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Electric Mobility in PowerACE

Integration of unidirectional and bidirectional charging in agent-based electricity market models

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Introduction

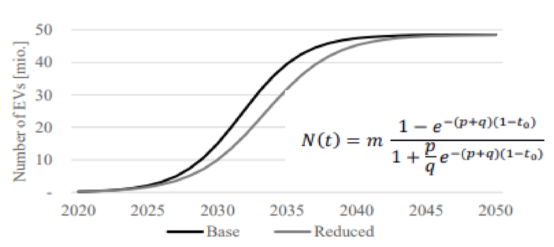
- A crucial challenge for the energy system of the future lies in aligning demand with supply. In this context, electric vehicles (EVs) offer significant potential to enhance flexibility within these future energy frameworks. Unidirectional Controlled Charging (UCC) harnesses this potential by adjusting the timing of charging sessions to allow a one-way flow of power from the charging station to the EV. Expanding on UCC, Bidirectional Controlled Charging (BCC) enables EVs to return electricity to the grid. This not only undermines their role as mobile electricity storage units but also opens up further opportunities for flexibility within the energy system.
- The PowerACE EV module incorporates electric mobility into its market model as a dynamic participant. It allows EVs to not only meet their electricity needs for mobility but also to offer both unidirectional and bidirectional flexibility to the energy market. This approach, looking ahead to the year 2040, anticipates the increasingly integral role that EVs will play in balancing energy supply and demand, thereby contributing to a more resilient and adaptable energy ecosystem.

Methodology

Estimation of EV Flexibility

Input 1: EV Diffusion Module

The size of future EV fleets is estimated based on a bass-diffusion model. The model parameters are estimated by fitting the curve to historical fleet data and future governmental EV targets.



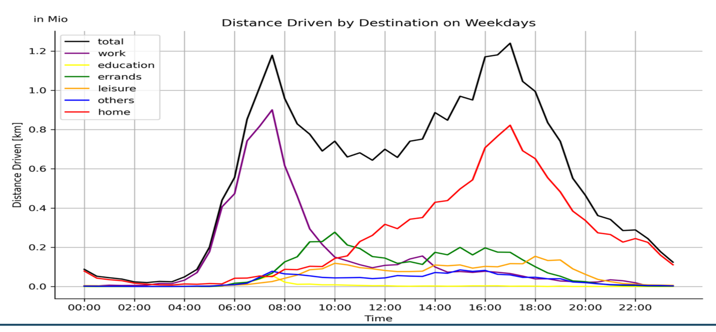
Input 2: EV Mobility Module

Drawing on insights from the Mobility in Germany (MID) Survey, mobility profiles are assigned to the fleet. These profiles are prioritized according to the likelihood of adopting electric vehicles (EVs) and are then systematically allocated to the EV fleet on an annual basis.

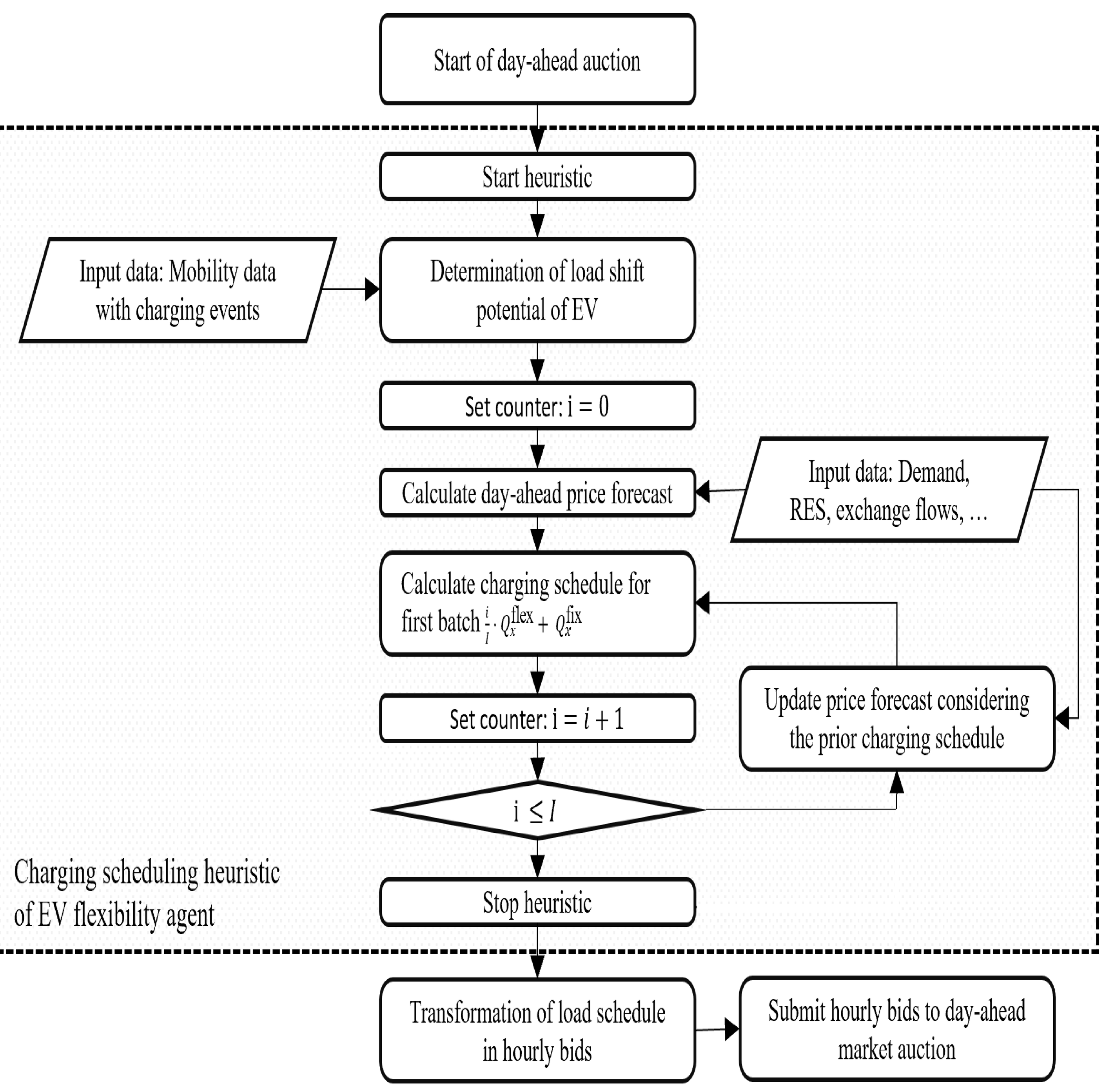
Input 3: EV and User Characteristics

Characteristics such as vehicle consumption, range, battery capacity, and battery type are assigned to each previously allocated driving profile. In addition, mobility profiles can be extended to include user data obtained from surveys. Such user data includes the likelihood to plug in the vehicle, the willingness to participate in controlled charging or the willingness to pay.

Based on the previous input flexibility profiles with the demand, load-shift potential, and user info are calculated. The flexibility profiles can be used in the PowerACE model.

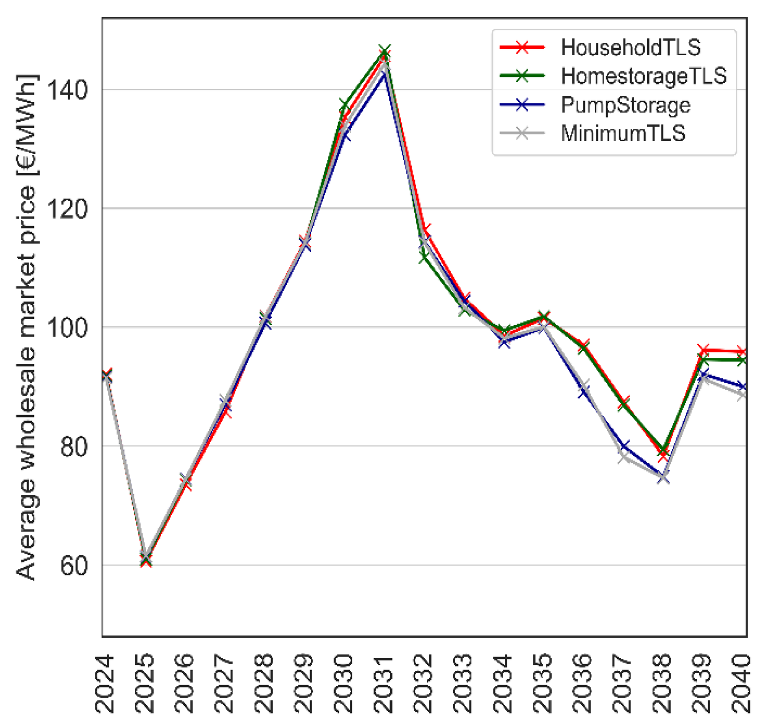


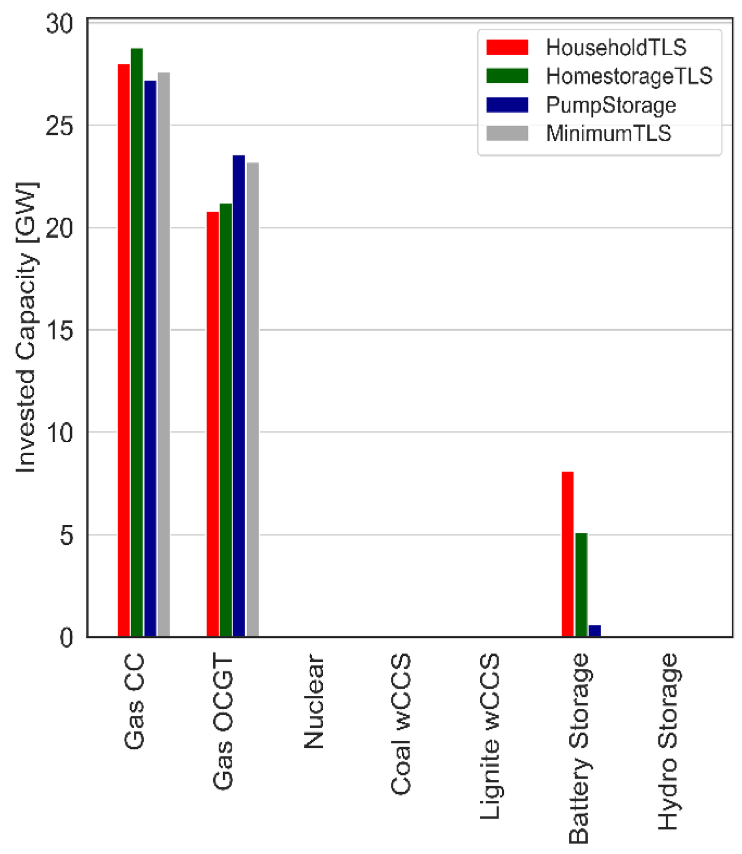
EV Agent in PowerACE



Exemplary Results

We analyzed the effects of various tax regimes on V2G trading. The effects on investments and wholesale prices are displayed subsequently.





Outlook/ Work-in-Progress

- New methodology to estimate the flexibility of EVs, which allows for a better depiction of the charging location of EVs.
- Inclusion of battery degradation in variable cost of EVs.
- Extending the scope of EV module to multiple European countries..
- Development of a new PowerACE marketing module that incorporates different approaches such as stochastic optimization and reinforcement learning.
- Analysis of EVs together with other household flexibility such as PV, home storage, and heat pumps.

Acknowledgement

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