ANNALS of Faculty Engineering Hunedoara – International Journal of Engineering
Tome XX [2022] | Fascicule 1 [February]

[1.]Držislav VIDAKOVIĆ, [1.]Silva LOZANČIĆ, [1.]Marijana HADZIMA–NYARKO, [1.]Marija KRAJNOVIĆ

ENERGY RENOVATION OF SCHOOL BUILDINGS IN OSIJEK–BARANJA COUNTY

[1.]Josip Juraj Strossmayer University of Osijek, Faculty of Civil Engineering and Architecture Osijek, Osijek, CROATIA

Abstract: The paper explains the need for energy renovation of public and other buildings and the regulatory framework (regulations and program procedures) through which this is sought. Important parameters of energy renovation of 48 school buildings in Osijek–Baranja County were processed and analyzed in more detail within the projects contracted in 2017 and 2018 (co–financed from the European Structural and Investment Funds within the Operational Program "Competitiveness and Cohesion" 2014–2020). The content of energy renovation works and their frequency in buildings and the expected energy savings were presented. The representation of existing energy classes and their improvement after reconstruction, regarding the construction period were analysed. The costs of renovation in relation to the age and area of buildings were considered as well. These data were compared to the results from the previous cycle of family houses' renovation in the same county (2015–2016), while the owners were co–financed, without the required minimum of improvement. The problems of the energy renewal process were highlighted and recommendations for better efficiency were given.
Keywords: energy savings, school buildings, energy classes, renovation costs, incentive programs

1. INTRODUCTION

Energy consumption saving in the EU of 20% by 2020 and 32.5% by 2030 is being planned, and various operational programs are being implemented at EU and Member State level to achieve this.

Energy efficiency means the usage of a smaller amount of energy consumed for the same level of economic activity or service. It is considered that by investing in energy efficiency a better economic and social return are achieved than by investing in energy supply [1]. Except reduced energy costs, better energy efficiency reduces dependence on energy imports and achieves lower greenhouse gas (CO_2) emissions and better air quality.

People spend most of their time in buildings and the largest share of energy consumption in the EU, as well as in Croatia, is related to buildings (part of the so–called general consumption) [1–3]. Bazan–Krzywoszanska et al. (2016) investigated energy consumption in Eastern European cities and found that it was mostly generated in residential and public buildings, [4]. The biggest aspirations are to save energy, as well as to reduce carbon emissions [5], so they are aimed at the construction of new buildings and measures that can be taken on existing ones. In Croatia, and in the rest of Europe, most residential and non–residential buildings are more than 30 years old, so the incentive programmes are focused on improving the energy efficiency of existing buildings. One should bear in mind that in buildings, regardless of their purpose, over 50% of energy is spent on heating (with which carbon emissions are mostly associated, [6]), hot water preparation and lighting (in households there is a higher share of energy consumption for heating and hot water preparation, while in public buildings for lighting), [7].

In addition to possible savings, it is necessary to calculate the costs of implementing measures to improve energy efficiency, which is different for each building. Peculiarities arise from the purpose of the space and construction solution (dispersed layout solutions, number of storeys, type of walls and roof, heating system, etc.) and the condition of the building, or its maintenance (how worn out the existing elements of the building are and when they need to be replaced).

2. LEGISLATION AND INCENTIVES FOR ENERGY RENEWAL

Legislation in Croatia is in line with legislation governing obligations to improve the energy efficiency of buildings at the EU level. According to the Directive on energy performance on buildings 2010/31 / EU (EPBD) and Directive on energy efficiency 2012/27 / EU (EED), each Member State establishes a system of energy efficiency obligations and a long–term strategy to encourage investment in the reconstruction of the national stock of residential and commercial buildings, both public and private. To encourage the renovation of energy–inefficient public buildings, which should serve as an example to the general public, the EPBD requires states to ensure that 3% of the total floor area of heated/cooled buildings in a possession and use of the central government is renovated every year from 2014, [8].

Increasing energy efficiency of residential and public buildings is achieved through the prescribing of legal obligations and financial incentives.

In Croatia, the Construction Act (2014) stipulates that each building, depending on its purpose, must be designed and constructed in such a way that during its duration it meets the basic requirements for the building and other requirements. One of the seven basic requirements for buildings is energy management and heat conservation, [9]. Regulations only require that buildings are maintained in such a way that their technical properties are preserved during their lifetime and that the requirements set by their design and the regulations are met in accordance with which they were built, [10]. According to the EPBD, in case of a significant renovation of an existing building, EU Member States must take measures to meet the established minimum energy efficiency requirements, if technically, functionally, and economically feasible, [8]. Therefore, the Technical Regulation on Rational Use of Energy and Thermal Protection in Buildings (2015) stipulates that before a significant renovation of a building (where more than 25% of the building envelope area is renovated) the design engineer should analyse the existing condition of the building and present measures for the improvement of the building's existing condition, together with investment assessment in terms of healthy indoor climate conditions, fire protection and earthquake risks, [11].

Until 2016, there was national (co) financing of energy renovation in Croatia [12], and since 2016 the renovation of public buildings has been financed from EU funds under the "Competitiveness and Cohesion" programme (approved by the European Commission at the end of 2014). This operational programme consists of 10 priority axes, and within Priority Axis 4 Promoting energy efficiency and renewable energy sources there is investment priority 4c – Supporting energy efficiency, smart energy management and the use of renewable energy sources in public infrastructure, including public and residential buildings sector. The Ministry of Physical Planning, Construction and State Property is a Level 1 Intermediate Body and the specific objectives within its authority are [3]:

- 4c1 Reduction of Energy Consumption in Public Sector Buildings
- 4c2 Reduction of energy consumption of residential buildings (multi apartment buildings and family houses).

The Fund for Environmental Protection and Energy Efficiency (EPEEF) is a central place for collecting and investing extra–budgetary funds in programmes and projects for environmental and nature protection, energy efficiency and the use of renewable energy sources in Croatia. In the system of management and control of the use of EU structural instruments in Croatia, the EPEEF has the role of Intermediate Body 2 for certain specific objectives in its field. Figure 1 shows the policy and programmes for energy efficiency improvement of buildings in Croatia in the period 2014–2020.

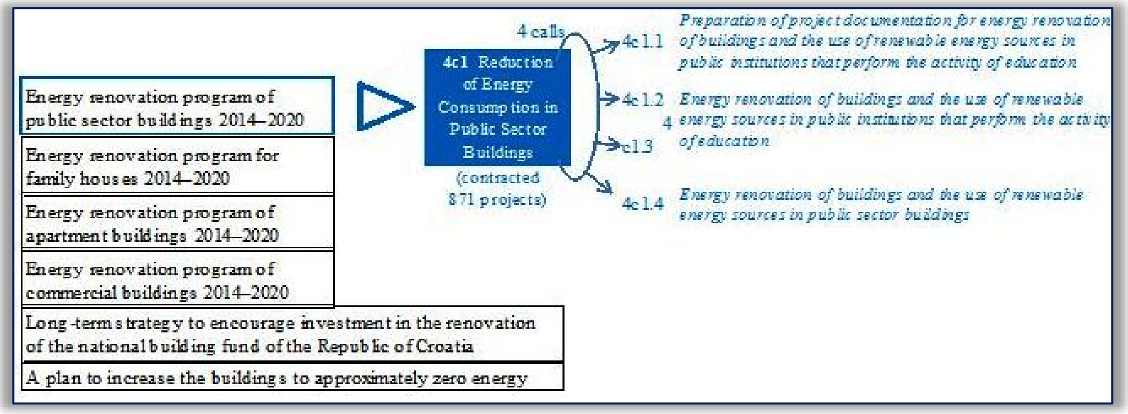

Figure 1. Review of previous policies and measures for energy improvement of the building stock in Croatia with emphasis on energy renovation of public buildings (according to [12]).

Although the highest consumption in residential buildings (single–family homes and apartment buildings) is the allocation of budgetary funds under EU cohesion policy for the period 2014–2020 for energy efficiency investments, it shows that investments in public buildings were slightly more than twice as high as investments in residential buildings. The investments structure in buildings' energy renovation in Croatia, according to EPEEF, shows that by mid–2019 the largest investments were in public sector buildings, slightly less in family houses, and more than half less in apartment and commercial buildings together (in apartment buildings about six times more than investment in commercial buildings), [13].

In 2017, the Energy Renovation Programme of Public Sector Buildings was adopted in Croatia with the aim of raising the level of activities in energy renovation to 3% of the total stock of public sector buildings per year, reducing energy consumption for cooling / heating of renovated public sector buildings to 70%, or annual savings of about 50 GWh and fulfillment of energy saving goals of public sector buildings (buildings of the central state, local and regional government units' buildings (counties, cities, municipalities), ie buildings owned by the public sector, in which social activities are performed (education, science, culture, sports, health and social care), etc.), [14]. Croatia has chosen an alternative approach and an energy savings target, expressed in petajoules (PJ) has been set. The National Energy Management Information System (NEMIS), which contains information on actual energy and water consumption in public sector buildings (for more than 14,000 buildings), was used to assess the energy savings target. The calculated target for Croatia of the equivalent of savings in energy renovation of state buildings of 3% per year is 0.00489 PJ per year, [2].

In order to transform the existing building stock into an energy efficient and decarbonized one, a long–term strategy for the renovation of the national building stock until 2050 was adopted at the end of 2020. According to that document, 5% of buildings in Croatia have been energetically renovated so far, and about 0.7% of the buildings' floor space has been renovated annually. The planned goal is to gradually increase the renovation rate, from 1% of the floor space in 2021 to over 3% after 2030, [15].

In order to overcome the existing obstacles (primarily to increase the thermal protection of the building envelope), the Ministry of Culture, in coordination with the Ministry of Construction and Physical Planning, developed Recommendations for the application of energy efficiency measures on building heritage.

The Croatian government has also adopted a National Recovery and Resilience Plan for 2021–2026 (which should start implementation at the end of 2021) in which one of the six components is the Initiative: Renovation of Buildings. This component of the plan will encourage the complete renovation of buildings and should contribute to the renovation of buildings after two major earthquakes in Croatia last year. The renovation will include residential and non–residential buildings, as well as public buildings, while respecting the importance of the public interest for health and educational buildings, [16].

Anticipated renew models of building renovation are [12]:

≡ Individual energy renewal measures (for achieving gradual deep renewal),
≡ Integral energy renewal (combination of several energy renovation measures with mandatory inclusion of thermal protection of the building envelope),
≡ Deep renewal – includes energy efficiency measures on the envelope and technical systems and should result in a reduction of energy consumption for heating ($Q_{H,nd}$) and primary energy (E_{prim}) on an annual basis of at least 50% compared to consumption before renovation,
≡ Comprehensive renewal – in addition to energy renovation measures of the building, it also includes measures to increase safety in case of fire, to ensure a healthy indoor climate, to improve the mechanical resistance and stability of the building (reducing the risk of earthquakes).

3. EDUCATION BUILDINGS' RENEWAL PROCESS 2017–2021

According to data from NEMIS, a total of slightly more than 13.8 million square meters of floor area of public sector buildings was recorded in Croatia (of which 43.9% was heated floor area). Education buildings are one of the categories of public sector buildings and have an area share of 40.7%. According to this share, the total energy consumption and CO2 emissions of these buildings stand out. This category includes primary, regional, and secondary schools (with and without a gym or a workshop), as well as university buildings and kindergartens. 54.5% of them were built before 1971, and in the period 1971–2006, 44.9% were built. These buildings are, in a larger number and area, owned more by local and regional government units, than by the central state administration, [14]. In continental Croatia, 28.6% of educational buildings are now in the three worst classes, and 17.6% are in the A and A + classes [15]. Figure 2 shows the existing distribution of energy classes in educational buildings according to the share in the total area of these buildings throughout Croatia. An overview of the energy efficiency classes of buildings by primary energy in Figure 2 shows a higher number of those with a poorer class compared to the energy classes determined by the energy required for heating. This is mostly because primary energy also includes cooling and lighting energy, which makes up a significant share of consumption in this type of buildings.

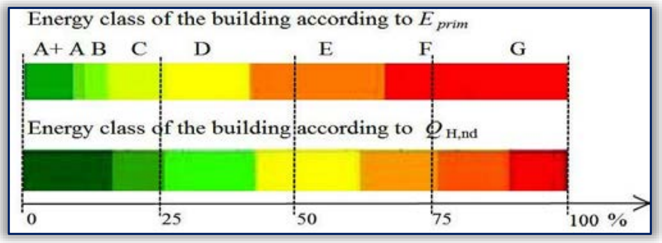

Figure 2. Energy efficiency classes of buildings for education according to the share in the total area of that type of buildings, viewed according to two methods of calculation (data from [15])

The school buildings' renewal projects in Osijek–Baranja County, analysed in this article, are co–financed by the European Structural and Investment Funds (established to implement EU regional policy aimed at reducing regional disparities in income, wealth and opportunities) under Operational Program "Competitiveness and Cohesion" 2014–2020. Based on the Public Tender of the Ministry in charge, this county applied as a beneficiary to (along with some other counties, individual cities and municipalities, various ministries and public institutions for their buildings, such as individual schools, kindergartens, health centers, hospitals, homes for the elderly and infirm, cultural centers, fire stations, etc., depending on the specific purpose), [17]. The calls were:

≡ 2017 for Specific Objective 4c1: Reduction of energy consumption in public institutions performing the activity of education (at the end of the same year, 214 contracts were signed for projects throughout Croatia) and
≡ 2018 for Specific Objective 4c1: Reduction of energy consumption in public sector buildings (a total of 550 contracts were signed throughout Croatia).

It should be noted that Osijek–Baranja County had the largest number of projects of all counties (20 + City of Zagreb), and in addition, some other schools in the area of this county were energetically renovated. The City of Osijek, which is the center of the county, was the beneficiary of these two calls for co–financing for five energy renovation projects of school buildings in its area. (These projects are not analysed in this article due to the lack of necessary data for comparison.)

In addition to non–refundable EU funds and funding from the Ministry of Regional Development and European Union funds, Osijek–Baranja County participated in many of these projects in funding with significantly less than 20% of the value. Financial support was provided for energy renovation measures that will result in a reduction of heating / cooling energy per year (kWh) of at least 50% compared to consumption before the implementation of the measures. Therefore, obtaining financial incentives for these projects was based on an energy audit showing an improvement in the energy class. The implementation period of these contracted renovation projects is 24 months.

4. THE ANALYSIS OF SCHOOLS' ENERGY RENEWAL IN OSIJEK–BARANJA COUNTY

48 schools' energy renewal projects in Osijek–Baranja County are analysed here (8 secondary and 40 primary and regional schools in cities and other places in this county) which data are publicly available on the website of Osijek–Baranja County for ([18]). Thus, a statistically significant number of samples was obtained (the least data of the same type is for 43 buildings, which is > 30).

Energy renovation projects were analysed with respect to the previously existing and improved energy class, project costs (known to all), achieved energy savings and reduction of greenhouse gas / CO2 emissions, age of buildings and building area (all these data are not known for all renovated schools).

Data on the year of construction are known for 45 buildings and among them there are those from the end of the 19th and the beginning of the 21st century. There are different classifications of buildings according to the time of construction (e.g. according to Housing Statistics in EU (2010) there are 7 construction periods: before 1919, 1919–1945, 1946–1970, 1971–1980, 1981–1990, 1990–2000, after 2000, [19] or on built until 1970 and those after that as in [14]). For this analysis, buildings are divided into periods characterized by the application of building materials and thermal insulation regulations in Croatia. The characteristic periods are explained in Table 1. The heat transfer coefficients of the characteristic structures of the outer envelope of buildings decrease most noticeably in glazed structures, continuously throughout all periods of construction. On the exterior walls' constructions, after the deterioration that took place after World War II and until the 1970s, there has been constant, significant improvement, [15].

Table 1. Periods into which buildings are divided to consider energy renovation parameters

Construct. period	The buildings' characteristics
before 1940	– massive constructions prevail (brick or stone walls thickness = 38 cm and more), basements and attics under sloping roofs (buffer heating zones), twin sash windows
from 1941 to 1970	– light reinforced concrete structures (without insulation, thermal bridges), flat roofs, single layered glass windows with poor quality profiles (worst construction)
from 1971 to 1987	– similar to the previous period – reinforced concrete walls (thickness = 16–18 cm) or made of brick blocks (thickness = 19 cm), but the first regulations on thermal protection were introduced (minimum insulation of the envelope with 2–4 cm of heraclite, wood or EPS plates)
from 1988 to 2005	– construction according to Yugoslav Standard, which prescribes better thermal insulation of the building envelope (for external walls 4–8 cm of stone wool and polystyrene, i.e. styrofoam, and for a sloping roof 8–12 cm of thermal insulation)
after 2006	– harmonized with technical regulations on rational use of energy and thermal protection in buildings (since 2006 the Technical Regulation on thermal energy saving and thermal protection in buildings has been applied)

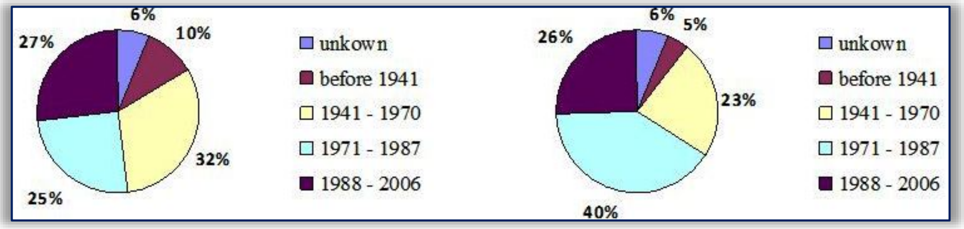

Figure 3. Share of renovated schools according to the construction period – left according to the number of buildings, and right according to the areas (without the buildings for which the area is not known)

Figure 3 shows the representation of school buildings according to the characteristic periods of construction. (For three school buildings for which there is no data on the time of construction, according to the external appearance, it can be assumed that they are probably from the period between 1941 and 1987).

In these school buildings, the main measures envisaged by the energy renovation project were:

≡ 100% thermal insulation of the envelope (walls / facade, ceiling to the attic and / or roof – depending on the construction of the building);
≡ 96% replacement of exterior carpentry and hardware with new, more energy efficient (e.g. wooden or aluminum with PVC);
≡ 79% reconstruction / improvement of the heating system (installation of a high–efficiency gas condensing boiler, change of energy source – transition from heating oil to wood biomass, new heating stations, installation of thermostatic valves on heating bodies, etc.);
≡ 17% replacement of lighting with more energy efficient (e.g. LED).

Figure 4 shows the share of energy efficiency classes that buildings had before and after renovation, and Figure 5 shows this by periods of construction and what is the average increase in classes per building in each period. The cost of renovation (project value) for all these buildings was close to 144 million kunas, or € 19,221,064 (according to the current middle exchange rate). For 43 buildings, for which the area is known (from 199 to 12,795 m^2), renovation costs per square meter were calculated and they are listed in Table 2, among other important parameters.

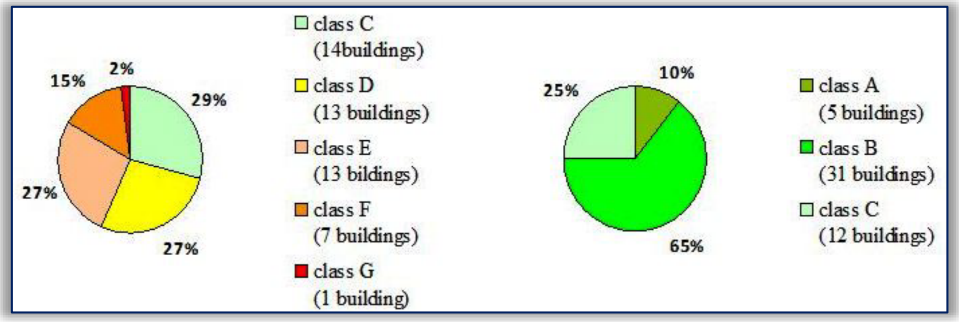

Figure 4. Number of species (share) of energy efficiency classes before (left) and after renovation of buildings (right)

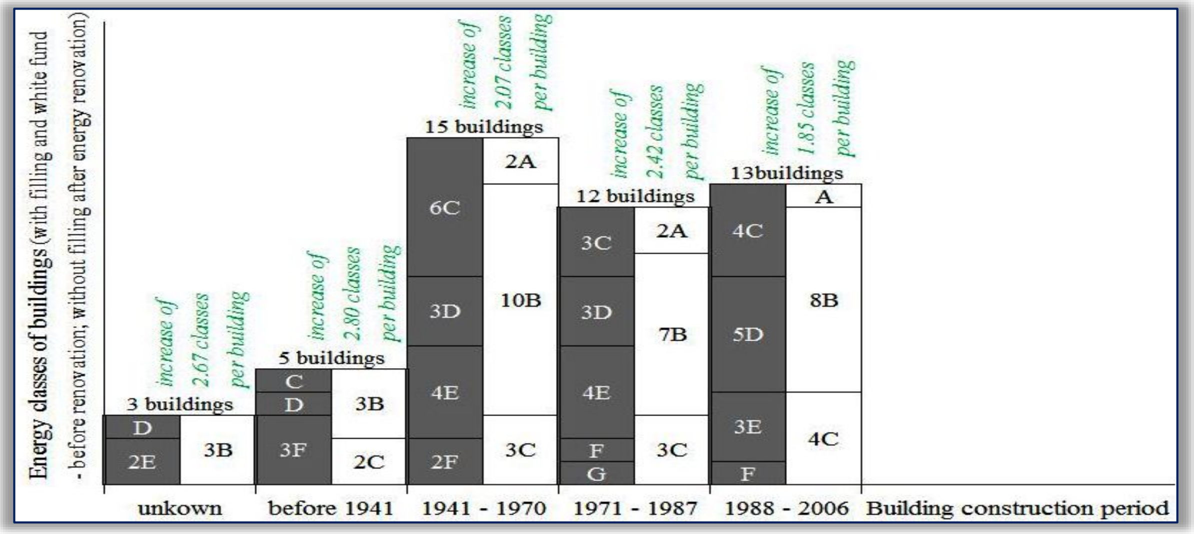

Figure 5. Energy classes of school buildings before and after renovation

Table 2. Average data on renovated buildings and data by periods

Parameters	Average for all buildings	Construction periods				
		unkown	before 1941	1941–1970	1971–1987	1988–2006
Area (m^2)	2,583	3,554	1,004	2,142	4,972	2,592
Costs per building	400,438	505,625	168,383	372,289	590,435	322,517
Costs per unit area (€ / m^2)	161	205	168	167	158	145
Reduced CO2 emi–ssions (% / building)	66	69	61	68	74	58
Planned savings kwh per building	193,784	34,851	48,829	173,257	319,179	166,537

Table 2 shows, as expected, that the cost of renovation per square meter of building area decreases in buildings constructed later and that the least energy savings are planned for buildings from the earliest period.

According to the data from [14], the average costs of the total investment (for the envelope of buildings, thermotechnical systems and lighting) of energy renovation of educational buildings in Continental Croatia built before 1970 were 1,295 kn / m^2 (173 € / m^2), and for those built later (until 2005) 920 kn / m^2 (123 € / m^2). The average energy renovation costs for the school buildings built before 1970, and analysed here, were 167 € / m^2 (less than the average for all educational buildings), and for those from the later construction period 144 € / m^2 (more than the average for all buildings for education). The conclusion can be drawn that the initial condition of school buildings from different periods is more uniform (at least in Osijek–Baranja County) than in all educational buildings in Continental Croatia. There is an interesting comparison with the energy renovation of family houses in the same county. The results of this renovation are presented in [7] on a sample of 100 family houses inspected and renovated in 2015–2016 (2% built before 1941, 13% from 1941–1970, 46% from 1971–1987, 32 % from 1988–2006 and 7% after 2006). This was in the last completed cycle of the Programme for energy renovation of family houses 2014–2020. At that time, the owners had their rennovation co–financed with 40–80% (depending on the area) exclusively from national funds and there were no conditions for achieving minimum energy savings. The average investment in the energy renovation of the considered houses was € 10,414 and considering the average renovated net area of the house of approx. 120 m^2 it is 87 € / m^2, [20]. Compared to school buildings, the initial energy classes of houses were worse in all periods of construction. (Before the renovation, 72% of these houses had one of the three worst energy classes and there was a ten times higher share of houses than school buildings with energy class G before the renovation.) This can be largely attributed to the poorer quality of construction and poorer maintenance of houses than public buildings. As with school buildings, the worst classes after the renovation of houses remained with those built before 1941. On average, 2.08 measures were taken to improve energy efficiency in houses (which is less renovation work than on school buildings). The most common measure was the replacement of the outer carpentry, followed by the thermal insulation of the outer envelope. This increased the energy class to 85% of the renovated houses, and the best energy class achieved was B, [7]. In the energy renovation of school buildings, the energy class of all buildings has been raised by a minimum of one and a maximum of four classes. The minimum energy savings for heating in renovated houses was 5% (where only the exterior carpentry was changed), and the largest was 63% (achieved by a combination of several renovation measures), which is significantly less than in the renovation of school buildings.

5. CONCLUSION

A more detailed processing and analysis of the parameters of energy renovation of school buildings in one continental county gives a more reliable picture of the state of the stock of buildings of this type and allows better framework planning of similar projects. It turned out that we should strive for the most comprehensive renovation of buildings, because in this way better results are achieved in less time and money than with partial measures. This is in line with the National Recovery and Resilience Plan 2021–2026 in Croatia which anticipates the reconstruction of energy reconstructed buildings damaged in the earthquake. Possible savings, i.e. avoiding costs when linking various maintenance and renovation measures of buildings with other works on them are shown in [21].

Croatia is facing a longer period of implementation of various programmes and projects to achieve the planned goals of reducing energy consumption, and given the always limited resources (financial, human, time), measures should be well planned and focused on the area where they will give the greatest effects. The existing building stock in Croatia represents an individual sector with the greatest potential for energy savings, [14]. Most of the existing buildings were built decades ago, in accordance with the energy requirements that are obsolete today, and belong to energy class E, F or G [3]. But they still have a long service life ahead of them and their energy recovery brings more very desirable effects. In addition to financial savings and pollution reduction, there are other, very diverse direct and indirect benefits of reconstruction that need to be considered. (e.g. better feeling of comfort and healthier conditions for space users (less moisture and its negative consequences), employment of the construction sector through the implementation of energy renovation projects, increasing the value of buildings, etc.). In case of public buildings, the energy savings achieved by investing in the energy renovation of residential buildings are monitored (not the case in case of residential buildings at all), but no other indicators measure the other benefits achieved with these investments [1]. This would be necessary for a more complete analysis of the efficiency of energy recovery and greater motivation for its implementation.

For the transformation of public, both school and other buildings, into energy–efficient and decarbonized buildings, different obstacles have been noticed: financial (long payback period), legal (complex and lengthy procedure for obtaining financial support, lack of legal obligation to improve the basic properties of the building in relation to those according to which built, protection of buildings that are cultural property, and which are among those for education) and social (insufficient availability of skilled labour and the trend of emigration and depopulation), [15].

After improving the energy performance of buildings, it is important to further proper and timely maintenance of these buildings and their equipment (heating and cooling systems, windows, etc.). Technical conditions for lower energy consumption (lower losses) are achieved that way, but to have these possibilities achieved, it is necessary to motivate the users themselves, especially if they do not pay the bills for the consumed energy.

Note: This paper was presented at IIZS 2021 – The XI International Conference on Industrial Engineering and Environmental Protection, organized by Technical Faculty "Mihajlo Pupin" Zrenjanin, University of Novi Sad, in Zrenjanin, SERBIA, in 07–08 October, 2021.

References

[1] European Court of Auditors, Energy efficiency in buildings: greater focus on cost–effectiveness still needed, Special Report 11/2020.
[2] Ministry of Environmental Protection and Energy (Croatia), Annual report, Zagreb, 2018.
[3] Internet source: Ministry of Physical Planning, Construction and State assets website: https://mpgi.gov.hr/o–ministarstvu–15/djelokrug/energetska–ucinkovitost–u–zgradarstvu/8303
[4] Bazan–Krzywoszanska, A., Mrówczynska, M., Skiba, M., Łaczakb, A.: Economic conditions for the development of energy efficient civilengineering using RES in the policy of cohesion of the European Union (2014–2020). Case study: The town of Zielona Gora, Energy and Buildings, Vol.118, pp. 170–180, 2016.
[5] Hsu, D.: How much information disclosure of building energy performance is necessary? Energy Policy, Vol.64, pp. 263–272, 2014.
[6] Krstić, H., Teni, M.: Algorithm for constructional characteristics data cleansing of large–scale public buildings database, High Performance and Optimum Design of Structures and Materials III, pp. 213–224, WIT Press, Southampton, 2018.
[7] Hećimović, D., Vidaković, D., Pavelić, K.: Energy reconstruction family houses in Osijek–Baranya county, Proceedings of 8nd International Natural Gass, Heat and Water Conference, pp. 156–165, Osijek, 2017.
[8] Directive on energy efficiency, 2012/27/EU
[9] Zakon o gradnji, Narodne novine, No.153, 2013.
[10] Tehnički propisi za građevinske konstrukcije, Narodne novine, No.17, 2017.
[11] Tehnički propis o racionalnoj uporabi energije i toplinskoj zaštiti u zgradama, Narodne novine, No.128/2015, 70/2018, 73/2018, 86/18, 102/2020.
[12] Žamboki, D., Križ Šelendić, I.: Energetska i sveobuhvatana obnova zgrada, Prezentacija izlaganja na 15. Danima Hrvatske komore inzenjera gradevinarstva, Opatija, 2021, Available at https://www.hkig.hr/docs/Opatija_2021/prezentacije/01–web_prezentacije/
[13] Šandrk– Nukić, I.: Sustainable management of energy consumption in public buildings as a determinant of sustainable economy, Ekonomska misao i praksa, Vol.29, pp. 247–268, 2020.
[14] Odluka o donošenju Programa energetske obnove zgrada javnog sektora za razdoblje 2016. – 2020., Narodne novine, No.22, 2017.
[15] Ministry of Physical Planning, Construction and State Asstes, Dugoročna strategija obnove nacionalnog fonda zgrada do 2050. godine, Zagreb, 2020.
[16] Internet source: Government of the Republic of Croatia, Central State Portal website: https://planoporavka.gov.hr/o–planu/inicijativa–obnova–zgrada/111.
[17] Internet source: Europski strukturni i investicijski fondovi, Natječaji – Energetska obnova i korištenje obnovljivih izvora energije u zgradama javnog sektora website: https://strukturnifondovi.hr/natjecaji/energetska–obnova–koristenje–obnovljivih–izvora–energije–zgradama–javnog–sektora/
[18] Internet source: Osječko–baranjska županija, Upravni odjel za investicije i razvojne projekte, Energetska obnova zgrada škola website: http://www.obz.hr/index.php/upravni–odjel–za–investicije–razvojne–projekte–i–fondove–europske–unije.
[19] Housing Statistics in European Union, T.H.M.o.t.I.a.K. Relations, 2010.
[20] Hećimović, D., Vidaković, D.: Analiza isplativosti energetske obnove obiteljskih kuća u Osječko–baranjskoj županiji, Proceedings of 27th International Scientific and Professional Conference ''Organization and Maintenance Technology'', pp. 97–104, Osijek, 2018.
[21] Vidaković, D., Hadzima–Nyarko, M., Ademović, N., Lozančić, S.: Maintenance of building elements to fulfill the basic requirements buildings, Proceedings of 30th International Scientific and Professional Conference ''Organization and Maintenance Technology'', Osijek, 2021

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN–L 1584 – 2665