field test data showed, that a proportional synchronous limitation of power output from distributed generators via grid frequency is possible.