How to model (and steer) the future uptake of PV battery systems?

Themenbereich 2. Strom- und Wärmeerzeugung sowie Speicher

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Motivation

Photovoltaics (PV) and li-ion batteries have the prospect of reduced cost in the near future – a development which could greatly enhance PV battery systems' financial attractiveness under certain self-consumption promoting conditions [1]. However, it is uncertain how an accelerated PV and battery uptake affects the overall electricity system – market prices and aggregated demand for electricity in particular. Some scenarios discuss the possibility of accelerated grid defection [2].
This paper wants to delve deeper into the following questions concerning PV battery systems: Under what conditions do they become economically viable? What is their prospective level of deployment, given certain scenarios of cost developments, remuneration, and retail price structure? Are they a source of flexibility or more a burden for the overall electricity system?

Methodological approach

Starting point of the analysis is a techno-economic assessment of PV battery systems. Profitability analysis via an NPV method is performed. The PV and battery size are varied to calculate an internal rate of return (IRR) matrix of possible system configurations. As several studies [8–10] have shown, the economic viability of self-consumption greatly depends on the load profile of the particular consumer. Generation and load profiles (data: [3]) are therefore varied as sensitivity analysis.
For the uptake scenarios, we vary 1) PV and battery cost development derived from learning curves, 2) remunerations and levies and 3) tariff design, as this is a source of uncertainty and variability in profitability of PV-battery systems [4]. Based on an empirical evaluation of past investment dynamics of residential PV systems in Germany [5], [6], the mean profitability of PV battery systems is used to model the historic and scenario-based prospective level of uptake.
Next, system effects are studied in the framework of an agent-based electricity market model [7], which has an internal representation of market prices (merit-order based spot market prices on hourly basis, dynamically calculated in dependence of the electricity mix). The share of self-consumed electricity is incorporated into the model in order to study the effect on the residual load in the system and possible reactions of suppliers.

Results and Conclusion

The scenario analysis reveals that great uncertainty still exists about the economic prospects of PV battery systems. First and foremost, the cost developments of PV and battery cells fundamentally determine the economic prospect. In many scenarios, there is a broadening window of system configurations which have a positive economic potential.
The findings of [8–10] can be confirmed: the economics and system operation of PV battery systems appear to greatly depend on system configuration (mainly the relative sizes of PV panels and battery), and on the load profile of the consumer. Figure 1 exemplifies this with the autarky rate, i.e. the share of consumed electricity which can be met by the PV battery system. The variability of values is shown in box plots, with the red line being the median of values, and whiskers indicating extreme values.
Figure 2 shows the result of the modeling of the historic uptake of PV battery systems in Germany (data: [11], KfW). This model calibration is used to substantiate the uptake scenarios.
Retailers and policy makers can actively influence the economic prospect of PV battery systems by adjusting levies, credit allowances and tariff structure. The question on how those actors can influence the dynamics of the uptake of PV battery systems will be tackled in the long version of this paper.

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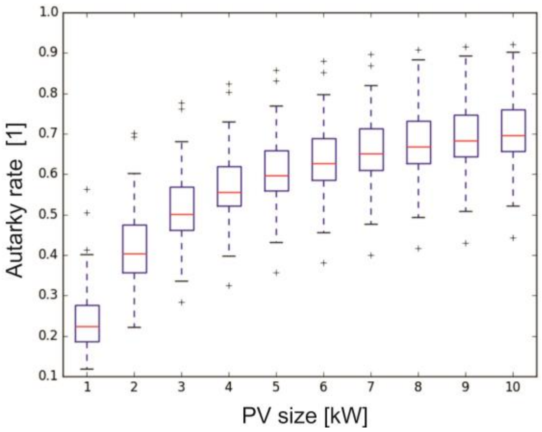

Figure 1: Example of the variability of autarky rates depending on PV size (x-axis) and different load profiles (box plots) for a battery size of 5 kWh.

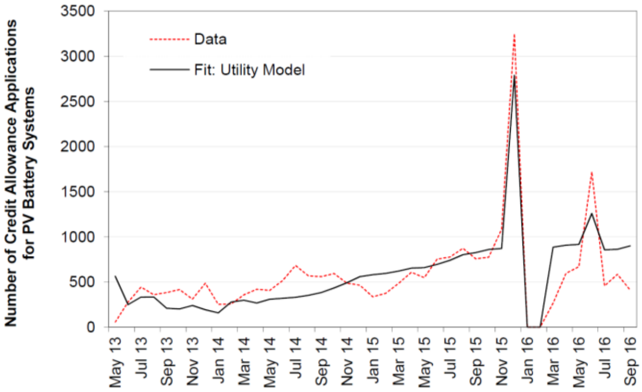

Figure 2: Example of uptake modeling of PV battery systems

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