Active Power Management of Photovoltaic Systems – State of the Art and Technical Solutions

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Executive Summary

In several countries, PV capacity has exceeded the country's minimum load. Unlimited feed-in at all times is therefore becoming less and less possible.

Active power management of photovoltaic systems, in some contexts also called curtailment, is a powerful grid integration measure. The energy loss due to curtailment is typically little compared to the increase of the PV hosting capacity.

Curtailment is not a goal. It is a method for increasing the utilization of power grids without exceeding their physical limits. The ratio of annual energy yield to peak power is smaller for PV systems than for many other power plants. This is why PV plants would need large grid capacities in relation to the energy yield. However, there is only little energy in the power peaks. Therefore, it is not economical to expand the electricity grids to the rated power of the PV plants.

Curtailment can be implemented in various ways, with today's PV systems accommodating many of these methods. The choice of method should align with the specific application for optimal results.

Once it is decided not to feed the power peaks into the grid, many new possibilities open up. The surplus electricity can be stored or used for less efficient applications. The feed-in can be ramped up and down highly dynamically. This makes system services for stabilising the electricity grid possible. A large number of such possibilities are outlined in this report.
If all these possibilities are exhausted, the PV system can also be curtailed so that the infrastructure is not overloaded.

The value of electric energy is typically zero or can become even negative when it is not needed. Curtailed energy usually has a low market value.

In the context of the energy transition efforts, it does not seem to make sense to curtail PV plants. However, with the costs that can be saved by avoiding grid expansion, much more solar power can be generated and fed into the grid without bottlenecks.

The remaining solar power becomes more valuable. Thus, the feed-in power of a curtailed PV system can both be increased or further reduced at any time and in a highly dynamic manner. For the first time, photovoltaic systems can assume full system responsibility and thus gain additional relevance and create new market opportunities.

Communication systems are becoming increasingly relevant. At the same time, their value increases with higher levels of PV.

While distribution grids used to be planned according to the "fit and forget" principle and PV systems were connected to the grid in an uncontrolled manner, PV systems with active power management may be actively controlled, based on the system conditions.

Autonomous controls such as static feed-in limitation, dynamic voltage limitation or even frequency control can be implemented decentrally without communication. However, if PV systems are integrated into the overall system and operated to optimise the distribution and transmission grid, communication systems are necessary. With increasing system responsibility of PV plants, the relevance of these systems increases.