Batteries in the grid for more PV energy

In areas where already a large number of photovoltaic systems are installed, impermissibly high voltages can occur in the power grid on sunny days. It therefore needs to be clarified how the energy generated can be optimally used both technically and economically. One idea is that new charging strategies for batteries can effectively relieve the grid by optimally integrating the energy storage systems.

Owners of photovoltaic systems are particularly delighted when the sun shines right from the early morning and not a cloud can be seen in the sky throughout the day until into the evening hours. Their modules, which are often installed on house rooftops, then produce electricity. They can use this electricity free of charge. But what should be done with the surplus energy produced? It could be fed into the grid or temporarily stored. The disadvantage of grid injection: The energy that PV systems are already producing in some regions on sunny days is creating excessive loads on the power lines. Although expanding the grid would help but new power lines are expensive. Researchers have therefore investigated how batteries can be integrated sensibly into the low voltage grid with a minimal need for expansion. Solar energy can then be better used by the generators and the power lines are relieved.

The idea of storing solar energy in batteries is not new, but existing charging strategies have several disadvantages. Existing storage processes can be divided into three versions:

- Direct charging
- Delayed charging
- Peak shaving

With direct charging the energy is preferentially consumed by the system operator themselves. If the energy generated exceeds the current

In rural areas there has been a comparatively large expansion of photovoltaics. The electricity grid, however, is relatively poorly developed here. This means that the electricity feed-in can be problematic.

Batteries in the grid

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The charging strategies are classically divided into three categories. They differ, for example, in terms of when the batteries are charged.

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Without intermediate storage the personal consumption is low and the down-regulation is high. In order to achieve a maximum yield and low grid loading, minimal down-regulation combined with high self-consumption are ideal.

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Voltage duration characteristic for the largest voltages: Here it can be easily seen that the highest voltage peaks are achieved in a scenario without batteries. The voltage stability effect is largest if the storage systems are
charging, the control unit stipulates a maximum battery charging level. Since this increases throughout the day, the PV system can always feed part of the energy into the grid while the remainder is stored. High feed-in peaks are reduced to a minimum. With grid-optimised operation (peak shaving), the battery only saves the peak power of the PV generation from a certain threshold. This lowers the load on the low-voltage grid. At the same time, however, the personal consumption also reduces owing to the prioritised grid feed-in. Although these control-based charging strategies can be implemented relatively easily, they offer few opportunities to adapt target figures.

**Optimal charging strategies and a sensible battery distribution enable high personal consumption and relieve the grid**

Researchers are deploying a self-learning model in a research project entitled “Optimising the system integration of intermittent power generated from renewable energy sources using the example of photovoltaics at the low-voltage level” (SYSPV-NS). They are investigating the extent to which a high level of personal consumption can be combined with a grid-supportive procedure for photovoltaic systems. Since with conventional PV system operation the grid feed-in output is reduced from a certain value, a greater energy yield can be achieved with optimal battery behaviour. In addition to the three previously described charging processes, the developers have designed a further version based on model predictive control (MPC). MPC is especially suitable for highly dynamic and complex systems. The researchers have shown that the MPC-regulated battery charging enables both a high level of personal consumption and the lowest possible down-regulation of the PV system. With perfect forecasting, they even managed to reduce the down-regulation in the area investigated to 6.4 per cent. By way of comparison: without the storage system, the PV systems would down-regulate 25 per cent of the annual yield.

Another aspect of the work was to investigate the topological distribution of the storage systems. Where do they help most of all to stabilise the grid voltage and where is their effect moderate? The project partners have limited their investigations to radial networks, such as those frequently found in rural areas. Here they have found that the largest effect occurs when the storage systems are installed at the end of the power line. This assumes that not every household is equipped with a battery. With the same total capacity the effect is most evident, however, when a battery with a correspondingly lower capacity is installed on each PV system.

Even if storage systems can reduce the grid expansion, they do not make immediate sense from a financial point of view. However, they can certainly be operated economically if there is increased personal consumption. Further research could examine the possibilities for an optimal grid expansion in, for example, meshed networks.

Other research projects on sustainable electricity grids can be found on the Web-based forschung-stromnetze.info research portal, which is funded by the German Federal Ministry for Economic Affairs and Energy.

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