Energy and Buildings 104 (2015) 122–130

Contents lists available at ScienceDirect

Energy and Buildings

journal homepage: www.elsevier.com/locate/enbuild

Long term experimental evaluation of the influence of heat cost allocators on energy consumption in a multifamily building

Tomasz Cholewa*, Alicja Siuta-Olcha

Faculty of Environmental Engineering, Lublin University of Technology, Nadbystrzycka 40B, 20-618 Lublin, Poland

ARTICLE INFO

Article history:
Received 16 January 2015
Received in revised form 23 May 2015
Accepted 23 June 2015
Available online 8 July 2015

Keywords:
Energy savings
Heat allocation
Heat cost allocator
Heat metering
Energy efficiency
Multifamily buildings
Residential sector
Thermostatic radiator valve
Heating cost

ABSTRACT

The education of energy users is one of many possibilities to reduce the energy consumption in existing multifamily buildings. Unfortunately, to the best authors' knowledge, there is no long term experimental evaluation of energy savings, which may be achieved in flats where heat cost allocators were installed.

This article presents the results of experimental research conducted during 17 heating seasons (from 1997/1998 to 2013/2014) in a multifamily building located in Poland. The heat cost allocators were installed in the right part of the building (part R) in 1996 and in the left part of the building of the same size (part L) in 2011. In the summer 2005, thermal renovation of external walls of the analysed building was made.

The energy consumption in part R of the building was on average 26.6% and 30.5% lower than in part L for the period before and after thermal renovation of external walls of the building, respectively. After the installation of the heat cost allocators in part L of the building, the amount of heat used for heating was also analysed. The comparison of saved energy to the cost of installing, reading, and maintaining the heat cost allocators was made.

1. Introduction

The energy consumption in buildings in developed countries accounts for more than 40% of total primary energy use [1]. For that reason, many countries are concentrated on the reduction of energy consumption in the residential sector, especially when taking into account energy efficiency goals included in the EU-Directive 2012/27/EU [2]. This may be achieved at the designing stage of a new, low energy building for example with the use of energy efficient heating system [3,4] and new technologies of buildings envelope [5–7]. For the energy efficient heating system, as the local regulation, the use of thermostatic radiator valves (TRVs), which control the indoor air temperature by changing the flow of heating medium to the radiator, is recommended (in some countries – obligatory).

Nowadays, one of the very recent possibilities to reduce the energy consumption in existing buildings, besides thermal retrofits of building envelope and the modernization of heating system [8–10], is raising the awareness of energy users which has already been underlined and investigated by many researchers [11–21].

The education of energy users may be done by providing residents with information about the energy consumption in their particular flats using individual metering and charging [22–25].

Yao et al. [26] summarized the current studies and techniques on the heating cost allocation. Liu et al. [27] proposed a new "wireless on-off control" system for adjusting and metering household heat. On the other hand, Celenza et al. [28] presented an in-depth analysis of thermal energy measurement devices for applications in historical buildings. As for Pakanen and Karjalainen [29] and Siggelsten [30], they investigated the heat transfer between adjacent apartments in multi-apartment buildings for allocation of heating costs.

The EU-Directive 2012/27/EU [2] enforces the installation of individual heat consumption meters by 31st December 2016. It is recommended to mount an energy meter on the radiator circuit in order to measure the amount of heat (thermal energy) delivered to the flat. However, more than one radiator circuit for each flat may not be a cost-efficient method. In such a case, the individual heat cost allocators should be used for measuring the heat consumption at each radiator. Heat cost allocators do not actually indicate the exact heat consumption of a given flat, but rather they refer to certain accounting procedures, designed to divide the energy costs among the individual apartments in centrally heated/cooled multifamily buildings [26].

* Corresponding author.
E-mail address: t.cholewa@wis.pol.lublin.pl (T. Cholewa).

http://dx.doi.org/10.1016/j.enbuild.2015.06.083
0378-7788/

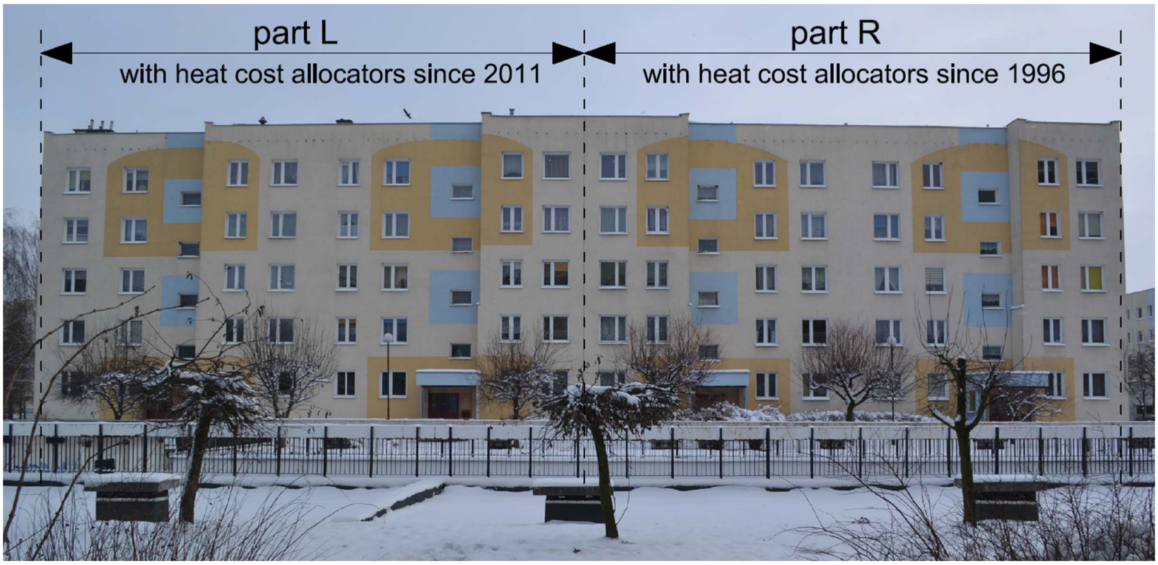

Fig. 1. View of the analyzed building.

According to EU-Directive [2], it is also possible to use alternative cost-efficient methods of measuring heat consumption; other than by using the heat cost allocators, if their installation would not be payable.

However, the authors noticed that there is no long-term experimental research on evaluations of influence of heat cost allocation on energy consumption and heating costs.

The present paper documents an experimental research made for 17 heating seasons, where the influence of the installation of the heat cost allocators on the heat consumption of the building and costs of heating are depicted.

2. Materials and methods

Experimental studies were carried out in a five-storey building located in Lublin, Poland during the period from December 28, 1997 to April 22, 2014 (17 heating seasons). Lublin is a city in the eastern part of Poland with an average annual temperature of 7.6 °C and a heating season of 222 days per year (3957 heating degree-days). For the analysed period of time, the heating seasons covered from 197 to 227 days and 3138–4239 heating degree-days. The average outdoor temperature during the heating season ranged from 0.5 to 4.3 °C. The heating season for the analysed building began between 1st and 5th October and ended between 22nd and 28th April.

The analysed multifamily building with 40 flats and total heated floor surface area equal to 2532 m^2, was built in 1991. The building faces east and west and there are no sideway windows. There are no sunlight obstructions for any of building's parts during the heating season (no high buildings), only some leafy trees close to the building.

In the building, there are four entrances with follow ups to separate staircases (Fig. 1). There are 10 flats at every staircase. Each flat has heated floor surface area equal to 63.3 m^2.

During the analyzed period of time (from December 28, 1997 to April 22, 2014) all flats in the building were inhabited during the heating seasons. The flats were never empty for more than 1–2 weeks in heating season (depending of the flats). However, in such a case the indoor temperature was not lower than 16 °C, which was set by the thermostatic radiator valves installed in the summer of 1998.

For the purposes of this article, the analysed building was divided into the left part (part L) and the right part (part R). These two parts are identical and each has heated floor surface area equal to 1266 m^2 (see Fig. 1).

Usually, in most multifamily buildings there is only one central heating installation for all flats in a building. In such a case, the central heating installation supplies radiators located in each flat with heat, which is generated by the main heat source for the building (for example, a gas boiler) or supplied from the district heating network.

However, in the analysed building, both parts (part L and part R) have independent (equal sized) central heating installations, which allow for a clear comparison of heat consumption of the both parts of the building.

Traditional central heating installations with convective radiators supplied directly from risers were used in each part of the analysed building. The central heating installations were supplied with the heating medium (80/60 °C) from the low temperature district heating network. Therefore, in each part of the building the heat meters were located on the entrance of the low temperature district heating network, allowing for the measurement of heat consumption for the needs of the central heating of the part L (Q_L) and the part R of the building (Q_R). It was presented in Fig. 2.

Horizontal pipes supplying the heating medium to the risers of the central heating installation were thermally insulated. The risers located in flats, as well as the pipes connecting risers with radiators, were not insulated.

In 1996 heat cost allocators were installed on radiators in the part R of the building (staircase III and IV), which allowed to determine the heating charges for every flat [31]. On the other hand, in the part L of the building (staircase I and II), heat cost allocators were not installed until 2011, and the costs of heating used to be charged on the basis of square metre of the floor surface area.

What is more, other modernization activities were made in the building in the period of the analysis (Table 1). They directly concerned both the heating system (the installation of thermostatic valves at radiators) as well as the building envelope (the thermal modernization of external walls). 10-cm thick styrofoam with the thermal conductivity of 0.04 W m^{-1} K^{-1} was used for external walls insulation.

The research data compared the mean outdoor temperature, as well as the total quantities of heat delivered to the part L (Q_L) and