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SOCIAL EMBEDDEDNESS OF ENERGY-EFFICIENT BUILDING METHODS IN THE NORTHERN GREAT PLAIN REGION

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Abstract

The aim of the study is to reveal the energy-efficient technologies, related knowledge and information sources of the population in the Hungarian Northern Great Plain Region and to gain a understanding of their attitude towards the implementation of these technologies. The survey included questions about the alternative building technologies as well as the cost burden limits of considering their application. Special attention was given to getting information about the energy characteristics and maintenance problems of the dwellings.
The lessons learned from the data analysis are sufficient for the more successful promotion of the energy-efficiency issue and for changing current public attitudes.

Key words: energy efficiency, Northern Great Plain Region, public knowledge

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1. Introduction

1.1. Energy demand of buildings in the European and Hungarian context

Building stock is responsible for approximately 40% of the primary energy consumption and approximately 25% of CO_2 emissions (Uihlein and Eder, 2010). At the same time, the household sector accounted for approximately 25% of total final energy consumption and 29% of total electricity use in the EU-27 (Bertoldi and Atanasiu, 2009; Guillet, 2010) and is expected to be a key factor in determining whether the EU meets its energy-efficiency targets (EC, 2010).

According to the Fraunhofer ISI's estimations, the residential sector may cost-effectively save approximately 19% of its final energy compared to the baseline in 2020 with additional policies to overcome barriers to adopting existing technologies (e.g. thermal insulation or energy- efficient household appliances) (Fraunhofer ISI, 2009).

Hungary, in comparison with other European countries, is characterized by low energy consumption per capita and high energy consumption per unit of GDP, in which fossil energy carriers have a determining (75%) role. The role of renewable energy sources, however, is below the European Union average (approximately 7%). The dependence of the country on external sources for its energy supply is strong: 60% of the total primary energy consumption is imported (Boutin et al., 2007). 40% of energy consumption is related to our buildings, which highly overrates the significance of our energy efficiency (MND, 2012).

Spreading the adoption of low- or zero-energy and -carbon buildings in the European Union is essential to reach the comprehensive European objectives to reduce energy consumption by 2020, producing 60–80 Mt/year in energy savings (a

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reduction of 5–6% of the EU final energy until the beginning of the new decade). In addition to these declared objectives, the common EU-level energy-efficiency policy frameworks should be flexible for country-specific policies, which derive from the considerable differences between the EU Member States concerning the energy-saving and energy-efficiency attitudes of communities (EU, 2012; Mills and Schleich, 2012).

As a consequence of the outdated heating technologies of residential buildings, the climatological difference-corrected domestic energy consumption in our country is high: as opposed to the EU average of 220 kW/m^2/year (2000-2007), the value for Hungary was 247 kW/m^2/year. 70% of the 4.3 million buildings in Hungary (and a significant portion of the public buildings) need serious energy-efficiency improvements, while the number of buildings with extremely low net energy demand is at most a few hundred. Thus, the building stock in Hungary consumes far too much energy, which, due to the structure of sources, means greater energy dependency, more environmental loading and higher energy costs than necessary (MND, 2012).

The National Energy Strategy, equally integrating the aspects of security of supply, competitiveness and sustainability, places emphasis on energy saving within the framework of which the building energetics programs may greatly promote the achievement of the European and Hungarian energetic, environmental and economic objectives. In view of the investments in recent years, the situation has improved, but in the absence of a monitoring system the extent of the changes is not known. However, current building renovation practices often result in 10-40% energy savings – instead of the 85% that could be reached with the current technological background. Following these suboptimal renovations, the Hungarian energy policy may get stuck at a stage with high energy demand and high CO_2 emission (lock-in), which can later be remedied only with gigantic additional costs.

The future building energetics programs in Hungary, therefore, envisage an increase of the "renovation depth": to achieve the 60% envisaged for 2030, at least 70% of deep renovations are needed from 2020. Directive 2010/31/EU on the energy performance of buildings overrates the establishment of buildings more efficient than specified: after 31 December 2020, only nearly zero-energy buildings can be constructed, in which in addition to thermal characteristics, the integration of energy from renewable sources, the modernization of heating and lighting and the information and communication technology-based services enhancing energy efficiency also become important (MND, 2011, 2012).

The pro for the spread of low net energy-demanding buildings is the spectacular decrease in energy consumption: 30% decrease in heating energy need allows for more than 10% saving in total domestic primary energy needs. This is important not only for environmental sustainability but also for saving 30-40% on natural gas imports, which promotes improvement in energy security and decreases energy dependency. The bigger employment-creating potential is also a positive yield from deep renovations: some calculations suggest that even 130,000 new jobs could be created, and the spread of the "learning-by-doing" approach may help Hungary to be one of the technology developers (CEU, 2010).

1.2. Aspects of the public attitude survey, methodological possibilities

The objectives of the planning and strategic documents might be achieved only with the considerable acceptance and participation of residents. The widespread adoption and use of new and clean technologies requires an understanding of public thinking and behavior instead of focusing only on the technological issues (Sovacool, 2009). From this perspective, it is essential to detect the attitudes and knowledge of residents concerning energy consciousness and energy-saving behavior to develop more information and marketing activities.

The custom or behavior element was shaded and emphasized in Sovacool's study drawing attention to the social and cultural aspects of the acceptance of new technologies. It is worth mentioning that only the rulemaking aspect of energy standards for residential appliances might have a significant effect on energy consumption (without special efforts from the residents themselves) (Meyers et al., 2003).

The attitude of the population – especially the participation in different energy-efficiency programs is quite hard to investigate (Davis and Krishnamurti, 2013). Haas noted the factors influencing the behavior of residents: income level, attitude, technical efficiency, energy price and energy policy (directly and indirectly by the energy prices) (Haas, 1997).

Most studies proved a positive correlation between the education level and energy-saving activities due to the broader basis of knowledge and education tending to be positively related with belonging to a particular social milieu group that approves of environment-friendly behavior (Ioan et al., 2004) (besides social status or lifestyle).

Age structure also has a special role in the attitude: Mills and Schleich explained that middle-aged households should be most likely to adopt capital-intensive energy-efficiency measures (Mills and Schleich, 2012), while younger households tend to prefer up-to-date technologies that are typically more energy efficient (Carlsson-Kanyama et al., 2005). Several reasons (concluded by Mills and Schleich, 2012) suggest accepting the negative correlation between age and environmental attitudes and preferences. One of these indicates the relation to education, which has resulted in younger people having better knowledge about environmental protection, renewable energy technologies and

energy-efficient measures than older people (Mills and Schleich, 2012). Regarding the methodological aspects on the field of surveying residents, there are no unambiguous practices that can be followed from the overview of literature.

The most frequently applied methods are interviews (Achtnicht and Madlener, 2014; Davis and Krishnamurti, 2013; Pelenur and Cruickshank, 2012) and questionnaires (McMichael and Shipworth, 2013); the latter is personal or managed via mail. The sample numbers are also very different (ranging from a few hundred to more a thousand depending on the financial background or the investigated area).

In the light of the above, the aim of the present study is to show the attitude of the population of the backward (Kincses et al., 2014; Pénzes, 2013) Hungarian Northern Great Plain Region (Fig. 1) towards low energy-consuming building technologies.

2. Materials and methods

When selecting the sample, a two-stage stratified sampling procedure was applied: first, the settlement type was selected, and then the age of the interviewees and their number by settlements were selected. The selection of the settlements was based on the number of houses in the Region.

Relying on the database of the CSO, the number of dwellings built in 10 years (2001-2011) in the given settlements was regarded as a starting point – because those who are active in housing have up-to-date knowledge about the process, and relevant information concerning energy-efficient construction may be expected in their cases.

After selecting the settlements, the number of questionnaires was assigned to them. As a result of the selection, 18 settlements were sampled with 582 questionnaires in total: 179 in county seats, 299 in other towns and 104 in villages. The interviewees (for relevance) included the active population aged 18-65 years. The survey was conducted by field workers in the form of computer-assisted face-to-face (personal) questionnaires (similar to the CAPI method) during August-September 2013. The questionnaire was divided into three topics: characteristics of the present dwelling, characteristics of the energy consumption and knowledge about passive houses. All of the obtained results were statistically evaluated by the method of descriptive statistics (%). The data were statistically analyzed using the Statistical Package for Social Sciences 14.0 (SPSS 14.0.).

3. Results and discussion

3.1. Housing conditions

Most of the respondents (75%) live in family houses, approximately 10% more than the Hungarian average. Consequently, the ground area of the houses is also much higher than the national average: 53% of them have a ground area of 75-120 m^2. A definite correlation can be observed between the settlement type and the size of the dwelling. With the average being 98 m², the dwellings in the towns are typically approximately 95 m², whereas in the villages the average value is 108.42 m².

Questions were asked about the walls. The most often used material is brick (62.5%), which is similar to the national trend (63.49%). The concrete panel buildings (13.9%) are in second place, and wattle and daub is in the third place (11.7%). The distribution of dwellings by wall material in the sample is more favorable than the regional and even national values.

The "other" category may be regarded as especially outstanding (8.8%), of which 1.9% are light gauge steel frame houses. The innovativeness of the respondents may be regarded as above average.

The survey also included the age of the dwellings, which revealed that as a result of the sampling method, the respondents lived in much younger houses than the Hungarian average (Fig. 2).

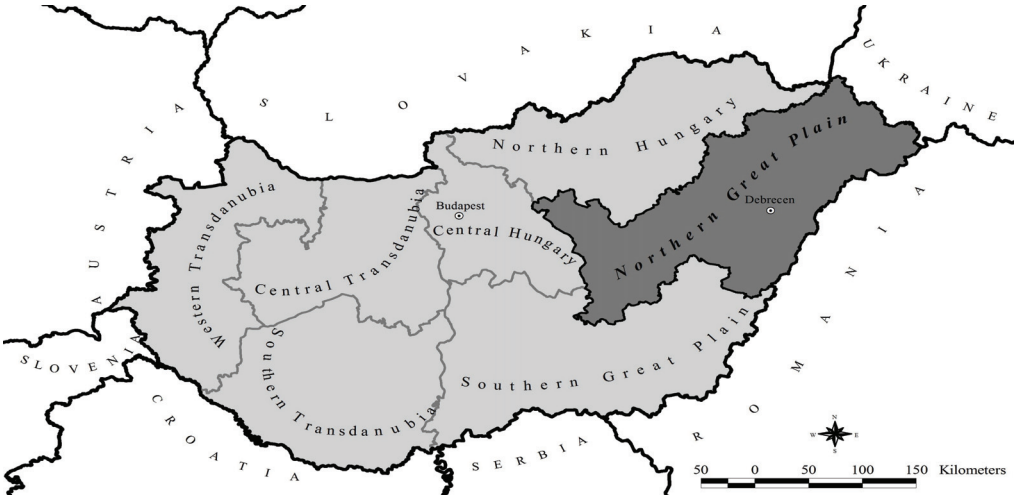

Fig. 1. Planning-statistical regions of Hungary

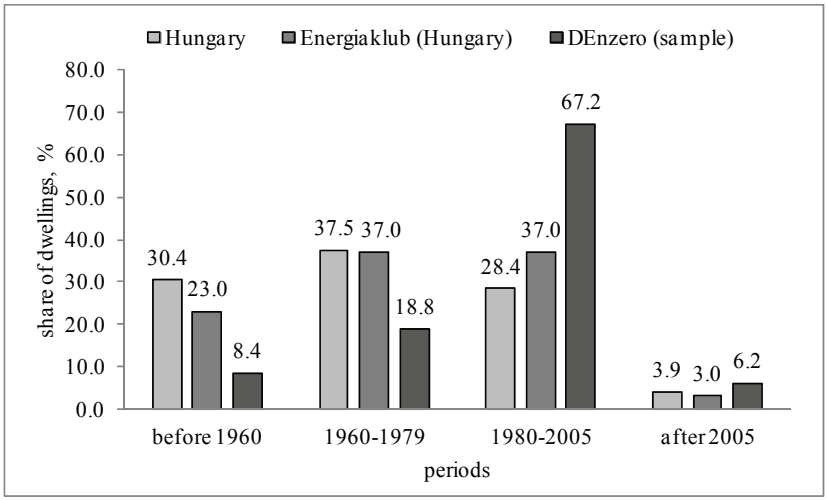

Fig. 2. Date of housing constructions in the samples of Energiaklub and DEnzero (own research) compared with the official data for Hungary (%) (CSO, 2013, Fülöp, 2011; and own survey)

Therefore, it is surprising that there is no insulation in the case of almost half of the dwellings even though they are significantly younger that the average. Only 21.8% of the dwellings were constructed using insulation, and 30.1% were insulated after construction, although lot of energy and money could be saved by insulation. Large differences can be observed between the settlement types with respect to insulation. Typically, the dwellings built in the county seats (69.8%) and in other towns (46.6%) are more often insulated than those in the villages (36.6%).

3.2. Energy consumption

The heating systems of the dwellings can be regarded as traditional: fossil energy carriers are used in most cases. The various forms of electric and alternative energy have a total value below 1%. The heating systems use gas (55%) and multi-fuel boilers and stoves (45%). The weight of district heating is the same as the national value (Fülöp, 2011), and the shares of gas and wood (coal) are also similar.

The quality of the systems is demonstrated by the fact that one-fifth (19.7%) of the respondents had renovation or repair work done in the past five years. Savings motivated many of respondents to renovate (43%), but constraint was also present in many cases (37.2%).

Comfort and aesthetics sank into insignificance, while environmental consciousness was named by only one respondent. Enhancing performance and full renovation appeared only randomly among the reasons.

The budget-wise attitude of the households was also surveyed. This attitude was most prevalent in relation to lighting. Typically, or very typically, 94.8% of the households are efficient in this respect: there is hardly anyone who does not regard it as natural. Nevertheless, they are much more lenient with respect to the use of television: almost 30% of the respondents are – even totally – non-economical. The indicator for the use of energy-efficient appliances is interesting. Normally, more than 50% of the households take this aspect into consideration, but the ratio of the response "not typical" is also high (18%), and the "not at all typical" has a share of 2.2%. These values reflect the uncertainty of energy-efficient attitudes.

Most respondents understand that using alternative energy carriers has the possibility of being more economical (Fig. 3). This notion is more likely to be motivated not by energy saving but by overhead saving. Principally, therefore, the respondents would be sparing with the use of the more cheaply produced energy instead of reducing the level of use. The use of solar energy is embedded in the collective conscious: two-thirds of the respondents regard solar thermal collectors, and almost the same percentage regard solar cells, as good alternatives.

The purchase of energy-efficient appliances (54.8%) is also mentioned by more than half of respondents. The concept of modernizing (efficiency improvement) is not strange to people as being another way to save energy. The improvement of insulation is considered only in the case of one-third of respondents, and heat recovery ventilation, which is important in the case of passive houses, were mentioned only by one-fifth (20%) of respondents. It is interesting that the more complicated heat pump process is more likely to be known (26.1%).

The differences between the intentions related to the procedures that could be applied for being more energy-efficient are interesting (Fig. 3). The thermal insulation of the walls, use of rollers and venetian blinds, or replacement of shutters as an option seems to be a more popular solution among the less-educated respondents.

Questions were asked in relation to the most important aspects of building or purchasing houses (Table 1). Interestingly, southern exposure, which is important when planning passive houses, is regarded the least important. It is followed by investment costs and the appearance of the house.

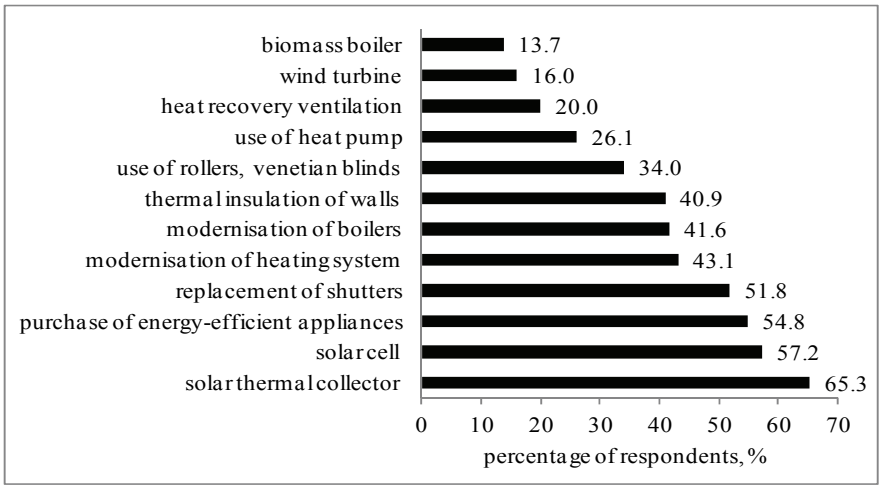

Fig. 3. Possible ways for being energy-efficient (%)

Table 1. Preferences in house building/purchasing (five-point scale: 1 – less important, 5 – most important, %)

	1	2	3	4	5
Existence of sewer system	0.9	0.5	1.4	5.5	91.7
Trouble-free maintenance	0.4	0.4	1.2	9.4	88.8
Revalorization of buildings	0.5	0.9	3.2	8.8	86.6
Low maintenance costs	0.7	0.7	3.9	10.4	84.3
High-quality insulation	0.5	0.5	3.0	13.6	82.4
Sunny and bright accommodation	0.5	0.5	3.7	16.8	78.5
Environment-friendly construction	0.7	1.9	6.0	16.8	74.6
Minimizing pollutant emission	0.7	0.9	4.4	21.6	72.4
Appearance of the dwelling	1.1	0.5	11.9	19.5	67.0
Low investment costs	1.6	6.9	16.8	19.5	55.2
Southern exposure	2.1	8.8	19.6	17.3	52.2
Pleasant living conditions	0.7	1.6	8.5	89.0	0.2

The latter allows a way in everything for the passive house planning. The most important aspects include trouble-free maintenance, revalorisation and low maintenance costs – the first two aspects are perfectly represented by the passive houses.

The level of environmental consciousness is demonstrated by the fact that the environment-friendly construction and the minimizing of pollutants are not among the aspects regarded as most important by the majority. Again, the aspect of saving on the private level precedes environmental consciousness. It may be generally established that the characteristics of passive houses are appreciated by builders/purchasers. They do not consider the investment costs as decisively important, but they think that the house should keep its value and be cheap to maintain. The situation is similar with the extra costs considered acceptable. The respondents are rather cautious, but the cost increase related to the construction of passive houses, currently estimated as 20-30%, is considered acceptable by 30-50% of respondents. The majority (28.5%) did not risk too much because they would undertake only 5% of the investment cost increase. The ratio of those who would pay 10% or even 20% more is somewhat lower, but it is still close to a quarter of the respondents. There is a strong relapse in the next category because only 8.6% of the population would accept a cost increase over 30%.

The results of our survey are in close relation to the findings presented in the analysis of Mills and Schleich about households in Hungary, which found that respondents were most likely to say it was more important to save electricity for financial savings (approximately 84%), and only 6 percent stated that it was more important to save energy for greenhouse gas reductions (Mills and Schleich, 2012).

3.3. Knowledge related to passive house construction

The last group of questions concerned passive houses and knowledge about them. Two-thirds of respondents have already heard about passive houses. As the level of qualification increases, the respondents have proportionally more knowledge about technology. 86% of those with a higher education degree, 65% of those with a secondary education and 32% of those with primary school degree have heard about buildings of this type. The related knowledge mainly comes from acquaintances (27.8%) and television (26.8%), and the Internet (15.2%) as a source is in the third place (Fig. 4).

Computers are available in 90% of the households, but still the traditional information flow

seems to be more efficient. This means that there is a serious task in promotion of energy saving (Hsueh, 2014). Schools could be especially important in this respect. 4% of the respondents heard about passive houses in school - though nature conservation and environmental protection-centered education could provide excellent opportunities for promotion. In the dissemination of information in the rural Hungary the role of the media and education is still important.

The more educated respondents could convert and calculate the cost-efficiency equation related to passive houses and could come to investment supporting decisions possessing more specific knowledge. They are the ones who rely on the Internet, professional journals and information from acquaintances more intensively, and also know more about the ministries and the non-profit organizations specializing in energy issues. The population with lower qualifications is more likely to rely on the media and the "official" (service providers, mechanics) bodies. The respondents confess that they are not satisfied with their knowledge about passive houses. Roughly one-third of them do not know of the technology, and those who have heard about it also feel that their information is deficient.

Placing their pieces of information on a five-point scale, one-fifth (20.6%) of them consider their knowledge insufficient, and more than one-quarter (27.7%) find it deficient. If these are added to the group of those who "have never heard about passive houses", constituting one-third of the total sample, then it may be established that about two-thirds of the respondents (32.5% have not heard about it and 48.3% of the remaining 68% have insufficient information) have a serious lack of information in this respect. The lack of information is not reflected in the opinions formed about the statements related to passive houses. If the one-third rate of those who have not heard about passive houses is also taken into consideration (typically, only 2.7% did not answer these questions, and the others were guessing), then almost perfect answers were given to the questions related to the investment cost increase (66.4%) and to the energy-efficiency of passive houses (69.4%). They cleverly recognized the hidden incorrect answers ("can be constructed only on sunny areas", "only passive houses are allowed to be built after 2019"), heard about the research station built on the Antarctic and about the heat recovery ventilation system, and were aware of the importance of thermal insulation.

Air tightness was more difficult for lay people to understand (44.7%), and the complexity of the operation was also hard to seize. This means that those respondents were more or less aware of the emblematic characteristics of passive houses if they have already heard about the "technology". Nevertheless, they found the available information insufficient (previous question) and were uncertain in the construction method.

One-tenth of the respondents gave a firm positive answer to the question, "Would you build a passive house?". Every second respondent (46%) would link the construction of a passive house to his or her financial ability. More than one-quarter (26%) of them, however, could not make a decision, and 18% gave a firm negative answer.

The more educated supported the technology more distinctly. 15% of those with a higher education degree would by all means use it, while more than half of them would use it depending on financial issues. Hardly one-tenth of them firmly refused it, and almost 30% cannot bring a decision about it. The situation is exactly the opposite in the case of respondents with primary education. 20% of the 582 respondents would build it by all means, but more than 40% would not build it on any account. Seclusion is the strongest in this respect (Fig. 5).

Uncertainty is greater with respect to the increase of investment costs. Typically, a cost increase of over 30% is assumed when building a passive house (67.4%).

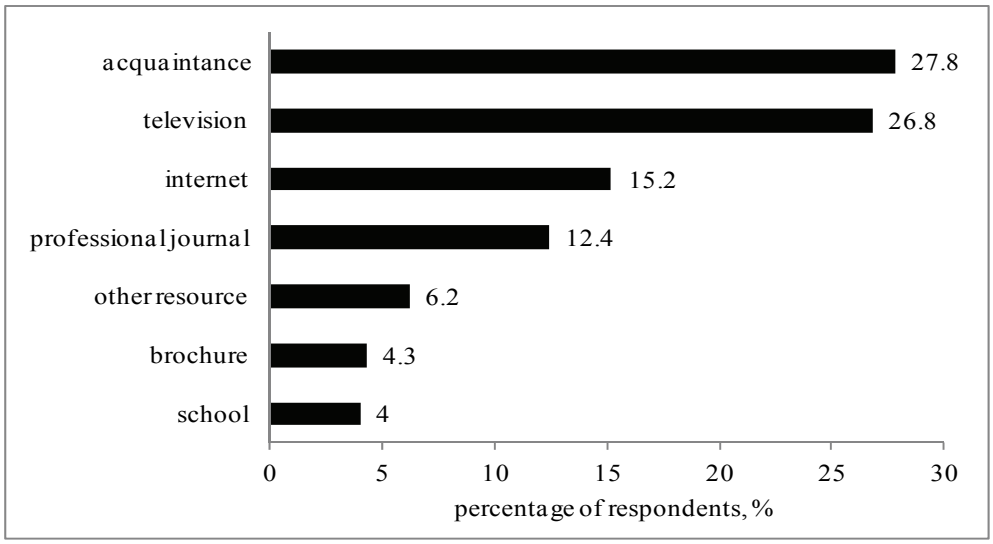

Fig. 4 Sources of information related to passive houses (%)

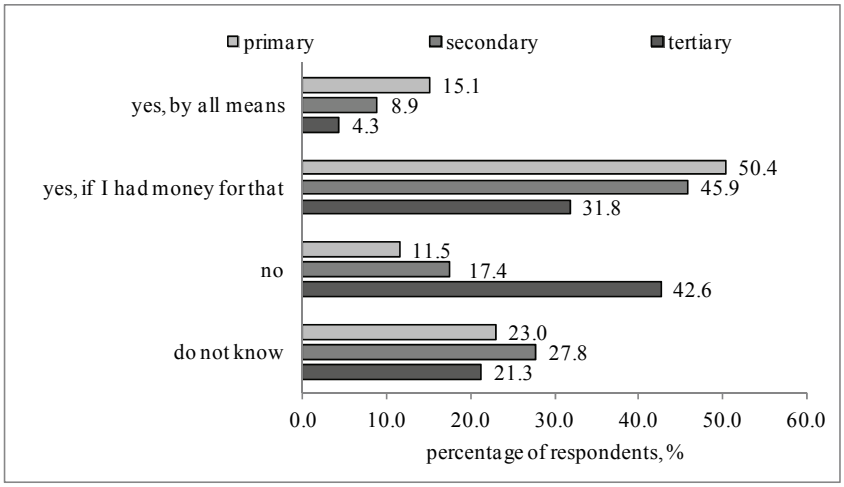

Fig. 5. Intention to build a passive house depending on the level of education (%)

This seems to contradict that 66.4% correctly chose the statement about the increase of 20-30% related to the passive houses. It is frightful to see that 46.5% of the respondents assume a cost increase of 50% or more if building passive houses. The lack of correct information may prevent the spread of the "technology".

The respondents envisage passive house building with 48.5% state support on average of those, people living in villages would be satisfied with 41.7% while those in towns would expect 50%. Those with a higher education degree are also more permissive with respect to the minimum level of state support necessary for building passive houses. They could have recalculated the cost-benefit equation of passive houses based on having more specific knowledge and thus could have reached a decision supporting the investment.

4. Conclusions

The aims of the energy, environmental and economic policies drafted at the European and national levels equally justify improving of energy efficiency where the housing stock representing a significant segment in energy consumption has a decisive role. For the sake of a higher percentage energy saving, the significance of deep renovations and new buildings with low net energy-need is increasing. The desired breakthrough is not only a public policy issue, the information level of the inhabitants and their attitude towards investments aiming at energy saving and energy efficiency essentially influence success.

Many surveys have already targeted the attitude of the population towards energy-saving technologies and within them, those related to the buildings and household equipment and their environmental consciousness. Nevertheless, a comprehensive picture about the attitude of the population cannot yet be drafted on a larger, regional level due to the complex differentiating effect of several influencing factors.

There have been many initiatives to study the issue, but there are no mature and generalized methods. In our opinion, the case study prepared in the sample region shows some peculiarities that may contribute to the improvement of efficiency in public energy consumption and the spread of the houses with low or zero energy needs.

In accordance with the experiences learned from the questionnaire survey, the current state of the housing stock in the Northern Great Plain Region may potentially create an opportunity from the aspect of spreading energy-efficient technologies. Half of the buildings are not insulated, and only one-fifth of them were renovated or modernized in the past five years.

The energy consumption of the households should also be improved. The notion of sparing can be sensed among the respondents, but for them, it is principally cost-effectiveness instead of energy saving. It is seen as using cheaper alternative energy sources and not by using energy-saving appliances. The elements of environmental consciousness are only secondary in this respect.

The respondents usually heard about energy-efficient construction methods (passive houses) from acquaintances, television or the press. Although almost 90% of the households are equipped with computers, the Internet occupies only third place on the list of information sources. Although, they are not fully aware of the facts necessary for decision-making (they overrate the cost increase related to the construction), one-tenth of them would by all means construct a passive house, and almost half of them make the positive decision based only on costs.

Significant differences may be observed in the context of the level of education with respect to knowledge concerning modern building technologies. Those with higher educational degrees use the Internet and professional journals, and their acquaintances may also help them informed about technical issues. The approval of the passive house technology is necessary to be popularized effectively among the people with secondary or primary

education through channels that are available for them: television, press and education may be the area that might bring achievements.

On the whole, the sympathy of the population for energy-efficient construction methods may be recognized despite of the significant lack of information. The spread of the idea of passive house construction (besides many other technical and technological issues) may be realized as a function of the promotion of the idea. A breakthrough should be reached in the fields of television, printed press and education, which are still the most popular means of conscious-forming, and these energy-efficient construction methods should be introduced to the public.

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References

Achtnicht M., Madlener R., (2014), Factors influencing German house owners' preferences on energy retrofits, *Energy Policy*, **68**, 254-263.

Bertoldi P., Atanasiu B., (2009), *Electricity Consumption and Efficiency Trends in the Enlarged European Union*, Status Report 2009, Brussels.

Boutin J. P., Gervasoni G., Hlep R., Seyboth K., Lamers P., Ratton M., McCormick K., Mundaca L., Plepys A., (2007), Alternative energy sources in transition countries. the case of bio-energy in Ukraine, *Environmental Engineering and Management Journal*, **6**, 3-11.

Carlsson-Kanyama A., Linden A. L., Eriksson B., (2005), Residential energy behaviour: does generation matter? *International Journal of Consumer Studies* **29**, 239-252.

CEU, (2010), *The influence of a large scale complex building renovation program targeting energy savings on the employment in Hungary* (in Hungarian), Central European University, Center for Climate Change and Sustainable Energy Policy, European Climate Foundation, Budapest.

CSO, (2013), *National Census of Hungary, 2011 – Houses*, Central Statistical Office, Budapest, Hungary.

Davis A.L., Krishnamurti T., (2013), The problems and solutions of predicting participation in energy efficiency programs, *Applied Energy*, **111**, 277-287.

EC, (2010), *Europe 2020 Strategy*, European Commission, Brussels.

EC, (2012), *Strategy for the sustainable competitiveness of the construction sector and its enterprises (2012)*, European Commission, Brussels, On line at: http://ec.europa.eu/DocsRoom/documents/276/attachments/1/translations/en/renditions/native

Fraunhofer ISI, (2009), *ENERDATA, Study on the Energy Savings Potentials in EU Member States, Candidate Countries and EEA Countries*, Final Report for the European Commission Directorate-General Energy and Transport. Karlsruhe/Grenoble/Rome/Vienna/Wuppertal /http://ec.europa.eu/energy/efficiency/studies/efficiency_en.htmS.

Fülöp O., (2011), *NEGAJOULE 2020 – Energy efficiency potential in the Hungarian residential buildings* (in Hungarian), Energiaklub, Research Report, Budapest, Hungary.

Guillet R., (2010), Energy and economical growth: overview and global challenges, *Environmental Engineering and Management Journal*, **9**, 1357-1362.

Haas R., (1997), Energy efficiency indicators in the residential sector, *Energy Policy*, **25**, 789-802.

Hsueh S-L., (2014), Evaluation of community energy-saving effects using fuzzy logic model, *Environmental Engineering and Management Journal*, **13**, 1207-1212.

Ioan C.C., Dedeurwaerder F., Dumitrascu G., Horbaniuc B., (2004), Curricular development perspectives: education for sustainable development, *Environmental Engineering and Management Journal*, **3,** 35-44.

Kincses Á., Nagy Z., Tóth G., (2014), The changing economic spatial structure of Europe, *Norsk Geografisk Tidsskrift - Norwegian Journal of Geography*, **68**, 301-309.

McMichael M., Shipworth D., (2013), The value of social networks in the diffusion of energy-efficiency innovations in UK households, *Energy Policy*, **53**, 159-168.

Meyers S., McMahon J.E., McNeil M., Liu X., (2003), Impacts of US federal energy efficiency standards for residential appliances, *Energy*, **28**, 755-767.

Mills B., Schleich J., (2012), Residential energy-efficient technology adoption, energy conservation, knowledge, and attitudes: An analysis of European countries, *Energy Policy*, **49**, 616-628.

MND, (2011), *Second Action Plan for National Energy Efficiency since 2016 with outlook to 2020* (in Hungarian), Ministry for National Development, Budapest, Hungary.

MND, (2012), *National Energy Strategy 2030* (in Hungarian), Ministry for National Development, Budapest.

Pelenur M.J., Cruickshank H.J., (2012), Closing the Energy Efficiency Gap: A study linking demographics with barriers to adopting energy efficiency measures in the home, *Energy*, **47**, 348-357.

Pénzes J., (2013), The dimensions of peripheral areas and their restructuring in Central Europe, *Hungarian Geographical Bulletin*, **62**, 373-386.

Sovacool B.K., (2009), The cultural barriers to renewable energy and energy efficiency in the United States, *Technology in Society*, **31**, 365-373.

Uihlein A., Eder P., (2010), Policy options towards an energy efficient residential building stock in the EU-27, *Energy and Buildings*, **42**, 791-798.