School of Electronic, Electrical & Systems Engineering

Considering cogeneration and thermal storage within a UK community context

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Introduction

- Combined Heat & Power (CHP) generation is an efficient method of supplying a site's demand [1].
- CHP has proven to be effective in applications where the intra-daily and seasonal demand variation is minimal [2].
- Domestic demand has a high load fluctuation and thus achieving efficient CHP operation has proven to be challenging [3].
- Domestic demand varies considerably based on factors such as number & type of occupancy and building insulation level [4].

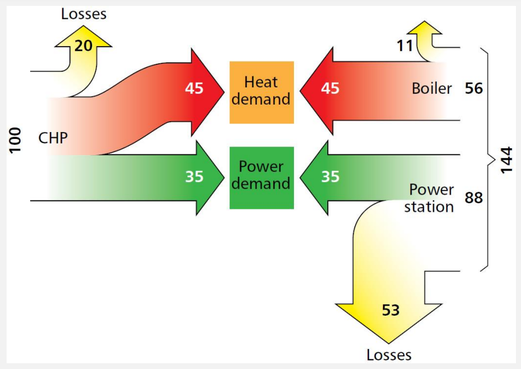

Fig. 1. Comparison of generation efficiency[1]

Supporting evidence

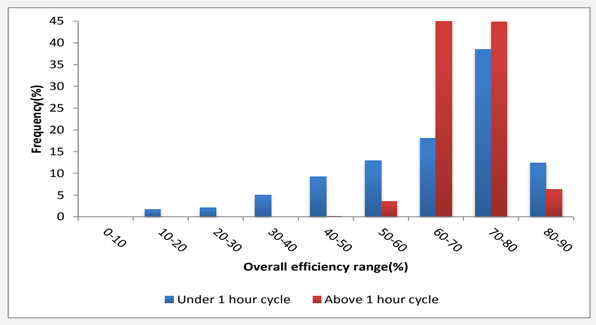

Fig. 2. Overall efficiency distribution by cycle duration

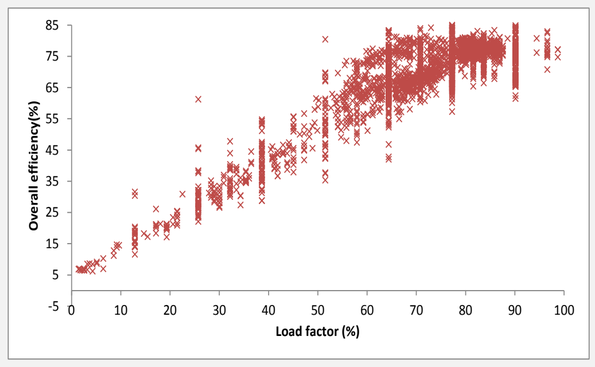

Fig. 3. Correlation between heat efficiency and load factor

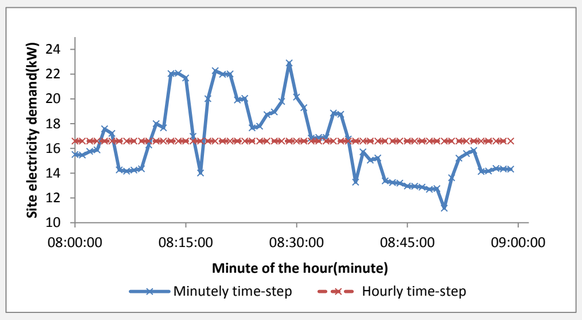

Fig. 4. Comparison of hourly and minutely electricity demand

Model description

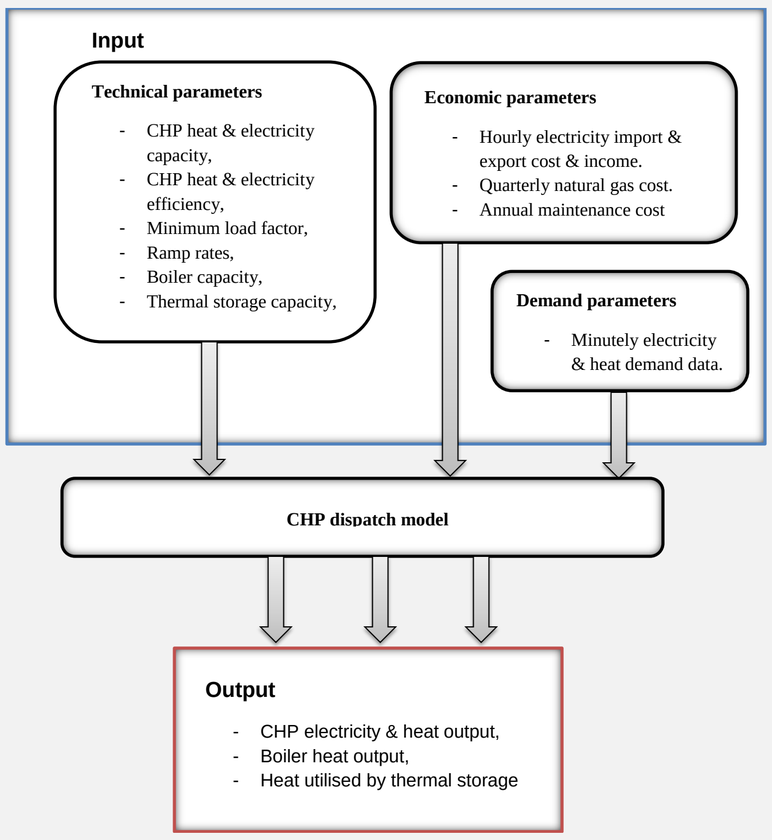

Fig. 5. Input/output of CHP dispatch model

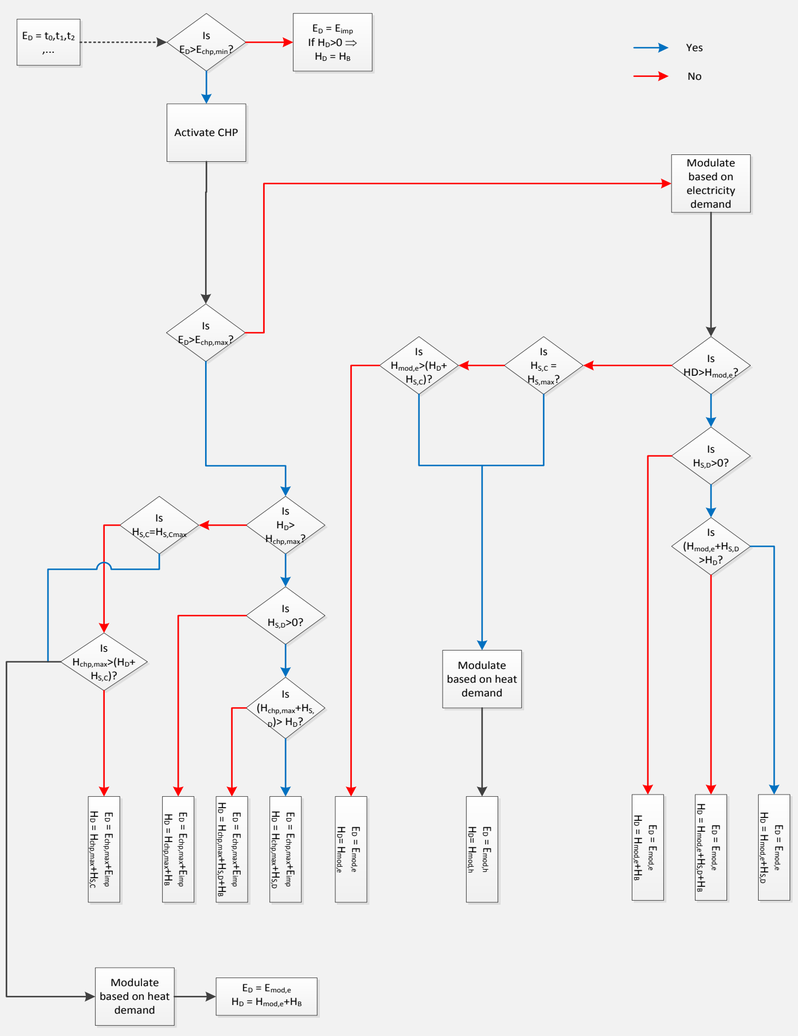

Fig. 6. Simplified decision tree for CHP control strategy

Objectives

- To develop a CHP dispatch & control model based upon high resolution stochastically generated heat and electricity demand data.
- To evaluate outcomes for different generation and storage unit sizes.
- To compare the effect of building layout and fabric properties on CHP operation.
- To analyse the contribution of thermal storage for different building fabrics.

Results

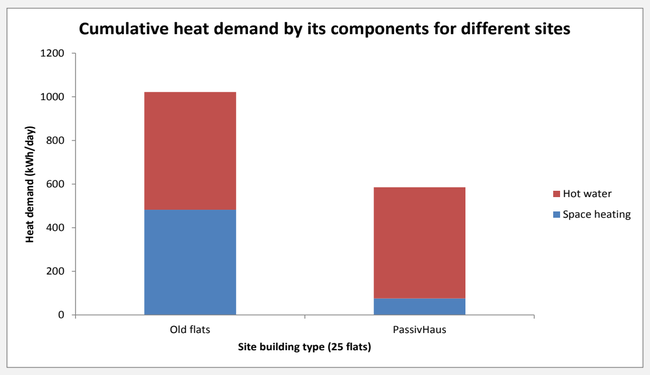

Fig. 7. Cumulative heat demand by its components for different sites

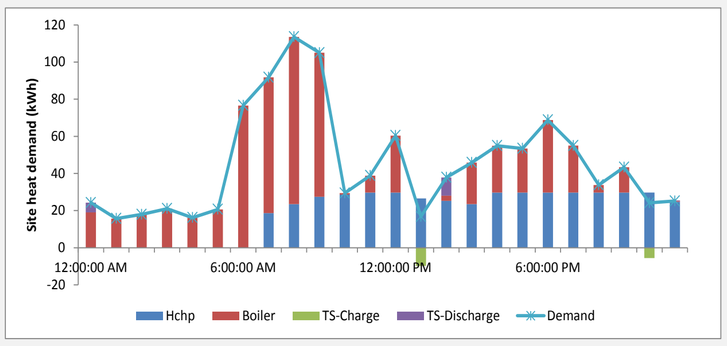

Fig. 8. CHP dispatch for a winter day: 25 old-flats, 15kW ICE, 1 m3 TES

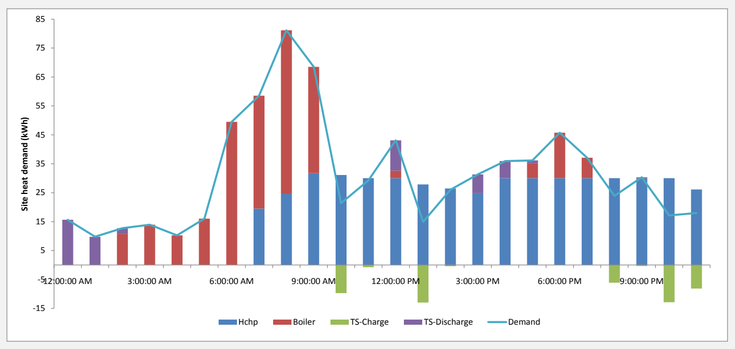

Fig. 9. CHP dispatch for a winter day: 25 PassivHaus flats, 15kW ICE, 1 m3 TES

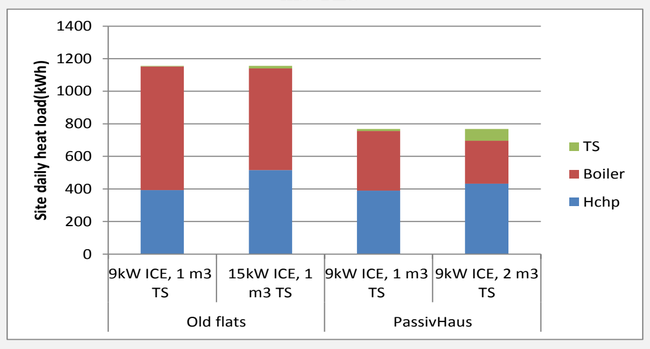

Fig. 10. Generation sources for varying building, CHP & TES capacities

Conclusion & further work

- Field trial data shows a strong correlation between CHP efficiency and load factor and generation cycle respectively (figure 3 & 4).
- High temporal resolution stochastic data is required to assess impacts varying domestic load factor on generation units,
- The comparisons were all conducted by dividing the heat supply to its generation components and storage: CHP, boiler and thermal energy storage, while the control strategy is mainly electricity led.
- When comparing the cumulative site heat demand, it is clear that the site consisted of PassivHaus flats space heating component is considerably smaller (figure 7). Therefore a more insulated site is likely to have a heat demand with lower inter-seasonal fluctuations. However, the heat demand peaks caused by domestic hot water usage (mostly in the morning) is covered by peak boilers in both cases.
- The high heat to power ratio of old flats pushes an electrically led CHP to be either undersized or oversized. Where in case of PassivHaus site TES has a higher utilisation rate since the heat to power ratio becomes lower(figure 10).
- Further work will includes annual analysis, calculating economic profitability and carbon emission savings.

References

[1]DECC, "The Future of Heating: Meeting the Challenge," 2013. [Online]. Available: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/190149/16_04-DECC-The_Future_of_Heating_Accessible-10.pdf.

[2]CIBSE, "CIBSE Guide AM12: Combined Heat and Power for Buildings," 2014. [Online]. Available:http://www.cibse.org/knowledge/cibse-am/am12-combined-heat-and-power-for-buildings-%28chp%29

[3]A. Hawkes and M. Leach, "Impacts of temporal precision in optimisation modelling of micro-Combined Heat and Power," *Energy*, vol. 30, no. 10, pp. 1759–1779, 2005.

[4]H. Lund and a. N. Andersen, "Optimal designs of small CHP plants in a market with fluctuating electricity prices," *Energy Convers. Manag.*, vol. 46, no. 6, pp. 893–904, Apr. 2005.