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INNOVATIVE LOCAL ENERGY CONCEPTS WITH E-MOBILITY CHARGING FOR RESIDENTIAL BUILDINGS

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Overview

The mobility sector is one of the largest energy consumers in Germany and therefore facing the necessity of major reconstruction in order to meet energy transition targets. The electrification of passenger cars is the main goal of the German federal government. Additionally, the electricity system becomes more and more decentralised and residential, local energy concepts become business models of high interest for municipal energy providers. We thus study different residential energy concepts with the inclusion of decentral electricity generation and different electric vehicle strategies. The analysis is based on the techno-economic feasibility of the concepts, considering factors such as installation costs, operational expenses, and technical performance. It further includes a scenario investigation to study the robustness of the behaviour under volatile prices in the future.

Method

For optimising the energy technology concepts, a mixed integer linear programming framework has been implemented using the oemof-solph library (Krien et al., 2020). The objective of the optimisation problems is to minimise the total annual costs which include the costs for installation of new technologies as well as maintenance and operational costs. The decision variables are the installation sizes of the technologies and their operation. The considered concepts all include wallboxes for charging electric vehicles – by default through the electricity grid, or with the variants of installing local photovoltaics (PV) modules with or without an additional battery storage. The charging demand of the electric vehicles is based on a simulation of the mobility behaviour according to Clearingstelle für Verkehr, 2017. Two charging strategies are applied: direct charging and smart charging. The models are applied to typical single-family and multi-family houses in the city of Düsseldorf, Germany, and energy prices following historical data from 2021 and projection scenarios for 2035 and 2050.

Results

The economic metric for the performance of the concepts is the annualised levelized cost of energy (LCOE). We find that the charging strategy of smart charging reduces the LCOE in comparison to direct charging. The installation of local electricity generation reduces the LCOE as to the full grid-connection. However, the variant without an additional battery reaches lower LCOE than the one with the battery. Still, the battery variant has a high technological performance. The self-sufficiency and the self-consumption are significantly higher in this concept. These findings hold irrespective of the scenario input data. Considering the installation sizes, we find that it is cost-optimal to build the PV up to the maximal available roof area, except for the case of the single-family house in a few price scenarios. Moreover, the battery inflow power is smaller in case of smart charging than for direct charging. The battery capacity increases linearly with the grid electricity price and decreases linearly with the household electricity demand.

Conclusions

In conclusion, we reinforce the economic feasibility of smart charging strategies for residential energy systems. This can propose an interesting business model for local energy providers in which they can apply a tariff scheme according to the charging strategy. The best economic performance is found for a concept with a PV installation on the buildings' roofs. An additional battery increases the self-sufficiency and self-consumption of the system, but also the LCOE. The grid electricity price has an influence on the installed battery capacity, but trends for the system performance are the same irrespective of the price input.

References

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