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Influence of duration of thermal comfort provision on heating behavior of buildings

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Abstract

Because of the permanent dilemma whether residential buildings using district heating should be heated continually or discontinuously, we evaluated how the yearly heating load and the peak heating load of a small building in Serbia depend on the duration of thermal comfort provision. Using HTB2 software, a product of the Welsh School of Architecture, it was found that an increase in the duration of thermal comfort provision in the building from 16 h to 24 h increases the yearly heating load by 20%, reduces the peak heating load by up to 40% and may increase the number of new customers served with the same heating plant by up to 40%.

Keywords: Building simulation; Heating load; Thermal comfort; District heating

1. Introduction

In Serbia, the energy used in the built environment represents around 50% of total energy use. During recent years, this percentage has been rising continuously. The largest part of energy use in residential buildings is used for heating, as the heating season lasts 6 months. Because of actual international efforts to protect the environment, the heating of buildings is an issue of permanent interest to the government of the Republic of Serbia and its ministries. Namely, the Serbian Ministry for Mining and Energy founded the Serbian Agency for Energy Efficiency in 2002, where one of its activities is to increase the energy efficiency in buildings [1]. Furthermore, the Serbian Ministry of Science, Technology and Development gives prominent funds to the universities in Serbia to work on National Research Programs in Energy Efficiency. One of these programs, "Energy Efficiency in Communal Systems", deals with district heating systems. It would be active in 2003 and subsequent years [2].

District heating systems that serve great numbers of buildings are complex compared to the central heating systems that serve only one building. A district heating system includes a heating plant, pipe network, substations, heated buildings and heaters inside the buildings. It provides heat to many buildings during the winter with the objective to maintain comfortable and healthy conditions for the occupants. Also, the system should be operated with the highest benefit for the occupants, operators and society, i.e. with a minimum expenditure of energy and money and a minimum impact on the environment (minimum local and global pollution). To achieve these benefits, one should separately study the energy performance of each part of the system and that of the entire system to maximize their operation efficiency. This paper reports only a study of the energy performance of residential buildings during their heating by a district heating system in Serbia.

To study the energy performance of residential buildings by a district heating system in Serbia, it is most important to determine the yearly heating load and the maximum

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Nomenclature

D	peak heating load, W	N	total number of heated rooms
$D_{\max,J}$	max hourly ($D_{I,J}$) required for heated room J, W	Q	yearly heating load for building, Wh
I	hourly time interval	$Q_{I,J}$	heating load (an output of HTB2) of room J during hourly time I, Wh
J	room index		

heat demand when the required temperatures are maintained inside the heated rooms. These values would be calculated either by using computer simulations or site measurements. The calculated value of the yearly heating load would help us speculate on the fossil fuel consumption (if fossil fuel is used as the heat source), money expenditure for the spent fuel and global and local pollution due to the fuel combustion. The calculated value of the maximum heat demand (occurring at heating start) will help us speculate on the size of heaters, on the size of heating plant, on the number of customers that can be served by this plant and on the global and local pollution due to manufacturing of radiators and erection of the heating plant.

Generally, for heated buildings, their energy performances depend on many factors such as the type of management, financial matters, type of heating, type of building, constructions applied to the building, type of heating system inside the building, method of temperature reduction for energy saving by a thermostat and method of morning heating initiation. The type of heating may be either continuous or intermittent. The method of temperature reduction would be characterized by the magnitude and duration of the reduction of the thermal comfort (TC) temperature by the thermostat during the day and night. The method of morning heating initiation would be characterized by the duration of the warm up period and the level of the radiator temperature in the morning initial hours. The designer and operator of heating systems and heated buildings should be advised by ongoing worldwide research to take care efficiently about all the above factors and attain the highest benefits to the residents, operators and society.

The factors for the studied residential district heating system in Kragujevac and residential district heating systems in all Serbia are currently the following. First, these systems are operated and owned by "public companies", meaning that their main managers are appointed by the city government. Second, the price of heat produced by the district heating system is established by the company and verified by the city government, taking into consideration the social status of citizens. Third, these companies are under constant pressure to be additionally concerned about the environment and energy security. Fourth, residential district heating is usually intermittent as it continually maintains TC in flats for 16 h daily, starting at 6 h and finishing at 22 h. Fifth, to sustain TC in the heated residence, the system maintains the temperature in the residence to be equal to or above the strictly prescribed temperatures by the Yugoslav standard given in Table 1. Sixth, if these houses are not occupied during heating, the tenants cannot and will not lower the temperature of the flats and, consequently, the heat consumption. The reason is the current non-existence of control equipment in residences due to the inadequate pricing policy for district heating energy. Seventh, an exact time schedule of residence heating is not decided and controlled by the tenants in residences. Eight, an exact time schedule of residence heating is decided and controlled by the district heating company officials. Ninth, this decision is established by the customary TC needs of the tenants in the heated buildings; however, we believe that the decision should be established by the eventual financial benefit for the district heating company and environmental and energy security benefit for the local and global society. Finally, the ongoing discussion among the district heating operators is devoted to the dilemma on the duration of intermittent heating, 16 h or more or entire day and night (continual heating) and the influence of the heating duration on the yearly heating load and heat start up power.

In the literature on building heating, three research efforts were identified. The first effort was devoted to energy efficient management of intermittent heating, the second to energy efficient management of continuous heating (operating during entire day and night) and the third to the benefits dealing with conversion of continuous to intermittent heating and vice versa.

For discontinuous heating, the research dealt with an attempt to save heat by using adequate control equipment currently available at low cost. The equipment would lower the TC temperatures in flats during the day and establish optimal parameters for morning heating start. Undoubtedly, lower TC temperatures in flats would yield heat savings. The optimal heating start parameters would yield heat savings, but this is still a matter of ongoing controversy. These parameters are the duration of the warm up period and the initial temperature of the radiators. It

Table 1
Temperatures maintained in different rooms in Serbian flats during district heating according to current standard applied in Serbia [3]

Room	Temperature (°C)	Room	Temperature (°C)
Living room	20	Bathroom	24
Bedroom 1	20	Anteroom	15
Bedroom 2	20	Corridor	10
Kitchen	20		