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Investigating the demand side flexibility of the residential building stock

Energy modeling

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Motivation und zentrale Fragestellung

With a growing share of volatile renewable electricity, demand shifting and demand response become increasingly important to maintain electricity grid stability. Shifting demand peaks in the residential sector can effectively reduce demand peaks in the electricity grid. This paper addresses the following overarching research question: How can active demand response measures of buildings with heat pumps (HP) in the residential sector affect the aggregate load profile on the national level?

Methodische Vorgangsweise

To deal with this question, we developed an optimization model. It takes the detailed building stock of a country by building archetypes into account. The occupants' behavior is considered by assigning different indoor set temperatures and days of absence to each building archetype. The optimization algorithm's objective function is to minimize each building type's end-users cost, assuming a dynamic electricity price function. The focus is on space heating, cooling, and hot water production. E-mobility and various smart household appliances, thermal and battery storage, and photovoltaic electricity production are considered as well. Heating and cooling loads are calculated hourly by a 5 resistance – 1 capacity model (EN ISO 13790), while the non-heating induced electricity and hot water consumption are exogenously derived. The optimization algorithm optimizes all these components added to the house. For buildings with no thermal storage, heating and cooling demand can still be shifted through thermal inertia. The load profiles thus obtained are compared to the load profiles without optimization. This way, the flexibilization potential of each building archetype with different users is investigated. By aggregating these results, we make statements about the flexibility potential of the entire residential building stock.

Ergebnisse und Schlussfolgerungen

Expected results to be presented in this paper include load profiles of a representative building in Austria for a particular building archetype considering the demand response with and without certain appliances. We quantify the cost reduction and the change in the load profile of a specific building. Our analysis shows that active demand response on the consumer level can shift electricity loads with Heat Pumps in the grid significantly even without any extra storage implemented into the buildings when considering the thermal capacity. The integration of additional storage appliances will improve the flexibility of the building stock further. Another result of our research will be the profitability of various storage systems, particularly thermal hot water storage for heating, battery storage, and PV. Subsequently, all building load profiles in Austria are aggregated and compared to a current profile that does not consider demand response in this region. In this way, we investigate the demand side flexibility of the residential building stock.

Literaturverzeichnis

EN ISO 13790. Energy performance of buildings - Calculation of energy use for space heating and cooling.