Techno-economic and business case assessment of multi-energy microgrids with co-optimization of energy, reserve and reliability services

Introduction and motivation

- **Grid-connected Microgrids (MGs),** which can aggregate, coordinate, and optimize distributed energy resources (DER), are emerging as attractive options to assist effective operation of the community multi-energy systems.
- By exploiting the flexibility of **DER** and **multi-energy vectors** (e.g., electricity, heating/cooling, and gas), MGs can provide a **wide range of grid services** to the local and upstream grid, such as:
  - Traditional **energy services**
  - **Reserve services**
  - **Reliability services** (by operating as island and exporting electricity during contingencies)
- However, their **business case is still unclear** in a pragmatic context where the provision of given services affects the economic operation of MGs, and may keep them from partaking in other services.
- In this context, this work presents a **techno-economic framework** to model and assess business cases for multi-energy MGs that can purse co-optimization of **energy, reserve,** and **novel reliability services.**

Techno-economic framework

- The proposed framework comprises **a mixed integer linear programming model** for the co-optimization of MG operation **(Fig 1)** in light of different services, and a model for the calculation of non-linear and dynamic reliability service price signals, which are estimated based on **sequential Monte Carlo simulations**.
- The MG operation is co-optimized under energy, reserve and reliability services price signals.
- MG islanding and the restoration process were simulated based on data from real networks

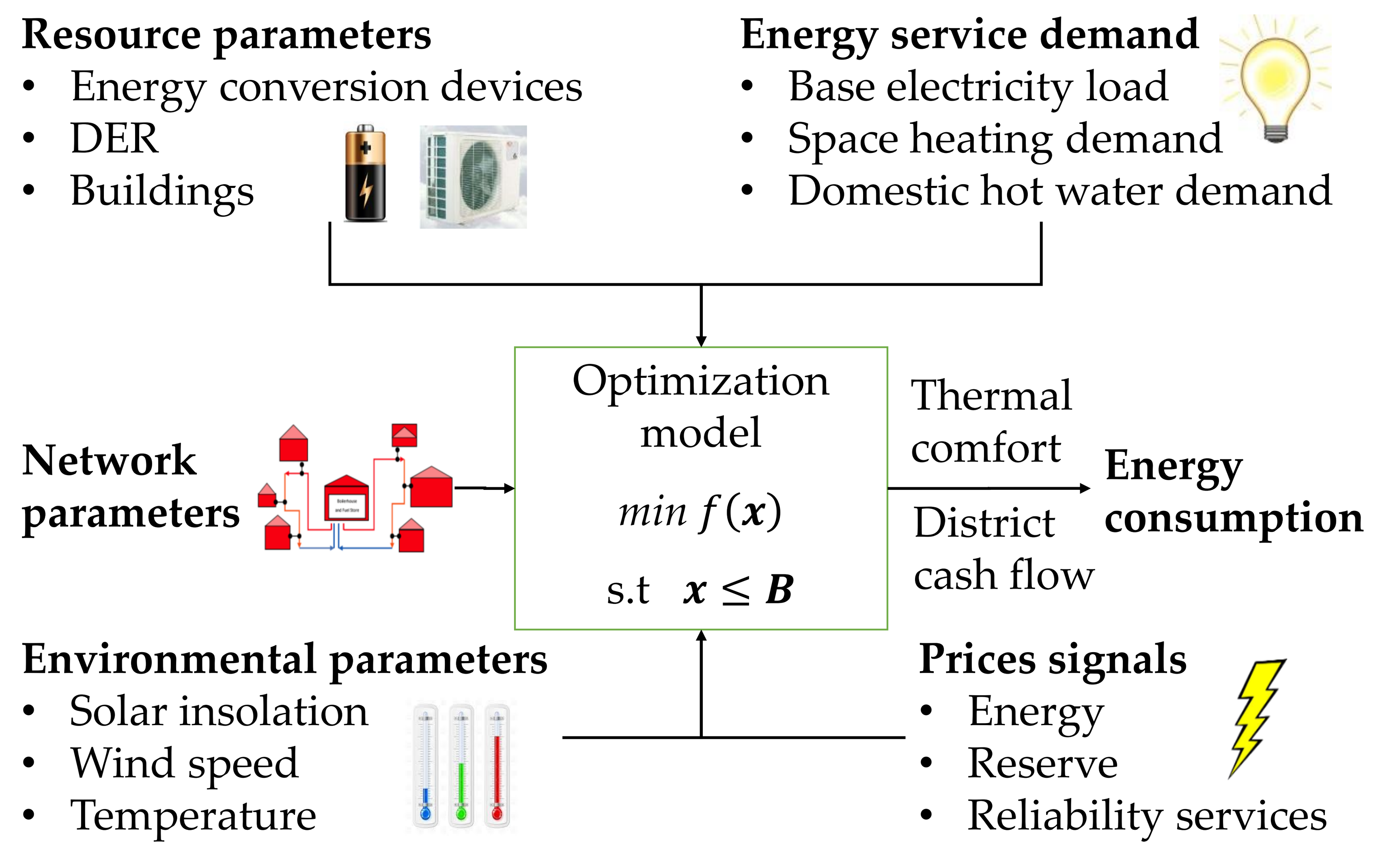

Fig. 1 MGs energy, reserve, reliability services co-optimization model

Case study

The business cases of MGs with different technologies (CHP+TES/PV+BES) providing multiple services under different price signals – retail energy, dynamic energy (DE), reserve (Res), and reliability (Rel) prices, are modelled using the proposed MG operation model.

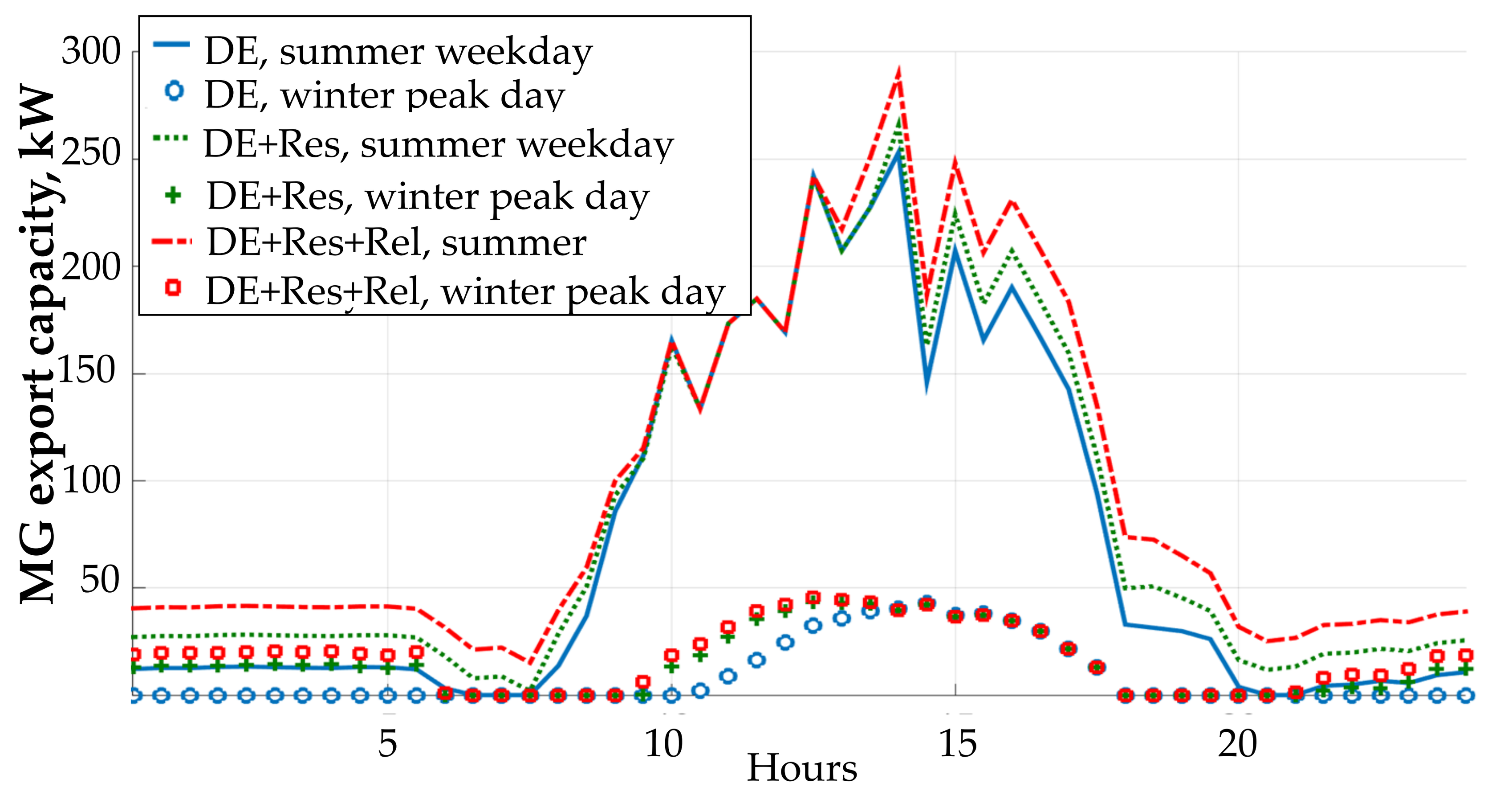

Fig 2. Comparison of MG export capacity, selected PV+BES MG

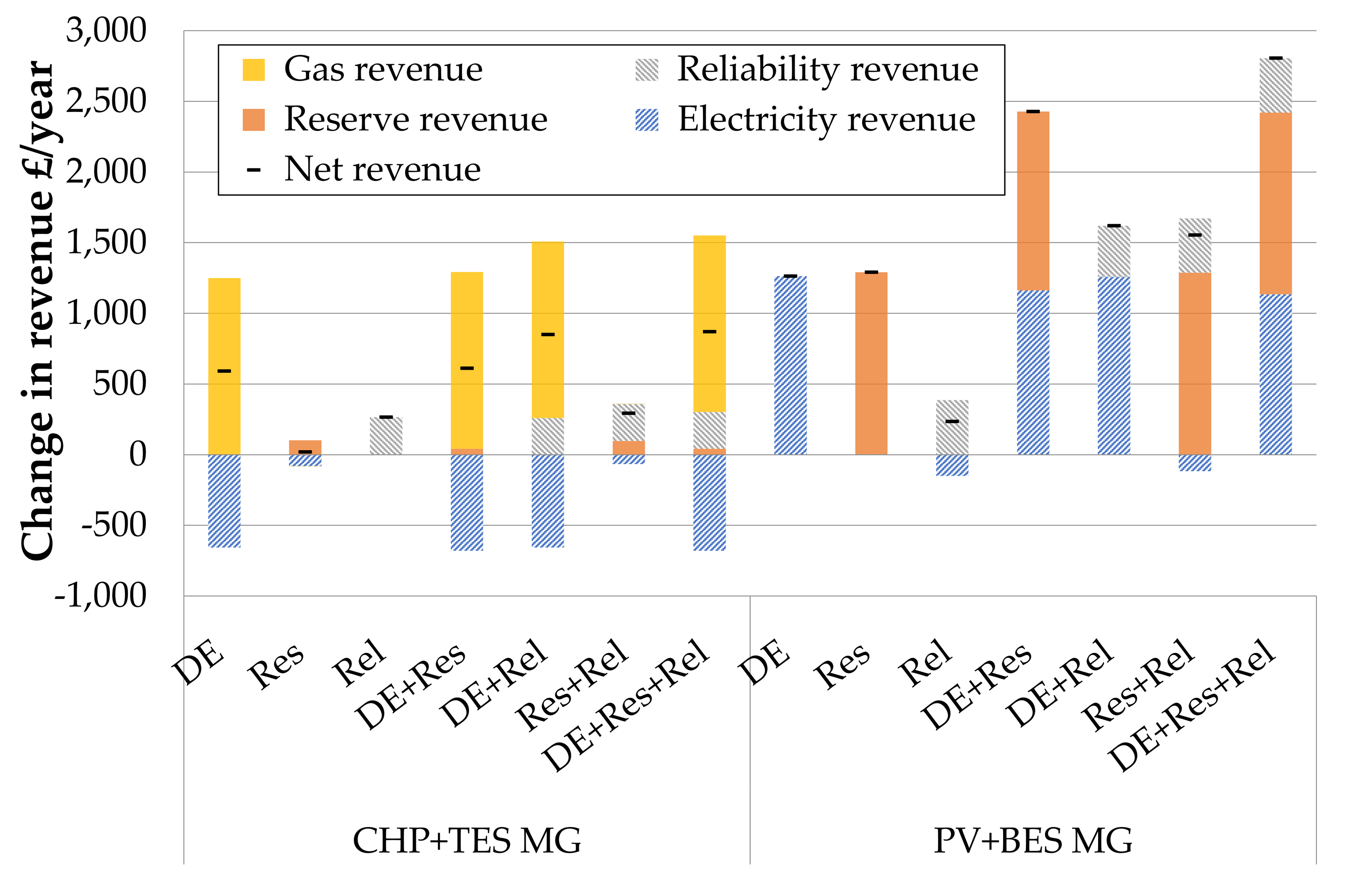

Fig 3. Change in test cash flow, compared to retail energy tests

Conclusion

The results highlight potential **conflicts and synergies** between the different services, which led to following findings and conclusions:

- Conflicts and synergies between **reserve and dynamic energy services** are case specific. That is, MGs may retain generation or storage to provide reserve, which may lead to benefits or costs due to energy arbitrage.
- **Reliability and reserve services** are generally synergistic
- **Reliability services and energy arbitrage** are mostly synergistic
- MGs could partake in the provision of **reliability services** at little or no additional costs

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Han Wang[1], Eduardo A. Martínez Ceseña[2], Nicholas Good[2], Pierluigi Mancarella[1,2]
[1]The University of Melbourne, [2]The University of Manchester
wangh12@student.unimelb.edu.au