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Storage in Thermal Building Mass

Utilizing thermal building mass for storage in district heating systems

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INTRODUCTION

District heating (DH) systems produce heat centrally and distribute it via transmission and distribution pipes. Heat storage, which is required when production and demand for heat is not in balance, are usually capital intensive investments. However, thermal building mass could be utilized for storage by implementing smart controllers. In order to investigate this potential, this paper investigates a building simulation model with a linear optimization model of the energy system.

All buildings that are connected to DH systems have certain thermal capacities for storing heat inside the structure of the buildings. Moreover, the cost of utilizing the thermal mass for storage is close to zero, as the building structure does not have to be modified additionally. Thus, utilizing thermal mass for storage could be an efficient solution for load shifting and/or peak shaving in district heating grids.

METHOD

Thermal storage can be realized in several different ways, such as central (closer to the supply side of the system) or decentral (closer to the consumer side of the system). Another solution considers the thermodynamic nature of the way heat is stored, i.e. whether it is latent, sensible or thermochemical storage.

The utilization of short term heat storage in the sensible thermal mass of the buildings has been investigated in a number of studies during the last years. The zero investment cost that is required for this solution along with the significant capacity available in the majority of buildings in northern climates makes it a promising storage solution.

. **1st** a detailed building energy model is presented. The model behind the simulation tool is a detailed physical representation of the transient heat transfer phenomena taking place in a building.

. **2nd** the system indicators for evaluation of thermal mass for storage are introduced and different building heating scenarios presented. To be able to determine the potential for thermal autonomy for all houses, different heating control strategies were implemented.

. **3rd** an energy system optimization model is described to represent the energy system. The output from the building simulation, such as the maximum capacity of avoided energy consumption during a cut-off event for each archetype, afterheating demand and the corresponding distributions, are then used as input for the optimization model.

CASE STUDY

The city of Sønderborg, located in the south of Denmark with 27,500 inhabitants, was chosen as the current case study. The city has many different types of energy supply plants and the whole municipality has started a transition towards net zero carbon by 2029. Housing in Denmark accounts for 64% of the total heat demand. It was therfore decided to focus on the residential building stock of Sønderborg to investigate the potential for energy flexibility provided by the thermal mass in the building envelopes and internal walls.

RESULTS

53% of the final heat energy demand was met by district heating in the whole municipality of Sønderborg in 2013. In 2015, the total district heat supplied to the customers in the city was 289 GWh (not including 23% of distribution losses), based on information from the operator of the district heating system, Sønderborg Fjernvarme. According to the energy transition plan towards 2029, an increased share of households connected to the district heating systems has been anticipated.

The study showed that operational savings in the DH system occurred in all the cases when thermal mass for storage was utilized. The economic savings in operational costs of the DH system were in the range between 1.3% and 8.1%. All the scenarios showed that the thermal mass for storage allowed more solar thermal to be effectively utilized in the DH system. The most significant energy savings originated from less use of residential gas boilers.

DISCUSSION

One of the main goals of this study was to focus on the impact of utilizing building thermal mass for storing district heating supply and its impact on operating expenses. The analysis showed that operational savings can be much larger in the future, when larger capacities of intermittent sources (wind and solar) are installed in the DH system and when higher average electricity prices in the energy system occurs.

Implementing smart controllers in the district heating grid on a very large scale is a significant task. Thus, one potential strategy would be to implement it when building refurbishments take place. That would reduce the installation costs and the controllers should be installed in the buildings that would have longer thermal autonomy times, after being refurbished.

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