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Potential And Optimal Sizing Of Combined Heat And Electrical Storage In Private Households

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Abstract

The increase in fluctuating renewable electricity generation requires growing flexibility and balancing capacities in the electric energy grid. Storage systems can provide the necessary balancing capacities. Therefore, it is analyzed which potential for flexible energy consumption can be found in private households. Heat and power in private households are heavily interlinked due to increasing numbers of electrical heating systems (e.g. heat pumps). In addition, installed PV systems on roof tops are making renewable electricity an attractive energy source for space heating and hot water supply. To maximize the consumption of self-generated electricity, battery energy storage systems (BESS) and thermal hot-water based storage systems are used in private households. The challenge is to find economically viable configurations for sizing of combined battery and thermal storage units. The introduced approach simulates a household with a variable size of the relevant components of the thermal and electric system, being the PV system, PV and battery converters (DC linked), the battery (lithium-ion), thermal hot water storage and a heat pump. Profiles for the electrical load are based on empirical analysis of resident behavior coupled with measurements from typical household appliances. The thermal load profiles are derived from representative simulation tools, simulating resident behavior and the resulting heat demand. Based on the simulation results, an optimal sizing of storage units is calculated.

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Keywords: PV home storage system; heat storage; thermal storage; self-consumption; battery energy storage system

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1. Introduction

The rising number of storage units in private households and the already immense feed-in from photovoltaics implicate growing challenges for the distribution grid. One goal is to maximize the self-consumption of own generated PV electricity, while minimizing negative influence on the grid. Together with a growing number of heat pumps in newly built houses the potential for PV battery energy storage systems (PV BESS) to be used for a maximization of self-consumption of own generated electricity is steadily increasing. Ideally, the potential of the heat and electric systems in private houses can also be utilized to relieve the grid.

Fig. 1 shows the development of installed PV peak power in Germany and the rising share of newly built houses which have installed a heat pump for domestic hot water (DHW) and space heating.

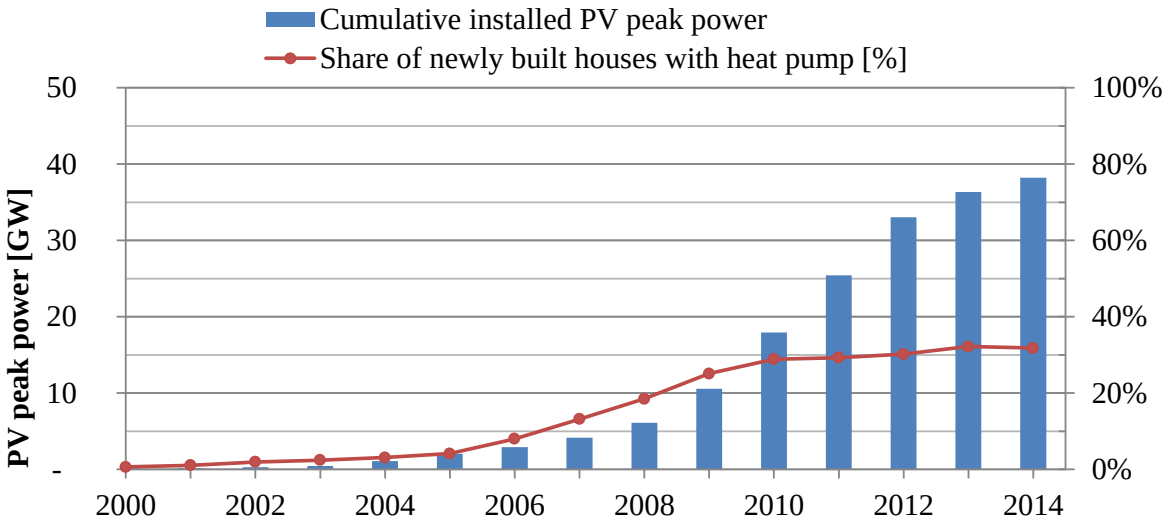

Fig. 1. Development of installed PV power and share of newly built one family houses with heat pump [1, 2].

It can be seen that the share of newly built houses having a heat pump installed has been increasing and is today at around 30 % in Germany. Together with the high level of installed PV peak power this leads to the incentive to investigate the potential to provide as much of the domestic demand for heat and electricity from photovoltaics as possible.

Storage units, especially thermal storage can already be found in today's households, mainly in the form of hot water storage tanks. Additionally, a rising number of PV battery energy storage systems (PV BESS) are being installed in addition to photovoltaics on rooftops. In Germany the installation of such systems is incentivized in the form of subsidies for battery storage systems and credits at reduced rates of interest provided by the KfW Group[1] [3].

1.1. Research objectives

Previous research has shown a distinct potential for relieving the power grid from consumption peaks, as well as renewable generation peaks through dynamic load shifting of electrical and thermal demands in residential buildings [4, 5, 6, 7, 8]. Based on that, we investigate in this study to what extend domestic energy storages empower such demand side management (DSM) in private households. Therefore, the DSM potential of the existing supply systems in one family houses (OFH) in Germany is evaluated and the question which degree of retrofit or new construction of the supply and especially storage systems is beneficial is answered. The goal is to find an optimal

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