Optimization-Based Control of a Battery Electric Storage System in a Single-Family Household under Uncertainty

(3) Sektorkopplung und Flexibilität
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Motivation / Motivation und zentrale Fragestellung

The combination of roof-top photovoltaics (PV) and battery electric storage systems (BESS) play an important role in the decarbonization of the building sector and the overall economy in the residential sector. The key to unlocking the true potential of these two technologies lies in the supervisory control of the BESS to serve the energy load as (cost-)optimally as possible with the available energy. In the context of industry or energy communities, optimization-based control methods have been effective in doing so [1]. However, as the major bottleneck of these methods is the predictive accuracy of their forecasting model, it is the central question of this work, whether these can be used for single-family households, whose load profiles are much harder to forecast.

Methods / Methodische Vorgangsweise

This work investigates the feasibility of an optimization-based control method for residential applications by integrating a novel load forecasting algorithm into an existing model predictive control (MPC) framework for a single-family household. The novel load forecasting algorithm is based on the transformer architecture [2], which has disrupted the field of machine translation. The transformer uses multi-head dot-product attention, which is an efficient technique of computing relevance between elements of a timeseries.

The operational costs of the MPC, which uses the transformer forecasting model, are compared to those of a rule-based controller under multiple tariff scenarios. The MPC method is depicted in Figure 1, which shows how the repeated sequential execution of forecasts, and a mixed-integer linear program (MILP) are able to control the BESS. The rule-based control method follows the logic of surplus charging.

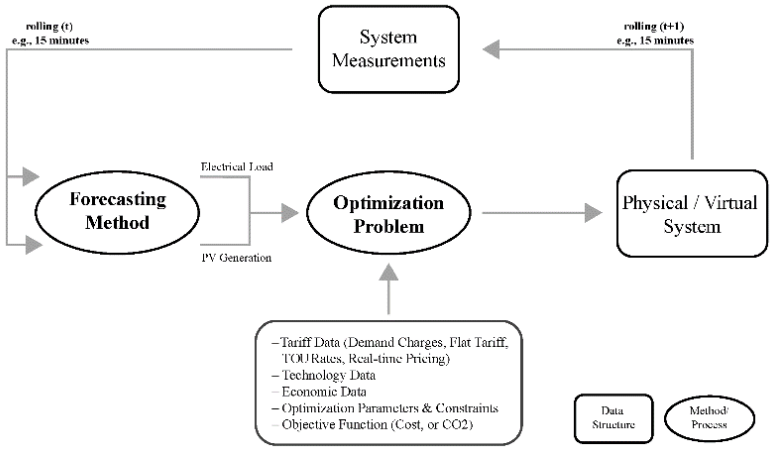

Figure 1: Model Predictive Control Framework

To obtain an upper bound on MPC cost savings, the same period is evaluated with "perfect foresight," i.e., substituting actual metered values for transformer forecasts.

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Preliminary Results / Ergebnisse und Schlussfolgerungen

The preliminary findings of this work suggest that the optimization-based control of single-family households is feasible for certain tariff scenarios (see Figure 2). The cost savings compared to a standard rule-based controller are significant, especially as the capacity of the BESS increases. However, cost savings seem to be thwarted primarily by the lack of predictive accuracy, as the difference between perfect and real foresight easily dwarfs the gains from larger BESS.

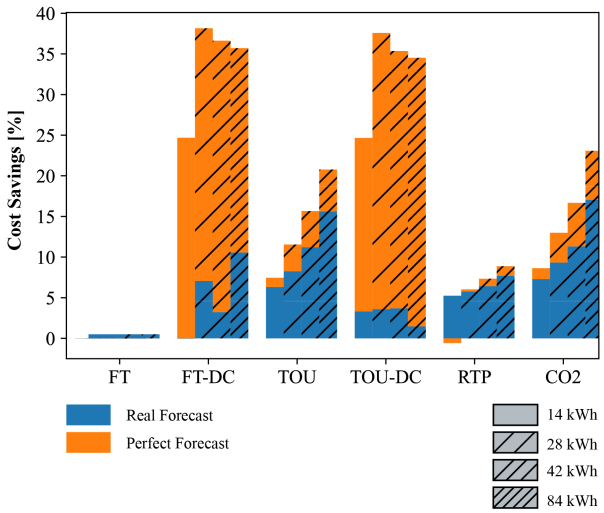

Figure 2: Real and ideal cost savings [%] of a single-family household under multiple tariff scenarios

Literatur

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[2] Vaswani, A., Shazeer, N., Parmar, N., Uszkoreit, J., Jones, L., Gomez, A. N., ... & Polosukhin, I. (2017). Attention is all you need. *Advances in neural information processing systems*, *30*.