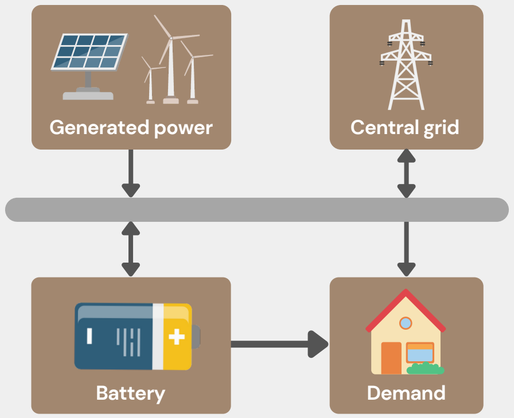
CSE3000 Research Project – Philippe de Bekker – Group 59 – Supervisors: Valentin Robu, Sho Cremers & Peter Zhang

Improving the efficiency of renewable energy assets by optimizing the matching of supply and demand using a smart control algorithm

Background

Model



Basic control algorithm*

more power than demand?

no	*yes*
battery not empty and battery power available	*battery not full and battery power available*

no	*yes*	*no*	*yes*
buy	*discharge + buy*	*sell*	*charge + sell*

Methodology

Design various logical cases that lead toward an enhanced definition of a control algorithm with optimized behaviour and assess its performance by running various simulations using probable data

Optimized control algorithm

Forecasting

Exploit insights gained by forecasting power, demand & prices

Example forecast (Residual power: subtract estimated demand from estimated power)

Optimal behaviour

- If we can cover excess demand on multiple occasions (surplus of generated power), charge the battery at times when export tariffs are the lowest
- If excess demand cannot be completely covered by the non-empty battery, discharge the battery at times when import tariffs are the highest
- Only charge the battery to cover future demand, this maximizes the surplus of energy to export
- If the battery can charge using imported energy, consider importing energy in advance when future excess demand with substantially higher import tariffs needs to be covered
- No algorithm can eliminate the need for importing energy beyond the constraints of the battery or lack of generated power, however, it should aim to achieve the maximum profit feasible within these boundaries

Experimental setup

UK Energy Communities

- London: 5567 households
- Thames: 200 households

Simulated battery

LI ION

Advantages lithium-ion:
- High depth of discharge
- Long lifecycle
- Low waste of energy

Agile Octopus Tariffs

octopus energy

Experiments

Perfect forecasts

- Data remains original

Range of forecasts

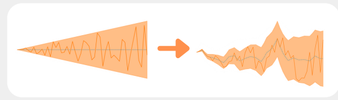
- 1 hour – 2 days ahead
- 10 – 15 ranges tested per experiment

Battery sizes

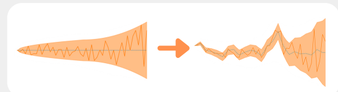
- Between < 1 kWh and 50 kWh per household
- 7 – 15 sizes tested per experiment

Uncertain forecasts

- Randomness is introduced
  - Only supply and demand
  - Supply, demand and tariffs
- Type of margin functions:
  - Constant
  - Linear

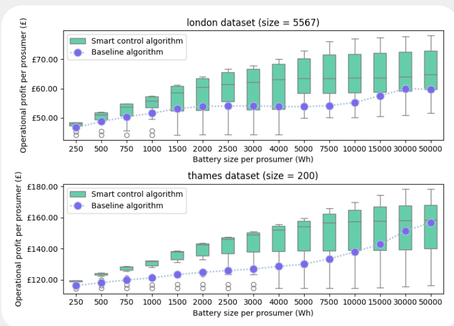


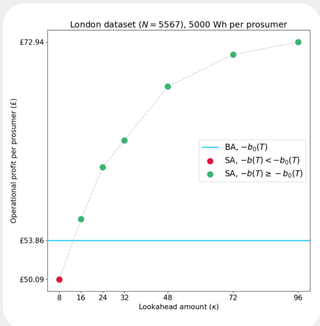
  - Converging and diverging



Results

Baseline vs. smart control algorithm *(using perfect forecasts)*





Conclusion

Based on several thousands of simulations, the smart control algorithm has demonstrated to gain additional profit for both theoretically perfect forecasts and plenty more realistic forecasts.

More simulations with actual forecasting techniques should be considered to move towards practical deployment and directly make an impact on the efficiency of renewable energy assets.

* Norbu, S., Couraud, B., Robu, V., Andoni, M., & Flynn, D. (2021). Modelling the redistribution of benefits from joint investments in community energy projects. Applied Energy, 287, 116575. https://doi.org/10.1016/j.apenergy.2021.116575

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