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ENERGY EFFICIENCY IN THE BUILDING SECTOR IN SERBIA - AN OVERVIEW

Minja Velemir Radović[1], Danijela Nikolić[2], Saša Jovanović[3]

Abstract: Energy efficiency is a key aspect of sustainable development, focusing on optimizing energy consumption to reduce costs and negative environmental impacts. The implementation of energy-efficient technologies and practices can significantly contribute to reducing greenhouse gas emissions and conserving natural resources. The building sector consumes about 30 percent of the total energy, making it highly suitable for implementing measures. Due to its significant share in overall energy consumption, improving energy efficiency in this sector can have far-reaching economic and environmental benefits. This paper analyzes the condition of buildings in Serbia, their typology and their energy efficiency. It presents the steps taken, as well as future ones, that will help achieve reductions in energy consumption, greenhouse gasses, and operational costs.

Key words: Energy efficiency, Building sector, Serbia

1 INTRODUCTION

Global energy consumption growth has accelerated compared to the average annual growth rate of 1.5% recorded from 2010 to 2019 [1]. Declining electricity consumption in advanced economies limited the growth of global power demand in 2023. The global demand for electricity increased by 2.2% in 2023, which is lower than the 2.4% growth recorded in 2022 [2]. Global electricity demand is anticipated to increase at a quicker pace over the next three years, with an average annual growth rate of 3.4% projected through 2026. The EU's energy efficiency goal for 2030 sets a limit of 1128 Mtoe (Million tonnes of oil equivalent) for primary energy consumption and 846 Mtoe for final energy consumption. Primary energy consumption represents the total domestic energy demand, whereas final energy consumption pertains to the

[1] Minja Velemir Radović, Researcher, University of Kragujevac, Faculty of Engineering, Kragujevac, Serbia, velemir94@gmail.com
[2] Ph. D. Danijela Nikolić, Associate Professor, University of Kragujevac, Faculty of Engineering, Kragujevac, Serbia, danijela1.nikolic@gmail.com
[3] Ph. D. Saša Jovanović, Associate Professor, University of Kragujevac, Faculty of Engineering, Kragujevac, Serbia, dviks@kg.ac.rs

actual energy used by end consumers [3]. Figure 1 shows energy consumption for buildings in a period from 2010 to 2022, and three possible scenarios for 2030, (STEPS – Stated Policies Scenario, APS - Announced Pledges Scenario, NZE = Net Zero Emissions by 2050 Scenario).

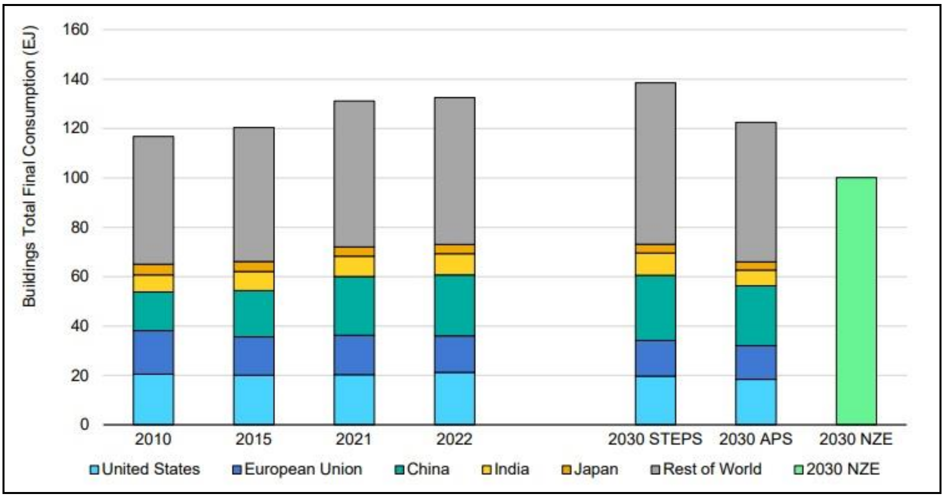

Figure 1. *Total energy consumption for buildings [4]*

In 2021, energy consumption in buildings represented approximately 30% of global final energy use, equating to around 132 exajoules (EJ) [5]. While buildings are much less prominent in terms of energy consumption and carbon dioxide (CO2) emissions compared to more energy-intensive sectors like transportation or industry, they are nonetheless crucial to any corporate strategy aimed at addressing climate change. The ISES White Paper indicates that it is both feasible and necessary for renewable resources to supply at least 50% of global energy by 2050 [6]. In 2021, the combustion of fossil fuels for heating in buildings—such as natural gas in boilers and oil and coal in furnaces—accounted for 8% of global energy-related CO2 emissions. Additionally, the indirect emissions resulting from the production of electricity and heat used for hot water, thermal comfort, and powering various appliances and devices in buildings contributed to 19% of these emissions. Between 2019 and 2021, both direct and indirect emissions from buildings increased by 2% [5].

Currently, approximately 75% of the building stock in the EU is energy inefficient, leading to significant energy wastage. This inefficiency can be reduced by enhancing the performance of existing buildings and incorporating smart technologies and energy-efficient materials in the construction of new homes [7]. In Europe, buildings are responsible for about 40% of total energy consumption and contribute roughly one-third of global CO2 emissions [8].

2. ENERGY EFFICIENCY IN BUILDINGS

Global energy consumption in buildings is projected to increase as urbanization, population growth, and per capita energy use rise in developing cities. Given their significant energy demand, residential, public, and commercial buildings present substantial opportunities for energy savings. In 2022, energy use in buildings represented 30% of the world's final energy demand and was responsible for 26% of global emissions. This included 8% points from direct emissions, like those from gas heating and cooking, and 18% points from indirect emissions due to electricity consumption. From 2010 to 2022, the energy intensity of residential buildings has steadily decreased, with an average annual improvement of 1.2% resulting in a 13% overall reduction. However, during the Covid-19 lockdowns in 2021, the energy intensity of residential buildings increased due to more people staying home. Despite this setback, progress partially rebounded in 2022, showing a 1% improvement. In 2021, Brazil and Canada were the leading countries in terms of the highest shares of renewable energy in buildings. France, Italy, and Germany also had above-average shares of renewable energy in buildings, largely due to their dependence on biomass for heating and, to a lesser extent, on renewable electricity. In contrast, among the top ten consuming countries, India, the Russian Federation, and the Republic of Korea had the lowest shares of renewables in buildings, each accounting for less than 5% [5].

Although the classification of energy services may differ between sources, this paper categorizes them into Heating, Ventilation, and Air Conditioning (HVAC); Domestic Hot Water (DHW); lighting; cooking; and other equipment, primarily including appliances and various plug-in devices [9]. Consumption of buildings by end-use categories for the global context, as well as for the US, EU, China, India, and Russia is shown in figure 2. In Europe, primary energy-consuming function in buildings is space heating, with the global heated floor area expected to rise from 157 billion m² in 2022 to 170 billion m² by 2030. Currently, fossil fuels dominate space heating; however, there is considerable potential for electrification. This is particularly true with the growing use of efficient electric heat pumps, which can be applied in individual homes as well as in district heating systems powered by waste heat sources like wastewater or data centers [4].

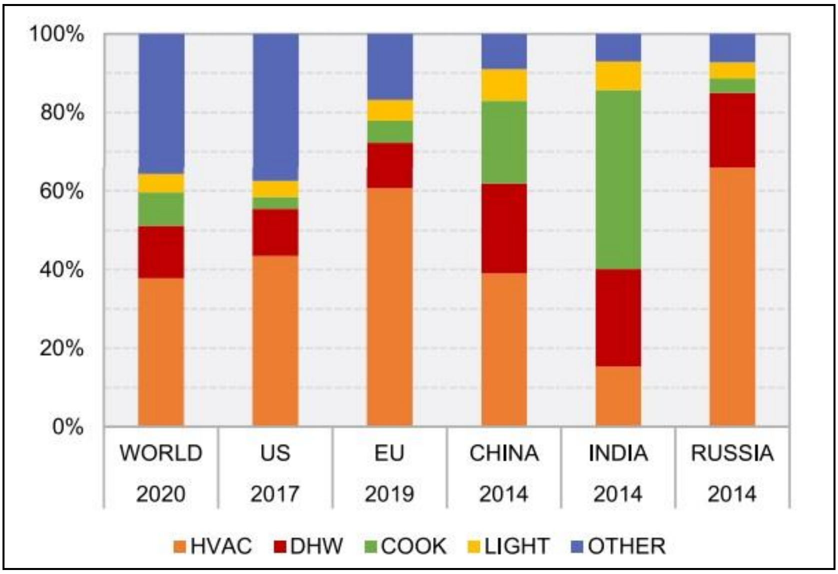

Figure 2. *Consumption of buildings by end-use categories [9]*

As of 2023, more than 110 countries have implemented minimum energy performance standards (MEPS), encompassing all major energy consumers. To promote consumer decisions that exceed these regulated minimums, MEPS are frequently paired with comparative labels, used in over 100 countries. Figure 3 presents the coverage for space cooling, space heating, water heating, refrigeration, and lighting in the residential sector, illustrating global energy use with minimum performance standards for major end uses from 2000 to 2023.

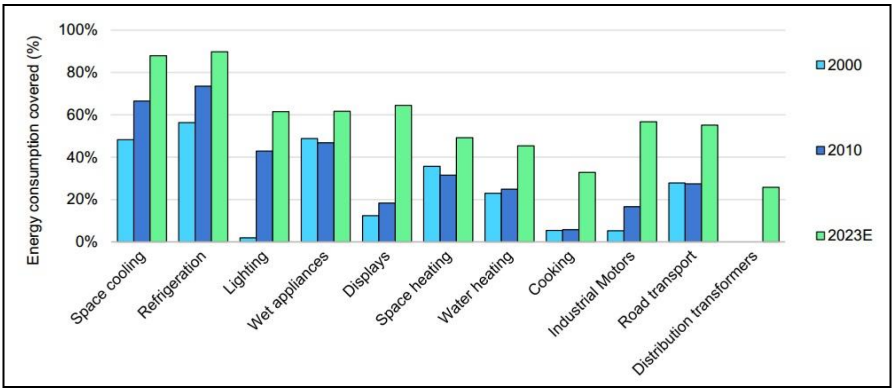

Figure 3. *Europe global energy use with minimum performance standards for major end uses from 2000 to 2023 [4]*

Energy efficiency is a fundamental aspect, if not the cornerstone, of green and sustainable buildings [10]. Improving energy efficiency in both existing and new structures offers a rapid solution to mitigate the environmental, economic, social, and other impacts within this sector [11]. To achieve sustainability in buildings, it is essential to focus on high energy efficiency by minimizing environmental effects through different methods [12].

2.1 Energy efficiency in Serbia

Energy efficiency is essential for advancing economic, social and environmental sustainability. It has been a key factor in managing future energy demand in Serbia. As of 2003, Serbia's economy was four times more energy-intensive relative to its GDP compared to the EU average. The government recognized the necessity to explore new avenues for boosting energy efficiency and developing renewable and alternative energy sources. Within the building sector, Serbia had significant untapped potential for energy efficiency improvements. Public buildings in the country often suffered from inadequate or absent insulation, deteriorated building seals, and inefficient heating systems [13].

Energy efficiency in Serbia is relatively low, with electricity consumption per unit of living space averaging approximately 200 kWh, compared to an EU average of around 140 kWh. Energy efficiency experts project that implementing energy-saving measures could lead to reductions in energy consumption of 30-40 percent. The Ministry of Mining and Energy, along with local municipalities, provides subsidies covering up to 65% of the investment in energy efficiency improvements for private households [14]. Electricity consumption for residential sector from 2010 to 2021 in Serbia is shown in figure 4.

Serbia ranks among the lowest in Europe regarding energy efficiency and rational energy use. In Serbian buildings, approximately 60% of total energy consumption is dedicated to space heating, with the remainder used for ventilation, lighting, and electrical appliances [16]. Figure 5 shows total energy consumption by end-use in residential sector between 2010 and 2021.

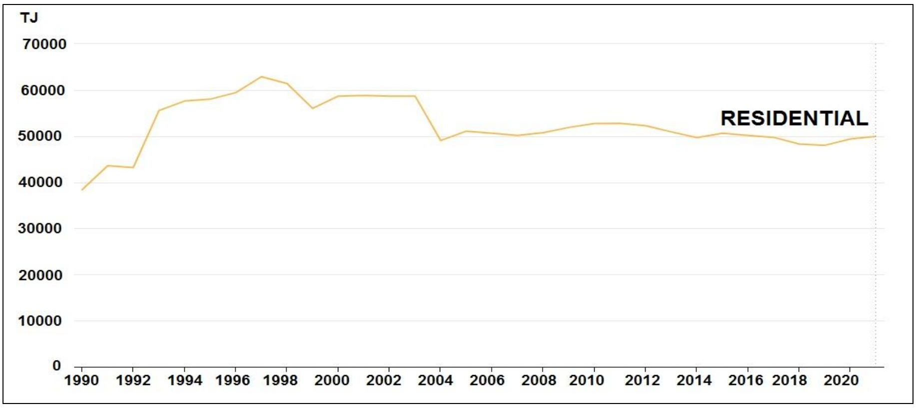

Figure 4. *Electricity consumption for residential sector in Serbia [15]*

This issue is underscored by the existence of 300,000 to 400,000 homes lacking thermal insulation, leading to an annual energy consumption of 220 kWh/m², compared to the European average of 60 kWh/m². Significant improvements could be achieved through energy-efficient building design, selecting suitable materials for new constructions, and applying principles that facilitate the effective energy rehabilitation of existing uninsulated buildings [16].

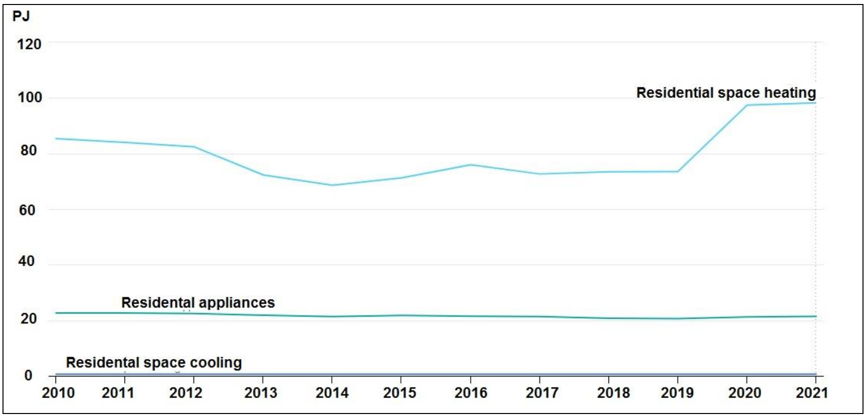

Figure 5. Total energy consumption by end-use in residential sector [15]

3. TYPOLOGY OF BUILDINGS IN SERBIA

The research team from the Faculty of Architecture, University of Belgrade, has published a National Typology of Residential Buildings in Serbia. This typology is derived from calculations of energy characteristics, including energy requirements for heating and CO_2 emissions for selected representative residential buildings. These calculations provide a foundation for developing potential roadmaps for enhancing energy efficiency and national standards for nearly zero-energy buildings. From these analyses, various strategies for the renovation of the national residential building stock can be formulated, and long-term planning can be established. A field survey was carried out involving nearly 20,000 residential buildings, which were cataloged and evaluated using a specially designed questionnaire. For this purpose, custom software was developed and employed. Figure 6 shows national typology of residential buildings in Serbia. In addition to the urban and architectural features of residential buildings, historical and socio-political national development served as fundamental principles for this typology. These core principles include:

- Classification based on historical and economic development, the introduction of thermal protection regulations, and the type of construction techniques used.
- Building types categorized according to urban characteristics, site positioning, and relation to neighboring structures, identifying six typical categories: two for family housing (detached and row houses) and four for multi-family housing (detached, row house, "lamella" row houses, and high-rises).
- Architectural traits, such as overall shape (compact or irregular), window-to-facade ratio, and the inclusion of attics or basements.
- Characteristics of envelope elements [17].

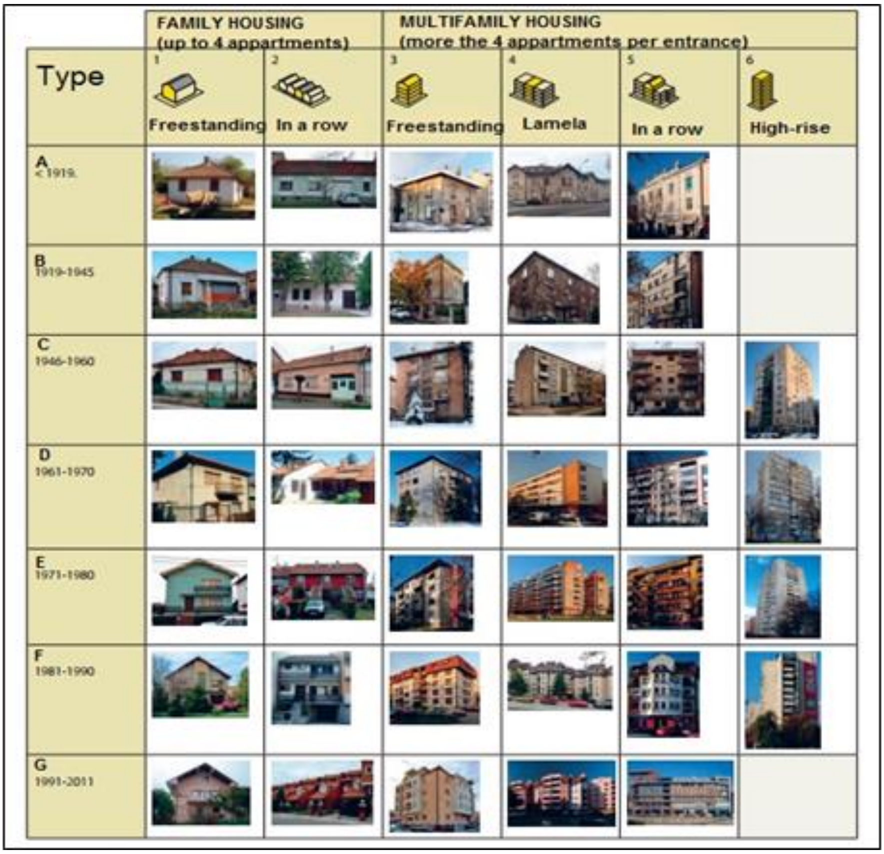

Figure 6. *National typology of residential buildings in Serbia [17]*

Natural features of the regions significantly shaped building technology and material use until the era of large-scale housing construction in the post-war periods. Since then, there has been a widespread unification of construction methods and materials. Statistical data indicates that the majority of Serbian individual housing stock was built between 1946 and 1980. Typological analyses reveal that the predominant type of individual housing units is the free-standing house, while row houses are scarce across most regions, except in Vojvodina. Brick is the main building material throughout the regions, primarily used for solid walls (typically 38 cm thick), though hollow clay blocks have become more common in recent decades. Wooden construction was widely used for inter-floor slabs in older homes but has since been replaced by reinforced concrete slabs and semi-prefabricated structures with hollow clay infill. Roofs are predominantly wooden, often covered with clay tiles. Windows tend to be small, featuring wooden double sashes with single panes and exterior blinds, which are now being replaced by thermal insulating glass with various frame designs. Most buildings, regardless of their construction period, still lack adequate thermal insulation [18].

4. CONCLUSION

For the effective implementation of energy efficiency measures, it is essential to not only initiate investments but also to ensure diligent monitoring and robust policies. Over the years, this market has been expanding significantly.Energy efficiency is recognized as a vital element for achieving global inclusive growth while transitioning to a sustainable energy system. Therefore, it is crucial for industrialized societies to strive toward meeting energy standards.

In Serbia, energy efficiency remains relatively low. Compared to Germany, Serbia consumes six times more energy in relation to its gross GDP, with nearly forty percent of energy consumption coming from buildings. There is substantial potential for improvement, particularly through energy-saving initiatives in public buildings such as schools and kindergartens. Factors such as inadequate insulation, structural damage, and outdated heating, cooling, and hot water systems contribute to elevated energy consumption.

The urban population is experiencing significant growth worldwide, particularly in developing countries like Serbia. This leads to higher urban density, increased energy use, more construction, greater pollution, and elevated costs. Consequently, it is imperative to adopt numerous directives and policies focused on energy efficiency. This will help ensure that people can live in a healthy and functional environment while maintaining their comfort and achieving high efficiency.

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