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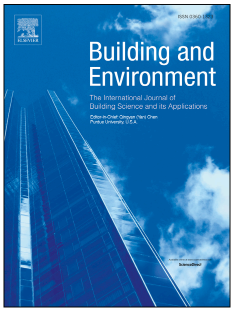


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# Development of an intelligent building controller to mitigate indoor thermal dissatisfaction and peak energy demands in a district heating system

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**Abstract**

District heating systems were gradually improved with the development of generation, storage, distribution technologies, and the demands continued to expand significantly. The percentage of houses supplied by district heating systems were fast grown up, and it was reported that the global market for the systems would expand by about 6% in the period between 2016 and 2024.

However, most studies for district heating models focused on fuel use in plants, energy distribution, and carbon reduction. Many simulations adopting computing technologies dealt with mechanical performances in the systems. Also, recent statistical analyses overlooked zone-scaled thermal comfort directly affecting users' workability in buildings.

This research proposes an intelligent controller to improve thermal comfort and reduce peak energy demands in a district heating system. An artificial intelligence based model with temperature and thermal comfort detectors optimizes supply air conditions to maintain desired room temperature responding to users' characteristics in four different building types. The model reduces peak demands for cooling and heating to optimize plant and distribution capacity. Comparative analysis describes the model's effectiveness that it maintains thermal comfort level by 27%, and that it reduces peak demands by 30% in comparison with a conventional controller. The model has an advantage that it properly responds to temperature changes with high performance to mitigate thermal dissatisfaction and energy loss in a district heating system. In spite of the sensitive controls to ensure human comfort, it is confirmed that the model can contribute to design optimization for energy supply system in urban scaled models.

## 1. Introduction

### 1.1. District model

Since late 19th century, district heating or cooling models were improved with the rapid development of technologies. Most developments were made in district model's components such as fuel supply, water pipes, valves, dampers, heat exchangers, chillers, boilers, and power generation systems. With the help of manufacturing and operational technologies, district heating or cooling systems contributed to substantial improvement of energy efficiency, environmental protection, operation and maintenance, and economic aspects such as life-cycle and construction costs [1, 2, 3, 4, 5]. According to a report, around 2000, the percentage of houses supplied by district heat was already over 90% in Iceland, 60% in Denmark, and 22% in Germany, and the global market for district systems will expand by 5.8% in the period between 2016 and 2024 [6].

In order to reduce heat loss during district heating distribution, improving insulations of pipelines were commonly studied, and standards related to specifications for pipelines were released [7, 8, 9]. Also, thermal dynamics of heat exchangers and chillers were analysed to improve energy efficiency by utilizing waste heat or heat excess in district heating models [10, 11]. Due to visual performance and ease of mechanical performance enhancement, most studied focused on the improvement of plant level. Combined Heat and Power (CHP) system is commonly preferred by using analyses of fuel cost and material associated with gas emission or heat production [12, 13]. Also, recent studies for district