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Energy Retrofitting Opportunities Using Renewable Materials—Comparative Analysis of the Current Frameworks in Bosnia-Herzegovina and Slovenia

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Abstract: Sustainable approaches for retrofitting buildings for energy efficiency are becoming necessary in a time when the building sector is the largest energy consumer. Retrofitting building stock is effective for reducing global energy consumption and decreasing resource exploitation. Less developed EU member states and neighboring developing countries show reluctance towards healthy and renewable materials. Implementation of sustainable materials for energy retrofitting is slowed down due to gaps in legislation and effective strategic programs, availability of bio-based materials, lack of knowledge regarding use and maintenance of renewable products, and marketing lobbies. Use of bio-based materials in refurbishment is important due to their negative or low global warming potential (GWP), low primary energy (PEI) need for production, cost-effective benefits, and recycling/reuse potential. Role of environmentally friendly solutions and low-carbon economy growth is particularly relevant in developing countries, such as Bosnia-Herzegovina, that cannot afford innovative energy recovery systems, yet possess a significant amount of poorly managed building stock. This research aims to analyze frameworks regarding retrofitting of residential buildings in Bosnia-Herzegovina and Slovenia. The analysis tackles indirect causes, studies the legal background, and examines strategic frameworks; thus, it indicates potential barriers for implementation of recommended retrofitting solutions based on renewable materials.

Keywords: legal framework; developing countries; existing building stock; energy efficiency; energy consumption; timber; renewable materials

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1. Introduction

A considerable proportion of existing building stock in former Yugoslavian countries was constructed before the introduction of energy use reduction demands. The energy performance of these facilities cannot fulfil necessary conditions such as the *U* value for transparent and opaque envelopes or indoor environment comfort parameters. Moreover, poor building maintenance and low environmental awareness are additional contributors to elevated energy demands. Therefore, the necessity for deep energy retrofit is indispensable and includes not only technical solutions, but also systematic approaches in occupant behavior and legislative support.

Energy retrofitting is considered to be one of the most effective measures for reducing energy consumption in building stock [1], which represents around 38% of all energy consumers in the European Union (EU) [2]. In 2010, according to the Intergovernmental Panel on Climate Change (IPCC), buildings were responsible for around 32% of global final energy consumption and around 19% of all global greenhouse gas (GHG) emissions [3,4]. According to the same source, around 32% of final energy consumption by end users in a residential building goes to space heating [3]. According to data from 2018, the building sector is responsible for almost 36% of the global final energy and 40% of carbon dioxide emissions [5,6]. In the EU, buildings consume 40% of all energy, and the share of related GHG emissions is 36% [7]. These numbers show that a significant amount of GHG emissions can be reduced by the strategic implementation of building energy retrofit by reducing necessity for stated amounts of energy needed for heating.

The retrofitting process starts with whole building analysis, and it aims to reduce energy consumption and improve buildings' structural stability, integrity, and aesthetics, as well as to prolong buildings' life cycles, enhance indoor thermal and air comfort, and provide a healthier environment for occupants. The concept of environmental improvement to which buildings and occupants belong, as well as their built environment, needs to be adopted in order to achieve a balance of interaction between that environment and development. From the perspective of occupants of residential buildings, they agree that green practices in building refurbishment can provide a better lifestyle in terms of safety and health [8]. Deep energy retrofit process is crucial for developing countries due to poor energy efficiency in the existing building stock and their influence on total energy production, mostly from non-renewable and health-risk sources. Thus, the process of building energy analysis and retrofitting should lead to a resilient system of healthy living environments.

The life cycle cost (LCC) analysis results indicated that investing in energy-efficient retrofitting techniques is more cost-effective than renewable energy source investments in the long term. This suggests that the initial investment in energy-efficient renovation is the primary factor in the LCC of an existing building [9].

When the EU first introduced energy certification for buildings, the energy performance indicator of buildings was calculated based on the energy need for heating ($Q_{H,nd}$). The primary goal was to assess the actual condition of buildings and their energy efficiency, potentially resulting from the construction and materialization of the building envelope [10]. However, assessment of cost effectiveness in terms of energy retrofitting is not realistic in the case of residential buildings, such as multifamily houses (MFH) and apartment buildings (AB), which are used by many occupants and have undergone various self-initiated changes due to the behavior of apartment owners. To encourage investments in retrofitting buildings, it is important that owners are well informed that the initial investment in energy efficiency of complete building envelopes will result in future savings from lower energy needs and increased market value of the building due to the implicit effect of the energy rating improvement [11].

Implementation of energy efficiency measures is expected to decrease the operation energy use of new and retrofitted buildings. Retrofitting measures contribute to save between 30 and 80% of operation energy in the remaining life of retrofitted buildings. The impact on the non-operation energy use of retrofitted buildings is largest when materials is used with the highest material quantity. In particular, wood and other bio-based materials used as building cladding and thermal insulation positively contribute toward this, considering the additional possibility of energy recovery at the end of their service life. The non-operation primary energy use can vary significantly depending on the choice of materials for thermal insulation, cladding systems and windows. The efficient post-use management of building materials is important for reducing the total primary energy use of retrofitting buildings. The effects of using different building materials (insulation materials, façade systems and glazing components) for retrofitting existing buildings to passive house standard was studied by Piccardo et al. in Sweden. They analyzed the complete life cycle in retrofitting a building, including production, operation, maintenance and end-of-life stages. Although the operation energy use decreases by 63–78%, they found that the non-operation energy for building retrofitting accounts for up to 21% of the operation energy savings, depending on the passive house performance level and the material alternative. A careful selection of building materials, especially wood-based materials, was suggested due to the potential reduction of the non-operation primary energy by up to 40% [12].

Wood and other renewable materials, especially from sustainably managed forests, are an ideal material for the circular bioeconomy [13]. At the same time, renewable materials help to reduce the amount of carbon dioxide in the atmosphere, and thus contribute to mitigation of climate change. Wood production and processing requires much less energy than other materials (such as steel, concrete, glass, and plastic). The increased use of wood in the production of durable goods could be considered a logical, convenient, technologically simple, and socially acceptable path towards a low-carbon society and a circular economy [14]. A large volume of durable wood can be used in buildings (construction and roof elements, interior furnishings) because their life span is the longest [15]. The other field where it is possible to used bio-based materials to improve the energy efficiency indicators and reduce emissions is in the energy refurbishment of building envelopes [16]. The use of wood and other renewable materials presents an opportunity for developing countries on the path to reducing energy consumption and the resulting carbon dioxide emissions.

According to the available data, current land coverage by forests in Slovenia has increased, and was around 61.97% in 2016; however, in Bosnia-Herzegovina (B&H), this percentage has considerably decreased over the years, and was around 42.676% in 2016 [17]. This scenario can be explained by unconscious export of wood products from B&H, mostly in the form of logs and not processed timber [18]. According to the same source, it is noticeable that production of other wood-based products, such as cellulose fiber thermal insulation, is not present or is not analyzed; thus, wooden industry in B&H is oriented towards export of raw and unprocessed wood and unconscious exploitation of forest natural resources.

In this manuscript, analysis of two frameworks will be shown with special emphasis on the presence of renewable and healthy materials and their incorporation in analyzed action plans and strategies. For energy efficient retrofitting and use of building materials in general, it is necessary to know the regulatory framework related to building materials that influence the energy characteristics of a building envelope.

Article 4 of Directive 2012/27/EU on energy efficiency defines the need to develop and adopt a long-term strategy to encourage investment in the reconstruction of housing and commercial, public and private buildings [19]. All of the EU member states, including Slovenia, but also B&H, which is not a member state, by signing the Energy Community Treaty, have pledged to assume the obligations of harmonizing the legal framework within the EU energy sector [20]. Both countries adopted the Building Renovation Strategies Draft in 2018 [21] and 2019 [22].

These strategies do not emphasize the refurbishment of building envelopes by renewable products and materials, only the use of renewable energy sources. Due to its membership in the EU, Slovenia certifies construction products and materials. Since January 2018, the Environmental Product Declaration—EPD—has been recommended, which encourages the use of renewable materials [23]. Green public procurement rules recommend that timber walls contain at least 10% recycled wood and new buildings contain at least 30% wood in the total volume of all construction materials used. In addition, high environmental standards for public procurement procedures, including construction of new public buildings and refurbishment of existing ones, are set [24]. The differences among strategies related to improvement of energy efficiency of buildings in neighboring countries was motivation for preparing this manuscript. The current situation in both countries is compared with an emphasis on factors that influence investment in use of renewable materials for building retrofitting. This research also has the indirect purpose of providing a good practice example for analogous analyses that might be performed in other developed countries. It is expected that the presented methodology will stimulate evaluation of recent practice towards compatibility with future law legislative and strategic plans of EU research and innovation programs (Figure 1).

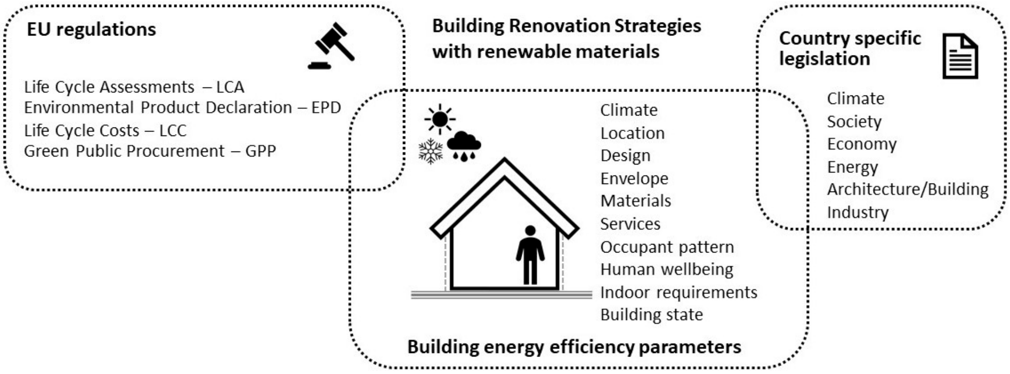

Figure 1. Building renovation strategies with renewable materials. Source: Authors' figure.

2. Strategies and Legislation Developed and Implemented in Bosnia-Herzegovina and Slovenia

2.1. Bosnia-Herzegovina Case

Energy intensity, defined as a measure of the energy inefficiency of an economy, is calculated as units of energy per unit of GDP. The energy intensity of B&H was estimated at 0.42 tonnes of oil equivalent (toe)/1000 USD of GDP according to data from the International Energy Agency from 2018 [25]. This is four times higher than the average in European Union and OECD member countries. Moreover, the average European country generates four times more national income for the same amount of energy consumed in B&H. According to the same source, B&H has ten times lower GDP and consumes three times less primary energy per capita compared to EU countries. The reasons for this are that B&H has a low standard of living and has an underdeveloped industry. The energy intensity of B&H was similar to Serbia and Bulgaria five years ago, but from 2018, it is getting poorer. Since 2018, B&H has the worst energy intensity of all the countries of the former Yugoslavia (e.g., Serbia [0.35], North Macedonia [0.24], Montenegro [0.23], Croatia [0.15], and Slovenia [0.14]). Compared to the best energy intensity, which was calculated for Switzerland (0.03), the differences are high. In addition, the final energy consumption in B&H is highest in the building sector, where 64% of energy is spent on space heating, while the remaining 36% is used for lighting, electrical appliances, cooking (66% of electricity), and hot water preparation (89% of electricity). In the first national action plan for energy efficiency from the 2012 analysis, energy consumption was 5% lower in the sector of residential buildings (Figure 2) [26]. This may be due to decreased energy consumption in the industrial sector.

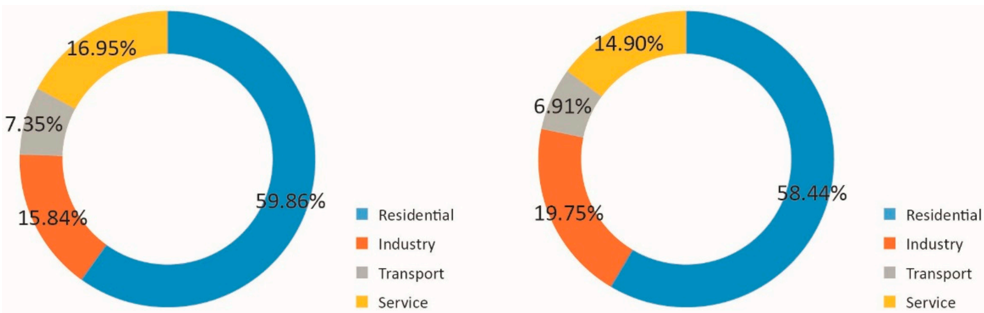

Figure 2. Energy consumption for 2010 by sectors in Bosnia-Herzegovina (**left**) and by sectors in Republika Srpska (**right**) [27].

According to data from the Energy Balance of Republika Srpska for 2019, there was almost identical consumption to that in 2010 in the building sector, while it increased in transport and industry (Figure 3). This latest energy balance also highlights the increase in final energy consumption from heating wood to 33.68% and the decrease in liquid fuels to

30.45%, which may indicate a decrease in total carbon dioxide emissions generated in the Republika Srpska.

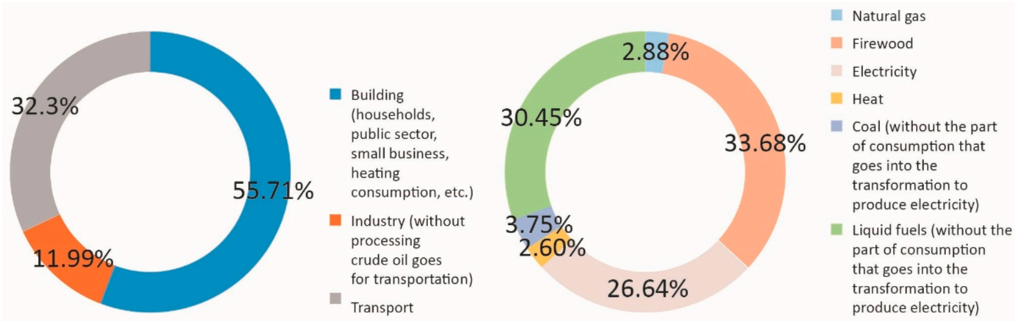

Figure 3. Share of energy use (**left**) and energy sources (**right**) for Republika Srpska according to the Energy Balance Plan for 2019 [28].

The original data on energy and energy consumption of the entities of Bosnia-Herzegovina (the Republika Srpska and the Federation of Bosnia-Herzegovina) can be followed from the balance plans from the official websites of the competent ministries. However, in order to present and compare the whole energy consumption of B&H and Slovenia, data from the International Energy Agency will be presented.

Figure 4 shows that after eight years, energy production in B&H increased from 6811 thousand tonnes of oil equivalent (ktoe) to 7865 ktoe. This is interesting, because in 2018, for the first time, B&H reported the production of renewable sources (wind, solar, etc.), which accounted for 0.14%. The share of energy from biofuels increased by over six times. However, B&H still has the largest share of coal and oil for energy production, at 53.78% and 21.41%, respectively. According to the data of the Statistical Office of B&H, for 2018 the energy supply amounted to 7766 ktoe, of which only 73.6 ktoe were imported and 213.3 ktoe were exported [29].

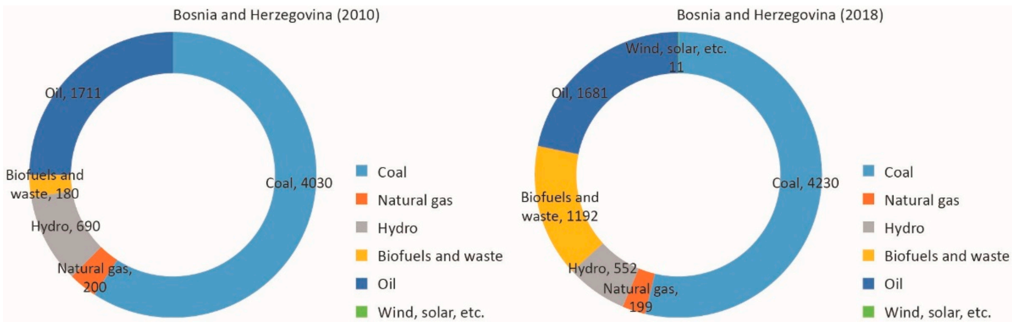

Figure 4. Energy sources used in Bosnia and Herzegovina in 2010 (**left**) and 2018 (**right**) [25].

In B&H, in the past, buildings did not need to be energy-efficient, but only to serve the functional needs of society/communities. This had an impact on the design of the country's old building stock, which ensured sufficient space for the intended use of buildings. Following the Directive on the Energy Performance of Buildings from 2002 and the Directive on End-Use of Energy in 2006, the Federation of Bosnia-Herzegovina adopted the Regulations on Rational Energy Consumption in 2010. Six years later, in January 2016, the Republika Srpska adopted the Regulations on Energy Efficiency in Building, presented in Figure 5. Great emphasis is placed on improving the energy performance of building envelopes by setting the energy certification of buildings based on their energy need for heating. The set of regulations that more closely control the field of energy efficiency in buildings in Republika Srpska are: Rulebook on Minimum Requirements for Energy Performance of Buildings, Rulebook on Methodology for Calculating Energy Performance of Buildings, and Rulebook on Performing Energy Audit of Buildings and Issuing RS Energy Certificate.

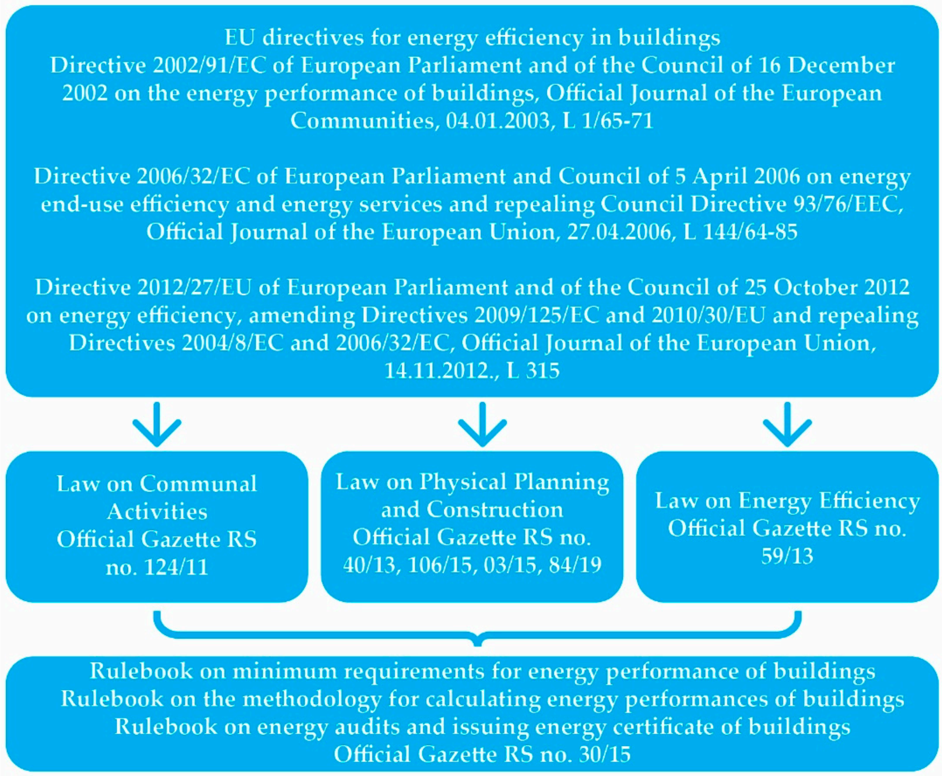

Figure 5. The scheme of legislative framework structuring for Energy Efficiency in Buildings in the Republika Srpska (Bosnia-Herzegovina). Source: Authors' figure.

The data would directly indicate the energy needed for heating in buildings, and the possible savings, and indirectly the consumption of total energy and carbon dioxide emissions. The starting point for the energy efficiency of a building was a basic indicator of the condition of the building envelope, not considering the technical systems within the building. Later, the building's technical systems took on an important role. Therefore, the energy efficiency indicator in buildings (energy certificate indicator) is the annual energy need for heating.

Starting with Directive 2010/30/EU, and then Directive 2012/27/EU, it is stated that the energy efficiency indicator must be guided by the delivered energy, primary energy, and/or carbon dioxide emissions. This requires an amendment to the rulebook, which the government of Republika Srpska is considering changing in 2020. Adequate building materials must be used for energy efficiency and overall renovation of buildings, and it is important to consider the adoption of legislation related to construction products, presented in Figure 6.

Following enactment of the relevant legislation, research was conducted that resulted in the release of two documents: Typology of Residential Buildings of Bosnia and Herzegovina [30] and Typology of Public Buildings of Bosnia and Herzegovina [31]. Both documents contain an overview of the energy need for heating through the existing building stock, its structure by construction period, and type of building. In addition to the complete data for Bosnia and Herzegovina, data by entities (Republika Srpska and Federation of Bosnia-Herzegovina) of Bosnia-Herzegovina are also presented.

According to typology data, there are a total of 861,965 residential and 7600 public buildings in B&H. Of that number, 331,589 residential buildings belong to the Republika Srpska, with 39,846,631 square meters of usable heating area and 2908 public buildings with a total usable heating area of 3,614,839 square meters. Less than 1% of public buildings are in the building fund of the Republika Srpska, while in the total usable area for heating 8.32% belongs to public buildings.

Figure 6. The scheme of legislative framework structuring for construction products in the Republika Srpska (Bosnia-Herzegovina). Source: Authors' figure.

Based on the data published in the typologies, the energy need for heating of all buildings in Republika Srpska is 8,427,652 megawatt-hours (MWh), of which 7,729,138 MWh belongs to residential buildings and 698,514 MWh to public buildings.

Standard improvement measures in typology of residential buildings, defined in accordance with usual measures applied during building reconstruction in the territory of B&H, includes two approaches. Improvement of thermal characteristics of walls and ceilings by technically common procedures, such as adding thermal insulation with a thickness of 10 centimeters with thermal conductivity $\lambda = 0.041$ W/mK, as well as possible replacement of the existing windows with new ones with better characteristics (defined minimal thermal transmittance coefficient of window U_w-value 1.6 W/m^2 K).

By applying standard measures to improve the envelope of existing residential buildings, it is possible to reduce the total annual thermal energy required for heating by 55.23%. Energy consumption of 19,593,880 MWh (70.53 petajoule PJ) can be reduced to 8,771,954 MWh (31.58 PJ). The results show that single-family houses are the dominant category in total energy consumption with 86.98%. After applying standard measures of improvement, the highest absolute values of savings can be achieved in this category.

Due to the better thermal characteristics of building envelope elements for buildings built in the period 1992–2014, the lowest relative savings are possible for single-family houses built in this period (32.43%) and for multifamily houses from the same period (33.77%) [32]. These measures do not correspond to the currently valid aforementioned rulebook of the Republika Srpska, because the *U*-value for façade wall is more demanding (e.g., about 12 cm of thermal insulation on walls, thermal conductivity of 0.041 W/mK is required).

A cost-optimal analysis of residential buildings in B&H aimed to determine adequate levels of residential building energy classes, according to the EU Directive of 2012, with new climate data not used in the existing typologies. According to the new climate data, the energy demand for the heating of residential buildings in the North zone is, on average, lower by 12.55–13.54%, while in the South zone, it is lower by 14.28–15.25%. For non-residential buildings, it is lower by 17% and 19% in the North and South zone, respectively [33]. The aforementioned research would require modification of the *U*-values and energy classes in the regulations on the minimum requirements for the energy performance of buildings.

The cost-optimal analysis included an analysis of the costs of applying different packages of 33 measures to the two most common types of housing: single-family houses and multifamily houses. Measures that improve the envelope, specifying thickness and thermal conductivity of the material/insulation or *U*-value of the product-window, are discussed without specifying the use of renewable materials. The measures of improvement of the heating system and domestic hot water (DHW) system mention the centralization of the system and the use of renewable energy sources.

The RS Building Renovation Strategy assumes three scenarios, representing different levels of ambition for future renovation, based on two drivers: renewal rate, defined as the ratio of the usable floor area of annually renovated buildings to the total usable area of the entire building stock, and depth of renovation, which indicates the energy savings achieved through the choice of renovation measures [22].

2.2. Slovenia Case

According to data from the International Energy Agency from 2018, the energy intensity of Slovenia was 0.14 toe/1000 USD of GDP (International Energy Agency, 2018), which is the average of EU countries.

Figure 7 shows that after nine years, energy production in Slovenia decreased from 7506 ktoe to 6804 ktoe. It is interesting that production from renewable sources (wind, solar, etc.) increased to more than double, from 37 ktoe to 87 ktoe, which accounts for 1.28% of the total energy production in 2019. The production of energy from coal and oil is 15.52% and 33.92%, respectively, which makes up half of the production of total energy in Slovenia. Energy from nuclear sources also has a large share, production of which slightly increased in the last nine years.

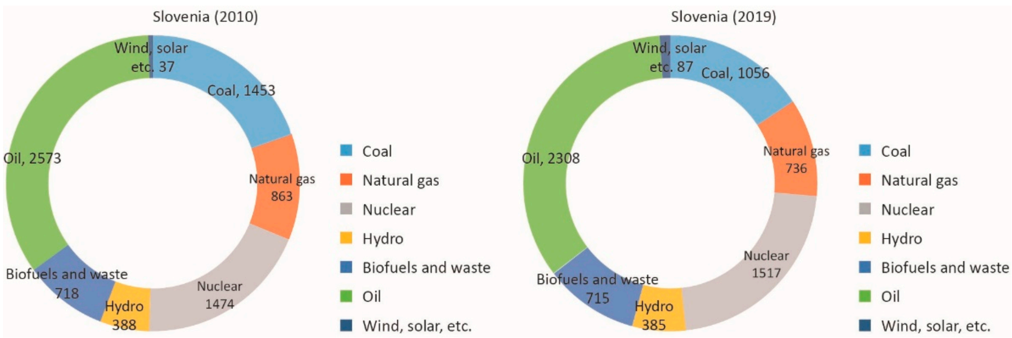

Figure 7. Energy sources used in Slovenia in 2010 (**left**) and 2019 (**right**) [25].

The data from the Energy Balance of Slovenia in 2019, presented in Figure 8, presents the production and consumption overview of energy supply in Slovenia. Total energy in Slovenia in 2019, produced and imported, was 426,246 terajoule TJ (10,180 ktoe). Domestic production accounts for 3536 ktoe, import energy for 6644 ktoe, while the total energy supply has been reported at the level of 6761 ktoe, which is almost equal to all imports.

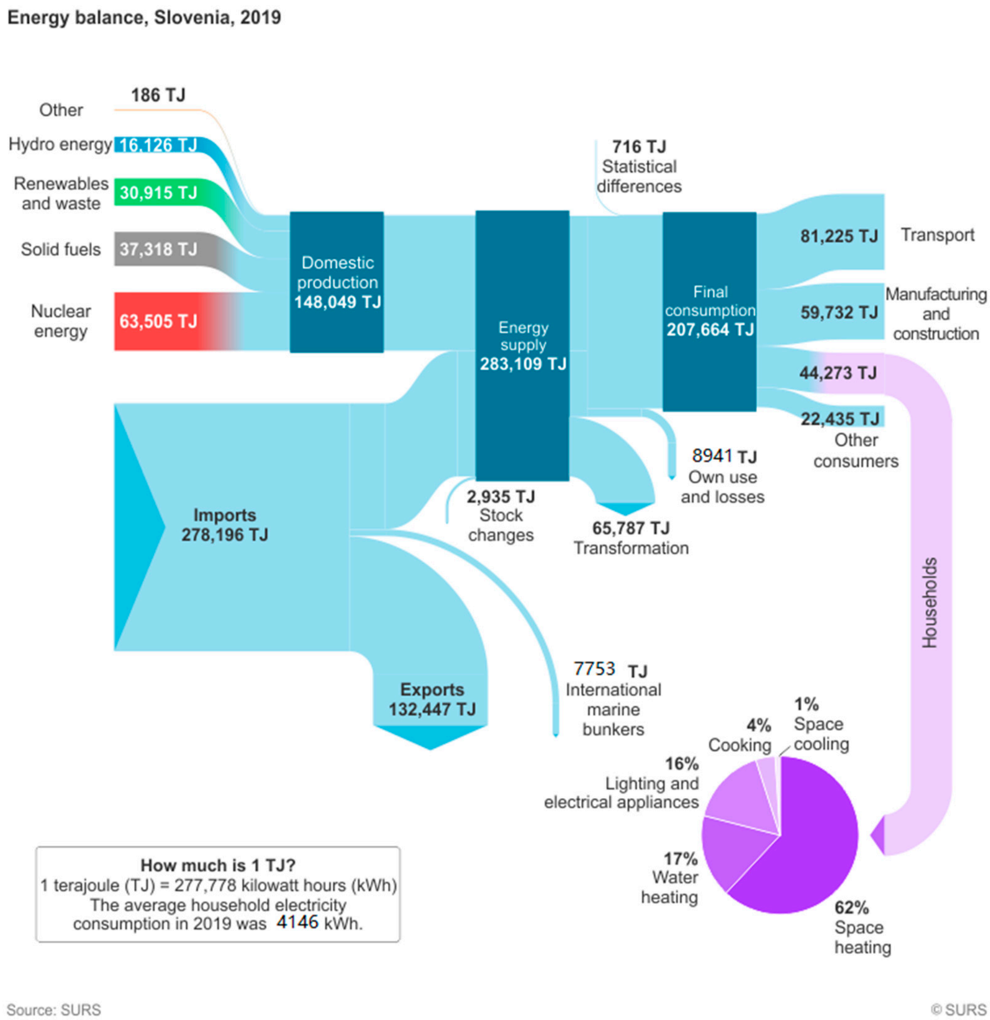

Figure 8. Energy balance for Slovenia in 2019 [34].

Final energy consumption was the highest for transport (39.11%), followed by industry (28.76%), residential (21.32%), and service (10.8%). Final energy consumption in Slovenia spent on space heating by the residential sector was 62% of all energy, while the remaining 38% was used for other consumption: space cooling (1%), lighting and electrical appliances (16%), cooking (4%), and hot water preparation (17%).

The legal framework for energy efficiency in Slovenia is heavily influenced by the EU. The highest legal document on the matter is the Directive on Energy Efficiency from 2012 [19]. It established a new system for encouraging investment in energy efficiency and reporting its results to the European Commission. The Directive became effective in Slovenia through the Energy Act (Energetski zakon, EZ-1) of 2014 (Figure 9), and through the strategic documents that derive from it; EZ-1 regulates the Slovenian energy sector as a whole, and it also deals with energy efficiency of buildings, products, and processes. The principles of "reduction of energy use", "efficient energy use", and "energy efficiency" are all cited among its main aims. The act also establishes the main tools of energy policy, such as action plans and strategies. The act obliges the government to adopt an action plan for energy efficiency (art. 26). The EZ-1 chapter is dedicated to energy efficiency (art. 314–350) and includes a subchapter that regulates energy efficiency of buildings (from art. 330 onwards). Here, an outline of the main policy tools is given. These are elaborated in detail in the strategic documents, but here the list of the main envisioned activities can be found: education and informing, financial incentives, and energy consulting. An important role is given to the ECO fund (Eko sklad—Slovenski okoljski javni sklad), which has the task of assigning financial incentives for energy refurbishments according to the aforementioned strategic documents [35].

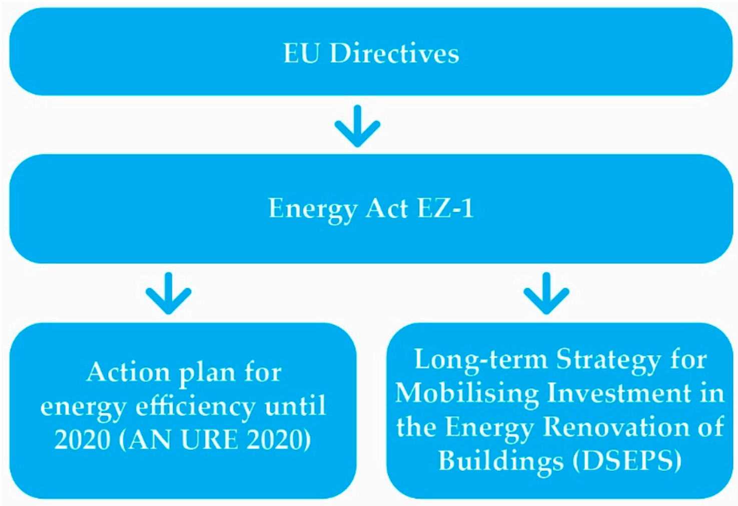

Figure 9. The scheme of the legislative framework structuring in Slovenia. Source: Authors' figure.

The ECO fund is the Slovenian public environmental fund, which was established in 1993 with a new Environmental Protection Act (Zakon o varstvu okolja, ZVO) [36,37]. The fund has evolved to be the main provider of financial incentives and subsidies for environmental projects in Slovenia. Its operation is still largely based on environmental legislation, but the EZ-1 gave to the fund new sources of revenue and new tasks regarding energy efficiency. The ECO fund has to take into account cost efficiency, social status, and environmental and other limitations while allocating funds [35]. EZ-1, together with the Decree on Energy Savings Requirements 2014 [38], also establishes a new financial contribution based on the achievement of energy savings that is paid by consumers, collected by energy companies (regarded as "polluters"), and forwarded to the ECO fund. Another measure that energy companies can adopt to achieve energy savings at the consumer level is investment in energy efficiency of buildings [35].

The subchapter about energy efficiency of buildings begins with establishing the requirement for all new buildings to have a nearly zero energy regime (Nearly Zero Energy Buildings or nZEBs) and tasking the government to adopt an action plan for such buildings. The final provisions put enforcement to begin on 31 December 2018 for new public buildings and on 31 December 2020 for all new buildings in general [35], while the Action Plan for Nearly Zero Energy Buildings 2015 [39] was adopted and expires in 2020.

EZ-1 requires the government to adopt a Long-Term Strategy for Mobilizing Investment in the Energy Renovation of Buildings [35], which has to be updated every three years and set a goal for a certain amount of buildings to be renovated every year. This amount is expressed in floor areas, and the next two articles deal with the methodology to measure them. The next chapter considers informing, educating, and raising awareness as policy tools. Special tasks of this kind are assigned to the national support center (a role given to the state-owned enterprise Borzen d.o.o, otherwise the operator of the Slovenian electrical energy market) [40] and the ECO fund (to establish energy consulting points in local communities) [35].

The Action Plan for Energy Efficiency until 2020 [41] was adopted by the government in 2014 and updated in 2017. The action plan addresses energy efficiency in a very broad sense. It sets the objective to increase energy efficiency 20% by 2020 (the threshold of 82.86 terawatt hour (TWh) of primary energy consumption must not be surpassed that year). The third chapter outlines the measures to be taken to increase energy efficiency. Horizontal measures affect all areas at the same time (buildings, traffic, industry, heating systems) and mostly derive directly from the EZ-1. Measures that target just buildings include: updating existing building regulations with the latest energy efficiency standards, establishing a quality assurance scheme for energy inspections and comprehensive monitoring of energy renovations, continuing the program of financial incentives from the ECO fund, mobilizing similar incentives from the European agricultural fund for rural development (EAFRD) for households in rural areas, introducing an energy efficiency scheme for vulnerable households (also funded by the ECO fund), establishing a network of energy consulting points in the local communities called ENSVET, introducing instruments for investment in multifamily buildings with many owners (and updated regulations for easier decision making among them), creating a scheme for sharing the investment burden between landlords and renters, establishing a scheme to fight energy poverty in rural areas (funded by the EAFRD), and other similar measures. Most of these respond to problems detected during the operation of the ECO fund in the past. Some measures target the public sector exclusively. Among them, it is possible to find updating of green public procurement (energy efficiency criteria for goods and services purchased with public funds), activating financial instruments for energy refurbishment of public buildings (through the ECO fund and EU cohesion funds), and establishing a special project office to coordinate energy renovations of public buildings [41].

The second strategically relevant document based on the EZ-1 is The Long-term Strategy for Mobilizing Investment in the Energy Renovation of Buildings (DSEPS) [42] adopted by the government in 2015 and updated in 2018. This strategy summarizes the measures already stated in all the previously described documents, which indicates an inverted logic of strategic planning (i.e., it would be logical to assume that action plans derive from strategies, and not vice versa). However, its importance lies elsewhere. DSEPS very clearly outlines its goals, which are divided in operational (2020), indicative (2030), and with a long-term vision to achieve carbon neutrality of buildings by 2050. The most prominent indicative goals are a reduction of final energy consumption in buildings of 30% and a reduction of greenhouse gas emissions from buildings of 70% (both compared to 2005 values). Operational goals follow the same pattern, but the aim to refurbish 3% of energy-ineffective public buildings per year (measured by floor surfaces) is added. The goals are not expressed just in percentile values, but are also quantified and measurable (number of buildings renovated, petajoules of energy saved, final terawatt hours of energy consumed, and number of demonstrative pilot renovations executed). The second important feature of this strategy is the in-depth analysis of the national building stock. Its presentation is based on several different parameters, such as age, typology, energy performance, and ownership. Furthermore, DSEPS also includes a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis of the risks and opportunities of energy renovation of the national building stock. Even further in the document, the methodology to determine the most cost- and energy-effective modes of renovation for each of the most common building types can be found [42].

The measures indicated above aim to update legal documents that influence the energy efficiency of buildings. Two of the most important will be mentioned. The Rules on Efficient Use of Energy in Buildings were adopted in 2010 and set the technical guidelines for the energy efficiency of buildings, including marginal values of heat transfer for different circumstances [43]. The second important document is the Decree on Green Public Procurement from 2017, which sets high environmental standards for public procurement procedures, including construction of new public buildings and refurbishment of existing ones. Among them is a visible provision that obliges timber walls to contain at least 10% recycled wood and new buildings to contain at least 30% wood in the total volume of all construction materials used [44].

There are other strategic documents that influence energy efficiency of buildings, but which do not derive from the EZ-1. The first is the Operational Programme for Reducing Greenhouse Gas Emissions until 2020 [45], which was adopted in 2014. It is based on Decision No. 406/2009/EC [46], issued by the EU in 2009, with the aim of reducing greenhouse emissions. Most of the measures coincide with the ones already given in AN URE 2020, but some of them are new. Here can be found additional convenient crediting schemes for energy refurbishment in households and public entities, the strengthening of energy contacting processes, and a scheme for energy efficiency of cultural heritage buildings [45]. Another important document is the Operational Programme for the Implementation of EU Cohesion Policy 2014–2020 [47], which is the basis for retrieving cohesion funds from the EU. Climate change and the transition to a carbon-neutral economy are among the target policy areas, and specific goals target energy efficiency of public sector entities and households. Funds for energy renovations of public buildings, implementation of energy contracting and demonstrative pilot projects target the public sector. Measures aimed at helping households include funds for energy renovations of multifamily buildings with an emphasis on demonstration and pilot projects and schemes to tackle energy poverty. These funds were also made available to private entities.

Lastly, an assessment of the implementation of the proposed measures is needed, but it is difficult to make, since the final reports will not be prepared before the strategies and action plans for the period after 2020 are published. However, a glimpse can be found in the last updates and annexes of AN URE 2020 (National Energy Efficiency Action Plan 2020) and DSEPS. Preliminary data for 2017 shows that primary energy consumption is in line with the 2020 goals (i.e., the value was 6788 Million tonnes of oil equivalent (Mtoe), which is lower than the 7125 Mtoe aimed to be achieved in 2020) [48]. In 2016, the renovated surface area of public buildings amounted to 11.307 square meters, which is roughly half of the required 3% aimed to be renovated every year [49]. This data is still too scarce to assess the success of energy refurbishments in Slovenia. The TABULA project, initiated by researchers at the Darmstadt IWU Housing and Ecology Institute, gave information about typology of residential buildings, number of buildings, reference floor areas, quantity and quality of building envelopes, and amount of energy needed for heating buildings in Slovenia [50,51].

3. Discussion of Bosnia-Herzegovina and Slovenia Cases

Bosnia-Herzegovina produces all the energy necessary for supply (7865 ktoe). Energy imports and exports were recorded at 0.94% and 2.74%, respectively (data for 2018). Slovenia produces 52.3% of all total energy required (data for 2019). Slovenia's energy supply was 6804 ktoe, having an almost identical quantity to that of imports (6644 ktoe). More than half (about 56%) of B&H's energy consumption is from the residential sector. Energy consumption by the residential sector in Slovenia accounts for about 21%. Although the Law on Construction Products in the Republika Srpska (B&H) has been in force since 2012, it has not yet taken effect in the territory of B&H. Review of contractor's documentation revealed that individual manufacturers do not have an adequate certificate/declaration of conformity for a product. Moreover, individuals hold multiple certificates, on which even different values for the technical and physical characteristics of the product/material (e.g., λ-coefficient of thermal conductivity) are most often due to the conditions under which the materials are tested.

The valid Regulation (EU) No 305/2011 [52] that replaced Directive 89/106/EEC [53] is not covered by the regulatory framework in B&H. That Regulation ensures the free movement of all construction products within the European Union by harmonizing national laws with respect to the essential requirements applicable to these products in terms of health and safety.

In 2012, EPDs of construction products and building materials in the EU were first introduced and constituted an important basis for assessing building sustainability, which is a completely unknown concept in the territory of Bosnia-Herzegovina.

Building renovation strategy shows an analysis of the Republika Srpska's existing building stock, their heating systems, and defines the energy needs of the buildings. Subsequently, it presents building renovation scenarios, which need financial investment, reviews potential barriers to building renovation, and provides measures and policies to encourage renovation.

After the research projects conducted in Bosnia-Herzegovina, "Typology of Residential Buildings" and "Typology of Public Buildings", a certain overview of building stock was made, and on this basis, it is possible to develop strategies and effective models for energy improvement. To create effective strategies for developing economies, it is crucial to use experiences from countries that passed that phase.

However, technical measures for the renovation of buildings are not very clear. Those are related to the improvement of architectural, construction, and thermo-technical systems of the building and the use of renewable energy sources, directly affecting the comfort and quality of life. Requirements for the minimum energy performance of buildings shall be revised and updated every five years, taking into account the technological development of building materials and building systems. The strategy does not specify any incentive proposals related to the use of renewable materials in the context of the renovation of the building envelope. For the building façade wall, measures are given through material thickness, thermal conductivity coefficient, and price, depending on the type of building and the construction period. This means that manufacturers of façade systems and producers of renewable materials need to adhere to that price value in order to be competitive in the market of Bosnia and Herzegovina.

Comprehensive analysis of the implementation of the strategies in Slovenia are expected in a couple of years. Beyond that, another conclusion has to be outlined: there is hardly any measure or provision in the analyzed documents that targets the use of renewable or recycled materials in energy refurbishments. The only document targeting the use of renewable materials in general is the UZJN, which requires public entities to include a certain volume of timber in new buildings or refurbished ones. The required amount of timber volume is 30%, or 20% timber combined with 10% of a material that has an environment type III certificate (i.e., the main type of EPD for construction materials; EPDs are otherwise voluntary in Slovenia) [44]. If a closer look is taken at the programs of the ECO fund, the body that executes a large number of the measures presented above, only targeted subsidies for replacement of old windows with new wooden ones in older buildings can be found [54]. In summary, the legal and strategic framework regarding energy efficiency of buildings in Slovenia is well defined. It includes a system of clear goals on one side and comprehensive measures on the other. Nevertheless, data about its success in practice are scarce and ambiguous, and most of the documents originate from the obligation to conform to EU rules and not from genuine domestic initiatives. In this process, the possibility of encouraging energy refurbishments with renewable materials has been almost completely neglected.

Previous research [55] by the authors indicated that Bosnia-Herzegovina and Slovenia have almost identical energy savings when comparing refurbishment of the entire building envelope for the same type of building (e.g., MFH—multifamily houses—and AB—apartment buildings), which would be adequate for renovation with renewable materials when analyzing the possibility of using prefabricated panels such as Timber Energy System (TES) [56], Building Energy Renovation Through Timber Prefabricated Module (BERTIM) [57], or energy, seismic, and architectural renovation through Prefabricated Timber Panels (PTP) [58].

Comparing the total energy need for heating residential buildings, both MFH and AB, the energy need for heating in B&H is higher than in Slovenia by 15%. Comparative analysis of data on the residential buildings in B&H and Slovenia was carried out through the methodological framework of "TABULA", a European international project, and the potential energy savings by refurbishment of the existing residential building envelopes (MFH and AB) suitable for prefabricated timber panels would be 1,243,328 MWh/a and 1,202,820 MWh/a in Bosnia-Herzegovina and Slovenia, respectively [55].

4. Overview on European Policy Landscape Related to Energy Retrofitting Opportunities

Several European countries have introduced information mechanisms through national and local energy agencies offering advice to building owners and public authorities and/or offered a broad range of financial incentives to facilitate investments in energy efficiency in existing buildings. These incentives range from low- or zero-interest loans (e.g., in Germany and France) to subsidies (grants, tax deduction, white certificates) in Italy, France and Spain [59]. Consequently, in many EU countries, various policy landscapes within the existing grant support schemes are implemented. In many cases, grant schemes are designed to focus on specific inputs, e.g., retrofit measures, and not outputs, e.g., energy savings. Nevertheless, building retrofit grant schemes that more effectively consider the pre-existing condition of a household as part of the initial application process could improve building energy efficiency standards even more effectively. The approach of customizing retrofits to homes, as suggested by Uidhir et al., is intended to address the issue of homeowners choosing suboptimal retrofit measures and hence improve the cost/saving benefits of the overall scheme [60].

In the Netherlands, the policy focus is on the development and implementation of a regulatory and stimulus framework to support reduced fossil energy use in buildings. This can be achieved by offering subsidies that offer financial support for the implementation of energy-saving measures such as (improved) insulation aimed at both individual and institutional homeowners and renters. However, the performance levels that can be achieved, are highly dependent on building type, construction technique, and period-specific technical and functional characteristics. Therefore, measures must be predicated on location specific to be effective [61]. Swan et al. suggested two distinct approaches used for modelling of energy demand: top-down and bottom-up. The top-down approach is not concerned with individual end-uses. It uses historic aggregate energy values and regresses the energy consumption of the housing stock as a function of top-level variables such as macroeconomic indicators, energy price, and general climate. In contrast, the bottom-up approach extrapolates the estimated energy consumption of a representative set of individual houses to regional and national levels [62]. However, as pointed out by Claude et al., building in a very dense area should not be treated in the same way as a stand-alone building, especially in terms of thermal radiation [63].

Many of the existing buildings in the EU are lacking LCA analysis. Efforts to address this knowledge gap can build on recent LCA-based studies from Sweden, Switzerland, Italy and the United States that have focused on evaluating the environmental performance of retrofit measures. Alternatively, the bottom-up, component-based method for defining and analyzing retrofit scenarios for period examples of the most common residential building archetypes encountered can be proposed [61]. Fernandes et al. concluded that in current Dutch energy mix conditions, material-intensive retrofit strategies are effective. However, this might change, especially when retrofit impacts play out over long time -periods, during which substantial changes may occur. Moreover, it was concluded that trading impacts in one category, such as GWP, for lower impacts in other categories may seem advisable from a residential building sector viewpoint, but might appear less favorable from a different or broader societal perspective [61].

For effective decision management in energy retrofitting, a global environmental, economic and social assessment method needs to be developed. All of these will facilitate all agents involved in the retrofitting (end-users, promoters, administrations, technicians and non-technicians) in selecting the best available energy efficiency measures, according to their requirements and specific needs. In general, the viability of energy efficiency measures depends mainly on investment costs and the payback periods [64].

5. Analysis of the Barriers Preventing Wider Use of Renewable Materials

The previous sections demonstrated that the use of renewable materials in energy refurbishments in B&H and Slovenia is rather uncommon and remains off the radar of policymakers. Even if it is a relevant topic in different countries, with some successful technological solutions being developed (for example, TES, BERTIM, MORE-CONNECT, and CLT panel façade systems) [56–58,65], there has not been a general breakthrough leading to a wider use of such solutions in the analyzed countries. However, mentioned prefabricated solutions have significant potential, yet there are still gaps in understanding their possible use for energy refurbishment. These products can be optimized and are easily replicable, with increased use of renewable materials, increased cost-effectiveness, and reduced time on the construction sites in the process of building refurbishment. Moreover, industry-optimized process reduces mistakes, increases the quality of the modules, and reduces amount of construction waste in the landfills [66]. Differences in costs between the solutions, with retrofitting based on ETICS and with prefabricated panels, were generally small, so the prefabricated panels solution seemed to be competitive. With respect to the fact that solutions like prefabricated panels can provide a higher standard of living and internal air quality since it integrates other services besides the thermal insulation function (e.g., mechanical ventilation, new heating piping, electrical wiring including Wi-Fi router), they can be considered beneficial from the point of view of sustainability and complex building stock retrofitting. On the other hand, such solutions have special requirements with regard to worker skills and expertise as techniques needed for assembling and completing the system are rather more complex compared to common practices [65].

There are obviously barriers that impede the flow of this knowledge toward industry, users, and policymakers. This publication attempts to form a set of hypotheses regarding potential barriers, based on a focus group discussion conducted with stakeholders in Banja Luka, Bosnia-Herzegovina.The main obstacles are briefly listed below. One of the reasons could be the higher price of natural renewable materials since it is quite common to perceive products labelled as “green” or “eco” as highly priced. However, this perception may not always reflect reality once a comprehensive cost–benefit analysis has been made. The second reason could be the lack of industrial capacity for production of energy refurbishment construction products, elements, and systems made from renewable materials. Countries in Eastern and Southeastern Europe frequently limit themselves to the export of raw materials or semi-finished products; thus, they lack the capability to finalize production of complex products. This phenomenon can be explained by the lack of knowledge and best practices present in these regions. In general, there is a poor exchange of knowledge regarding renewable materials from a cross-border perspective, and also between institutions and organizations in the region. Finally, and most importantly, a lack of public awareness about renewable materials for (energy) refurbishments of buildings seems to play an important role. Often, only the energy performance of buildings is the main focus, and a larger and more holistic view of sustainable refurbishment is missing. This is motivated by the direct financial consequences for users. Consequently, the influence of building materials on the overall carbon footprint and environmental impact of a building is often neglected. However, this hypothesis is not confirmed by the scientific literature presenting the attitudes for any of the social groups. The lack of public awareness is transferred to decision-makers (as a topic of low political importance) and industry (through consumer behavior). To improve this situation, actions aiming for improvement of the general flow of information among stakeholders are indispensable. This can be achieved by knowledge transfer from scientific institutions to industry, implementation of know-how at the industrial level to build production capabilities, and awareness-raising campaigns aimed at both the public and policymakers. Only with careful planning and simultaneous execution of the mentioned activities can an increased use of renewable materials in energy refurbishments be achieved.

The focus on energy retrofits and/or including energy efficiency measures in routine building maintenance works of existing buildings is justified by the low rate of new constructions in Europe. To this end, it is key to provide more targeted consumer information (e.g., through enhanced energy performance certificates) and financial support through tailored instruments, which empower final users to invest in energy efficiency [59]. Energy efficiency policies for buildings can take the form of regulatory or control instruments, building codes, consumer information campaigns and economic or financial incentives. However, the evaluation and assessment of existing policies for EE in buildings suggest that there is no single policy that alone can achieve a substantial transformation of the existing building stock and reduce significantly energy consumption. Important developments have also occurred in the diversification of instruments and tools deployed in energy efficiency policy, moving from policies solely comprising building codes up until the 1990s to comprehensive policy packages from the 2000s onwards. In this context, policy packages require the setting of quantitative and measurable targets, allowing policymakers to track overall progress and give clear direction to all involved stakeholders. Recently proposed by the European Commission, the European Green Deal is expected to create a tailored policy framework to mobilize all stakeholders in the buildings sector, address any regulatory or other barriers and scale up new innovative mechanisms. This should ultimately act as a catalyst for innovation and bring new opportunities which will not only enhance the energy performance of European buildings but will also ensure future resilience to climate change risks and adequate living conditions for all Europeans [59].

6. Conclusions

This paper analyzes the regulations and strategic documents that affect energy retrofits in Bosnia-Herzegovina and Slovenia. It was found that, despite the differences in overall architecture of the legal and strategic networks of both countries, they share some particular common features. To some extent, both are influenced by EU regulations, and both overlook the importance of renewable materials use during energy refurbishments of buildings, thus neglecting the influence of building materials to the overall environmental impact of the building through its entire life cycle. The research mentioned above suggests the use of pre-assembled, timber-based components or prefabricated timber panels because external dry-installation reduces implementation costs and time, embodied energy, and occupants' disruption, which results in a sustainable system from a social, economic, and environmental point of view. However, in B&H and Slovenia, the potential impact of the healthy and user-friendly living environment that these materials create has not yet been recognized. Even if many technological solutions that allow energy refurbishments with renewable materials have already been tested, a proper flow of knowledge and information about them between scientific institutions, industry, the general public (occupants), and policymakers is still missing.

Data on the comparison between housing construction funds in B&H and Slovenia had already been collected through a methodological framework for research of residential buildings typology, based on the European international research project "TABULA". The potential residential building stock for which the building envelope could be upgraded can be examined through a comparative analysis of data for both countries, as proposed in this manuscript. It has to be mentioned, however, that within the same typology, buildings differ in terms of orientation, built environment, and microclimatic conditions as well as the existing thermal characteristics of building envelopes and technical systems. Such analysis can serve as background for further examination and assessment of energy retrofitting processes of buildings. Analysis of strategic and legal frameworks carried out in this research should be continued and expanded for the purposes of comparison between different building stocks. Finally, potentially applicable models for energy retrofitting of buildings should be defined, validated, and applied. This might be particularly relevant in the case of residential buildings, such as MFH and AB, which belong to many owners and have undergone various self-initiated and coordinated changes due to the occupants' behavior.

In many EU countries, various policy landscapes within the existing grant support schemes are implemented. In many cases, grant schemes are designed to focus on specific inputs (retrofit measures), and not outputs (energy savings). The evaluation and assessment of existing policies for EE in buildings suggest that there is no single policy that alone can achieve a substantial transformation of the existing building stock and reduce significantly energy consumption. In optimal situation merging environmental, economic and social assessment method need to be developed for an effective decision management in energy retrofitting. It is expected that the European Green Deal recently proposed by the European Commission will create a tailored policy framework to mobilize all stakeholders in the buildings sector, address any regulatory or other barriers and scale up new innovative mechanisms.

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