

POSSIBILITIES FOR IMPLEMENTING PRINCIPLES OF A CIRCULAR ECONOMY IN THE RECONSTRUCTION AND ADAPTATION OF BUILDINGS IN SERBIA

Jana Petrović¹, Belgrade, Serbia

Jelena Pavlović¹, Belgrade, Serbia

Ana Radivojević¹, University of Belgrade, Faculty of Architecture, Belgrade, Serbia

The circular economy is a new economic model which provides the necessary goods and services for maintaining and improving living standards without increasing the consumption of raw materials and waste. The traditional model of the linear economy is viewed as an unsustainable long-term solution because it does not take waste treatment into account, and thus the impact on the environment. The European Union has recognized this problem and obliged its members to apply the circular economy model as a strategy for a climate-neutral, resource-efficient, and competitive economy. By adopting the European Green Deal at the Western Balkans Summit, the Republic of Serbia has committed itself to abide by the new growth strategy, which includes the application of the circular economy in all industrial sectors. The construction industry is one of the most environmentally harmful industries in the world, with a direct impact on the use of raw materials, life cycle of buildings, and the overall environment. The paper explores the circular economy concept, its principles, and possibilities for implementation, both at the national level of the Republic of Serbia and the level of the European Union. The role of the circular economy in the construction industry has been examined through the analysis of legislation currently in force with regard to the treatment of construction materials and waste. This paper aims to highlight the importance of employing the circular economy in the Republic of Serbia, as well as to define guidelines for its further implementation, especially in the reconstruction and adaptation of buildings.

Key words: circular economy, building stock, construction, reconstruction, adaptation.

INTRODUCTION

The exponential growth of the world's population and accelerated urbanization over the past few decades has significantly affected the quality of the environment and exploitation of natural non-renewable resources. It is estimated that half of the total greenhouse gas emissions and losses of more than 90% of biodiversity are caused by their acquirement and processing (European Commission, 2020a). These data indicate that the current linear economy model has reached its limits, and that it cannot be considered a sustainable long-term solution. A new economic model has been devised, known as the *circular economy*, in order to mitigate, and ultimately eliminate, the negative impact

on the environment. It provides the necessary commodities and services for maintaining and improving living standards without increasing consumption of raw materials and waste.

Application of the circular economy model represents the inevitable future of all economic systems. The building construction sector, which is recognized as one of the most environmentally harmful industries in the world, and has a direct impact on the use of raw materials and the way they are used, is still in the early stages of transition from a linear to a circular economy (Bertino *et al.*, 2021). Therefore, the research aims to define the possibility of implementing circular economy principles in the process of reconstructing and adapting buildings in the Republic of Serbia. The paper analyzes legislative acts and strategies for achieving climate neutrality by applying the circular economy model specified by the European Union, and comparing them with current

¹ Grčića Milenka 56, 11000 Belgrade, Serbia
janapetrovicarh@gmail.com

regulations in the Republic of Serbia. The circular economy principles are identified through the aspects of energy and material management within the policies and guidelines, and their practical implementation.

THE CONCEPT OF A CIRCULAR ECONOMY

Today, the concept of a circular economy is becoming increasingly common in all economic activities, and it is often referred to as a new paradigm that will overcome the traditional barrier between the environment and economic prosperity (Pomponi and Moncaster, 2017). Along with the growth of interest in the issue, numerous schools of thought have been developed. Therefore, one can find various definitions of the circular economy in the literature, such as: increasing the productivity of raw materials instead of increasing the amount used; elimination of waste by treating used raw materials as future technical or biological components; maintaining or increasing the value of raw materials in environmental and economic terms; and planning within a circular system aimed at extending the life of raw materials and energy by using waste as an input. A comprehensive definition of the concept of a circular economy focuses on eco-design, cleaner production and ecological networks, in order to form a recycling-oriented society (Adams *et al.*, 2017).

The previous socio-economic model, which is still the most widespread, is defined in the literature as the linear economy, and its crucial feature is the quantity of waste products after usage. The main disadvantage of this model is the erroneous assumption of infinite amounts of natural resources. The linear economy implies the use of resources ("take") and their disposal ("waste") (Figure 1). Theorists also characterize this system as "take, make, waste" or "from cradle to grave", as opposed to the circular "cradle to cradle" concept (Laumann and Tambo, 2018).

According to the European Commission (2020a), global consumption of resources such as biomass, fossil fuels, metals and minerals is expected to double in the next forty

years. In addition, an increase in annual waste production is estimated at 70% by 2050. According to the same source, considering the fact that half of the total greenhouse gas emissions and more than 90% of biodiversity loss are caused by the exploitation and processing of natural resources, the linear economy model cannot be considered a sustainable solution.

The gradually raised awareness of the soon-to-be-reached limits of the linear economy has sparked interest in forming a new economic model that would provide the necessary goods and services to maintain and improve living standards without increasing raw material consumption and waste. According to the traditional model, it was impossible to accept economic growth without increased exploitation of resources or raw materials, as stated after the global economic crisis in 2008 (Bonciul, 2014). Prosperity without growth represents a new paradigm because it requires a new attitude, a new perspective, which is represented by the circular economy.

The official position of the European Commission on the circular economy was presented for the first time on December 17, 2012, in a document titled "Manifesto for a resource-efficient Europe", where the first paragraph states: "In a world with growing pressures on resources and the environment, the EU has no choice but to go for the transition to a resource-efficient and ultimately regenerative circular economy." (European Commission, 2012). After that, the "The European Green Deal" (European Commission, 2019) launched an integrated strategy for a climate-neutral, resource-efficient and competitive economy. According to the European Commission, the utilization of the circular economy by leading economies should contribute to achieving climate neutrality by 2050 and separating economic growth from the use of resources, while ensuring long-term competitiveness of the EU and leaving no environmental footprint. The aim of adopting this type of economic model is to ensure regenerative growth, which means returning resources to the planet, limiting consumption, and reducing the ecological footprint (European Commission, 2020a). The circular economy model encompasses and merges different environmentally sustainable concepts, which makes it a very important model for a sustainable future.

Numerous countries have recognized the importance of the circular economy and formed legislative frameworks that support this model. Among the first countries, China stands out, where the Law on the Promotion of the Circular Economy was adopted in 2008, followed by the Netherlands, then the United States and France (Laumann and Tambo, 2018).

CIRCULAR ECONOMY IN THE REPUBLIC OF SERBIA AND WIDER REGION

According to data from a survey conducted by the Chamber of Commerce and Industry of Serbia, the concept of a circular economy in the Republic of Serbia is unknown to most respondents: 21.6% have never heard of it, while 60.5% have heard but are not familiar with the details (Privredna komora Srbije, 2022). Such results indicate insufficient information, but ultimately testify to its inadequate application. Although

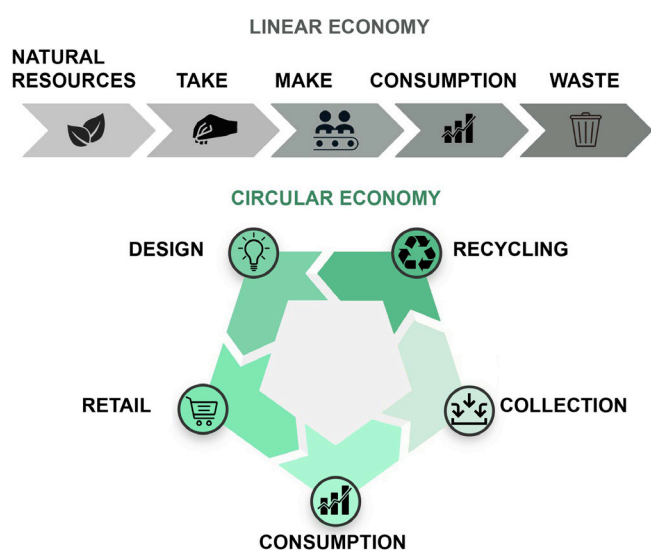


Figure 1. Comparative overview of linear and circular economics (Source: Jana Petrović)

the Republic of Serbia is an EU membership candidate, and therefore committed to implementing the circular economy concept (Mihajlov *et al.*, 2019), it can be argued that it is only in its early stage of transition from a linear to a circular economy. On the other hand, the fact that 76.1% of respondents consider the application of a circular economy useful (Privredna komora Srbije, 2022) is encouraging, as well as the increasing public interest in a circular economy recorded year by year, according to the exponential growth in the number of related articles in written media, as well as the number of conferences and workshops organized (Mihajlov *et al.*, 2019).

During the Stabilization and Association Process, EU directives represent principal non-binding guidelines for the Serbian administration refer to when devising contemporary legislation, such as national strategies and roadmaps on specific issues that are defined accordingly. More detailed programs or action plans may specify key elements, priorities, and methodologies for further application. A framework for the binding development of national, regional, and local laws and regulations is thus formed in order to operationalize the efforts. The following section presents the development path through the adopted strategies and laws important for the implementation of the circular economy in the Republic of Serbia and surrounding region.

At the Western Balkans Summit in Sofia on November 10, 2020, an agreement was signed in which the Western Balkan countries, including the Republic of Serbia, recognized the European Green Deal (Figure 2) as a new growth strategy of the European Union, for a modern, climate neutral, competitive, and resource-efficient economy. Thus, they laid the foundation for a major transformation of the region, which can turn the challenges of sustainability and flexibility into opportunities, and transfer elements of the European Green Deal to all interlinked priority sectors (Regional Cooperation Council, 2020). In accordance with this, the Circular Economy Action Plan, as a supporting document of the European Green Deal, will be analyzed as the most relevant document for the further economic development of the Republic of Serbia and the region, followed by the Roadmap for Circular Economy in Serbia, adopted in the same year by the Ministry of Environmental Protection (Mapa puta za cirkularnu ekonomiju u Srbiji, 2020).

Adopted in March 2020, the Circular Economy Action Plan (CAP) is the EU's industrial strategy to address two challenges: green and digital transformation. The purpose of the new action plan is to modernize the EU economy and to take advantage of the opportunities of the circular economy at national and international levels. The main goal of the

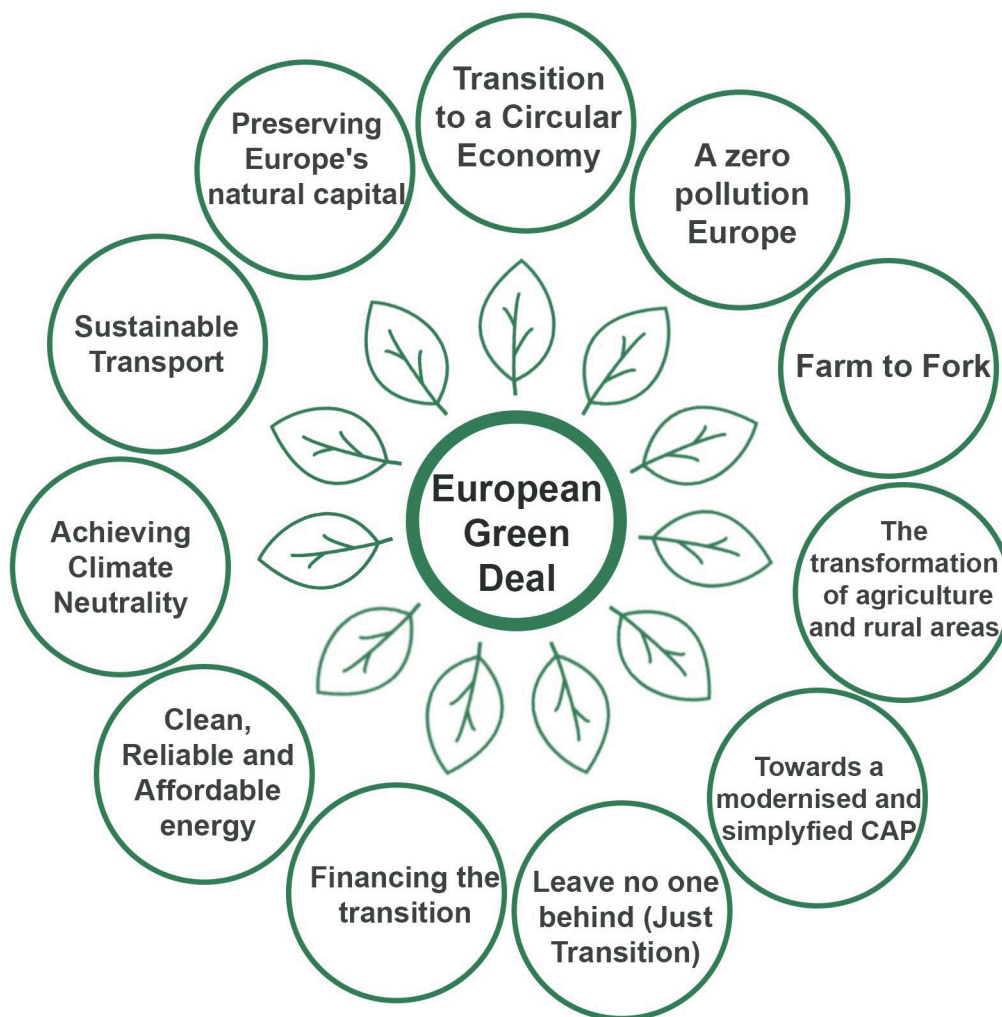


Figure 2. Goals of European Green Deal
(Source: Jana Petrović)

new policy framework is to encourage the development of leading markets for climate-neutral and circular products, both in the EU and beyond (European Commission, 2020a).

Designing sustainable products

The Circular Economy Action Plan includes a policy of “designing sustainable products” as a support to the circular design of all products, based on a common methodology and principles whose priority is to reduce and reuse materials before recycling. In this way, new business models are encouraged, and methods are defined to prevent the placing environmentally harmful products on the market, while increasing the responsibility of producers. Although the action plan is intended for the transition of all sectors, the action is especially focused on resource-intensive sectors. They are the textile, electronics and plastics sectors, in addition to the particularly influential sector of construction and buildings (European Commission, 2020a).

Empowering consumers and public buyers

The Circular Economy Action Plan also includes measures to encourage companies and enable consumers to choose durable, repairable products that can be reused. Furthermore, the Action Plan includes a requirements analysis for the “right to repair” and a change in the common concept of obsolescence of devices, especially electronic ones. Consumer protection policy should help people make well-founded decisions and take an active role in the ecological transition. New business models based on renting and sharing goods and services should be included if they are truly sustainable and affordable (European Commission, 2020a).

Circularity in production processes

Circularity is an essential part of the wider industrial transformation towards climate neutrality and long-term sustainability. It can provide significant savings in materials and production processes, increasing overall value and enhancing economic opportunities. Methods of achieving circularity include: assessing the possibilities for further promotion of the circular economy in industrial processes through examples of best practice on the best available techniques; development of evaluation and certification systems in production processes; supporting a sustainable and circular bio-sector through the implementation of the Bioeconomy Action Plan; promoting the use of digital technologies for monitoring and mapping resources, promoting the implementation of green technologies (European Commission, 2020a). Accompanied by the application of the framework for sustainable product policy, design methods, production and utilization should be radically changed, encouraging industry in the spirit of the circular economy and improvement of the digital sphere. A new industrial strategy for Europe is to support Europe’s dual transition to a competitive industry and enhance its strategic autonomy (European Commission, 2020d).

The Republic of Serbia adopted timely national strategies that were in line with official EU recommendations and directives, even before receiving the official candidacy for accession to the European Union on March 1, 2012. Those strategies included the National Program of Environmental

Protection (Službeni glasnik RS, br. 12/2010), the Waste Management Strategy (Službeni glasnik RS, br. 29/2010), the National Environmental Approximation Strategy (Službeni glasnik RS, br. 80/2011), and the National Strategies for Sustainable Use of Natural Resources and Goods (Službeni glasnik RS, br. 33/2012), which established the method of acknowledging universally adopted principles and policies regarding environmental treatment in the European Union, even though some of them were later replaced by more recent documents.

The Law on Environmental Protection (Službeni glasnik RS, br. 135/2004, 36/2009, 36/2009 - dr. zakon, 72/2009 - dr. zakon, 43/2011 - odluka US, 14/2016, 76/2018, 95/2018 - dr. zakon i 95/2018 - dr. zakon) defines a system of environmental protection which includes all levels of government, legal entities, and individuals. Their responsibility for any activity that affects or may affect the environment negatively is clearly determined, as well as the consequences for failing to take environmental protection measures in accordance with this law. It strongly emphasizes the necessity of raising awareness of the importance of environmental protection through the activities of governing bodies, public institutions and associations, the system of education, scientific research, and public information. Mutual coordination in decision-making and implementation is important, along with international cooperation. The majority of the basic principles in this law were taken from the National Program of Environmental Protection. It defines sustainable management of natural heritage through planning, control, and protection. Waste management implies acting within the system of collection, including preparation for reuse of the waste. These measures are primarily aimed towards preventing or reducing waste generation, as well as reuse and recycling, the separation of raw materials, and use of waste as an energy source, which highlight the need for adapting the concept of a circular economy.

Therefore, the Roadmap for the Circular Economy of the Republic of Serbia (*Mapa puta za cirkularnu ekonomiju u Srbiji*, 2020) is one in a series of documents prepared by the Republic of Serbia that introduced EU principles and directives into national regulations during the process of Stabilization and Association to the European Union. It introduces the notion of a circular economy into Serbian national regulations in order to encourage society to thoroughly change its “thinking, culture and attitudes towards resources”, thus committing to changing public policies and dialogues. It is necessary to promote the application of circular business models that aim to create new jobs and improving business in Serbia through the implementation of sustainable solutions.

However, the utilization of the circular economy is still based on a few individual examples of good practice, mostly due to insufficient information and understanding of the concept, unavailability of funds, grants and subsidies, and consumer culture. Waste is characterized as problematic, given the “inadequate and outdated” waste management policy with unresolved issues from the past and problems in the application of regulations. In addition, the market for secondary raw materials is undeveloped and there is a low

level of awareness of the potential of waste as a raw material for production (*Mapa puta za cirkularnu ekonomiju u Srbiji*, 2020).

It is clear that the introduction of the circular economy requires a “multi-layered and multi-sectoral integration of national public policies and regulations” in order to create favorable conditions for investment, but also a consensus on the part of executive authorities on creating a “policy of sustainable use of resources in the context of circular economy”. Furthermore, two parallel transitions are defined: the transition to a circular economy and digital transformation, which are mutually assisted. Priority is given to the use of renewable energy sources with efficient use, innovative technologies, green public procurement, replacement of hazardous substances, and changes in consumer habits in Serbia (*ibid.*).

CONSTRUCTION AND THE CIRCULAR ECONOMY

The construction industry is considered to be one of the most environmentally harmful industries in the world, which has a direct impact on how raw materials are processed and used, the life cycle of buildings, and the impact on the overall environment. However, the construction sector is still in the early stages of transition from a linear to a circular economy (Bertino *et al.*, 2021). In the 1990s, buildings were responsible for 40% of the use of material resources and a third of the energy consumed globally (Pomponi and Moncaster, 2017). Three decades later, the construction sector is still one of the world’s largest consumers of raw materials and carbon dioxide emissions. Globally, buildings are responsible for 40% of the total registered waste (by volume), 40% of the total use of material resources (by volume) and 33% of the total emissions of gases caused by human activities (Eberhardt *et al.*, 2020).

According to a European Commission report, it is estimated that the construction sector is responsible for over 35% of total waste generation in the EU. Additionally, greenhouse gas emissions from material exploitation, production, construction, and reconstruction account for 5-12% of total emissions. By using materials that have higher efficiency, those figures could reduce up to 80% of greenhouse gas emissions (European Commission, 2020a).

Improvement strategies include the transition to a circular economy, which will have a positive impact on achieving climate neutrality, energy efficiency of buildings, efficiency of materials and construction waste management, also extending the lifecycle of buildings. Some of the circular economy principles include: the use of recyclable construction products or those produced from recycled raw materials; promoting measures to increase the lifecycle of buildings; implementing lifecycle assessment in public procurement; establishing legislative frameworks for construction waste management; promoting initiatives to reduce soil pollution through the rehabilitation of abandoned brownfields, and increasing the safe, sustainable, circular use of excavated soil (European Commission, 2020a). Extending the life cycle of buildings implies a “closed loop system” in which all elements and materials are optimally used and maintained at their highest value (Rahla *et al.*, 2021).

The regulation for determining conditions for placing construction products on the market was established in 2011 (European Union, 2011). Sustainable use of natural resources is implied within the basic requirements for construction works; however, particular attention should be paid to recyclability and reusability, durability of construction works, and the use of environmentally friendly raw materials and secondary materials. The Law on Construction Products of the Republic of Serbia (Službeni glasnik RS, br. 83/2018) is based on the stated principles, and indicates the beginning of digitalization of the sector, following the trend of digital transition, by means of “electronic contact points for construction products”, as a way of providing information on technical regulations in force, competent authorities and legal means. On the other hand, the law indicates the life cycle of construction products as a sequence of consecutive and interconnected phases of life, spanning from obtaining the raw materials or production to their permanent disposal, which demonstrates the presence of linear thinking in the economic regulations for production in Serbia that are still in force. Furthermore, it emphasizes the importance of enhancement according to the current knowledge and policy harmonization.

The comprehensive goals of a circular economy in architectural design and construction practice can be summarized as reduction of waste, optimization of material use, control of the impact of design, and a choice of materials that consider the environment throughout the lifecycle of a building (European Commission, 2020b). To achieve these goals, all actors in the process of construction and use of buildings (users, designers, contractors, manufacturers, investors, and regulating authorities) must respect the principles of a circular economy, three of which stand out as the most dominant:

- Durability: medium length to long term planning for the life of buildings, as well as all associated elements (materials, installations, etc.);
- Adaptability: prolonging the lifespan of buildings, in terms of repurposing their function, including changes of usage for certain elements; and
- Waste reduction and enabling high quality waste management: future circular use of construction materials, products and parts should be enabled, with a focus on waste reduction and the potential for reuse or high-quality recycling after reconstruction or adaptation. This process includes: 1) reusing or recycling materials so that most of the value of the material is retained and restored at the end of the life of the building; and 2) design of parts and use of different construction methods in order to influence reuse or recycling (European Commission, 2020b).

Considering the prominence of waste management as a means of enabling the circular economy (Mihajlov *et al.*, 2021), it is important to consider the current Waste Management Program of the Republic of Serbia for the Period 2022-2031 (Službeni glasnik RS, br. 12/2022), recognizing the interconnection, preceded by the Waste Management Strategy 2010-2019 (Službeni glasnik RS, br. 29/2010) that set an integrated waste management system but resulted in insufficient recycling rates and application

of economic instruments. With the vision of controlling waste generation, waste recovery and economic incentives by applying the circular economy, the program anticipates reducing environmental pressures and improving the quality of life. In that sense, it defines general and specific objectives, as well as measures and instruments, such as necessary infrastructure, economic instruments, and performance indicators for monitoring implementation of the program. With classification of waste being based on its content and industry, waste from construction and demolition, which is of particular interest to us, has been identified as a special waste stream that requires specific regulations, since only metal waste has been collected on a larger scale, in contrast to very small amounts of other components.

Furthermore, in the Republic of Serbia, building construction is one of the sectors with the highest greenhouse gas emissions after the energy sector, manufacturing, and transport (*Mapa puta za cirkularnu ekonomiju u Srbiji*, 2020). Five areas have been defined to represent the key for implementation of the circular economy, which would contribute to the missing reduction of global greenhouse gas emissions, following decarbonization of the energy sector by switching to renewable energy sources. These areas include cement, plastic, steel, aluminum, and food, four of which are closely related to the construction industry. Therefore, construction in Serbia is one of the primary sectors selected for the transition to a circular economy, and for applying this concept in the fastest and most adequate way, based on its recognized potential. Two segments have been singled out: construction from environmentally friendly materials with the application of circular design, and reduction of demolition and construction waste.

It is possible to recycle up to 80% of construction waste, but in Serbia the quantity recycled is unknown, since there are no suitable landfills for this type of waste, and so it is mixed with other waste. This certainly does not mean that construction waste landfills should be planned, because, in the spirit of the circular economy, their use should be considered with the aim of eliminating waste through sustainable business models. Specific recommendations are the adaptation and reconstruction of buildings in order to eliminate waste, the promotion of sustainable construction, and the use of environmental materials (*ibid.*).

RENOVATION WAVE AS A CIRCULAR MODEL FOR BUILDING STOCK MANAGEMENT

Renovation is one of the circular economy strategies to prevent waste generation in construction, and also one of the key strategies for achieving climate neutrality. According to the *Renovation Wave* document (European Commission, 2020c), the reason for considering launching such an endeavor is due to several facts: most of the existing buildings units in the EU do not meet minimum requirements for energy efficiency, about 85% of them were built before 2001, and 85-95% of them will still exist in 2050. The current renovation rate of 11% in the EU does not entail an improvement in energy performance, which is estimated to be present at only about 1%. At the same time, *deep* renovations, which reduce energy consumption by over 60%, are performed on about 0.2% of the building

stock annually. Such renovations are expected to reduce the pressure for greenfield construction, thus supporting the preservation of nature, biodiversity, and valuable agricultural land.

The key principle for building renovation is 'energy efficiency first', followed by affordability, decarbonization and integration of renewables, circularity, high standards of health and environmental protection, green and digital transition, respect for aesthetics and quality of architecture. According to the existing regulations in these fields, the minimum conditions and efficient targeted investments have yet to be determined, along with education and promotion of the sustainable built environment (European Commission, 2020c).

Improvement of the building stock is mainly focused on renovating structures with the weakest performance – which includes a fight against energy poverty in regulatory, structural, financial and any other sense; and renovating public buildings, such as administrative, educational, and health facilities – in order to improve them, as well as to promote the concept (*ibid.*).

MATERIAL ASPECTS OF IMPROVING THE BUILDING STOCK IN SERBIA

The Directives on the energy performance of buildings and energy efficiency, adopted during 2010 and 2012 are still valid in the European Union (European Union, 2010; European Union, 2012). The methodology of calculating energy performance includes thermal characteristics, heating and air-conditioning, energy from renewable sources, elements of passive heating and cooling, shading, indoor air quality, natural light and the building's design. According to existing EU standards, energy performance calculations throughout the year, and not only during the heating season, show the energy to be consumed for the needs of the building annually – heating, cooling, domestic hot water, etc. The aspects affecting the material component most directly, and are included in the calculation of energy performance, are the thermal characteristics of the structure, such as heat capacity and insulation. The importance of energy efficiency and energy improvement of the existing building stock lies in preserving the buildings and their material values, as well as prolonging their lifecycle. Based on the energy performance, buildings receive an energy certification, for which there is a basic mechanism of implementation and control. Holders of public authority "should lead by example" and apply recommendations for improving energy efficiency in public buildings. European funds help promote advocacy for *green technologies* and the development of energy efficient systems and materials for new and renovated structures. They are applied at national, regional, and local levels for the EU Member States (European Union, 2010).

The 2012 directive defines the notion of energy efficiency, which decreases the primary energy consumption, thus reducing energy imports and enhancing the security of energy supply. It also directly lowers greenhouse gas emissions and mitigates the effects of climate change. Accelerating the development of innovative technical solutions strengthens economic growth and creates new

business opportunities. In quantitative terms, energy efficiency is the ratio of performance, services, supplies, or energy to energy intake. It is especially important to set energy performance requirements for the elements that form part of the building envelope (European Union, 2012).

The latest such directive, passed in 2018, through its amendments, in particular predicts general decarbonization of the building stock by 2050, while acknowledging the minimum requirements for energy performance according to local regulations both for new and renovated buildings (European Union, 2018).

Buildings that are under legal protection, such as cultural monuments, represent an exception to this rule, where the application of energy efficiency regulations is not mandatory while performing interventions. However, due to awareness of the necessity for improving the building stock, "Guidelines for improving the energy performance of historic buildings" were given in 2016, in the form of the European Standard for Conservation of Cultural Heritage (European Standard, 2016), which was subsequently adopted in Serbia. It serves as an addendum to existing energy performance standards for construction, with a focus on the specific qualities that these structures possess as immovable tangible cultural heritage. The guidelines can be applied to a wide range of structures that need special consideration of energy performance, building use and conservation, in order to find a sustainable balance. They include a systematic approach to individual situations, for the purpose of reaching the most optimal solution and selecting appropriate measures in each particular case, with an assessment of the impact of selected procedures on the preservation of "character-defining elements" of the said heritage.

In terms of general regulations in the field of building construction in Serbia, the principal legislation is the Law on Planning and Construction (Službeni glasnik RS, br. 72/2009, 81/2009 - ispr., 64/2010 - odluka US, 24/2011, 121/2012, 42/2013 - odluka US, 50/2013 - odluka US, 98/2013 - odluka US, 132/2014, 145/2014, 83/2018, 31/2019, 37/2019 - dr. zakon, 9/2020 i 52/2021). According to this law, one of the basic principles for organizing and using space is the principle of sustainable development through an integrated approach to planning. It represents harmonization of all aspects of development, rational use of non-renewable resources and providing conditions for substantial use of renewables. Sustainable construction is ensured by applying technical measures, standards and requirements in all phases of planning, design, construction and the use of structures and spaces. Energy properties of a building should enable energy savings by reducing consumption of all types of energy. Construction products and materials should meet the requirements specified by law and special regulations, as well as basic requests regarding buildings, and technical demands in specific fields. An integrated procedure that includes use of a digital platform for submission of technical documentation and applications throughout all phases of planning and construction, not only contributes to efficient ruling in particular cases, but also supports the digital transition in one of its most influential spheres.

The Rulebook on Energy Efficiency (Službeni glasnik RS, br. 61/2011) is the current regulation of the Republic of Serbia which sets technical requirements and parameters related to the energy properties of new and existing structures. These requirements are important for the circular model of improving the built environment, as well as its comfort conditions. The rulebook defines terms (physical quantities, labels, units, indexes) and their values used for calculating all aspects of energy properties and consumption. It includes a method for determining the thermal properties of buildings and specifies the contents of energy efficiency studies, as they are a mandatory part of the technical documentation intended for acquiring permits for construction or intervention on existing structures. It also introduces the concept of energy rehabilitation, which is aimed at increasing the energy efficiency of existing buildings. The process must not affect the stability or safety of buildings, or the fire protection and environmental protection, but it can change the exterior appearance, if the necessary approvals are obtained. Major renovation, in accordance with European standards, means performing adaptation or rehabilitation works with an estimated value of at least 25% of the value of the building (land included), or subjecting a minimum of 25% of the envelope to energy rehabilitation.

The Rulebook on Conditions, Content and Manner of Issuance of Certificates of Energy Performance of Buildings (Službeni glasnik RS, br. 69/2012 i 44/2018 - dr. zakon) prescribes the process of building certification after passing building inspection, as part of the technical documentation needed for obtaining a use permit. It introduces the concept of energy classes to indicate the energy performance of buildings in the standardized form of an Energy Passport, for residential, non-residential or other buildings that use energy. A class of C or higher is obligatory for all new buildings, whereas improvement by at least one class is required for energy rehabilitation and other interventions.

TREATMENT OF MATERIALS WITHIN THE CONCEPT OF A CIRCULAR ECONOMY

As previously stated, the overall goals of a circular economy in architectural and construction practice can be summarized as: reducing waste, optimizing the use of materials, and controlling the impact of design and choice of materials on the environment during the life cycle of a building (European Commission, 2020b). Correspondingly, the treatment of materials in reconstruction and adaptation can be carried out through two methods:

- recycling of existing (found) materials or construction elements – waste becomes a resource;
- using recyclable materials where recycling of previously applied materials is not possible.

Recycling existing materials or building elements implies a complex series of activities, whose long-term goal is to extend the life of the building without negative impacts on the environment. According to Blomsma (Blomsma, 2016; Blomsma *et al.*, 2018) some of the mentioned activities include:

- **Direct reuse** of the same material or element without any additional intervention. In the process of

reconstruction and adaptation of buildings, this type of use can be interpreted in two ways: material or elements intended for demolition can be implemented in a new design without additional processing (example: reuse of bricks in landscaping as a type of paving) or sold through product sharing platforms. The application of this principle enables a positive economic and environmental effect – savings are made through the quantity of materials used or earnings due to sales, and the environmental impact is reduced. Expenditure is mainly recognized as the cost of logistics, storage, or organizing exchange between clients;

- **Surface corrections** are made on products whose direct reuse is not possible, or they contain expendable parts that are expected to be further surface treated before reuse. From the architectural standpoint, the processes within this approach include dismantling, followed by surface corrections and reuse (example: a wooden roof structure in good condition can optionally be dismantled, surface treated and reused). The benefits of this principle are the same as those previously analyzed, while the costs of logistics can be reduced;
- **Reconfiguration** is the process by which a product is disassembled, and then assembled in a different configuration. It can be applied to most building materials such as wood, brick, concrete, and even glass. However, the efficiency of reconfiguration depends on the complexity of the process – in some cases the process may be more expensive than buying new and recycling old, so a cost-effectiveness analysis is needed (example: use of wooden structural elements in the production of urban furniture); and
- **Improvement – Innovation** is a special case of designing a product that would be able to be innovated in future life cycles. Therefore, in addition to the reconfiguration model that expands the range of product usability and prolongs the product life cycle, a time dimension is added, in which innovations are expected in the design of more complex products and a production base is set up to support new, more efficient, or multifunctional products. Important expenses of this system are market planning, as well as designing products that are resilient over an extended period of time, while a significant benefit factor is the creation of an ecosystem of products that is somewhat dependent on the primary manufacturer.

The use of recyclable materials is an alternative when none of the mentioned processes is possible. Their benefit is environmental by nature (recyclability), while the costs may be higher than the proposed systems previously analyzed.

CONCLUSION

The official position of the European Commission is that use of the circular economy will contribute to achieving climate neutrality by 2050, as well as provide regenerative growth in the form of returning resources to the planet, limiting consumption, and reducing the ecological footprint (European Commission, 2020a). The Republic of Serbia's recognition of the European Green Deal, as well as the Circular Economy Action Plan, its supporting document, came with

the obligation to adopt, develop, and apply the circular economy as a principle for further economic development. For that cause, a strategy has been established in the form of the Roadmap for the Circular Economy in Serbia, adopted by the Ministry of Environmental Protection. However, in practice, more significant results have been lacking and the application of the circular economy is still present only in a small number of separate examples. The following problems were identified as crucial: insufficient information and overall understanding of the concept, unavailability of funds, grants, and subsidies, consumer culture, inadequate waste management policy, and an underdeveloped secondary raw materials market (*Mapa puta za cirkularnu ekonomiju u Srbiji*, 2020).


Although there is a tendency in the Republic of Serbia to follow international legislation and adopt their equivalents within national regulations, practical barriers for implementation are evident, given the insignificant improvement of the building stock and the slight movement of the construction industry towards circular economy models. Despite these facts, the potential is great and there is a clear determination to raise awareness and apply the acknowledged principles. Improving the possibility of applying the principles of a circular economy in reconstruction and adaptation is feasible through:


- determining the conditions on the market for placing construction products which ensure recyclability and reusability, durability of construction works, use of environmentally compatible raw materials and secondary materials;
- using alternative sources of energy and ensuring minimum conditions for the energy efficiency of buildings; and
- promotion and education with regard to the circular economy as a sustainable economic model of the future.

European Union plans regarding construction materials, as well as harmonized national regulations of the Republic of Serbia, define not only the application of energy efficient materials and solutions, but also the entire process from extraction to the end of the use of finished products – in the spirit of the circular economy, maximizing opportunities for reuse and recycling, while minimizing the usage of raw materials, waste, and pollution. The circular economy model encompasses and merges different environmentally sustainable concepts, which makes it very important in terms of enabling a sustainable future. Promoting the application of circular business models enables the creation of new jobs and the improvement of business in Serbia through the application of sustainable solutions.

ORCID

Jana Petrović  <https://orcid.org/0000-0002-7928-1655>

Jelena Pavlović  <https://orcid.org/0000-0001-7137-7735>

Ana Radivojević  <https://orcid.org/0000-0002-8145-4623>

REFERENCES

Adams, K. T., Osmani, M., Thorpe, A., Thornback, J. (2017). Circular economy in construction: current awareness, challenges and

- enablers, *Waste and Resource Management*, Vol. 170, No. 1, pp. 15-24. <https://doi.org/10.1680/jwarm.16.00011>
- Bertino, G., Kissler, J., Zeilinger, J., Langergraber, G., Fischer, T., Österreicher, D. (2021). Fundamentals of Building Deconstruction as a Circular Economy Strategy for the Reuse of Construction Materials, *Applied Sciences*, Vol. 11, No. 939, pp. 1-30. <https://doi.org/10.3390/app11030939>
- Blomsma, F. (2016). *Making sense of circular economy - how practitioners interpret and use the idea of resource life-extension*. (Doctoral dissertation, Centre for Environmental Policy, Imperial College London, London, UK). <https://spiral.imperial.ac.uk/handle/10044/1/47907> [Accessed: 20 Feb 2022].
- Blomsma, F., Kjær, L., Pigosso, D., McAloone, T., Lloyd, S. (2018). Exploring Circular Strategy Combinations - towards Understanding the Role of PSS, *Procedia CIRP* 69, Vol. 69, pp. 752-757. <https://doi.org/10.1016/j.procir.2017.11.129>
- Bonciu, F. (2014). The European economy: From linear to circular economy, *Romanian Journal of European Affairs*, Vol. 14, No. 4, pp. 78-91.
- Eberhardt, L. C. M., Birkved, M., Birgisdottir, H. (2020). Building design and construction strategies for a circular economy, *Architectural Engineering and Design Management*, Vol. 18, No. 2, pp. 93-113. <https://doi.org/10.1080/17452007.2020.1781588>
- European Commission (2012). *Manifesto for a resource-efficient Europe*. Brussels: European Commission.
- European Commission (2019). *The European Green Deal*. Brussels: European Commission.
- European Commission (2020a). *A New Circular Economy Action Plan For a cleaner and more competitive Europe*. Brussels: European Commission.
- European Commission (2020b). *Circular Economy Principles for Building Design*. Brussels: European Commission.
- European Commission (2020c). *A Renovation Wave for Europe – Greening of Buildings, Creating Jobs, Improving Lives*. Brussels: European Commission.
- European Commission (2020d). *A New Industrial Strategy for Europe*. Brussels: European Commission.
- European Standard (2016). *Conservation of Cultural Heritage - Guidelines for improving the energy performance of historic buildings*. Luxembourg: European Union.
- European Union (2010). *Directive 2010/31/EU on the energy performance of building (recast)*. Official journal of the European Union, Vol. L 153, pp. 13-35.
- European Union (2011). *Regulation (EU) laying down harmonized conditions for the marketing of construction products and repealing Council Directive 89/106/EEC*. Official Journal of the European Union, Vol. L 88, pp. 5-43.
- European Union (2012). *Directive 2012/27/EU on energy efficiency*. Official journal of the European Union, Vol. L 315, pp. 1-56.
- European Union (2018). *Directive (EU) 2018/844 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency*. Official journal of the European Union, Vol. L 156, pp.75-91.
- Laumann, F., Tambo, T. (2018). Enterprise Architecture for a Facilitated Transformation from a Linear to a Circular Economy, *Sustainability*, Vol. 10, No. 3882, pp. 1-16. <https://doi.org/10.3390/su10113882>
- Mapa puta za cirkularnu ekonomiju u Srbiji* (2020). Beograd: Ministarstvo zaštite životne sredine.
- Mihajlov, A., Mladenović, A., Jovanović, F. (2019). *Circular economy in Serbia: process started*. Belgrade: Environmental Ambassadors for Sustainable Development (EASD).
- Mihajlov, A., Mladenović, A., Jovanović, F. (2021). Country in Transition (Serbia) Case: Circular Economy Starts from Waste Management, *Environmental Research & Technology*, Vol. 4, No. 1, pp. 83-88.
- Pomponi, F., Moncaster, A. (2017). Circular economy for the built environment: A research framework. *Journal of Cleaner Production*, Vol. 143, No. pp. 710-718. <https://doi.org/10.1016/j.jclepro.2016.12.055>
- Privredna komora Srbije (2022). *Stanje cirkularne ekonomije u Srbiji 2021/2022*. Beograd: Privredna komora Srbije.
- Rahla, K. M., Mateus, R., Bragança, L. (2021). Implementing Circular Economy Strategies in Buildings—From Theory to Practice, *Applied System Innovation*, Vol. 4, No. 26, pp. 1-14. <https://doi.org/10.3390/asi4020026>
- Regional Cooperation Council (2020). *Sofia Declaration on the Green Agenda for the Western Balkans*. Sofia: Regional Cooperation Council.
- Službeni glasnik RS (br. 12/2010). *Nacionalni program zaštite životne sredine* (in Serbian). Belgrade: JP „Službeni glasnik“.
- Službeni glasnik RS (br. 29/2010). *Strategija upravljanja otpadom za period 2010-2019. godine* (in Serbian). Belgrade: JP „Službeni glasnik“.
- Službeni glasnik RS (br. 80/2011). *Nacionalna strategija za aproksimaciju u oblasti životne sredine za Republiku Srbiju* (in Serbian). Belgrade: JP „Službeni glasnik“.
- Službeni glasnik RS (br. 61/2011). *Pravilnik o energetske efikasnosti objekata* (in Serbian). Belgrade: JP „Službeni glasnik“.
- Službeni glasnik RS (br. 33/2012). *Nacionalna strategija održivog korišćenja prirodnih resursa i dobara* (in Serbian). Belgrade: JP „Službeni glasnik“.
- Službeni glasnik RS (br. 135/2004, 36/2009, 36/2009 - dr. zakon, 72/2009 - dr. zakon, 43/2011 - odluka US, 14/2016, 76/2018, 95/2018 - dr. zakon i 95/2018 - dr. zakon). *Zakon o zaštiti životne sredine* (in Serbian). Belgrade: JP „Službeni glasnik“.
- Službeni glasnik RS (br. 83/2018). *Zakon o građevinskim proizvodima* (in Serbian). Belgrade: JP „Službeni glasnik“.
- Službeni glasnik RS (br. 69/2012 i 44/2018 - dr. zakon). *Pravilnik o uslovima, sadržini i načinu izdavanja sertifikata o energetske svojstvima zgrada* (in Serbian). Belgrade: JP „Službeni glasnik“.
- Službeni glasnik RS (br. 72/2009, 81/2009 - ispr., 64/2010 - odluka US, 24/2011, 121/2012, 42/2013 - odluka US, 50/2013 - odluka US, 98/2013 - odluka US, 132/2014, 145/2014, 83/2018, 31/2019, 37/2019 - dr. zakon, 9/2020 i 52/2021). *Zakon o planiranju i izgradnji* (in Serbian). Belgrade: JP „Službeni glasnik“.
- Službeni glasnik RS (br. 12/2022). *Program upravljanja otpadom u Republici Srbiji za period 2022-2031. godine* (in Serbian). Belgrade: JP „Službeni glasnik“.