

Techno-Economic Optimization of Energy Systems



Introduction

- Business cases for renewable energy systems face challenges in viability at high renewable penetration levels.
- Uncertainties arise from factors such as energy prices and consumer behavior.
- This research aims to improve techno-economic models and optimization techniques for robust system sizing. The focus is on energy systems that deliver value both locally and in energy markets.

Contributions

- Assessed the potential for cost and emission reductions through optimized PV and battery sizing combined with smart EV charging.
- Quantified the added value of incorporating ancillary services (e.g., grid balancing) into the asset value stack.
- Demonstrated how EV charging optimization and other loads influence the optimal PV size.

Methodology

- Used real-world consumption, production, and energy price data.
- Simulated energy system control optimization to minimize total costs, employing physical models (Python and algebraic modeling).
- Evaluated multiple scenarios across a broad range of asset sizes to assess sensitivity to key parameters.

Interim Results

Shared energy systems in local energy districts (Figure 1, data 2023)

- Larger PV capacity increases both self-sufficiency and annual value.
- Battery capacity improves self-sufficiency but reduces annual value, particularly with smaller PV systems.

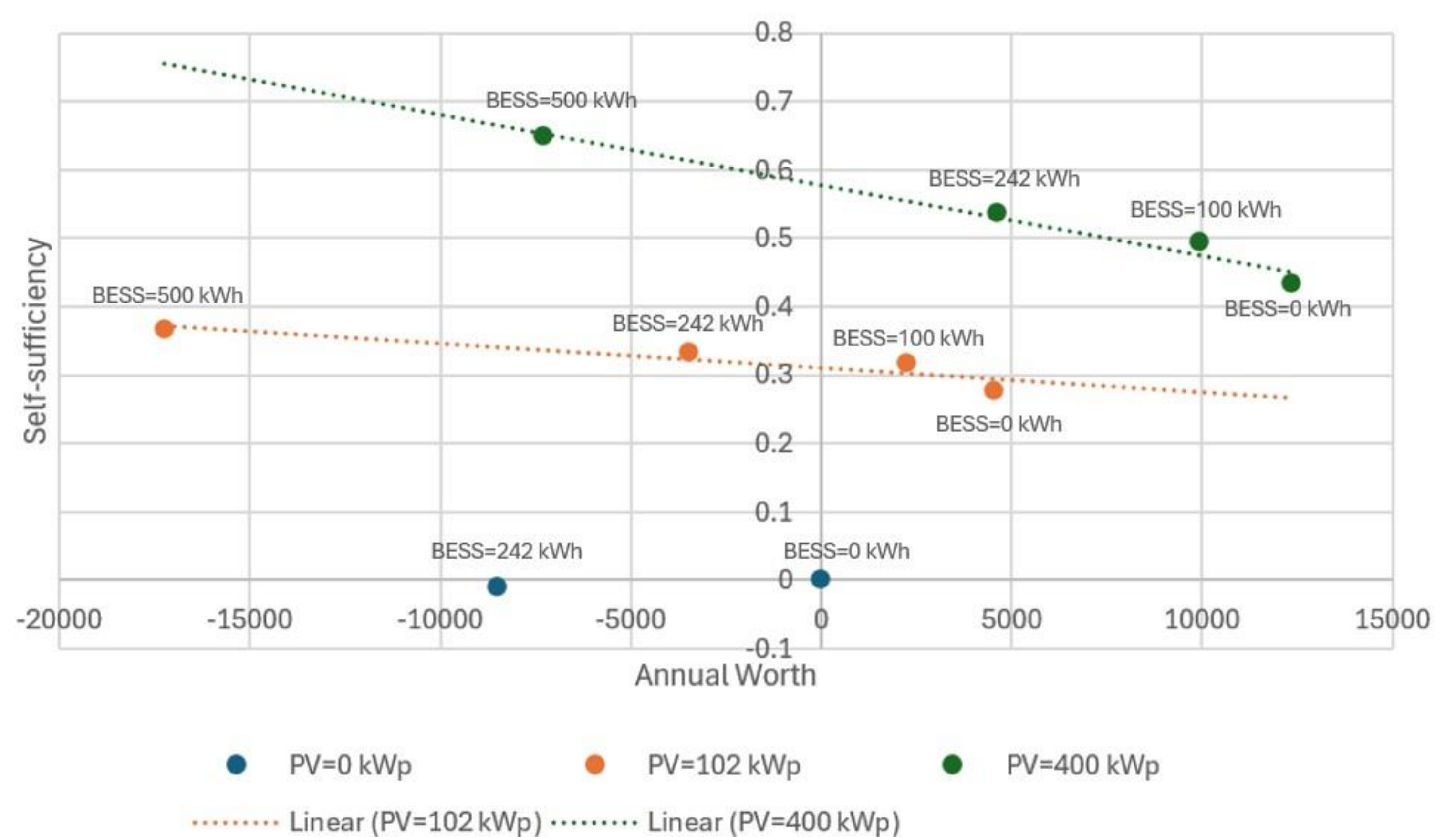


Figure 1: Self-sufficiency and annual worth of PV - BESS combinations

Optimization of smart charging hubs (Figure 2, data 2024)

- Smart charging significantly increases net present value compared with conventional charging.
- Optimal PV capacity rises when office load is combined with office EV charging load.
- Smart charging further supports higher economically viable PV capacity.

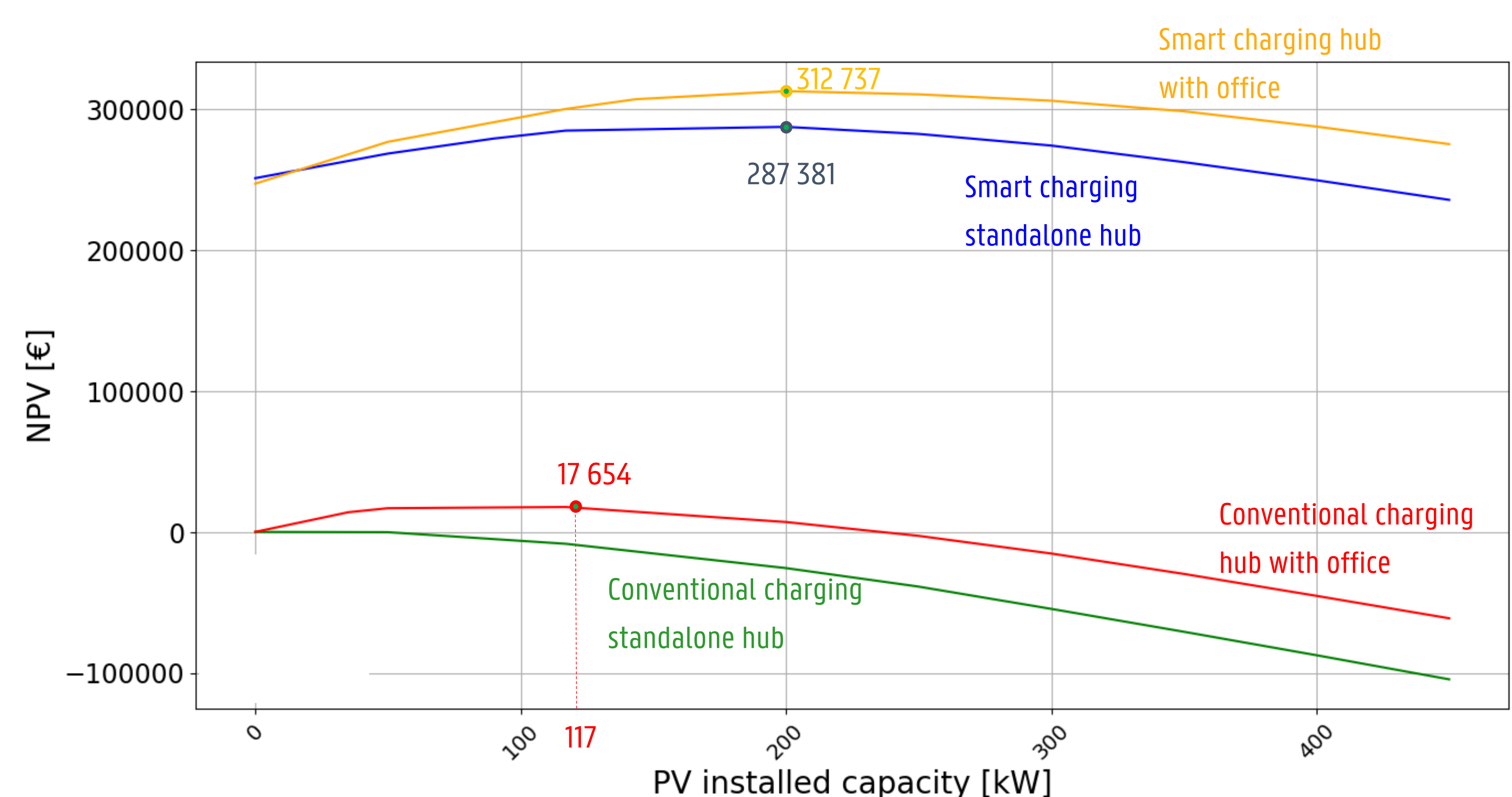


Figure 2: NPV of scenarios as function of PV capacity

Conclusions

- Mid-size battery systems are not economically viable in shared energy districts unless additional value is captured from ancillary services.
- PV installations can be attractive for large buildings or sites, though their viability at scale depends strongly on costs and energy prices.
- Smart EV charging at office hubs reduces costs substantially without compromising user comfort, while enabling larger economically viable PV installations.

Future Research

- Develop techniques to reduce model complexity, enabling optimization of large stochastic systems.
- Design efficient evolutionary algorithms for asset sizing optimization.

Contact

karel.herregodts@ugent.be
technoeconomics.idlab.ugent.be/

Universiteit Gent

@ugent

Ghent University