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OPPORTUNITIES AND LIMITATIONS IN THE MANAGEMENT OF ALTERNATIVE ENERGY

Lehetőségek és korlátok az alternatív energiagazdálkodás területén

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Abstract

Our research aims to examine what options are available for the general public in the field of renewable energy sources and what limitations an average household has to face when choosing energy-saving solutions in the future. In recent decades more and more studies support that the basis for future energy savings may lie in the financial sacrifices made in the present. We hear a lot in the media about the need for environmental protection but on its own it is not enough to motivate households to think about energy saving solution either in terms of heating, lighting or even in the field of transport. Our study includes the analysis of the 2011 HCSO (Hungarian Central Statistical Office) census data on the state of households. The analysis revealed that there are almost 4 million inhabited homes registered. In 2011 96.3% of homes were owned by private individuals, 3.7% were owned by government or other institutions, thus modernization, investment in energy efficiency can be to connected individuals. The number of prefabricated apartments in housing estates is high; almost one and a half million people live in such homes. District heating is also significant. District heating is based predominantly on hydrocarbon fuels: 80% of it comes from natural gas while the rate of coal consumption is only 10%. Of all the renewable energy sources the utilization of biomass (7%) is the most significant. The population is increasingly using heat economically, reducing heat loss in homes can be contributed to the replacement of doors and windows, external insulation, the upgrading of heating systems, and regulated heating. On the basis of the available data it can be stated that there were 250.000m^2 of solar panel systems installed in 2014, while in 2001 the total surface are reached only 20.000m^2. The goal is to increase the amount of these systems to 2.5 million m^2 by 2020.

Keywords: *biomass, energy efficiency, saving, environment protection, legal regulation*

JEL Cole: *Q42*

Összefoglalás

Kutatásunk célja annak vizsgálata, hogy a megújuló energiaforrások terén milyen lehetőségek állnak a lakosság rendelkezésére és vajon milyen korlátokkal is kell szembenéznie egy átlagos háztartásnak, ha szeretne takarékos megoldást választani a jövőbeni energiafelhasználás terén. Az elmúlt évtizedekben egyre inkább felgyorsultak azon kutatások melyek alátámasztják annak szükségességét, hogy a jövőbeni energia megtakarításunk alapját a *jelenben meghozott anyagi áldozatok adhatják. Sokat hallunk a médiában a környezetvédelem szükségességéről, de ez önmagában kevés háztartást motivál arra, hogy energiatakarékos megoldásban gondolkodják akár a fűtés, világítás vagy éppen a közlekedés terén. Vizsgálatunk kiterjed a KSH 2011-ben végzett népszámlálás során gyűjtött lakások állapotára vonatkozó adatok elemzésére. Az elemzés során megállapítható hogy hazánkban közel 4 millió lakott lakást tartanak nyilván. 2011-ben a lakások 96,3%-a magánszemélyek tulajdonát képezte, 3,7%-a önkormányzat vagy más intézmény tulajdonában volt, tulajdonképpen a korszerűsítések, energetikai célú beruházások magánszemélyekhez köthetők. A lakások között magas a jellemzően házgyári technológiával épített lakótelepi lakások száma, melyekben csaknem másfélmillió ember él. Jelentős a lakások távhőszolgáltatással történő ellátása. A távhőtermelés döntően szénhidrogén alapú, a hőtermeléshez felhasznált tüzelőanyag 80%-a a földgáz a szénfelhasználás aránya mindössze 10%. A megújuló energiaforrások közül a biomassza hasznosítása a legjelentősebb (7%). A lakosság egyre takarékosabb módon használja fel a hőt, a lakások hőveszteségének csökkentéséhez hozzájárult a nyílászárók cseréje, a külső hőszigetelés, valamint a fűtési rendszer korszerűsítése, a fűtés szabályozhatóvá tétele, azonban ezek hatékony kiegészítője lehet a megújuló energiaforrások hasznosítása melynek több példáját is bemutatjuk.*

***Kulcsszavak**: biomassza, energiahatékonyság, megtakarítás, környezetvédelem, jogi szabályozás*

Introduction

Our aim is to review the state of the housing stock for which we used the latest HCSO census data. Before the analysis of secondary data we present the areas and the specific domestic features of renewable energy addressing the areas of current regulations. The renewable energy sector has a number of areas and possibilities which include but are not limited to solar energy, wind power, hydro energy, hydrogen, geothermal and bioenergy. In Hungary the most popular alternative energy source for households is solar energy, which is negatively affected by the Act No. LXXXV of 2011 on environmental protection fee by which an EU directive is to be enforced in our country as well. Household consumption of domestic hot water and district heating has decreased by 17% 19% respectively since 2007. We must emphasize the concept of nearly zero energy buildings defined in the Minister of Interior decree of 20/2014. (III. 7.), which was defined in connection with the amendment of regulation 7/2006 (V. 24.) on the energy characteristics of buildings. Explicitly, a nearly zero-energy building is: constructed at a cost-optimal level according to the government decree on the energy characteristics of buildings or at a greater energy efficiency level, in which at least 25% of the annual primary energy demand is satisfied by energy from renewable sources including energy from renewable sources produced on-site or nearby. The following lines have appeared on several internet forums dealing with this topic: the imposition of a higher than justifiable fee in Hungary negatively affects the green, solar power generation, which is already lagging behind. http://www.alternativenergia.hu/a-napelemek-dragulasat-hozhatja-az-uj-termekdij/70517

At the end of their lifespan, which is thought to exceed 25 years, solar panels have to be collected, professionally disassembled and recycled. This is to be ensured by the 2012/19/EU (WEEE) EU directive, which had to be integrated into the legal system of each EU country by

14 February, 2014. Hungary agrees to centrally recycle these waste items for an environmental product recycling fee, thus the country conforms to the EU directive. Thus, based on literature, our research shows alternative energy sources as potential possibilities. Taking into account the natural and geographical conditions solar energy seems to be the obvious solution in Hungary. That is why there are a number of examples of the utilization of solar energy presented in this study. The utilisation of renewable energy and especially that of solar energy can be prominent among households. The detailed analysis on the state of the domestic housing assesses this potential. The reason is that other solutions are needed when dealing with homes built with traditional panel technology than in the case of independent houses. The past few years have demonstrated that the use of thermal insulation and modern windows can lead to increased energy savings, but this does not entirely relive the household budget.

Materials and Methods

The examination and analysis is based on primary and secondary data. The HCSO conducted a comprehensive study on the state of the Hungarian housing stock in 2011, this information was made available to the public in 2013. The examination of the data was carried out by means of the analysis of traditional statistical indicators as well as by curve fitting. In the second part of the analysis solutions for the use of solar energy are presented in case studies. In order to illustrate the data tables and diagrams are used. The presented good example was analysed with indicators of return discussed in the domestic and international literature. Investments create high-value, long-lasting assets, hence the common characteristics of investments are: significant financial burden, the capital expenditure appears "today" but returns are realised later in time and absolute certainty is not known, they define the company's technical and technological characteristics and economic and financial situation for a long time, and in many cases bad investment decisions are irreversible, or can be corrected only at huge costs. (Bannock et al., 2002; Parkin, 2013)

Based on the interaction between the investment proposals three categories can be distinguished: independent projects, mutually exclusive projects, and projects that depend on other investments. Independent projects include investment proposals whose acceptance or rejection is independence of other investments. In the case of mutually exclusive investments the acceptance of a project precludes other proposals. The category of projects that depend on other investments includes ones whose acceptance depends on whether there is another investment realised. Such projects should be merged and treated as a single project. (Ross, 2008)

Economic calculations can be grouped: one category involves techniques in which the decisions do not take into account the time value of money – these are called static indicators, such as: - the payback period (PP), and - the average rate of return (ARR). The other group consists of rules that take into account the time value of money at decision making. These rules are collectively called present value calculation or discounted cash flow based techniques or dynamic indicators, such as: net present value (NPV), profit index (PI), and internal rate of return (IRR). (Katits, 2002; Dlabay –Burrow, 2008)

The payback period is one of the most well-known non-discounting based decision-making techniques; it responds to the question of how long it takes for us to recover our originally invested money from the income generated as the result of the investment.

The formula is:

Payback period = the cost of investment / average net income

The other widely used non-discounting financial model is the average profitability of the investment. The average profitability of investment is calculated in % by comparing the average of the annual incomes generated during the entire lifetime of the project to the original cost of the investment. (Clayman, 2012; Parkin 2013):
The formula is:

Average profitability of the investment = average net income / the cost of investment

The net present value is an indicator of difference and it expresses the net income (yield) by subtracting the original cash flow from the discounted sum of the cash flows generated during the entire lifetime of the investment. Since the sign of the initial cash flows is always negative (cash outflows), and the combined present value of operating cash flows are generally positive, NPV can be defined as follows:

$$NPV = -C_0 + \sum_{i=1}^{n} \frac{C_i}{(1+r)^n}$$

NPV = net present value
Co = the cost of investment
n = number of years
Ci = return on investment in a given year
r = interest rate in a given year

When using the net present value as a rule, investments with positive net present value are acceptable. If the task is to choose the best one of more mutually exclusive investments, obviously the investment with the highest net present value have to be chosen. (Illés, 2007; Dlabay – Burrow, 2008)

Results

Potentials in renewable energy sources

At the beginning of the third millennium we have arrived at a critical phase of human history where we have to face an interrelated, consequential and mutually reinforcing system of global crises. Industrial development in the last 200 years required the use of significant amounts of energy. Due to the recurring energy crises from the 1970s onwards it started to become obvious that fossil fuels, particularly the easily exploitable resources, are not inexhaustible, and their use heavily pollute the environment. (Tamás – Blaskó, 2008)

Renewable energy sources offer the opportunity for everyone to use sustainable energy. The widespread application of these can provide the solution to replace fossil fuels, which currently add up to almost 80% of the total global energy consumption. In the different regions of the Earth the conditions are favourable for the utilisation of different renewable energy sources. Of all the renewable energy sources the potentially exploitable wind energy could replace the least amount of fossil fuels. The highest average wind speed areas can be found in Denmark, the Netherlands, Belgium, Great Britain, and Iceland. Owing to the strong winds significant wind energy potentials are at disposal in Northern Europe along the coastal zone of the North Sea. Of the renewable energy sources solar energy is the most abundantly available. The energy arriving at the surface of the Earth is approximately ten thousand times greater than our energy requirement. (Bartholy et al., 2013) Hungary's climate is rather one-sided, the amount of global solar radiation in most of Hungary is approximately 4200-4600 MJ/m^2. Most of the radiation is detectable in the middle of the area between the Danube and Tisza rivers, as well as the central and eastern parts of the Great Plain. The least amount of radiation is measured at the foothills of the Alps and the Northern Mountains, where the annual amount of radiation barely reaches 4100 MJ/m^2. (Horváth, 2011)

The use of hydro energy to generate electricity and the exploitable energy reaches the value of 200 Mt oil equivalent. The utilization rate of the potentially recoverable hydropower in North America and Europe is around 70%. This percentage is significantly lower in Australia (49%), South America (33%) and Asia (22%). The smallest proportion – less than one-tenth of the potentially available hydroelectric power – is utilised in Africa.

The situation in this respect is exceptionally good for those countries where high mountains and rivers of high stream gradient can be found, such as Switzerland, Italy and Norway, where the value of the maximally exploitable annual hydro energy calculated for the entire country is larger than 1,000 MWh/km^2. Because Hungary is situated in the Carpathian basin it does not belong to the above-mentioned countries, the amount of hydroelectric power potential is less than 100 MWh/year km^2. As for geothermal energy, the capacity of geothermal power plants in 2012 exceeded 11 GW globally. The bulk of the current production takes place in the USA where 30% of the global geothermal energy production is realised. Production is also significant in the Philippines, Mexico, Italy, Indonesia and Japan, which together provide 56% of the total global power generation from geothermal sources. Areas with the highest heat flux density – even exceeding 150 mW/m^2 – can be found in Iceland, the central part of Italy, Greece and the western part of Turkey. Our country also has favourable conditions: in most parts of the country geothermal heat density is over 80 mW/m^2. (Bartholy et al., 2013)

Research in Hungary is justified by the fact that there are large amounts of small-medium (below 130 degrees Celsius) temperature layer and karst water resources available, but in certain areas at specific depth there are high-temperature (130-250 degrees Celsius) resources which allow power plant utilization for electricity generation. (Pesthy, 2012)

Of the renewable energy sources biomass has the greatest potential to be used. Despite the fact that biomass is the most evenly distributed renewable resource globally, its exploitation is not so straightforward as it is the source of our daily food. The biggest source is still the firewood (67%), followed by charcoal (6%) and reused wood (6%). The different agricultural sources such as agricultural waste (4%), animal by-products (3%) and energy crops (3%), contribute only 10% to the total energy supply. Another 8% of energy is generated from industrial waste wood (3%), municipal waste (3%), black liquor (1%), and forestry waste (1%). (Bartholy et al., 2013)

Environment protection? - Features of product award

By the end of 2014 8829 homes were equipped with solar panels while a year earlier there were only 4855 such homes. The scale of change is shown by the fact that in 2010 there were only 292 such buildings. Through the increased volume of production price competition has reached the level at which the production and distribution of these systems is unimaginable at a considerably cheaper rate. Solar panels have to be installed only once, and then due to the decreased electricity bill the owner will have fewer headaches. http://www.greenfo.hu/hirek/2015/07/30/ideje-megszabadulni-a-villanyszamlatol Act No. LXXXV of 2011 on environmental protection fee, by which an EU directive was to be enforced in our country, presented significant problems. At the end of their lifespan, which is thought to exceed 25 years, solar panels have to be collected, professionally disassembled and recycled, which is to be ensured by the 2012/19/EU (WEEE) EU directive. The product fee is HUF114 per kilogram, but solar panels are still the best investment as the annual yield of photovoltaic systems in our country is 10%. The product fee is added to the HUF35,000 to 55,000 + VAT price of the photovoltaic modules, which further worsen the payback time, which is already the longest in our country. Currently thousands of employees of approximately 700 businesses produce solar panels, they plan, install, and operates these solar panel systems. Installation price is typically between HUF 5,000 and 10,000 per panel, thus fees rise substantially. Owing to the product fee and the outstanding VAT rates businesses with foreign headquarters enjoy great advantages, since the product fee must be paid by the distributor and the VAT is significantly lower in all the neighbouring countries. Solar pane systems are increasingly being installed by Slovak firms in our country for ever growing extra profit. http://www.mnnsz.hu/napelemekre-is-kiszabtak-a-kornyezetvedelmi-termekdijat/ At purchasing power parity – i.e. measured against our wallet – Hungary is in the last third of the EU's 28 Member States considering the combined costs of gas and electricity. Not coincidentally, more than two-thirds of Hungarian homes are in need of renovation from the energetics point of view. Since the turn of the millennium the heating energy consumption per square meter of Hungarian households barely improved. (Enerdata, Energy Efficiency Trends for Households in the EU http://www.mnnsz.hu/a-rezsicsokkentes-tartalekai-az-energiahatekonysagban-vannak/)

In consideration of the energy efficiency improvement of Hungarian households in the last decade the EU average is 2.5 times higher than the Hungarian one. The number of domestic small-scale power plants and the installed capacity increased by leaps and bounds in recent years: Their total capacity at the end of 2008 was 0.51 MW, while by the end of 2014 it exceeded 69 MW. In 2012 the total capacity quadrupled compared to the previous year, in 2013 and 2014 it doubled again.
http://www.mekh.hu/download/b/cd/00000/MEKH_foldgazrendszer_statisztika_2013.pdf

It must be pointed out that – as we have already noted – the best way to reduce energy consumption, to protect the environment and to preserve finite resources is not by improving energy efficiency. In parallel to this energy saving and the limited use of energy should be pursued. (Sebestyénné, 2013)

The power consumption characteristics of Hungarian households

Since 2000 the number of household consumers of electricity increased by 6.5%, while the monthly consumption per consumer increased until 2008 and then declined in subsequent years. The specific consumption level in 2013 was the same as in 2001. The increase of the number of settlements with installed piped gas systems slowed down. In 2013 three new settlements had piped gas systems installed thus the proportion increased to 91.3%. In 2013 there were six electricity distribution companies in operation in Hungary. The total amount of electricity sold by the distributors has changed little since 2011, in 2013 it was 34,205 GWh. Nearly a third of the electricity was supplied to households, their share remained virtually unchanged over the past decade. The consumption of households have been modestly decreasingly since 2009, in 2013 they used 10,580 GWh of electricity, which is 6% below the peak consumption of 2009. In 2013 5 million 531 thousand consumers had access to electricity, 91% of them were household customers. Compared to the 2000 level the number of customers increased by 8%, while the number of household customers increased by 6.5%. The latter can be explained partly by the housing stock increases and partly by the power grid expansion to outskirts, resorts, and the surroundings of small villages. The average monthly consumption per household consumer increased by 7% between 2000 and 2003 and then stabilized at a high level of 185 kWh/month until 2009. Since then, however, it decreased by 6%, and in 2013 it was identical to the 2001 level of consumption. Household energy consumption is regionally differentiated. The specific power consumption of households is the highest in Győr-Moson-Sopron and Pest counties where they consume 17 and 29% more respectively than the national average, while in Zala and Somogy counties consumption is 24 and 22% behind the national average respectively. Since 2000 household consumption in Hungary – with the exception of Fejér county – decreased, especially in Tolna (-18%) and Somogy (-13%) counties. In the rest of the country – with the exception of Borsod-Abaúj-Zemplén county – it increased, most significantly in Pest County (by 14%).

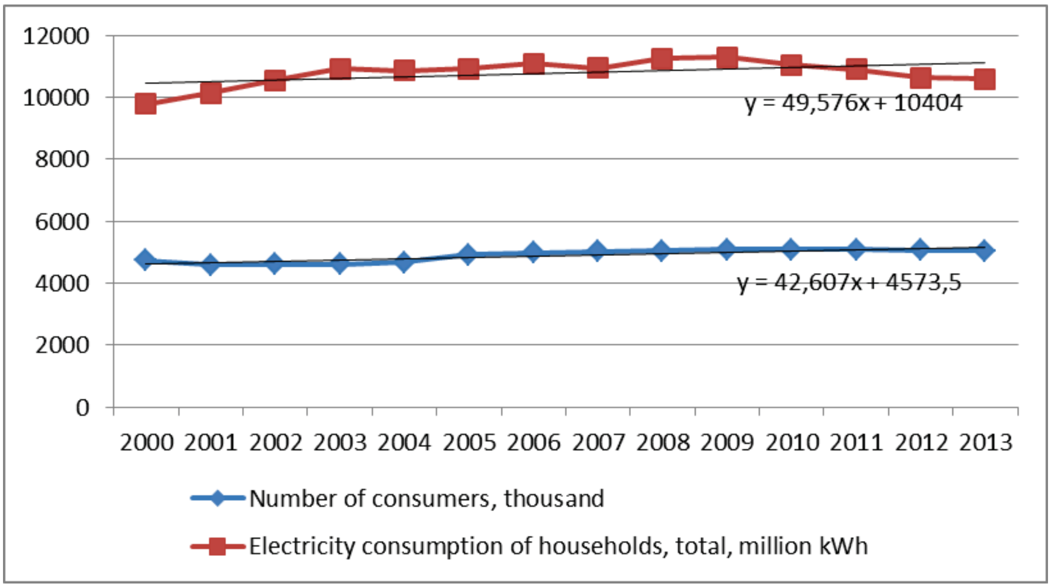

Figure 1 Details of the electricity consumption of households

Source: Own edition based on: Infrastructural provision of settlements 2013, Statisztikai tükör

The household use of electricity in the total consumption barely changed during the examined period, the average share is 31.9%, energy consumption per capita (kWh month) in 2008 was 186.1 kWh/month, in 2013 it was only 175.1 kWh/month, lower consumption than this was measured only in 2000, when the consumption stood at 173.3 kWh/month. In 2013 the mostly local government-run district heating companies sold a total of 25 PJ of heat energy for communal purposes, 73% of which went to the residents. In addition, these companies provided heat for a significant number of public and municipal institutions. In 2013 in 96 settlements of the country 648 302 households – about 15% of the housing stock – benefited from district heating. Almost one and a half million people live in housing estates which were typically built with prefabricated technology. The number of homes connected since the regime change has not changed since large public investments into housing constructions terminated. Most of the apartments with district heating (37%) are located in Budapest, over a quarter of the apartments in the capital city has this service. Their number is also significant – with the exception of Békéscsaba and Zalaegerszeg – in the county seats. The proportion of households connected is almost 90% in Almásfüzitő and also significant in the large, previously industrial cities such as: Dunaújváros (84%), Tiszaújváros (76%), Tatabánya (74%), Kazincbarcika (64%) and Oroszlány (62%). In 2013 2880 settlements had pipelined natural gas supply in Hungary. The supply in settlements has been at 91% for years. The number of customers was 3 million 465 thousand in 2013, 94% of them are household consumers. Gas suppliers satisfied the energy needs of nearly 3.3 million households. 84.6% of the households used natural gas for heating purposes. Nationwide, 74% of the homes use gas. Most of the houses connected to the gas network can be found in Budapest and Csongrád (both 83%) and Pest County (82%), while Komárom-Esztergom (44%) and Tolna Counties (49%) have the least. The total volume of sales of natural gas to customers in Hungary was 8.1 billion m^3, 702 million m^3 less than the previous year. The consumption of households in 2013 exceeded the previous year by 3.2 billion m^3 or 8%, which reversed a downward trend since 2005. The proportion of the population in the total consumption also increased. Although the share of the gas consumption of the population within the total consumption exceeded 40% annually between 2000 and 2009 (nearly 45% in 2003 and 2004) it was below this level in each year between 2010 and 2013. The average monthly gas consumption per household gradually decreased from the peak consumption of the annual 125.4 m^3/month in 2003 to 74.7 in 2012 then consumption increased again to 82.6 m^3/month in 2013

The number of homes with district heating services related hot water is 598 241, which is somewhat lower than the ones mentioned previously. The Hungarian Energy and Utility Control Office reported that in more than 60 settlements the supplied heat energy came from power plants that generate heat and electricity. This technology can increase energy efficiency and it is also environmentally beneficial because the heat generated during the production of electricity can be used in district heating. The district heat generation is predominantly based on hydrocarbon fuels, 80% of it is natural gas while the rate of coal consumption is only 10%. Of the renewable energy sources the utilization of biomass is the most significant (7%).

Table 1 Summary data of domestic natural gas consumption

Year	Amount of gas sold, $million\ m^3$		Number of consumers, thousand		Monthly average gas consumption per household m^3/month	Rate of settlements with piped gas network, %
	total	of which: for households	total	of which: household		
2000	8415	3466	2984	2824	102,3	80,0
2001	9213	3782	3068	2899	108,7	84,1
2002	9192	3954	3149	2970	111,0	85,8
2003	10227	4571	3223	3037	125,4	88,6
2004	10159	4425	3299	3101	118,9	89,9
2005	10457	4600	3366	3158	121,4	90,5
2006	10015	4413	3429	3215	114,4	90,5
2007	9081	3796	3479	3260	97,0	90,8
2008	9118	3794	3513	3292	96,0	91,1
2009	8544	3625	3552	3333	90,6	91,1
2010	9580	3625	360	3396	89,0	91,1
2011	8006	3094	3537	3312	77,9	91,2
2012	8756	2948	3516	3288	74,7	91,2
2013	8086	3221	3465	3251	82,6	91,3

Source: Own edition based on: Infrastructural provision of settlements 2013, Statisztikai tükör

Household consumption of domestic hot water and district heating has decreased by 17% 19% respectively. The population is increasingly using heat economically, reducing heat loss in homes can be contributed to the replacement of doors and windows, external insulation, the upgrading of heating systems, and regulated heating. Although it would be possible to switch to a different heating system, it is still not a realistic option because of the disproportionate additional costs in the case of housing estates which were originally designed to have district heating. However, it is the district heating systems that may provide opportunities for switching to alternative solutions (alternative sources of energy: biogas, biomass, geothermal and solar energy). In 2008 the energy consumption of households in Germany was 27% (and not 40 percent, as is often claimed) of the total energy consumption. Households in 2007 consumed 721 TWh, by far the largest portion of the final energy consumption was used for heating, whose share remained of around 75% during the period. http://energiavadasz.hu/?p=1816, 2015. 09.28.

It is almost impossible to further reduce the energy consumption of households, because the number of homes in Germany is growing, which increases the amount of consumption. Between 1991 and 2007 the average floor area of residential properties increased by 23%, while the number of apartments by 17%. Population growth in the same period was only 4%. The better insulation of buildings and the proliferation of efficient heating systems are clearly reflected in the statistics according to the Federal Environment Agency: the energy consumption of residential heating per unit in 1998 was 200 kWh/m2, which decreased to 161kWh/m2 by 2007. This decrease is despite the fact that both the living space per capita and the number of single-person households has been growing continuously since 2000. The reduction in household energy consumption refers to more efficient energy use, says the study. http://www.detail.de/research/, http://energiavadasz.hu/?p=1816

The major features and state of the Hungarian homes

In Hungary during the 2011 census about 3.9 million homes were registered, which is complemented by 470 thousand unoccupied flats, totalling approximately 4.4 million homes. Methodologically the HCSO defines homes in the following way: Originally built for purposes of permanent human accommodation, residence (home) or converted into a home and is still suitable for residential purposes; a technologically (architecturally) complex unit of premises of specific purposes (residential, cooking, health, etc.) which has its own independent, private entrance from a public area, yard or common space within the building (staircase, corridor, etc.). A technically (architecturally) connected group of rooms with internal gateways was considered a flat during the census even if the gateway of one or more rooms were temporarily (not walled) closed. Separate rooms or buildings – such as the so called "summer kitchen" of houses – which were built with the aim to form part of the apartment were considered complex units when these were used by people occupying the main building. However, summer kitchens used by subtenants had to be considered separate residential units. If the originally complex unit was separated (technically) into independent homes then the formerly one home had to be calculated as many units as they were according to the current state after the division. If two or more previously separate flats are technically connected (i.e. with internal doors) it counts as only one apartment. In 1920 the average number of residents in 100 occupied homes was 420, in 1970 327 people, and in 2011 only 248 people were registered by the office so these data clearly shows the decrease in the number of population. However, in 1920 there were only 5 bathrooms per 100 homes while by 2011 this number increased to 105, so it is not uncommon that a household has more than one bathroom. In terms of room numbers nearly 40% of the homes have 2 bedrooms, 31.6% have 3, and 10.4% have only one room. In 2011 96.3% of the homes were owned by individuals, and 3.7% were owned by the municipality or other institutions. In fact, modernization and investment into energetic refurbishment can be linked to individuals, the municipalities as owners are interested in the energy-efficient management of public buildings. Of the 3,371,417 homes in 1980 610,823 (18.1%) were classified as fully equipped with all modern conveniences, 1,093,036 (32.4%) had modern amenities, 255,591 (7.6%) were of reduced amenities, and 1,271,932 (37. 7%) were without comfort. In 2011 there were 3,912,429 homes registered 61.4% of which were fully equipped with all modern conveniences, 31.0% had modern amenities, 2.7% were of reduced amenities, and 4.4% were without comfort, which means that compared to the 80s a significant improvement in the quality of homes is observable in terms of degree of comfort and quality structure. During the next decades focus will be on the creation of energy-saving "green" homes, which is beneficial for both the environment and the wallet of the tenants.

Changes in the type of heating of occupied dwellings

In addition to the growing number of homes the role of central heating is becoming more and more significant, individual room heating is disappearing, which represents some savings when implementing the construction as for example fewer chimneys are required. This solution may be decisive in the methods of the implementation of modernization since better performance is combined with efficiency, which can uniformly manage the conversion needs of such homes. In 1980 17% of homes had central district heating which somewhat grew to 15.5% by 2011, which means that energy saving is preferred not only in terms of modern heating systems but also as properly insulated walls and doors and windows as well.

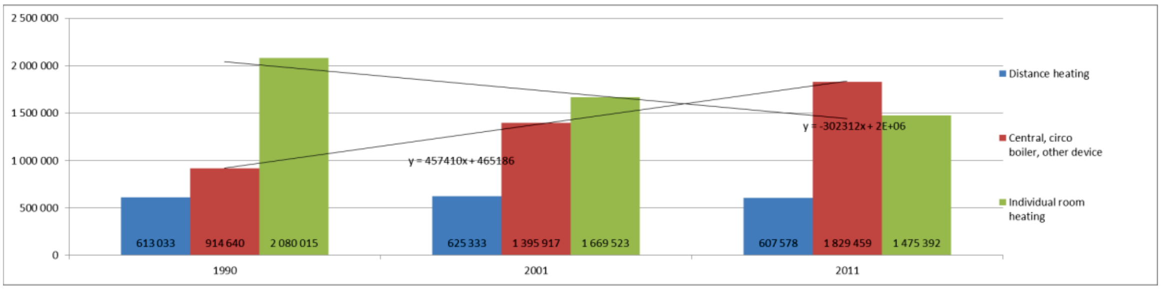

Figure 2 Changes in the type of heating of occupied dwellings
Source: own edition based on: 2011 census, HCSO, Homes and their occupants. Hungarian Central Statistical Office, 2013

The figure clearly indicates the dual process in which individual room heating solutions are pushed into the background while technical solutions using central heating boilers are increasingly becoming preferable. In recent years fewer and fewer small prefab apartments were built, they are the ones that mostly had district heating. The occupants of these homes could apply for state aid for the energetic modernization.

Table 2 Occupied homes by type of ownership, floor space, and year of construction

Year of construction	Owned by private person	Owned by municipality	Owned by other institution, organisation	total
before1946	676481	42450	11 368	730 299
1946–1980	1869432	42618	12 653	1 924 703
1981–2000	875892	12867	6 082	894 841
2001–2005	199533	7006	2 878	209 417
2006-2011	147424	1359	4 386	153 169
total	3 768 762	106 300	37 367	3 912 429
Floor space, m^2				
-39	243959	40079	5 394	289 432
40-59	955870	43617	12 355	1 011 842
60-99	1629619	20000	13 193	1 662 872
100-	939314	2544	6 425	948 283
total	3768762	106300	37 367	3 912 429

Source: own edition based on: 2011 census, HCSO, Homes and their occupants. Hungarian Central Statistical Office, 2013

49.6% of the homes owned by individuals were built between 1946 and 1980; if we consider the number of homes built in the previous period, then we can say that 67% of the homes were built before 1980 which will certainly have to be renovated and modernised; this includes more than 2.5 million homes. As for municipal real estates the least amount of them was built between 2001 and 2005, 80% of the homes were built before 1980, which means more obligations for the local governments. Real estates owned by non-municipality institutions can be characterised by similar processes of age structure. The size of the floor space is between 60 and 99m^2. 91.6% of homes are used as own property, the lease makes up only 7%. For a significant number of properties to be renovated the costs of energy consumption can be reduced by installing well-designed and properly implemented solar equipment which could also be used for heating purposes. In Sweden electricity is used for heating purposes to a large extent because the energy produced by hydroelectric power plants is significantly cheaper than the use of other fossil fuels.

Table 3 Occupied homes by floor space, wall structure and number of rooms

	-29	30-39	40-49	50-59	60-79	80-99	100-	Total	average floor space, m^2
	m^2 home								
wall structure									
brick, stone, masonry unit	51328	132410	179932	298676	479507	573795	777359	2484007	84
medium or large block, poured concrete	4813	10490	34714	85614	53355	29618	38980	257584	69
prefab	9168	57952	79309	231203	131134	8567	2346	519679	54
wood	1181	1752	1552	1508	3504	4091	5748	19336	80
adobe, mud, etc.	4914	13963	35109	67404	187656	167066	107377	583489	77
other	452	1009	1928	3893	10222	14357	16473	48334	88
total	71856	217576	332544	679298	865378	797494	948283	3912429	78

Source: own edition based on: 2011 census, HCSO, Homes and their occupants. Hungarian Central Statistical Office, 2013

16% of the homes are below 50m2, 17% of them are between 50 and 59m^2, 42.5% of them are between 60-99m^2 and the proportion of homes above 100m^2 is also significant, in 2011 it was more than 24%. The heating and energy supply of homes with high floor space is obviously more expensive than smaller ones, thus the owners of large homes can expect greater savings in the long run regarding operation and maintenance. Savings and upgrading depend significantly on the quality of the walls. It is clear shown by the data that 63% of the homes are made of brick, stone or masonry units, which means that the value of the property would increase with high quality insulation. The average size of these homes is 84 m^2, the largest of the individual categories. The rate of prefabricated panel housing and adobe homes is similarly 13%. According to HCSO data heating is provided by boilers that supply one or more flats with a higher average floor area, while smaller ones use district heating.

Table 4 Occupied homes by year of construction, wall structure and type of heating

	before 1946	1946-1960	1961-1970	1971-1980	1981-1990	1991-2000	2001-2005	2006-2011	total
wall structure									
brick, stone, masonry unit	4458983	291484	382003	450386	364112	217429	183993	135617	2484007
medium or large block, poured concrete	-	6550	57804	96866	64500	14904	9618	7342	257584
prefab	-	-	48228	277907	185229	7236	759	320	519679
wood	327	151	381	1522	2301	3914	6677	4063	19336
adobe, mud, etc..	262202	153904	96328	43767	12303	8605	4077	2303	583489
other	8787	5540	5465	6417	9408	4900	4293	3524	48334
									type of heating
individual rooms	475058	276606	274630	240927	116096	50969	25607	15499	1475392
boiler supplying one or more homes	245665	154409	220309	343954	353133	199010	178736	134243	1829459
district heating	9576	26614	95270	291984	168624	7009	5074	3427	607578
total	730299	457629	590209	876865	637853	256988	209417	153169	3912429

Source: own edition based on: 2011 census, HCSO, Homes and their occupants. Hungarian Central Statistical Office, 2013

Less than 10% of the homes were built in 2001 or later, 90% of them were completed prior to that. Prefabricated panel flats began to appear in 1961, their heyday was between 1971 and 1980, when nearly 278,000 of these homes were built from this material. The oldest prefab block of flats is over fifty years of age, which in itself is not necessarily a problem, however, the condition of the windows, radiators, and pipes may be problematic. Even if the latest technology was used during their construction, by now they must be in need of a thorough renovation. As has been mentioned above most of these homes are heated by district heating but wall insulation must be provided by the residential community while it is possible for individual households within the block to change their doors and windows for modern ones. Central heating used by one or more homes is becoming increasingly popular as opposed to the separate room heating. Homes built before 1946 normally have individual heating (32%) but this proportion is steadily decreasing, 1% of the homes built between 2006 and 2011 have this heating solution according to the HCSO. Most homes (876 865) were built between 1971 and 1980. About 300,000 apartments are 40-59 m^2, while 333,000 of the flats are between 60 and 99m^2. 72% of the then built homes are equipped with all modern conveniences. The least homes were built during the period between 2006 and 2011, about 153,169 homes, 89% of which are equipped with all modern conveniences. In terms of the age composition of the tenants, 33% of themes are inhabited by young and middle-aged people. The number of homes inhabited exclusively by young people in 2011 was 166,170 while the number of homes populated only by old people was 1,025,222. 17% of the apartments are occupied by more generations living under one roof. In the case of the elderly the proportion of housing made out of mud or adobe is dominant. Unfortunately, there is hardly any chance to modernise the property in the case of the most desperate cases and the question whether there is a reality of the refurbishment of those properties or whether it would be cheaper to build a new one. This is the case for almost 580,000 homes of which nearly 200,000 are inhabited only by old people while another more than 100,000 are occupied by middle-aged people. According to the statistical records most of the homes built of adobe and mud were constructed before 1960.

The condition of the property thus determines the direction of reconstruction, the possibilities and the energy-efficient operation, this is supported by the so called “panel program”. However, this program focuses on insulation rather than the use of renewable energy resources. Statistical data clearly show that the domestic housing stock is obsolete thus it cannot be expected to reduce energy costs significantly in the long run. Administrative tools can be applied to reduce overheads, but the value and modernity of the property or its long-term energy saving capability will not change, what is more an effective solution to this problem may even be postponed. Based on international data the widespread use of renewable energy will become inevitable in our country too, the state of properties make it even more urgent.

Table 5: Installed photoelectric capacity (MW)

Country	2008	2010	2013
Germany	5979	17193	35651
Italy	432	3470	16361
Spain	3568	4029	5166
Hungary	1	2	35

Source:http://www.kovet.hu/sites/default/files/knowledge/jaszaytamas_kovet_energetikai_munkacsoport_2014_05_08.pdf, IEA, Roland Berger – 2013

Good practices to be followed in the utilization of solar energy

Solar energy as a renewable energy possibility can be used to reduce the costs of public institutions and households and even inspires the establishment of solar power plants and in order to support this a few examples are present. Our research primarily focussed on the energy consumption of domestic households as well as the potential possibilities of renewable energy thus examples supported by numerical data are presented.

"Reducing peak electricity consumption of buildings by installing photovoltaic systems"

The following case study aims to reckon a specific planned investment through a producing and service providing organization. The investor intends to replace part of its electricity consumption with the operation of a photovoltaic system by placing 1,379 polycrystalline solar cells on the roof plane of the building and on the ground at the production site. The electric power generation capacity of the apparatus is 344. 75 kWp, its expected energy yield is 338740kWh/year, its annual specific energy yield is 982.57 (kWh/kWp), while its planned reduction of greenhouse gas emission is 316.654 tons/year.

Main original data:

- The current annual energy need of the building located at the site is [kWh/year]: 768814
- Connection power [kW]: 297,00
- Amount of energy produced [kWh/year]: 338 740
- Amount of energy utilised [kWh/year]: 338 740

The possible quantifiable results of the investment

- Reduction of greenhouse gas emissions [t/year]: 316,654
- Increased use of renewable energy sources (power generation)* [GWh/year]: 0,33874
- Increased use of renewable energy sources [GJ/year]: 1 219,464

Planned expenditure of the project [gross]: HUF 208 018 668

- The "purchase of equipment and construction costs" primarily include the costs required to install the solar system, therefore the costs recorded in these lines (eligible and non-eligible) are calculated in the specific value.
- Development costs [net]: 145 046 235 Ft
- Size of development [kW]: 297
- Unit value [HUF/kW]: 488 371
- Specific limit [HUF/kW]: 700 000 (Károly Róbert College, KEOP-2014-4.10.0/K/14-2014-0026)

Quantifiable results of the investment

Monitoring indicators	Original value (target value)	Maintenance period:				5 years
		Date to reach target value:				
		2016.05.29	2017.05.29	2018.05.29	2019.05.29	2020.05.29
Reduction of greenhouse gas emissions [t/year]	316,654	316,654	633,308	949,962	1 266,617	1 583,271
Increased use of renewable energy sources (power generation) [GWh/year]	0,3387	0,3387	0,6775	1,0162	1,3550	1,6937
Increased use of renewable energy sources [GJ/year]	1 219,464	1 219,464	2 438,928	3 658,392	4 877,856	6 097,320

Source: own edition

Source: self-made photo

Solar Power Plant in Hungary

The solar power plant built in 2015 by Mátra Power Plant Zrt. is the so far largest photovoltaic project in Hungary.

Project board at the site of the investment

Source: self-made photo

Key figures on the Mátra Power Plant:

- 950 MW installed capacity,
- Mátra Power Plant Zrt. satisfies almost 15% of the Hungarian electricity needs,
- produces more than 20% of the domestic electricity generation. (www.mert.hu, http://www.mert.hu/zold-ut-a-zold-projektnek, 2015.08.19.)

Basically it is a lignite powered plant, but has been producing green energy for a decade, and in recent years it has increased the share of biomass in electricity generation to 8 - 10%.

In addition to the traditional activity the Mátra Power Plant is expected to (have) install(ed) Hungary's largest solar power plant of 15 MWp installed capacity by October, 2015.

According to plans the new photovoltaic power plant will generate electricity after the trial operation.

The project

The following project summary is based on personal interviews and the official website of the Mátra Power Plant (www.mert.hu).
The project site is an area to be recultivated because of previous operations of Mátra Power Plant.
"The combustion residual material of the power plant – slag and fly ash – is mixed with water and stored in landfills in the form of thick slurry, which forms fly ash stone within a few weeks. With reference to the environmental and other regulatory requirements the area must be recultivated." (www.mert.hu)

On the basis of regulatory requirements a number of site specific alternatives have been developed for the recultivation of the area. The 30 acre perfectly flat surface is suitable for the installation of photovoltaic solar cell power plant.
The area is suitable for a 15 MW unit.
Mátra Power Plant Ltd is building/has built Hungary's largest solar power plant with an installed capacity of nearly 18.5 MWp. This volume corresponds to the total capacity of all the solar panels installed in our country by 2013.
The power plant finances 50% of the investment from its own sources, the other 50% is from development tax credit which was granted by the Ministry of National Economy in 2014.
The total investment cost of the solar power plant is more than HUF 6.5 billion.
The Wire-Vill Kft . – IBC Solar gmbH – Energobit S.A., an Austrian-Hungarian-Romanian consortium, won the construction of the solar power plant through a public procurement procedure.

Solar power plant – site of investment (Mátra Power Plant Ltd. Visonta, Őzse-völgy tailings ponds)

Source: self-made photo

On the 30-hectare recultivated area 72,480 polycrystalline solar cells with a rated output of 255W each are attached to a fixed support structure. (See photos above)

The generated direct current is turned into alternating current by 10 800 kVA SMA inverters which are placed into concrete transformer station. The alternating current is collected in a medium-voltage switchgear equipment installed in a concrete central switching station. Furthermore, an engineer station, which can fully control the entire system, is placed on the site. The DC and AC control system provides string depth intervention enabling continuous monitoring.

The solar energy generated by the solar power plant gets from the central station to the medium voltage switchgear (to be built at the site of the power plant) and to the 6,6 kV side of the new 132/6.6 kV 24 MVA starter transformer through a 1750 m long medium-voltage ground cable.
The power plant feeds the generated energy into the MAVIR Detk substation at 132 kV voltage level through existing cables.
The solar power generated electricity can supply green energy, measured at the average household scale, to a small town – approximately a thousand four-member households. (www.mert.hu, http://www.mert.hu/zold-ut-a-zold-projektnek, 2015.08.19.)

Solar Systems at household level - solar power generation

Those who buy solar cells will buy energy. Basically a 7.5-8 m^2 solar panel surface can generate 1 kW. Voltage: 230V AC. The feedback rate is approximately 1250 kWh/year/kW installed capacity. There are no maintenance costs.
On the basis of the manufacturing technology solar cells of different properties are available. Three main types can be differentiated: amorphous (thin-layer) crystalline solar cells, polycrystalline solar panels, monocrystalline solar cells. The efficiency and production cost of the above type of solar cells significantly differ.

However, generally speaking, the energy conversion efficiency of modern solar module varies from 13-18%, their average lifetime is at least 30-35 years. In addition to the rated power the so-called **power tolerance** is also indicated by the manufacturers, which normally means a +/- 5% power tolerance. It means that, for example, the output of a 200 Wp (watt peak, i.e., the peak power of a solar cell in ideal conditions) solar cell can vary between 190 and 210 Wp with respect to the nominal value. Thus, in reality, the manufacturer practically guarantees only 190 Wp power. (Source: www.wagnersolar.hu) In connection with solar panels essentially two types of guarantees can be differentiated. Product warranty lasts 2 - 10 years while the performance guarantee after 10 years of use is generally 90% and after 25 years it usually decreases to 80%.

Example – for the solar cell investment needs and savings of a house with a HUF 8666/month energy bill.

- energy bill: HUF 8666/month
- annual energy bills: HUF 104,000
- annual electricity consumption: 2,600 kWh
- minimum area requirement of the solar panels: 17 m^2
- the expected number of solar panels: 10
- carbon dioxide saved by the solar system (CO2): 1574 kg/year

– capital expenditure needs HUF 1587 500

Source: www.wagnersolar.hu

The total investment cost is HUF 1587500, which will result in an annual energy cost savings of HUF104000. The contractor grants 20 years of warranty on the equipment. Accordingly, if we assume 20 years of running time, it is clearly visible in the figure below that at a 2.72% rate of return NPV is zero in year 16.

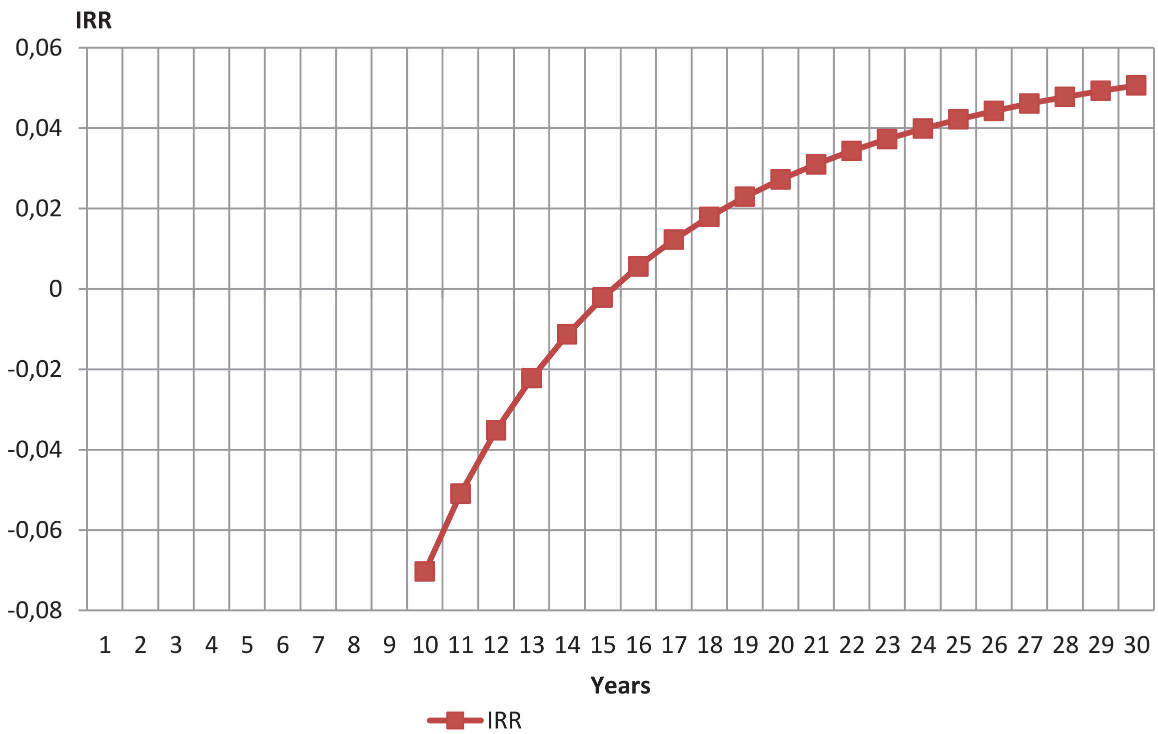

Figure 2 The development of the internal rate of return on investment in each year

Source: based on own calculation

If we consider that the operating period is 30 years, about which experts say that operation is almost as efficient as in the first 10 years, then the IRR is 5.06%. If the interest rate is compared to the current central bank base rate, which is 1.35%, the advantages of the investment will become undisputable. Households should think not only in terms of traditional savings, as it has been described in detail in a domestic study. (Botos et al., 2012)

Conclusions

Our research aims to demonstrate and evaluate the alternatives of renewable energy utilization in our country. Both the domestic and international literature has been dealing with these areas for decades and everyone agrees that finding and exploiting these resources extensively already seems inevitable in the short term. In our country increasing amounts of renewable energy is utilised either by institutions or individual customers. However, considering potential investment costs and the return on investment it is solar energy that seems to be the most obvious solution for the population. In our research we presented in detail the evolution of the energy consumption of the domestic households. Since 2000, the number of household consumers of electricity has increased by 6.5%, while the monthly consumption per consumer increased until 2008 and then declined in subsequent years. The total amount of electricity sold in 2013 was almost identical with the 2011 level, in 2013 it amounted to 34,205 GWh. Nearly a third of the electricity supplied was consumed by households their share remained virtually unchanged over the past decade. The consumption of residential users modestly decreases since 2009, in 2013 they used 10,580 GWh of electricity, which remains 6% below the 2009 peak consumption. The average monthly consumption per household consumers increased by 7% between 2000 and 2003 and then stabilized at a high level of 185 kWh/month until 2009. The district heating and piped gas services were also presented in our analysis. In 2013 in Hungary 2880 settlements had pipelined natural gas supply. Penetration has stood at 91% in settlements for years. The number of customers was 3 million 465 thousand in 2013, 94% of them were household consumers. Gas suppliers satisfied the energy needs of nearly 3.3 million households. 84.6% of household consumers used gas for heating purposes. Nationwide, 74% of the homes use gas. Detailed examination has been carried out considering the utilisation of renewable energy and the need for energy conservation in terms of energy consumption of households on the basis of a survey by the Hungarian Central Statistical Office in 2011, which clearly shows that the population is increasingly rearranging their heating habits. Considering the evolution of the heating mode of occupied homes it can be stated that in addition to the growing number of homes central heating is becoming more representative, individual room heating has a decreasing role, which means some savings during the construction and fewer chimneys are required. This solution may be decisive in the methods of the implementation of modernization since better performance is combined with efficiency, which can uniformly manage the conversion needs of such homes. In 1980 17% of homes had central district heating which somewhat grew to 15.5% by 2011, which means that energy saving is preferred not only in terms of modern heating systems but also as properly insulated walls and doors and windows as well. In terms of age structure properties are also in need of continuous renovation and modernization, the possibility of solar energy appears during the implementation. As for the utilization of solar energy the environmental product fee on solar panels negatively affects the return on investment but the steady declining purchase prices may balance it. The examples used in this study appropriately show that significant economic gains may be achieved from the current regulations for the companies that consider the utilisation of renewable energy as a significant development tax relief may be available in case of realization of projects of this nature. In respect of households national and EU funds could be the solution to ensure a faster return on investment. In the future priority should be given not only for the support of institutions within the framework of tenders, rather incentives and financial support must be provided for households as well since in the long run it can pay off economically both at the household and national levels.

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