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"Gheorghe Asachi" Technical University of Iasi, Romania

CHARACTERISTICS OF ENERGY EFFICIENT BUILDINGS IN DIFFERENT REGIONS OF EUROPE

Gábor Kozma[1*], Ernő Molnár[1], Balázs Kulcsár[2], János Pénzes[1], Károly Teperics[1], Zsolt Radics[1]

[1]*Faculty of Sciences and Technology, University of Debrecen, 4032 Debrecen, Egyetem tér 1., Hungary*
[2]*Faculty of Engineering, University of Debrecen, 4028 Debrecen, Ótemető utca 2-4., Hungary*

Abstract

Among the various environmental problems arising today, special attention must be paid to the issues related to energy; in particular one of the most important tasks to address environmental issues is the decreasing of the energy consumption of buildings. As a result, much attention has been given recently to research projects aiming to analyze the technological, economical and environmental features of energy efficient buildings. This paper examines such buildings in four regions of Europe that have received less attention, regarding differences in terms of their spread over time, the influence of geographical factors and the various functions involved. The most important conclusion drawn is that the above factors are significantly influenced by the income position of the groups of countries, the applied technology and the geographical location of the settlements within the country concerned.

Key words: energy efficient buildings, geographical location, income conditions

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1. Introduction

Foremost among the environmental challenges faced by countries around the world are the tasks related to the energy situation which include, on the one hand, the improvement of energy efficiency, and on the other hand, the increase of the proportion of energy from renewable sources. A significant part of energy consumption is related to buildings, and consequently, in recent years much attention has been devoted to the development and large-scale dissemination of various energy-efficient construction methods ('passive houses', to use an expression in wide circulation today).

Past research in this area mainly concentrated on the construction technology (Nikoleau et al., 2013; Romila et al., 2012; Siroky et al., 2011; Trandabat, 2012; Zeng, 2011), efficiency (Audenaert et al., 2008; Benedek et al., 2013; Harangozó and Zilahi, 2012; Jakob, 2006) and environmental characteristics (Georges et al., 2012; Mago and Chamra, 2009; Trauman et al., 2012) of the buildings concerned; at the same time, very few papers have been devoted to their distribution according to functions and geographical location. Publications in this latter category (Kozma et al., 2014; Lang, 2010) indicated that the largest majority of such buildings are located in Germany and Austria; at the same time, less attention has been given to buildings of these types located in other countries of Europe. In light of the above, we believe it is important to examine other parts of Europe as well in this respect.

2. Materials and methods

In the course of the research project, we used the databases of organizations in the field (e.g., the Passive House Institute,

* Author to whom all correspondence should be addressed: E-mail: kozma.gabor@science.unideb.hu; Phone+36 52518667; Fax: +36 52518667

http://www.passivehousedatabase.eu/search_detail.php, and the International Passive House Association - http://www.passivhausprojekte.de/projekte.php), which contained detailed information on the dates of construction, the size and the function of the buildings concerned. For the purposes of our analysis, we divided Europe into four larger units (Fig. 1), as mentioned before, Germany and Austria were not examined) and performed the analysis of the data with the use of the PASW Statistics 18 software package.

Fig. 1. The four regions of Europe examined

3. Results and discussion

In recent decades, the number of energy efficient buildings increased worldwide (Fig. 2): while only 268 such buildings were recorded at the turn of the new millennium, by 2012, this number has approached 3,000. The share of the four regions examined from the total building stock was very low initially in the period examined (only 2.7% in 2001); however, by the early 2010s, this proportion was over 10% (reaching 12.5% in 2012).

The source of this initially small proportion lies in the history of the technology of energy efficient buildings (passive houses). The concept of energy efficient buildings was born in Germany in the 1990s; consequently, in the first few years, the technology mainly spread in that country as well as in Austria, due to the same language being shared between them and their proximity. By the first decade of the new millennium, however, the necessary knowledge has become available in other languages as well, and the successes also have made this technology popular in other countries. As a result of the above, in the last decade, the proportion of energy efficient buildings in European countries other than these two gradually increased (Fig. 3).

Regarding the share of the four regions within the area examined (Fig. 4), the high proportion of Western and Northern European countries is apparent in the entire period. This result can be fundamentally explained by the fact that the application of the technology concerned requires substantial costs, and it was mainly the citizens and governments of countries with higher incomes that were able to finance these higher costs.

At the same time, the temporal processes in the first decade of the 21st century are indicative of significant changes. In the first few years of the decade – mainly as a result of the costs related to the introduction of the technology – the share of Western and Northern Europe was even higher than the average; however, in the second half of the decade, the increase of the role played by Central and Southeastern Europe can be observed. The source of this increase lies in the improved flow of information and the decreasing of the costs resulting from the technological development.

The economic crisis, however, affected this part of the continent quite badly: in 2011/2012, the number of energy efficient buildings completed dropped to half of the previous levels. At the same time, in recent years, a significant increase can be identified in the Southern European region, which is attributable to technological development: in the initial period, passive houses could be primarily used in continental climate, but due to the development of recent years, significant energy savings can now be achieved also in the Mediterranean region. If we analyze the distribution of energy efficient buildings according to function of the building (Table 1), we can find significant differences from the global characteristic data in two areas.

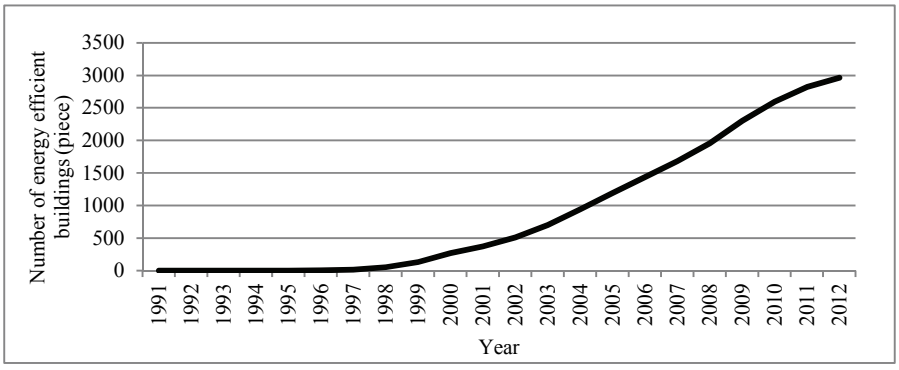

Fig. 2. The number of energy efficient buildings worldwide between 1991 and 2012
(Source: databases of the Passive House Institute and the International Passive House Association)

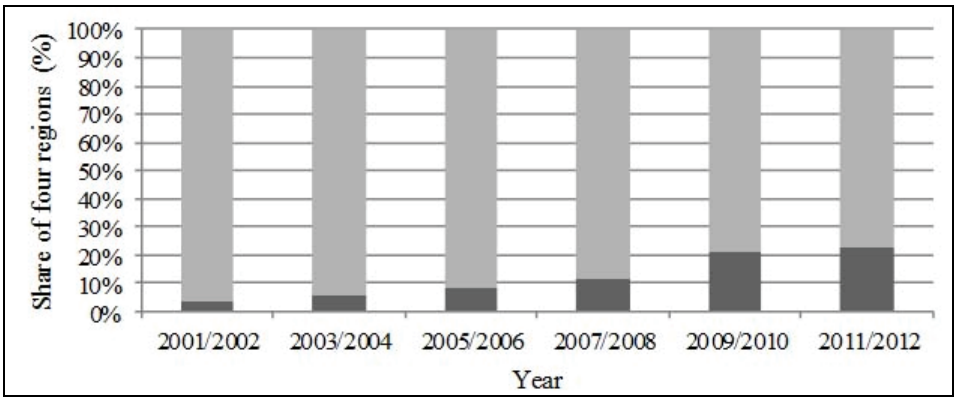

Fig. 3. The share of the four regions examined within the total number of energy efficient buildings completed in the given period (%)(Source: databases of the Passive House Institute and the International Passive House Association)

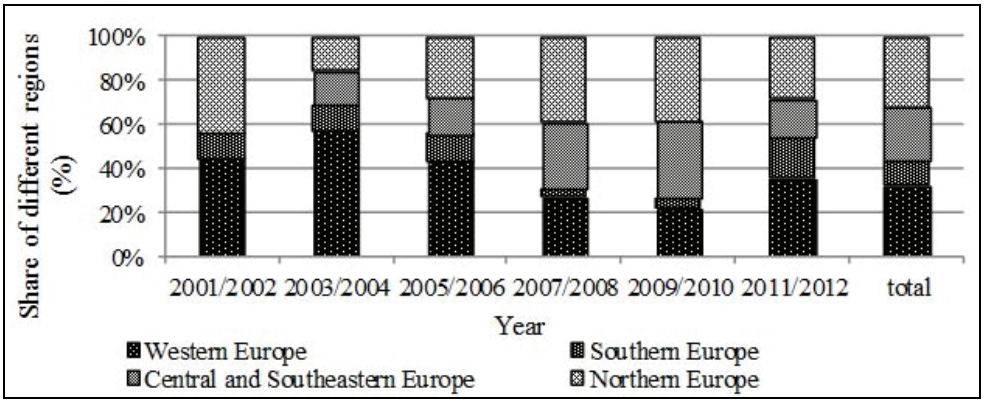

Fig. 4. The share of the four regions within the total number of energy efficient buildings completed in the given period (%) (Source: databases of the Passive House Institute and the International Passive House Association)

Table 1. Functions of the energy efficient buildings in the World and in the four regions examined

	World	***four regions examined***
single detached family houses	60.5	67.2
other residential function*	26.8	21.4
residential function	87.3	88.6
administrative function	3.7	4.2
mixed (residential and commercial) function	1.4	0.5
commercial function	1.9	0.8
education function	4.2	4.9
sport function	0.7	0.5
social and healthcare function	0.8	0.5
total	100.0	100.0

** - apartment houses, semi-detached houses, terraced houses; (Source: databases of the Passive House Institute and the International Passive House Association)*

Table 2. Changes in the functions of energy efficient buildings in time in the four regions examined between 2001 and 2012 (%)

	2001/2002	***2003/2004***	***2005/2006***	***2007/2008***	***2009/2010***	***2011/2012***
single detached family houses	33.3	73.1	71.8	72.8	68.2	62.8
other residential function	66.7	23.1	17.9	15.3	21.5	21.6
residential function	100.0	96.2	89.7	88.1	89.7	84.4
administrative function	0.0	3.8	7.7	3.4	3.7	4.3
mixed (residential and commercial) function	0.0	0.0	0.0	0.0	0.7	0.9
commercial function	0.0	0.0	0.0	1.7	0.7	0.9
education function	0.0	0.0	2.6	5.1	5.2	6.9
sport function	0.0	0.0	0.0	1.7	0.0	0.9
social and healthcare function	0.0	0.0	0.0	0.0	0.0	1.7
total	100.0	100.0	100.0	100.0	100.0	100.0

Source: databases of the Passive House Institute and the International Passive House Association

On the one hand, within the residential function, the proportion of detached single family houses is much higher and the proportion of buildings with other residential purpose is lower; on the other hand, the share of the commercial and mixed function is below the average. In terms of the change over time in the function of the buildings (Table 2), the effects of several processes can be recognized. In the first half of the first decade of the 21st century, energy efficient buildings almost exclusively served a residential function. In the second half of the decade, however, the improvement of the technology allowed the spread of energy efficient buildings in other sectors as well.

The next important change occurred in the 2010s, when both the absolute number and the relative proportion of newly constructed residential buildings decreased. This change is because fewer private individuals, who were much worse hit by the economic crisis, started building homes that involved costs above the average than municipal governments and other organizations. In 2009/2010 the construction projects started before the crisis were still being completed, so the actual effects of the crisis were manifested on a large scale only in 2011/2012.

In the distribution of energy efficient buildings according to function, major differences can be observed between the various regions (Table 3). On the one hand, in Central and Southeastern Europe, the proportion of residential-purpose buildings was much higher than the average; this higher than average proportion is likely because municipalities, which play an outstanding role in the investments aimed at the construction of buildings of other functions, had very little financial resources in this region, and those resources were typically used for more visible developments that would better win the approval of the population. On the other hand, the significantly higher than average proportion of other residential function is clearly observed in Southern and Northern Europe, which is most likely because in these countries, multi-family buildings (i.e., not detached single family houses, but buildings of other residential function) represented a higher share (Table 4). Regarding the ground area of energy-efficient buildings (Fig. 5), the smallest average ground area can is observed to be for buildings of partly or fully residential function, and specifically for detached houses, while among buildings constructed with the use of this technology, the largest ground areas are found to be for buildings for administrative, educational and social-healthcare purposes.

Regarding the differences between the various regions, the most apparent fact is that Central and Southeastern Europe have the lowest values for both residential functions, which can be attributed to the income differences: as a result of the lower income of the population in these countries, the buildings erected are typically smaller than the average (Fig. 6).

Regarding the location of energy efficient buildings of different functions within the countries, some major differences can be observed (Table 5). First, the majority of buildings of non-residential function can be found in big cities, which can be explained by the fact that it is typically these settlements where such (primarily administrative and educational) tasks emerge. Second, in the case of residential buildings, a much higher proportion of energy efficient buildings of other residential function (e.g. condominium buildings, terraced houses) are observed in big cities. This observation is because of the higher real estate prices, the available free land area in these settlements is much smaller; and therefore, there will much smaller buildings constructed with a higher density level. Third, in the comparison of the suburban and the rural areas: the proportion of residential-purpose energy efficient buildings is higher in the former.

This observation is primarily because these settlements predominantly serve residential purposes; therefore, the demand for the construction of service-related buildings (e.g., schools and offices) is lower than in rural areas.

5. Conclusions

On the basis of the data presented in this paper we can draw the conclusions that in the second half of the first decade of the 21st century, energy efficient buildings received increasing attention in European countries outside of Germany and Austria and that the distribution between the groups of countries varied as a function of the income situation and the applied technology.

Table 3. Functions of energy efficient buildings in the four regions of Europe examined

	Western Europe	*Southern Europe*	*Central and South Eastern Europe*	*Northern Europe*
single detached family houses	73.0	48.6	86.2	52.4
other residential function	14.7	37.9	9.5	32.3
residential function	87.7	86.5	95.7	84.7
administrative function	6.6	8.1	2.1	2.4
mixed function	0.0	2.7	1.1	0.0
commercial function	0.0	0.0	0.0	1.6
education function	4.1	2.7	1.1	9.7
sport function	0.8	0.0	0.0	0.8
social and healthcare function	0.8	0.0	0.0	0.8
total	100.0	100.0	100.0	100.0

(Source: databases of the Passive House Institute and the International Passive House Association)

Table 4. The proportion of multi-family buildings within the total stock of buildings constructed in the given year, in 2004 and 2009, in certain European countries (%) (Dol and Haffner, 2010)

		2004	***2009***
Western Europe	Belgium	49.0	49.0
	France	38.0	49.0
	Netherlands	25.0	42.0
Southern Europe	Greece	69.0	n.a.
	Portugal	63.0	59.0
	Spain	75.0	n.a.
Central and	Czech Republic	51.0	44.0
Southeastern Europe	Hungary	45.0	52.0
	Slovak Republic	32.0	52.0
	Slovenia	57.0	n.a.
Northern Europe	Finland	58.0	49.0
	Denmark	39.5	35.0
	Sweden	61.0	65.0

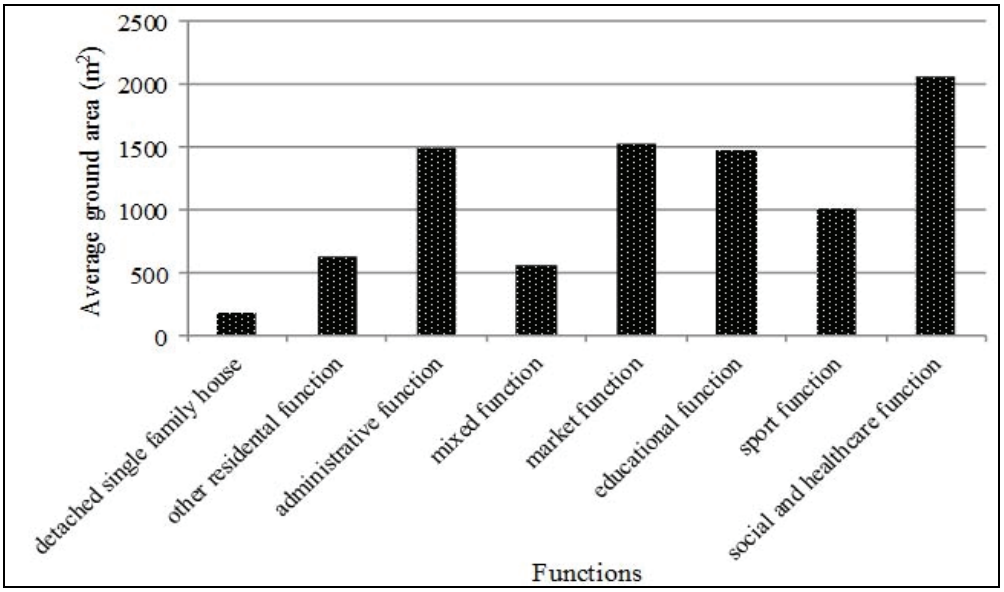

Fig. 5. The average ground area of energy efficient buildings of different functions in four regions examined (m^2) (Source: databases of the Passive House Institute and the International Passive House Association)

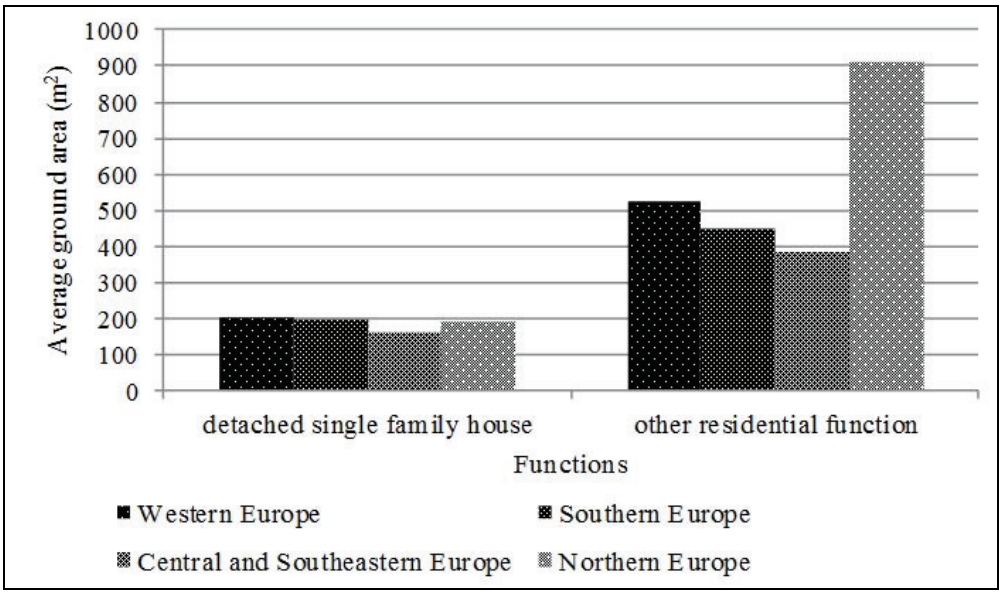

Fig. 6. The average ground area of buildings of different residential functions in four regions examined (m^2)

Table 5. The geographical distribution of energy efficient buildings of different functions in the four region examined

	Large cities[1]	*Suburban areas*[2]	*Rural areas*[3]	*Four regions examined*
Single detached family houses	37.5	84.7	72.4	67.2
Other residential function	35.3	11.4	19.6	21.4
Residential function	72.8	96.1	92.0	88.6
Administrative function	11.8	1.0	2.7	4.2
Mixed function	1.2	0.0	0.5	0.5
Commercial function	1.2	0.0	0.0	0.8
Education function	9.4	2.9	4.3	4.9
Sport function	2.4	0.0	0.0	0.5
Social and healthcare function	1.2	0.0	0.5	0.5
Total	100.0	100.0	100.0	100.0

1 – the 10 largest cities of the individual countries; 2 – settlements in the agglomeration of the 10 largest settlements of the individual countries; 3 – other settlements

Regarding the distribution of the buildings according to function, the most important role is played by the residential function; at the same time, there are, on the one hand, significant changes over time, and on the other hand, the geographical location of the buildings within the country can also be regarded as an influencing factor. Regarding the ground area of energy efficient buildings, major differences are observed between the individual functions. In addition, the effect of the different income situations of the groups of countries can also be identified as far as the residential function is concerned.

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