Optimisation of combined heat and power production for buildings using heat storage

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Highlights

•Half-hourly heat demand data shows the high variability of building heat demand.
•Sharp spikes in heat demand were observed when some heating systems are activated.
•25% of the annual heat demand was found to be independent of outdoor temperatures.
•Seasonal differences of heat store operation affect its environmental and economic advantages.

Abstract

Reducing carbon emissions from buildings is vital to achieve goals for avoiding dangerous climate change, and supplying them with low-carbon heat is essential. In the UK, the development of heat networks for supplying low-carbon heat is being encouraged for urban areas where there is high heat demand density. This paper investigates heat demand variability, the role of heat networks and combined heat and power (CHP) in satisfying this demand, and finally the advantages of using heat storage in the system.

Building heat demands from 50 buildings were analysed at a half-hour resolution with modelling to determine CHP operation patterns with and without heat storage. Daily total heat demand was found to vary from 25% of the full-year average in summer months up to 235% of the average on the coldest days in winter. The heat demand was shown to correlate to outdoor temperatures measured with the degree-day parameter, except for approximately 100 days during the warmest part of the year falling outside the heating season. Sharp spikes in heat demand were seen at the half-hourly time scale coinciding with the switching on of heating systems in some buildings with consequences for building energy supply options.

It was shown that for an annual heat demand of 40,000 MW h, the use of thermal storage can significantly increase the running time of a CHP energy centre with 4 MW capacity designed to supply this demand. The cost savings resulting from increased on-site heat and electricity production resulted in a payback period for heat storage investment of under four years with further benefits if it can assist other heat sources on the heat network. Environmental advantages of using heat storage included further carbon dioxide emission reductions of 1000–1500 tonnes per year depending upon the CHP configuration.

Keywords

Building energy use; Heat demand; CO2 emissions; CHP; Thermal energy storage

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