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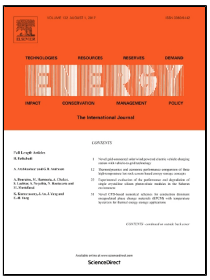

Cost optimal sizing of smart buildings' energy system components considering changing end-consumer electricity markets

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Cost optimal sizing of smart buildings' energy system components considering changing end-consumer electricity markets

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Abstract:

Managing the electricity system becomes increasingly challenging, calling for modifications of the current electricity market. High fluctuations in power generation could make the introduction of dynamic end-consumer electricity pricing reasonable. Furthermore, the prediction of end-consumers' power consumption would get easier when charging the maximum power capacity, instead of the consumed energy. Thus, this paper discusses the capability of smart buildings to cope with such market models and evaluates how the design of the electrical and thermal energy system of a modern German building is affected. Therefore, cost optimal sizing of the main supply system components is carried out based on a hybrid MILP and a heuristic optimization algorithm. The results indicate that local photovoltaic generation is beneficial in almost all market conditions, while except for the capacity market, batteries are only economical if prices decrease by more than 60%. The identified electricity price dynamics are too low to incentivize investments into load shifting capable supply or storage systems. Nevertheless, if an installed heat pump and the associated thermal storage have smart home capabilities, they support the maximization of PV self-consumption and reduce electricity cost.

Keywords:

Electricity market, cost optimization, dynamic electricity pricing, capacity market, smart grid, demand side management

1. Introduction

The vastly growing renewable energy sector induces the challenge of highly fluctuating and unpredictable renewable energy generation (e. g. from photovoltaic (PV) and wind). Due to the current inflexibility of electricity demand, it is not always possible to match the renewable energy generation with the demand. The rising share of wind and PV in the total energy portfolio will further aggravate that challenge in the upcoming years [1]. Residential and commercial buildings, which are accountable for up to 30% of Germany's final energy consumption [2], can provide flexibility to counter these imbalances between supply and demand in the electrical grid [3, 4]. However, there are several technical and energy political boundary conditions which strongly impact this potential. Technical challenges mainly arise from the energy demand of buildings, which is driven by space heating and supply of domestic hot water (DHW). Therefore, electricity driven heating systems (e. g. heat pumps, direct electric heating) are required to effectively utilize energy flexibility offered by buildings [3].

Furthermore, the energy only market (EOM) currently established in Germany and many other European countries, does not provide any motivation for flexible, grid supportive electricity consumption. Market models have to change in order to provide incentives for customers to change their consumption behavior. Grid compatibility could be encouraged by market models comprising dynamic electricity pricing dependent of the currently available electricity generation, while market