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The value of e-mobility flexibility for aggregators – Portfolio management and contract design based on price and quantity uncertainty

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Motivation: Electric vehicles (EVs) are crucial for providing flexibility in future electricity systems, complementing renewable power generation. However, aggregators face economic obstacles in tapping into this flexibility potential. The lack of EV user-centered contract design hinders the widespread adoption of EV-based flexibility, leading to missed opportunities for reducing greenhouse gas emissions. Therefore, it is essential to investigate the impact of different contract design specifications on the financial performance of EV aggregators. By assessing different contract specifications, we can identify promising combinations that may promote the adoption of EVs and thus support the transition towards a low-carbon economy. However, uncertainties with electricity market developments and the uncertainties associated with EV mobility behavior make it challenging to value the EV user's flexibility for the electricity system. Therefore, this study aims to provide a comprehensive understanding of the relationships between contract design, flexibility valuation, aggregator financial performance, and end-consumer behavior. We provide a framework that can be used to evaluate operational decision making of EV aggregators, implications on contract design including pricing strategies.

Methodology: This work addresses the research gap by extending the commonly used Least Square Monte Carlo approach that is considered to assess the effects of marginal decisions under uncertainty. We will investigate the impact of various contract design specifications, such as minimum battery filling levels and fast recharge options, on the financial performance of EV aggregators. As novelty, our methodology will not only account for the uncertainties associated with electricity price uncertainty but is extended to cover the EV users'mobility behavior including arrival and departure times. We will use historical data on the continuous intraday electricity market and EV mobility behavior derived from the Mobilität in Deutschland 2023 study. Applying a short-term forecast model to obtain probabilistic price trajectories, the simulation model will be used to simulate the preferrable decision making of the aggregator to maximize the profit. The financial performance of the aggregator for exemplary weeks is used to derive implications on contract design.

Expected results: The study provides insights storage valuation and EV flexibility contract design. We also expect to find that the financial impact of contract design specifications, specifically guaranteed filling levels at preferred departure times in the morning, as well as (lower) minimum filling levels during nighttime, vary depending on short-term electricity price patterns on the continuous spot market, as well as the mobility behavior of the EV users. Whereas forecasted high electricity price volatility is preferential for the aggregator, longer plug-in times of the EV users only provide a decreasing marginal benefit.

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