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Influence of different loading strategies for domestic PV-battery energy systems on the residual loads at regional scale

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In Germany, the use of domestic battery systems coupled with roof-top mounted photovoltaic plants has gained popularity in the recent years. The reason for this is in many cases the goal of independency by higher self-consumption rates of households. From the grid operators' perspective, however, battery storage devices can also enable a better integration of the volatile energy production and therefore reduce problematic negative peak loads of domestic PV-systems in the electricity grid. Thus, the battery loading strategies belong to the decisive factors, which determine the degrees of autarky, but also the smoothing of negative load profiles.

The applied model consists of a consumption, a solar energy production and an accumulator component on domestic scale. It is integrated in the physically-based spatial land surface process model PROMET using a temporal and spatial resolution of one hour and 100 m. The input data includes technical parameters like efficiencies of the battery and PV-systems or domestic consumption profiles, but also the natural conditions, such as the radiation.

Three loading strategies for the battery devices are analyzed for the years 2015 and 2045 including climate change effects: (i) the maximization of self-consumption, (ii) a fixed feed-in limit of 70% to minimize shut-off times and (iii) a variable feed-in limit, which optimizes the self-consumption and the reduction of the peaks. The threshold values needed for the third strategy are determined in advance from the obtained hourly energy deltas from each household.

The selected study region consists of three Bavarian districts south of Munich, Germany. App. 2000 roof-top domestic photovoltaic plants between 3 and 10 kWp were chosen for the study, which are coupled to lithium-ion accumulators with a storage capacity of the according peak power.

The simulation results of the self-consumption strategy show the lowest domestic dependencies but high negative peak flows into the grid in the summer time as soon as the batteries are fully charged. This effect can not be balanced out on regional scale. The second strategy leads to apparently smoother grid loads, but the degree of autarky of the households is low. The third strategy optimizes the two expectations leading to a relatively high self-sufficiency but also reduced load peaks in the grid. The daily optimum feed-in level strongly depends on the location and orientation of the photovoltaic plant. Climate change has only minor effects on the results for 2045 due to the expected low influence on the solar radiation within the model region.

The results show that the development of algorithms, which predict the domestic energy deltas with high accuracy, can contribute to a reduction of the costs for the grid adjustment due to the volatile solar energy. In the long-term perspective domestic battery storage devices can therefore lead to a significantly better integration of the decentralized renewables.