

PowerACE – An Agent-based Electricity Market Model



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PowerACE is an agent-based electricity market model. Its modeling approach makes it possible to examine the interplay between market mechanisms and agent behavior. The framework includes modules for analyzing both operational decision-making and strategic behavior. Different agents and technologies can be represented, and a variety of market conditions can be explored. As a bottom-up model, PowerACE represents unit-level assets and firms to capture heterogeneity, learning, and long-term investment dynamics, enabling rigorous assessments of policy, market design, and system adequacy under uncertainty.

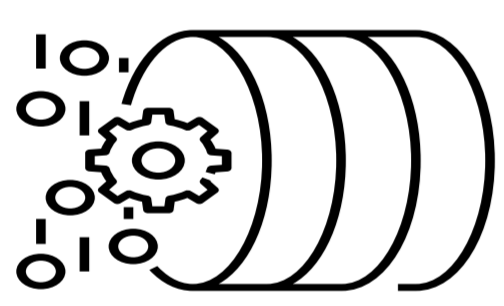
Through interfaces, additional models, such as (optimal) power flow models or reinforcement-learning modules, can be combined with the model. This enables PowerACE to support comprehensive analyses within the energy system.

Case-study dynamic grid fees



1. Step: Optimal power flow calculation

Determine locational marginal prices within the transmission grid using an AC Optimal Power Flow model.



2. Step: Determine grid fees

Calculate grid fees for every hour and node based on locational marginal prices. Low-priced nodes get a markup, while high-priced nodes get a markdown. The number and distribution of affected nodes and the magnitude of the fees depend on the parameters and methodology chosen for the approach.



3. Step: Simulation of the electricity market considering grid fees

The additional costs are allocated to thermal power plants and renewable energy sources based on their locations.



4. Step: Redispatch calculation

Determine necessary redispatch volumes and costs based on the PowerACE dispatch.

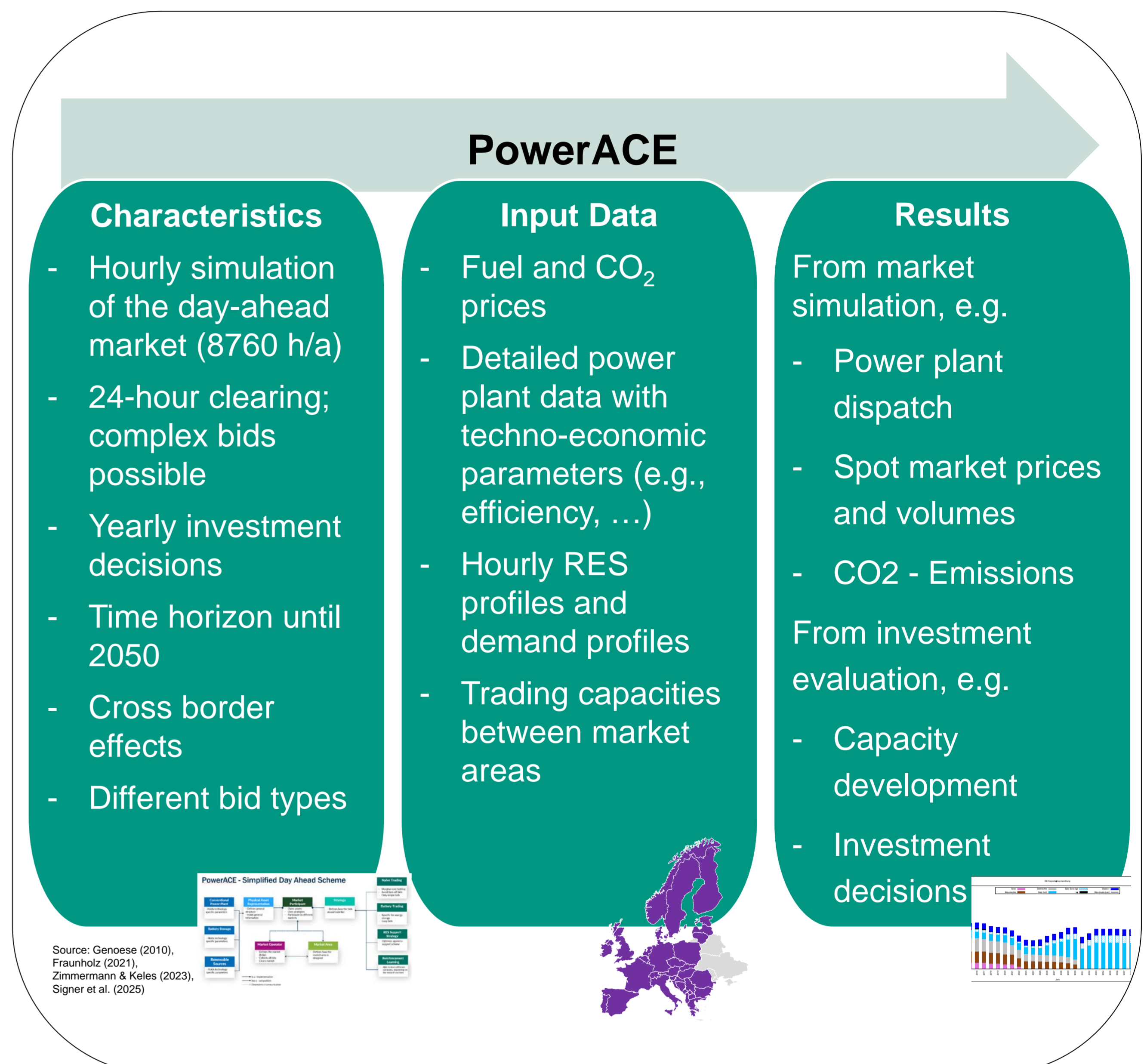
Results

In an initial case study for Germany, a 40% reduction in redispatch costs was achieved over one year, with only small changes in the market price (+/- 1 €/MWh on average). The primary driver behind the cost reduction is a roughly 30% decrease in grid-related renewable curtailment. Side effects include a generally lower domestic renewable generation and higher net imports, which result from the dynamic grid fees being applied solely within Germany.

Current developments

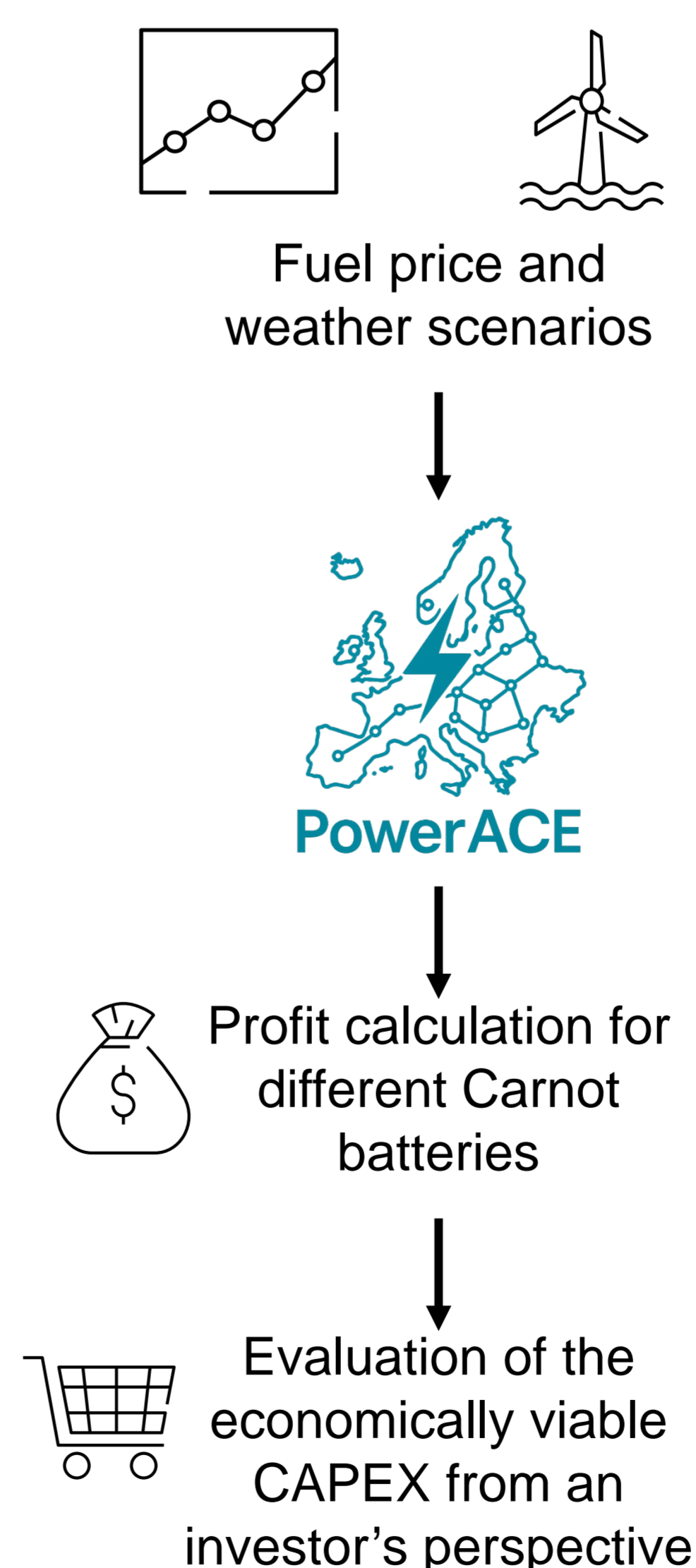
- Flow based market coupling
- Improved demand side response
- Portfolio optimization for day-ahead dispatch
- Reinforcement Learning
- Further bidding strategies
- Improved price forecasting for investments

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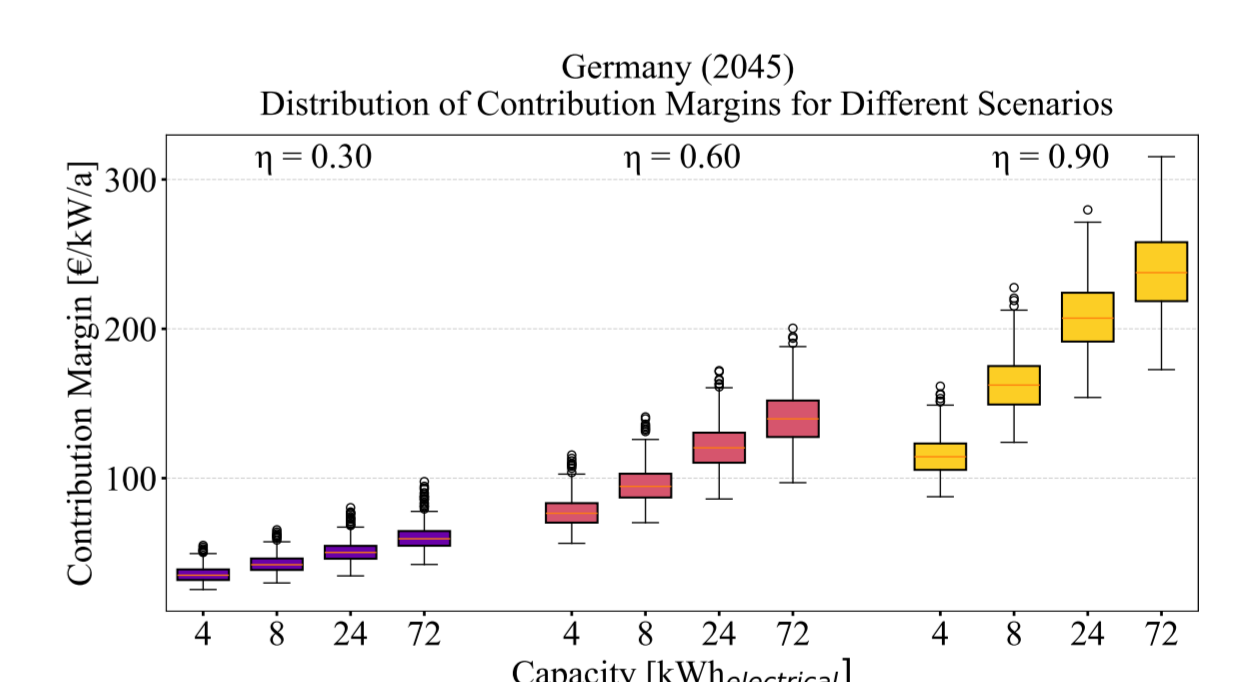


Case-Study Carnot batteries

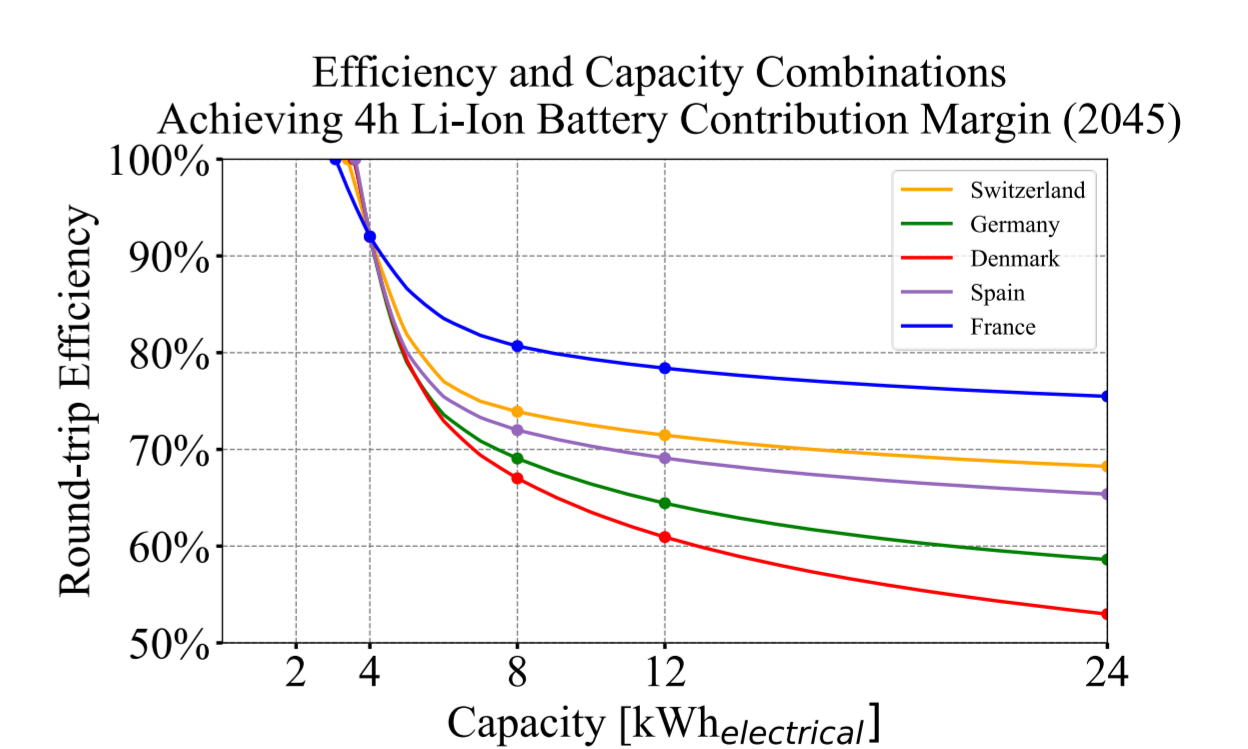
Workflow



Results



Larger storage capacities lead to increasing contribution margins. Nevertheless, a saturation effect can be observed, as well as an increasing uncertainty.



Competitiveness relative to lithium-ion batteries depends strongly on the market and increases with a higher energy-to-power ratio.