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Considering cogeneration and thermal storage within 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-hourly and seasonal demand variation is minimal [2].
- Domestic demand have high load fluctuation and reaching an efficient CHP operation has proven to be challenging [4].
- The domestic demand vary considerably based on factors such as number & type of occupancy and building insulation level [3].

Aim & objectives
- To develop a CHP dispatch model which would control the unit considering high resolution stochastically generated heat and electricity demand data.
- To compare the outcome (CHP dispatch) for different generation and storage unit sizes.
- To compare the outcome between different sites: a site consisted of old non-insulated flats and another site consisted of PassivHaus flats.

Model description

![Input/output of CHP dispatch model](image)

**Input**
- Technical parameters:
  - CHP base & electricity capacity.
  - Boiler heat & electricity efficiency.
  - Minimum load factor.
  - Ramp rates.
  - Boiler capacity.
  - Thermal storage capacity.

**Economic parameters**
- Hourly electricity import & export cost & income.
- Quarterly natural gas cost.
- Annual maintenance cost.

**Demand parameters**
- Minutely electricity & heat demand data.

**Output**
- CHP electricity & heat output.
- Boiler heat output.
- Heat utilized by thermal storage.

![Simplified decision tree for CHP control strategy](image)

**Fig. 5. Input/output of CHP dispatch model**

**Fig. 6. Simplified decision tree for CHP control strategy**

![Supporting evidence](image)

**Fig. 1. Comparison of generation efficiency[1]**

**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**

Results

![Cumulative heat demand by its components for different sites](image)

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

![CHP dispatch for a winter day: 25 old flats, 15 kW ICE, 1 m³ TES](image)

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

![CHP dispatch for a winter day: 25 PassivHaus flats, 15 kW ICE, 1 m³ TES](image)

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

![Generation sources for varying building: CHP & TES capacities](image)

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

Conclusion & further work
- Data from the previous field trial indicates a strong correlations: between overall efficiency and load factor; overall efficiency and generation cycle (figure 3 & 4).
- In order to see the effect of varying domestic load factor on generation units, high resolution stochastic data is generated to represent the site demand (figure 5).
- The comparisons were all conducted by dividing the heat supply to its generation components and storage: CHP, boiler and thermal energy storage.
- 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 demand more consistent inter-seasonally. 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