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CONTENTS

ASSESSMENT OF THE QUALITY OF HOUSING STOCK IN BELGRADE ACCORDING TO ENERGY CONSUMPTION

Ljiljana Đukanović[1]

Abstract

Assessing the housing quality of existing residential buildings is always a topical issue for research, because the built housing stock is a constantly growing resource whose structure, quality of construction, and compliance with modern housing requirements, largely define housing comfort. On the other hand, modern society recognizes that energy savings are a prerequisite for responsible behavior towards future generations, which, given the dominant consumption in the field of housing, puts the focus on the residential buildings stock. Given the fact that numerous buildings that make up the housing stock of Belgrade were built at a time when there were no regulations on thermal insulation and in most cases no energy improvements were made, we can talk about a significant resource that "wastes" energy whose renovation can lead to significant energy savings. The paper will analyze model buildings, which by their structural characteristics represent characteristic periods of construction of residential buildings, and based on the obtained data, conclusions will be made about the quality of the housing stock from the point of view of energy consumption.

Key words: *housing stock, energy consumption, thermal comfort*

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1. INTRODUCTION

The need for energy reconstruction of existing buildings has been a concern of experts in energy savings for many years, given their high percentage contribution to total energy consumption. Buildings are responsible for 40% of the total energy consumption in the EU and 36% of harmful gas emissions. However, the percentage of building renovations at the European Union level remains very low, as shown by data published in the 2020 strategy 'A Renovation Wave for Europe' [1]. Alarming data about the state of the European building stock were presented, emphasizing the necessity of intensifying its renovation in order to achieve carbon dioxide neutrality by 2050, a major goal set by the European Green Deal [2]. It was highlighted that the European building stock is highly heterogeneous and old, with 85% of buildings (220 million structures) built before 2001 and 35% of them being older than 50 years (built before 1970). About 75% of the existing EU building stock is not energy-efficient. Only 11% of the building stock undergoes any level of renovation annually, with only 1% of these renovations focusing on improving energy efficiency. The European Commission initiated the Renovation Wave strategy precisely to stimulate the necessary changes required to reduce overall energy consumption and carbon dioxide emissions [1].

Precise data regarding the state of Serbia's building stock in terms of energy consumption and information about energy-efficient renovations of existing buildings are not available. However, it can be assumed without much doubt that the situation is alarming, similar to the rest of Europe, and that the need for more extensive energy reconstruction is a priority. The question that certainly arises from the very beginning is what our building stock is like, what its structure is, and what possibilities exist for achieving energy savings. A prerequisite for any intervention is understanding the structure of the residential building stock and defining the existing quality of residential comfort within it.

This study presents an analysis of the current state of the residential building stock in Belgrade, aiming to showcase the existing conditions and possibilities for its renovation. Specific models representing past construction practices have been singled out for energy consumption analysis. The focus of the study is primarily on multi-family residential buildings as they are subject to legal regulations and have undergone intensive technical improvements.

2. METHODOLOGY

The research on the quality of the residential building stock in Belgrade from the perspective of energy consumption was conducted through an analysis of adopted typical models that represent former architectural concepts and were materialized in a manner that was prevalent in the past. The residential building stock was analyzed through characteristic time periods that represent coherent entities in terms of applied thermal envelope assemblies and construction techniques used at the time. In this way, characteristic construction types were defined, typical thermal envelope assemblies were identified, and based on this, models were created representing specific architectural periods.

The periodization of the residential building stock and the typological approach to analyzing energy consumption and potential energy savings were applied in the project "National Typology of Residential Buildings in Serbia." This project was carried out using the Tabula methodology within a three-year research period (2010–2012) by a group of professors and collaborators from the Faculty of Architecture in Belgrade [3]. In the Tabula project, the analysis of the building stock was performed on specific buildings that, based on their characteristics, corresponded to a typical sample obtained through statistical data analysis. In this study, the approach is different, as the analysis of the building stock is conducted on a model apartment that is materialized differently in accordance with the characteristic construction methods for the considered period [4]. Considering that the current Regulation on the Conditions, Content, and Method of Issuing Energy Performance Certificates for Buildings [5] also includes energy certification of apartments, this approach provides a closer determination of the quality of individual residential units in terms of thermal comfort, which is of great importance for apartment users.

The model apartment is part of a typical floor in a standalone residential building, and in terms of its functional and dimensional characteristics, it is identical across all models (Fig. 1). The building's layout is typical and can be recognized across all construction periods; it is organized with a centrally positioned staircase and four two-bedroom apartments of the same dimensions, with an area of approximately 60 m2. Variable window dimensions and floor heights reflect the characteristics of the construction period. In terms of vertical arrangement, the residential unit is integrated into the central part of the building so that there is residential space both above and below, which is the most common arrangement in multi-family residential buildings. The apartment is one-sided and south-facing, but other orientations and different apartment positions were considered, along with the consequences this has on energy consumption.

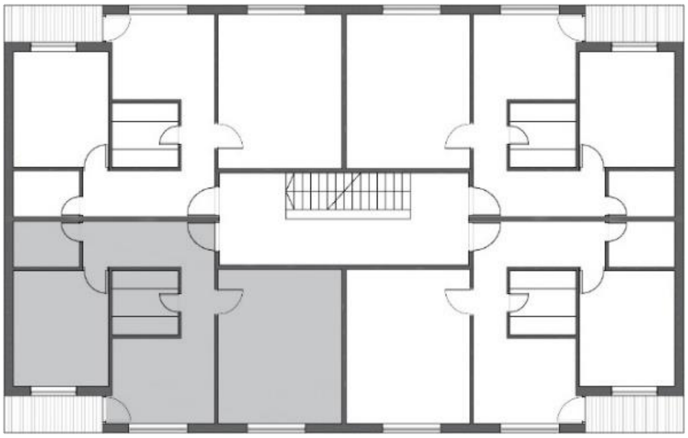


Figure 1. Analyzed residential unit within the typical floor (Image by author)

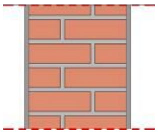
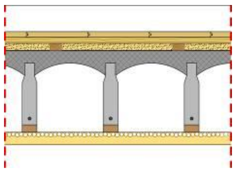
3. REPRESENTATIVES OF THE BELGRADE RESIDENTIAL BUILDING STOCK

The models used for energy efficiency analysis are materialized to represent buildings constructed in the past, which now constitute the city's residential building stock.

The first model represents traditional brick construction, which was prevalent until the end of the 1950s, when the intensive use of prefabricated systems began (Table 1). It is materialized according to the principles of interwar construction: the walls are made of new-format bricks introduced in 1931, and the intermediate floor structure is a ribbed semi-precast type called Herbst, which was commonly used at the time. Wide window recesses were used throughout this period until the advent of prefabricated systems and thinner walls. Such a window, with a wide wooden frame and a three-part opening (dimensions 200/160 cm), is adopted in the first model.

The heat transfer coefficient does not meet current thermal insulation requirements for the wall assembly and windows, while it falls within permissible limits for the intermediate floor structure [6].

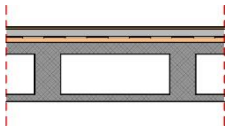
Table 1. Model 1: building envelope structure and Heat transfer coefficients

Model 1			
External view	**Building envelope structure**		
	Eternal wall	**Floor construct.**	**Window**
			
	brick wall 38 cm plastered on both sides	Herbst floor construction with parquet floor and reed ceiling	wooden, double frame, (wide box) external roller wooden blind
Heat transfer coefficient (W/m²K)	**U=1.25** U > Umax=0,4	**U= 0.78** U < Umax=0,9	**U= 2.6** U > Umax=1.5

The second model represents prefabricated construction, which began in the 1960s with intensive use of the domestic skeletal prestressed IMS system (Table 2). Buildings were designed in the spirit of modernism, with simplified forms, a cubic appearance, and facades often conceived as horizontal bands alternating between window openings running the entire length of the room and prefabricated parapet panels designed as multi-layered elements. Reduced parapet wall thicknesses, as well as construction savings, led to the more widespread use of windows with connected frames, displacing the use of double windows with wide and narrow recesses. Such a configuration with fabric blinds is adopted in this model. Changes also occurred in dimensional standards, with legal regulations allowing for significantly lower floor heights, which affected residential construction. A minimum clear height of 240 cm was introduced, although it was less commonly applied in practice. In the second model, a height of 250 cm is used.

The heat transfer coefficient does not meet current thermal insulation requirements for the wall assembly and windows, while it falls within permissible limits for the intermediate floor structure. This can be explained by the specific characteristics of the floor slab, which include a layer of trapped air within its structure.

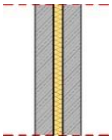
Table 2. Model 2: building envelope structure and Heat transfer coefficients

Model 2			
External view	**Building envelope structure**		
	Eternal wall	**Floor construct.**	**Window**
			
	parapet element, combination of regular and foam concrete	IMS construction, prefabricted concrete with parquet floor	wooden, double frame, connected sash; single glazed canvas roller blind
Heat transfer coefficient (W/m²K)	**U=1.46** U > Umax=0,4	**U= 0.81** U < Umax=0,9	**U= 2.8** U > Umax=1.5

The third model represents the period of advanced prefabrication, which began in the late 1970s and continued throughout the 1980s, reaching its peak with the implementation of the Rad-Balansi system. This system was used in the construction of many residential complexes in Belgrade, and its characteristics, as a representative of advanced prefabrication, are incorporated into this model (Table 3). The Balansi system consists of reinforced concrete panels, which are installed in a transverse direction for larger residential blocks, so that the longer side of the facade panel is designed as a load-bearing element, often of one floor's height, with formed openings. Facade panels are structured as multi-layered reinforced concrete elements with thermal insulation in the interlayer space. The intermediate floor structure consists of prefabricated, assembled 16-cm-thick panels with a floating floor and a finishing layer of parquet. In buildings realized during this period, a model of facade panels with two smaller openings instead of one larger opening was often used, which is adopted in this model. Two windows with dimensions of 1/1.4m are applied. By the late 1970s, due to advancements in thermal glass production technology, single wooden windows with built-in seals and glazed coatings had emerged, replacing double windows with connected frames in the following decade. Wooden shutters are often used in combination with such windows as external shading devices.

The results of the thermal calculation for the third model indicate that none of the applied structural elements have a heat transfer coefficient within the limits specified by the existing EEZ regulations. By comparing these values with the standards applicable at the time of the construction of such buildings, their compliance with the thermal regulations of that era can be assessed.

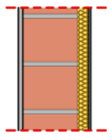
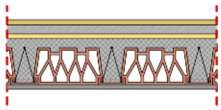
Table 3. Model 3: building envelope structure and Heat transfer coefficients

Model 3			
External view	**Building envelope structure**		
	Eternal wall	**Floor construct.**	**Window**
			
	prefabricated reinforced concrete panel 20cm with thermal insulation	reinforced concrete slab 16cm, with parquet floor	wooden, double glazed unit, wooden shutters
Heat transfer coefficient (W/m^{2}K)	**U=0.82** U > Umax=0.4	**U= 1.84** U < Umax=0.9	**U= 3** U > Umax=1.5

The abandonment of prefabricated reinforced concrete systems and the return to traditional construction methods characterize the late twentieth century. The relinquishment of construction activity to market conditions, along with the decline of large construction companies that possessed experience and equipment for extensive construction projects, contributed to newly formed investors and contractors resorting to simpler and more cost-effective building solutions, utilizing maximum savings. This approach had implications for housing quality. An improved traditional construction system is applied, and clay elements are once again widely used in wall and ceiling construction (Table 4). The structural parts of walls are covered with thermal insulation materials, typically 5-8 cm thick, and the final layer is usually composed of a thin-layered facade render, a characteristic finishing for cost-efficient residential construction aimed at saving on all aspects of the building. Architects' aspiration for more flexible façade design, compared to the rigid regulations imposed by the prevailing norms regarding parapet height, introduced a new dimensional relationship where the absence of a wall parapet is compensated with an external railing of regulated height. On the facades of newly constructed residential buildings, elongated window openings with low parapets, or without them, are noticeable, along with so-called French balconies featuring single or double doors and an exterior railing of appropriate height. In the 1990s, the production of plastic windows began, which gradually displaced wooden windows, primarily due to their easy maintenance, good thermal properties, and low cost. In line with the aforementioned observations on façade element formation and the materials used for its construction, an opening is designed in the fourth model for assessing residential comfort quality. It features plastic doors with dimensions of 140–220 cm, made from plastic profiles, and an external shutter of the same material.

The results of the thermal calculation for the fourth model show that the analyzed individual components do not meet the currently prescribed heat transfer coefficient values [6].

Table 4. Model 4: building envelope structure and Heat transfer coefficients

Model 4			
External view	**Building envelope structure**		
	**Eternal wall**	**Floor construct.**	**Window**
			
	cavity clay block wall with plastered thermal insulation	LMT reinforced concrete construction with hollow clay block 20 cm, parquet floor	single three-chamber plastic window, double glazed, external roller blind
Heat transfer coefficient (W/m²K)	**U=0.53** U > Umax=0,4	**U= 0.93** U < Umax=0,9	**U= 3** U > Umax=1.5

4. THE RESULTS OF THE THERMAL CALCULATION

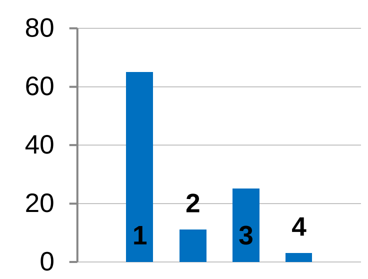
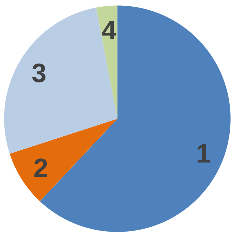
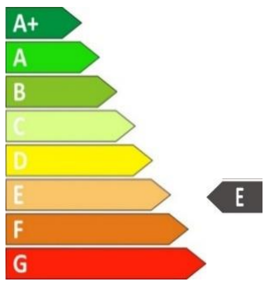
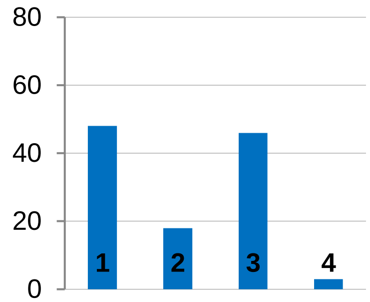
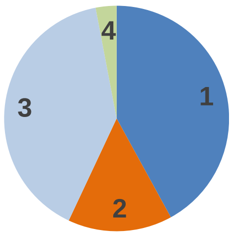
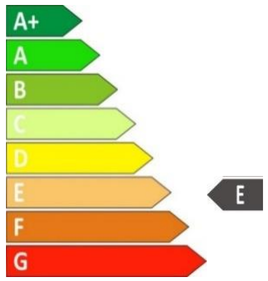
The energy efficiency calculation for the adopted models was performed using the Knauf Term 2 software, developed by Dr. Aleksandar Rajčić [7].

The energy balance of the first model is presented in Table 5, indicating that the highest transmission losses occur through the external wall. This arises from the dominant surface area of this building envelope element and the heat transfer coefficient values that triple the allowed limits. By summing up all relevant factors, the heating energy demand per unit area is calculated as Qh,an = 121.97 kWh/m²a, corresponding to energy class E, which exceeds the prescribed values according to the existing regulations for existing buildings [5].

The distinctiveness of the second model, compared to the other representatives, lies in the envelope structure, where the surface area of the façade wall is equal to the surface area of the windows on the south facade, a result of the design characteristics of the early prefabricated buildings in Belgrade. Horizontal window bands alternating with concrete parapet elements are characteristic of this construction period, leading to certain specificities in the thermal calculation results.

The high thermal conductivity coefficient of the adopted window with connected frames (which has poorer thermal characteristics compared to windows with separate frames), along with its greater representation in the envelope structure, contributes to heat losses through the window that are nearly equal to losses through the external walls (Table 5). The higher proportion of transparent components in the overall envelope area, combined with the façade parapet element, which also has unfavorable thermal characteristics, results in the highest transmission losses for this model.

Table 5. Models 1 and Model 2: Heat losses, energy class and energy consumption

<table>
<tr><th colspan="3">Model 1</th></tr>
<tr><td>Heat losses (W/K)</td><td>Heat losses (%)</td><td>Energy class</td></tr>
<tr><td>
</td><td>
</td><td>
</td></tr>
<tr><td colspan="3">Heat losses of elements of the thermal envelope: area, heat losses (W/K and %)
1. external wall: 51.4 m², 64.4 W/K, 62.6% 3.windows: 10.6 m², 27.5 W/K, 26.7 %
2. wall to unheated area: 14 m², 7.8 W/K, 7.6% 4. door: 2.1 m², 3.2 W/K, 3.1 %</td></tr>
<tr><td>Transmission losses:
Qt = 6692.50 kWh</td><td>Solar gains:
Qsol = 1026.6 kWh</td><td>Heating energy
Demand $Q_{h,nd}$ = 7037.58 kWh</td></tr>
<tr><td>Ventilation losses:
Qv = 2419.76 kWh</td><td>Other gains:
Qp+Qel= 1048.04 kWh</td><td>Heating energy demand
per m² $Q_{h,an}$=121.97 kWh/m²a</td></tr>
<tr><th colspan="3">Model 2</th></tr>
<tr><td>Heat losses (W/K)</td><td>Heat losses (%)</td><td>Energy class</td></tr>
<tr><td>
</td><td>
</td><td>
</td></tr>
<tr><td colspan="3">Heat losses of elements of the thermal envelope:
1. external wall: 32.7 m², 47.7 W/K, 41.7 % 3. windows: 16.3 m², 45.7W/K, 39.9%
2. wall to unheat. area: 11.4 m²,17.8 W/K, 15.6% 4. door: 2,1 m²,3.2 W/K, 2.8 %</td></tr>
<tr><td>Transmission losses:
Qt = 7294.37 kWh</td><td>Solar gains:
Qsol = 3295.3 kWh</td><td>Heating energy Demand
$Q_{h,nd}$ = 6407.07 kWh</td></tr>
<tr><td>Ventilation losses:
Qv = 3456.60 kWh</td><td>Other gains:
Qp+Qel= 1048.04 kWh</td><td>Heating energy demand
per m² $Q_{h,an}$=110.98 kWh/m²a</td></tr>
</table>

Ventilation losses, indicative of poor sealing of the windows, which is characteristic of windows with connected frames, also contribute to the model's unfavorable situation. When combined with transmission losses, this leads to the highest overall energy requirement for compensation. A large share of transparent components, in combination with inadequate shading systems (adopted fabric blinds as a typical solution in buildings from that period), results in extreme solar gains, contributing to a reduction in total heat losses and a more favorable overall energy balance (Table 5).

By summing up all the aforementioned relevant factors, the heating energy demand per unit area is calculated as $Qh,an = 110.98$ kWh/m²a, corresponding to energy class E. The pronounced unfavorable aspects revealed in the calculation of heat losses were mitigated by high solar gain values, leading to a slightly more favorable overall energy balance for the second model compared to the first.

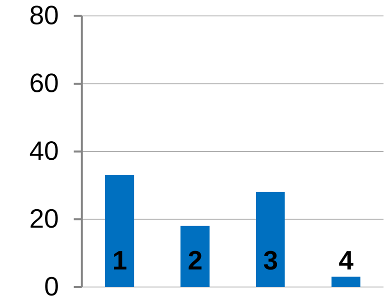
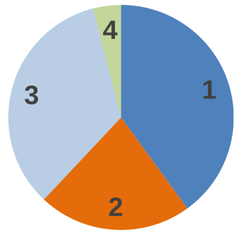
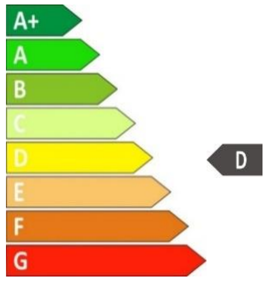
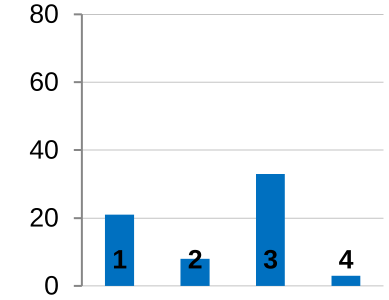
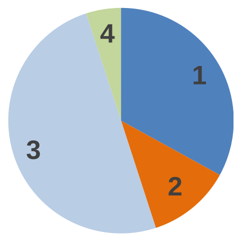
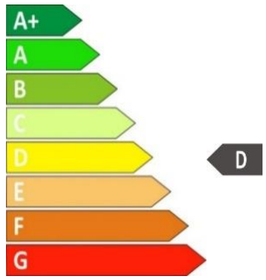
The results of the thermal calculation for the third model show the extreme value of the wall adjacent to the unheated staircase area, and its contribution to the total transmission losses is significantly higher compared to the previous cases. When compared with the values that were relevant during the construction of such buildings, compliance with the thermal regulations of that time is assessed. The envelope structure graph in the table indicates a predominant surface area of the façade wall compared to the window element (ratio of 80% to 20%), but the redistribution of transmission losses through the envelope shifts and balances the window's contribution in the total calculated values (Table 6). This situation can be explained by significant differences in heat transfer coefficient values between the external insulated wall and the single-pane wooden window with thermal insulating glass (wall: $U=0.8$ W/m²K, window: $U=3.0$ W/m²K).

The energy balance of the third model is presented in Table 6, showing that the values of losses and gains are the lowest compared to the previously analyzed cases. This is a result of the better thermal characteristics of the external wall and significantly reduced ventilation losses due to the estimated better sealing of the applied windows. On the other hand, thermal gains are influenced to some extent by the shading equipment factor ($Fz=0.3$), which leads to the lowest values (compared to previously analyzed models) of the required energy for heating per unit area: $Qh,an = 88.58$ kWh/m²a, corresponding to energy class D.

The results of the thermal calculation for the fourth model indicate that the analyzed individual components do not meet the current prescribed values for heat transfer coefficients, which is particularly pronounced in the case of windows, which now dominate in the share of heat losses (Table 6). This is a consequence of the significant differences in heat transfer coefficients between the two represented components of the building envelope (wall: $U=0.53$ W/m²K, window: $U=3.0$ W/m²K).

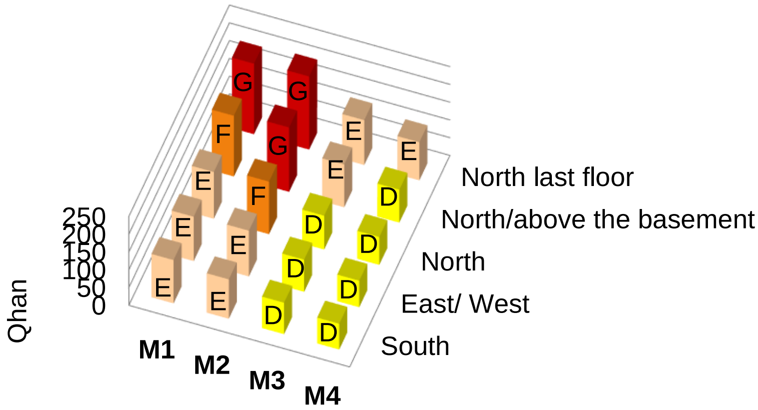
The energy balance of the fourth model (Table 6) shows higher values of transmission losses compared to ventilation losses, with values similar to those in the previously analyzed case. Ventilation losses are identical due to the same volume of space and the same window sealing characteristics. Transmission losses are slightly lower than in the previous model, but solar gains are also lower, resulting in the final energy balance required for heating per unit area: corresponding to energy class D.

Table 6. Model 3 and Model 4: Heat losses, energy class and energy consumption

<table>
<tr><th colspan="3">Model 3</th></tr>
<tr><td>Heat losses (W/K)</td><td>Heat losses (%)</td><td>Energy class</td></tr>
<tr><td>
</td><td>
</td><td>
</td></tr>
<tr><td colspan="3">Heat losses of elements of the thermal envelope:
1. external wall: 40.6 m^2, 33.1 W/K, 40.2 %
2. wall to unheat. area: 12 m^2, 18.2 W/K, 22 %
3. windows: 9.3 m^2, 28 W/K, 4 %
4. door: 2.1 m^2, 3.2 W/K, 3.8 %</td></tr>
<tr><td>Transmission losses:
Qt = 5365.30 kWh</td><td>Solar gains:
Qsol = 700.9 kWh</td><td>Heating energy Demand
$Q_{h,nd}$ = 5113.72 kWh</td></tr>
<tr><td>Ventilation losses:
Qv = 1497.88 kWh</td><td>Other gains:
Qp+Qel= 1048.04 kWh</td><td>Heating energy demand
per m^2 $Q_{h,an}$= 88.58 kWh/m²a</td></tr>
<tr><th colspan="3">Model 4</th></tr>
<tr><td>Heat losses (W/K)</td><td>Heat losses (%)</td><td>Energy class</td></tr>
<tr><td>
</td><td>
</td><td>
</td></tr>
<tr><td colspan="3">Heat losses of elements of the thermal envelope:
1. external wall: 40.3 m^2, 21.4 W/K, 32.8 %
2. wall to unheat. area: 11.9 m^2,7.8 W/K, 11.9%
3. windows: 11 m^2 33 W/K, 50.5 %
4. door: 3.2 W/K, 4.8 %</td></tr>
<tr><td>Transmission losses:
Qt = 4348.62 kWh</td><td>Solar gains:
Qsol = 594.5 kWh</td><td>Heating energy Demand
$Q_{h,nd}$ = 4203.43 kWh</td></tr>
<tr><td>Ventilation losses:
Qv = 1497.88 kWh</td><td>Other gains:
Qp+Qel= 1048.04 kWh</td><td>Heating energy demand
per m^2 $Q_{h,an}$= 72.81 kWh/m²a</td></tr>
</table>

5. DISCUSION

Based on the presented results, it can be concluded that the first two models, representing older construction periods (up to the mid-1970s), have thermal characteristics that are one energy class worse than the apartments built later. This is expected considering the development of technical regulations in this field, which tightened thermal standards and contributed to qualitative changes. It's important to emphasize that the study considered the more favorable positions of apartments that are south-facing and located between residential floors in terms of the building's height. If the apartment's orientation is different or its position within the building is less favorable, the amount of energy required for heating and the energy class can change. Figure 2 shows different positions and orientations of the model apartments, which were materialized according to typical configurations characteristic of specific construction periods. The most significant variations occur in the first two models, where depending on the orientation and position within the building, the energy class can change by up to two energy levels (from E to G).



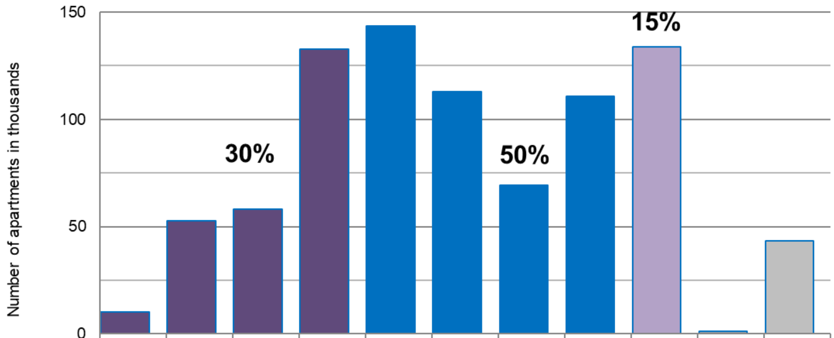
	M1	M2	M3	M4
South	121.97	110.98	88.58	72.81
East/ West	124.82	128.87	90.68	74.82
North	131.68	148.05	95.32	78.72
North/above the basement	171	181.37	120.52	92.82
North last floor	198.58	205.87	126.32	107.42

Figure 2. Energy consumption depending on the different orientation of the apartments and position in building (Image by author)

6. CONCLUSION

The 2022 census provided data indicating that the housing stock in Belgrade consists of 868,752 units (Fig. 3). If these data are juxtaposed with the years of enactment of regulations related to thermal insulation, a clear picture emerges of the types of structures constituting the city's housing stock.

Specifically, the issue of thermal insulation of buildings was first introduced in the domestic technical regulations within the framework of the 1967 Regulation on Minimum Technical Conditions for the Construction of Apartments. However, the most significant change in this field occurred in 2011, when thermal protection requirements were considerably tightened, thermal transmittance coefficients were drastically reduced, and mandatory building certification was introduced. By comparing the graph of the number of constructed housing units with the pivotal year of legal enforcement of thermal insulation norms, it becomes evident that by that time, 30% of the existing buildings had already been constructed. From then until the adoption of the Energy Efficiency Regulation [6] in 2011, 50% of buildings were constructed according to standards significantly below contemporary thermal protection requirements, while 15% of buildings were constructed to modern standards. The European Union's strategy [1] envisages the possibility of certifying existing buildings to stimulate a wave of energy retrofitting. Given that the trend of energy retrofitting existing buildings is not extensively observed in our context, these data undeniably indicate that only a small number of buildings meet modern thermal protection criteria and necessitate reconstruction.



	before 1919	1919-1945	1946-1960	1961-1970	1971-1980	1981-1990	1991-2000	2001-2010	2011-2021	unfin.	unknown
number of units	10193	52724	58258	132766	143322	112923	69424	110886	133843	1168	43245
%	1.17	6.07	6.71	15.28	16.50	13.00	7.99	12.76	15.41	0.13	4.98

Figure 3. The number of apartments according to the periods of construction and according to the years of adoption of thermal regulations (Image by author)

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International Conference
Synergy of Architecture & Civil Engineering
sinarg 2023
Niš (SERBIA) - Science & Technology Park Niš - September 14-15, 2023

Niš, 20. 08. 2023. God.

Poštovana **Prof. Dr Ljiljana Đukanović,**

Zadovoljstvo nam je da Vas kao stručnjaka u oblasti održive i zelene gradnje, profesorku Arhitektonskog fakulteta Univerziteta u Beogradu, pozovemo da svojim prisustvom i predavanjem po pozivu, doprinesete održavanju **VI GREEN BUILD KONFERENCIJE 2023,** pod nazivom,

SINERGIJA INDUSTRIJE & AKADEMSKE ZAJEDNICE / Zelena agenda srbije

koja se održava u okviru **Međunarodne konferencije "Sinergija arhitekture i građevinarstva - SINARG 2023"**, 14.09.2023. god., u NAUČNO TEHNOLOŠKOM PARKU NIŠ, ul. Aleksandra Medvedeva 2A, NTP - MOTOROLA HALL.
Klaster zelene gradnje Niš, u saradnji sa Građevisko-arhitektonskim fakultetom Univerziteta u Nišu, želi da organizovanjem ove mini konferencije, približi koncepte odrzivog projektovanja i gradjenja svim zaintresovanim studentima i profesionalcima iz oblasti arhitektonsko-gradjevinske struke, ali i da se pridruži obeležavanju Svetske nedelje zelene gradnje **#WGBW23** (World Green Building Week 23) i ovom manifestacijom da svoj mali doprinos.

Sa postovanjem,

Ivana Lukić	**Prof. dr Slaviša Trajković**
direktor	dekan
Klaster zelene gradnje Niš	Građevinsko-arhitektonski fakultet Univerzitet u Nišu

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Niš, 14. 09. 2023. god.

SERTIFIKAT

Dr Ljiljana Đukanović

"Ocena kvaliteta stambenog fonda Beograda sa stanovišta potrošnje energije"

Potvrda/Zahvalnica na održanom predavanju po pozivu na **VI GREEN BUILD KONFERENCIJI 2023, SINERGIJA INDUSTRIJE & AKADEMSKE ZAJEDNICE / Zelena agenda srbije** koje je održano kao mini konferencija u okviru **Međunarodne konferencije "Sinergija arhitekture i građevinarstva - SINARG 2023"** dana 14.09.2023. god. u NAUČNO TEHNOLOŠKOM PARKU NIŠ, ul. Aleksandra Medvedeva 2A, NTP - Motorola hall.

Ivana Lukić	**Prof. dr Slaviša Trajković**
direktor	dekan
Klaster zelene gradnje Niš	Građevinsko-arhitektonski fakultet Univerzitet u Nišu

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SCHEDULE	**THURSDAY 14TH SEPTEMBER**
12:15 – 12:30	**OPENING CEREMONY**
	Ivana Lukić, CEO, *GreenBuild Cluster, Niš, Serbia*
	Professor Miomir Vasov*, PhD, Faculty of Civil Engineering and Architecture, University of Niš, Serbia*
12:30 – 13:30	**INVITED LECTURES**
12:30 – 12:50	***Associate Professor Ljiljana Đukanović,*** *PhD, Faculty of Architecture, University of Belgrade,Serbia* *Assessment of the quality of housing stock in Belgrade according to energy consumption* *Ocena kvaliteta stambenog fonda Beograda sa stanovišta potrošnje energije*
12:50 – 13:10	***Associate Professor Aleksandar Rajčić,*** *PhD, Faculty of Architecture, University of Belgrade,Serbia* *Energy efficiency of buildings in Serbia-some personal exspiriences from the process of design and realization* *Energetska efikasnost zgrada u Srbiji – neka lična iskustva iz procesa projektovanja i realizacije*
13:10 – 13:30	***Assistant Professor Andrej Josifovski,*** *PhD, Faculty of Architecture, University of Belgrade,Serbia* *Re-VILLAGE ECOlogical experiments in architecture* *Re-SELO EKOloški eksperimenti u arhitekturi*
13:30 – 13:50	***Professor Miomir Vasov****, PhD, Faculty of Civil Engineering and Architecture, University of Niš, Serbia* *Bioclimatism as a tipping point* *Bioklimatizam kao ishodište*
13:50 – 14:10	***Associate Professor Goran Vučković,*** *PhD, Faculty of Mechanical Engineering, University of Niš,Serbia* *Heat pumps in the function of sustainable construction in the building sector* *Toplotne pumpe u funkciji odrzive gradnje u sektoru zgradarstva*
14:10 - 14:30	**SPONSOR PRESENTATIONS**
14:10 - 14:30	***Aleksandar Nedeljković,*** *Sika Srbija* *Sika green building concepts* *Sika koncepti zelene gradnje*
14:30 – 15:00	**Discussion**
15:00 – 16:00	**LUNCH BREAK**