ENERGY SAVINGS FOR RESIDENTIAL HEATING IN TWO PAIRS OF BUILDINGS ACHIEVED BY IMPLEMENTATION OF ACTUALLY CONSUMED ENERGY MEASURING

by

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The paper presents results of heating energy consumption measurements in two pairs of buildings in community New Belgrade for two heating seasons. Influence of these measurements on energy savings is also presented. The measurements were carried out during heating seasons 2002/03 and 2003/04 in buildings in Block 34 and 63, connected to the district heating system "Beogradske elektrane". The buildings in each pair have similar architectural and thermal characteristics. One of the buildings in a pair was "test" building and the other "control" one. In the "test" building the energy consumption for heating of each apartment was measured, as well as total energy consumption for the whole building in the substation. Occupants were able to regulate the heating system. In the "control" building the energy consumption was measured only for the whole building, and occupants had almost no impact on heating energy consumption. The comparison of energy consumption for heating in the "test" and "control" buildings is given in the paper, as well as analysis of the influence of energy consumption measurements on the achieved energy savings.

Key words: *district heating system, heating consumption measurement, allocators, energy savings*

Introduction

This paper has resulted from the development and research project "Implementation and monitoring of effects of heat flow meters in pilot-buildings in community New Belgrade connected to the district heating system PU Beogradske elektrane", financed by the Ministry of Science, Technology and Development of the Republic of Serbia. This project has been supported by German government through KfW bank, which had provided necessary equipment for measuring energy consumption for heating delivered by district heating system.

Objective of the project was to show potential benefits of installed heat flow meters to energy consumption for heating. The obtained results show that energy savings are achieved with small investment, without sacrificing thermal comfort.

Research has been made using two pairs of buildings connected to the district heating system. All substations have been reconstructed prior to the heating season. One

of the buildings in each pair was a “test” building, in which measured was energy consumption for heating in every apartment. The other one was a “control” building in the substation of which measured is only energy consumption of the whole building. Heat flow meters have been installed in all substations. In addition, in “test” buildings there have also been installed thermostatic radiator valves and allocators on each radiator. In such a way, occupants in “test” buildings have been given opportunity to control automatically energy consumption supplied by district heating system in accordance with actual heating demands, thus save energy together with satisfying thermal comfort. Remote reading and parameter setting were also available.

Buildings description

One pair of buildings is located in the Block 34, in Bulevar AVNOJ-a Street. These buildings were built about 20 years ago with relatively good thermal insulation (average U-value is 0.7 W/m^{2}K). The “test” building is in Bulevar AVNOJ-a Street 209-217, and has a basement, ground floor, 6 floors and an attic (fig. 1 left). There are 135 apartments in the building. Total building area is 6653 m^2. Heat loses for the whole building are 778.65 kW for the design conditions, and installed heating capacity is 854.982 kW. The “control” building is in Bulevar AVNOJ-a Street 183-193, with similar architectural and thermal characteristics and total building area of 7369 m^2. There are 125 apartments in the building. Heat losses for the whole building are 716.713 kW for the design conditions, and installed heating capacity is 767.85 kW.

Figure 1. Pilot-buildings in community New Belgrade, Blocks 34 and 63, where energy consumption for heating was measured

The other pair of buildings is in Block 63, in Nehruova Street, older than the first pair and with poorer thermal insulation (average U-value is 0.9 W/m^{2}K). These are high-rise buildings with a basement, ground floor and 17 floors. The "test" building is in Nehruova Street 61 (fig. 1 right). Substation is located in the basement. There are 70 apartments in the building. Total building area is 5282 m^2. Total heat losses for the design conditions are 619.673 kW, and installed heating capacity is 688.64 kW. Specific heating capacity per square meter of an apartment is 130.5 W/m^2. The "control" building is in Nehruova Street 77 and is identical to the "test" building.

The obtained results of measurements

Measurements have been made during two heating seasons. Research has resulted in determining savings of energy for heating, delivered by District Heating Company (DHC) "Beogradske elektrane", for each heating season. Figures 2 and 3 show cumulative energy consumption for heating in "test" and "control" buildings for two heating seasons.

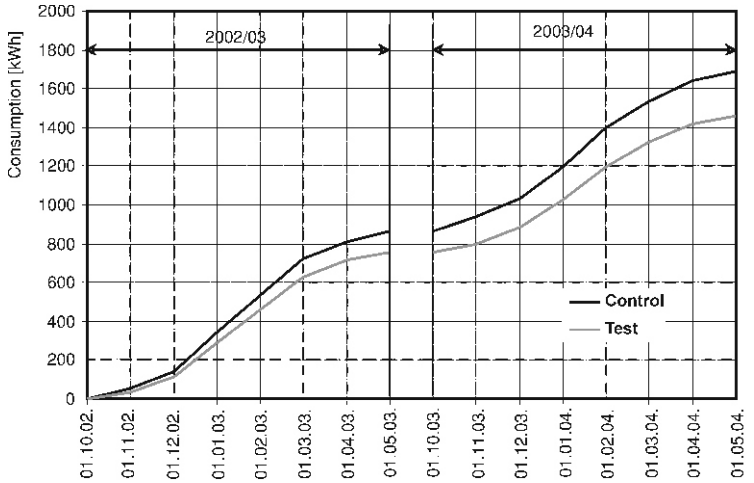

Figure 2. Cumulative energy consumption for heating in "test" and "control" buildings in the Block 34 for two heating seasons

Energy savings in the "test" building in the Block 34 amount to 13.8%, *i. e.* 105 MWh in the heating season 2002/03, and 15%, *i. e.* 123.6 MWh in the heating season 2003/04. In the Block 63, the "test" building energy savings in both heating seasons

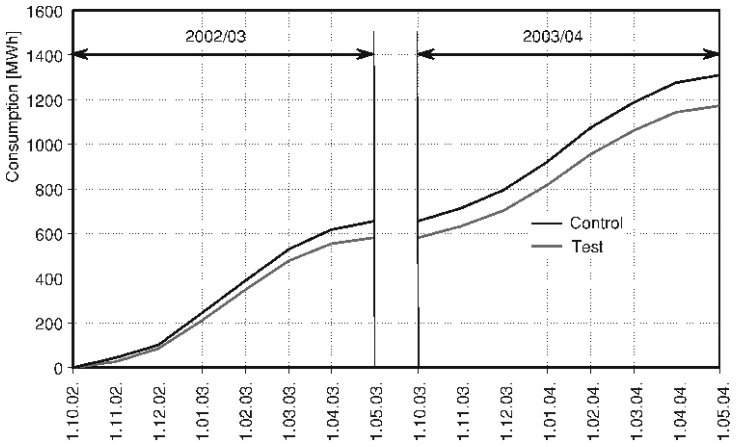

Figure 3. Cumulative energy consumption for heating in "test" and "control" buildings in the Block 63 for two heating seasons

are almost the same, *i. e.*, 10.5% – 70 MWh. Centrifugal pumps with electrically controlled speed were installed in substations of "test" buildings, thus enabling working regime with variable flow. There are also significant power savings for pumps operation in "test" buildings of about 40% – 2 MWh in each heating season.

Energy consumption distributed by district heating system was measured in regular periods of time during each heating season, thus enabling determination of energy consumption per month. Absolute energy savings in "test" buildings achieved per month are shown in figs. 4 and 5. Maximum absolute energy savings are achieved during colder months and at the beginning of heating seasons.

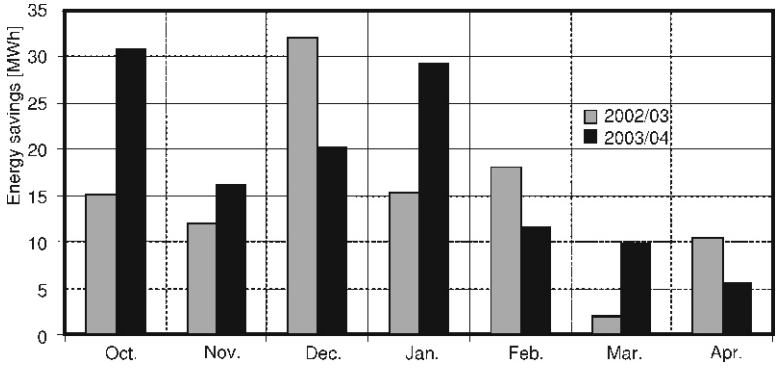

Figure 4. Absolute energy savings in "test" building per month achieved in Block 34 for two heating seasons

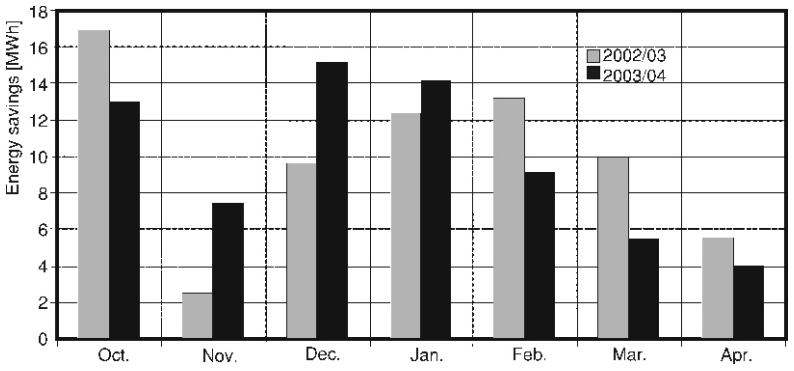

Figure 5. Absolute energy savings in "test" building per month achieved in Block 63 for two heating seasons

Since there is a difference between "test" and "control" buildings in the Block 34 (mentioned above in buildings description) concerning the total apartment area, it is necessary to determine energy consumption per square meter of an apartment. Monthly energy consumption per square meter of an apartment for "test" and "control" buildings in Blocks 34 and 63 for two heating seasons is shown in figs. 6 and 7.

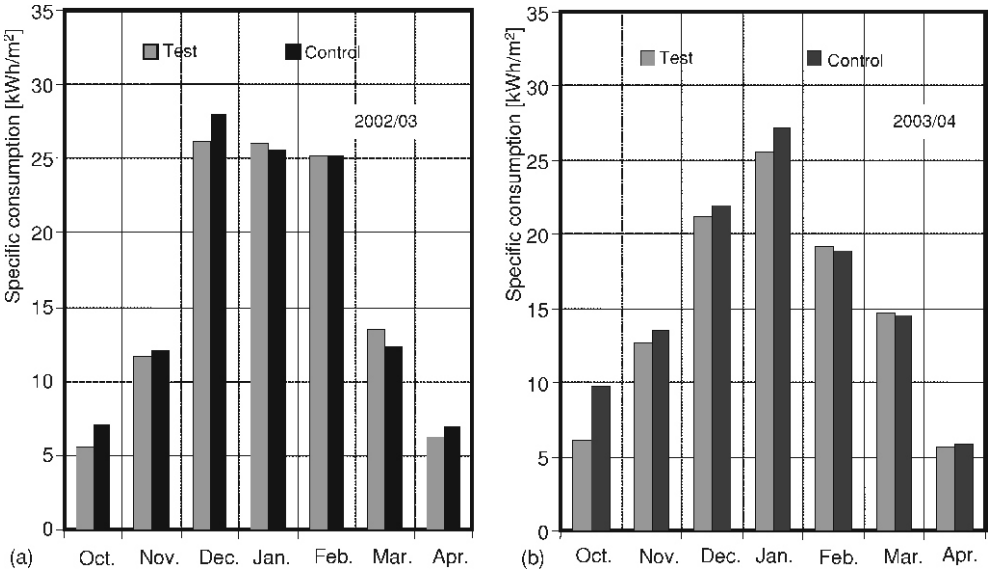

Figure 6. Monthly energy consumption per square meter of an apartment in the "test" and "control" buildings in the Block 34 for heating season 2002/03 (a) and 2003/04 (b)

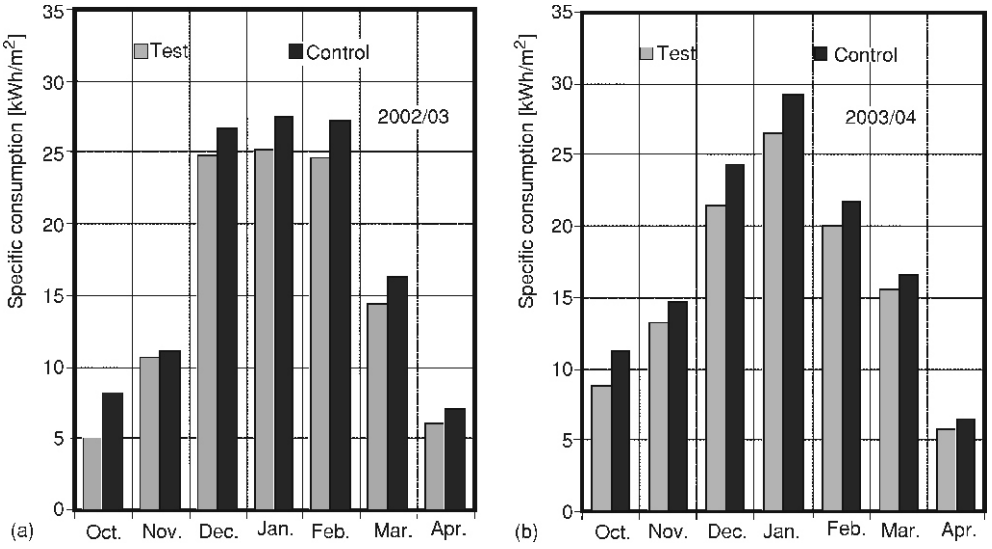

Figure 7. Monthly energy consumption per square meter of an apartment in the "test" and "control" buildings in the Block 63 for heating season 2002/03 (a) and 2003/04 (b)

From the fig. 6 one can see that consumption per square meter of an apartment in the "test" building is higher in January and March 2003, as well as in February and March 2004. Since these periods were the coldest, occupants in the "test" building had taken opportunity of heating system regulating possibilities and had increased own thermal comfort, thus energy consumption too, comparing to the "control" building. In the Block 63 the "test" building had been saving energy during both heating seasons, since the energy consumption per square meter of an apartment was lower than in the "control" building for each month.

Relative energy savings per month in "test" buildings are shown in figs. 8 and 9.

Maximum relative energy savings were achieved at the beginning and at the end of heating seasons. During these periods the outdoor temperatures were higher, as well as Solar heat gains, so occupants in "test" buildings had regulated heating in the apartments avoiding overheating. Relative savings of less than 10% achieved during colder periods of heating seasons are not neglectable, because there were significant absolute energy savings, as shown in figs. 4 and 5.

Figures 10 and 11 show the measured energy consumption of each apartment in "test" buildings during two heating seasons.

The "test" building in the Block 34 consists of 5 lamels (Bulevar AVNOJ-a No. 209, 211, 213, 215, and 219). Each lamel has between 22 and 35 apartments. Figure 10 shows only energy consumption of apartments in Bulevar AVNOJ-a 213, in lamel 3. Energy consumption was measured in all 135 apartments in the building, but in this paper is given a diagram of energy consumption of apartments in lamel 3, as representative data. Diagrams of energy consumption for other four lamels are more or less similar. As it is

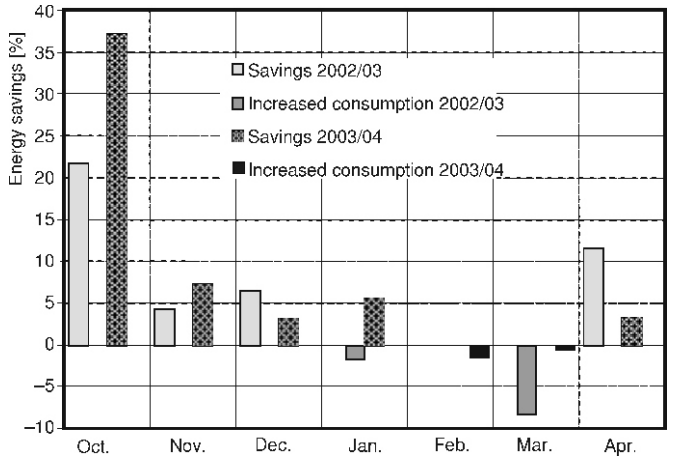

Figure 8. Relative energy savings per month achieved in "test" building in the Block 34 for two heating seasons

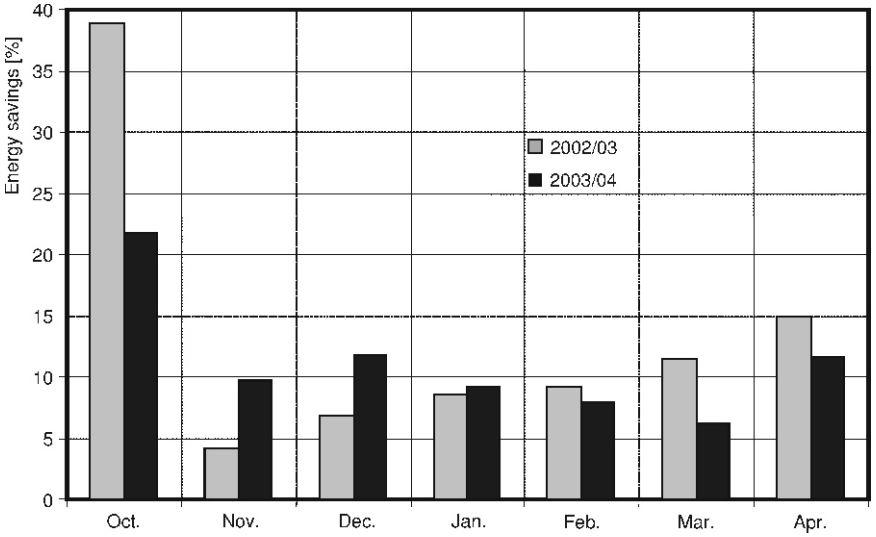

Figure 9. Relative energy savings per month achieved in "test" building in the Block 63 for two heating seasons

obvious from the figs. 10 and 11, energy consumption differs a lot between apartments. In this case energy consumption per apartment is affected by many factors, such as: position in the building, orientation, total apartment area and, of course, occupants' willing-

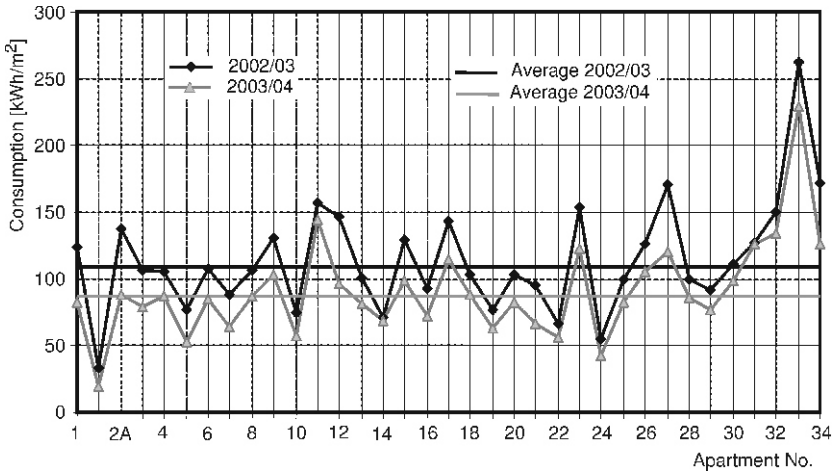

Figure 10. Energy consumption per square meter of each apartment in Lamel 3 (Bulevar AVNOJ-a Street 213) of "test" building in the Block 34 for two heating seasons

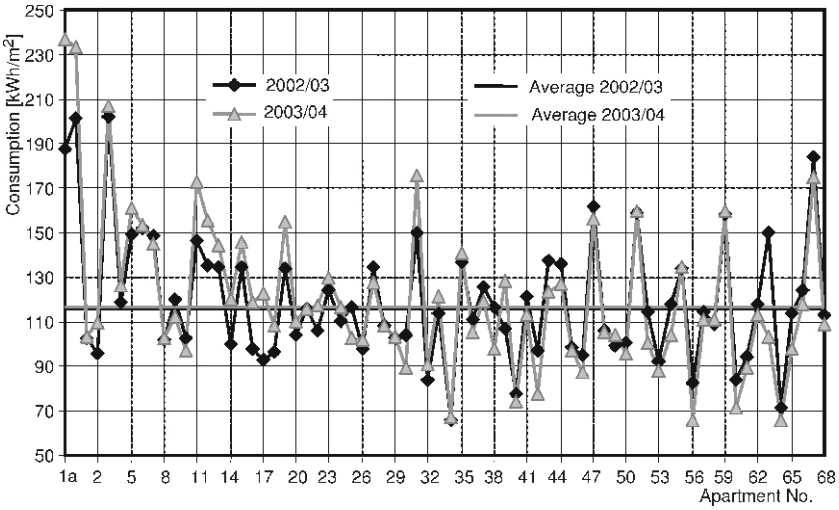

Figure 11. Energy consumption per square meter of each apartment in "test" building in the Block 63 for two heating seasons

ness to save energy for heating. Since there were no changes in tariff system, which means that occupants still pay fixed price for heating depending only on the apartment size, there was no stimulation for occupants to be rational concerning energy consumption for heating.

Table 1 shows average annual energy consumption per square meter of an apartment in each building for two heating seasons.

Table 1. Average annnual energy consumption per square meter for two heating seasons

Heating season	Average annual energy consumption [kWh/m^2]			
	Block 34		Block 63	
	"Test"	"Control"	"Test"	"Control"
2002/03	114	117	111	124
2003/04	105	111	111	124

Conclusions

On the basis of the obtained results, possible savings evaluation has been made for the scope of the "New Belgrade" heating plant, as well as for the whole city. It is necessary to emphasize that energy savings were accomplished without tariff system change, which means that the "test" buildings occupants still pay flat sum for heating in dependence of the apartment size, and not in accordance with actual energy consumption. Results can be applied to all district heating systems in Serbia.

Results obtained by measurements of energy consumption for heating in each apartment in two "test" buildings, with total area of 12000 m^2, show energy savings of 180 MWh of heat energy in each heating season, which is proportional to fuel savings of 23 t per year. If all the apartments in the scope of the "New Belgrade" heating plant applied the same measures (installing of radiator valves with thermostatic heads and allocators on each radiator), the estimated energy savings would amount to 52800 MWh per year, which is proportional to fuel savings of 6750 t per year. If the results are applied to the whole city of Belgrade, savings in DHC "Beogradske elektrane" will be 115000 MWh per year, *i. e.* 14700 t of fuel per year.

With the corresponding tariff system change along with charging actual energy consumption from the district heating system, conditions for motivating users to save energy would be formed. On the basis of experiences reached during this research project and experiences of other East European countries with similar winter climate conditions, evaluation shows much higher savings. They would be about 324000 MWh per year of energy from district heating system in Belgrade, *i. e.* 41000 t per year of fuel savings.

In order to achieve these savings necessary is to provide:

- technical conditions for energy savings for apartment heating (thermostatic radiator valves), and
- occupants' motivation for heating energy saving (measurement of energy consumption from district heating system and charging the actual energy consumed).

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