

Article

Unlocking the First Fuel: Energy Efficiency in Public Buildings Across the Western Balkans

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Abstract

Energy efficiency presents significant potential, especially for Western Balkan (WB) countries, if effectively addressed through energy efficiency measures. The building sector, which includes residential, commercial, and public buildings, is the most energy-intensive sector globally. Public buildings in the Western Balkan countries are characterized by poor energy efficiency performance. The average energy consumption in public buildings is anticipated to exceed double the European Union (EU) requirement, given that more than 60–70% of these structures were built over 60 years ago with no regard for energy efficiency. This study assesses the Public Building–Energy Efficiency Readiness Index (PB-EERI) to evaluate how legislative specificity, institutional capacity, financing mechanisms, renovation guidelines, energy market conditions, and societal awareness collectively influence the readiness of Western Balkan economies to enhance energy efficiency in public buildings. The index serves as an operational diagnostic to identify the presence of enabling conditions, determine the most significant gaps, and prioritize policy efforts accordingly. This study presents a novel approach by integrating, within a single transparent index, (i) the existence of energy laws, (ii) market feasibility, (iii) renovation needs of public buildings, and (iv) societal awareness. The awareness pillar is both central and novel. By utilizing harmonized Regional Cooperation Council (RCC) data, this article quantifies societal awareness, thereby ensuring that the index accurately reflects the importance of stakeholder comprehension in the success of renovating initiatives for public buildings. The theoretical framework derives from the application of composite indicators in numerous studies and reports to illustrate the status of energy or energy efficiency. The methodology for developing this indicator is derived from the Organization for Economic Co-operation and Development (OECD) *Handbook on Constructing Composite Indicators*. For the aggregation method, the summation of weighted and normalized sub-indicators was used. The PB-EERI reveals considerable regional variations, with total scores ranging from around 39 to 72% and concentrating around the mid-0.5s. The findings reveal systematic differences in most indicators' performance. The legal framework indicator significantly influences variation between countries, together with market conditions and societal awareness. Energy efficiency in public buildings, praised as the “first fuel”, should be prioritized beyond mere compliance with EU regulations. The PB-EERI emphasizes that success relies more on the capacity to transform formal strategies into concrete renovation programs, quantifiable objectives, and higher awareness of society to ensure uptake of the renovation measures.

Keywords: energy; energy efficiency; public buildings; Western Balkans; sustainable development

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1. Introduction

As the global economy expands rapidly, the need for energy consumption, particularly in the building sector, rises, while energy production and resources are becoming progressively limited [1]. In addition to the shortage, contemporary environmental challenges have emerged as a significant concern in discussions of energy generation. In this context, global energy organizations and research entities have urged nations and governments to prioritize cleaner and more economical energy alternatives, emphasizing the importance of energy efficiency as the first fuel [2–4]. The message conveyed by Danfoss in the digital campaign at COP26 [5], “...the greenest energy is the energy we don’t use,” is the most suitable to understand the importance of energy efficiency.

The building sector, which includes residential, commercial, and public buildings, is the most energy-intensive sector globally. Building activities constitute 30% of worldwide final energy consumption and 26% of global energy-related emissions [6]. Advanced energy-efficient renovations and construction methods could decrease worldwide energy consumption for buildings by 50–90% by 2050 relative to 2005 levels. Despite the growth of the construction industry, this would result in a decrease in the overall energy demand by the mid-century. The *Global Energy Assessment* [7] indicates that energy cost reductions from mitigated heating and cooling demand might reach approximately USD 57 trillion by 2050, far exceeding the projected USD 15 trillion needed for essential upgrades. The realization of these objectives hinges on the prompt and synchronized implementation of advanced energy efficiency measures in the design, construction, and renovation of both new and existing buildings [7–9].

In the European Union, almost 40% of the final energy consumption goes into the building sector and contributes over 30% of the total energy emissions [1]. Energy efficiency presents significant potential, especially for Western Balkan countries, as energy consumption in the building sector (residential, commercial, and public) reaches 55% in Bosnia and Herzegovina. The increased energy demand in the building sector, if effectively addressed through energy efficiency measures, may yield savings of up to 50% of the current energy usage, contingent upon the building typology in the Western Balkan countries [2].

As these statistics show, adding emphasis on the European Green Deal, it is clear that renovating public and private buildings is essential for improving energy efficiency and achieving climate objectives. In October 2020, the European Commission launched the Renovation Wave Strategy, within the European Green Deal [10], to expedite renovations across the EU, aiming to double renovation rates within ten years and improve energy and resource efficiency. As part of the Berlin Process, all six Western Balkan countries (WB6), since 2020, have voiced their commitment to transform their energy sector and have adopted the Green Agenda for the Western Balkans [11], where energy efficiency is part of its main pillars. This commitment comes as part of the long European Integration process that WB6 started in 2003. In compliance with the Stabilization Association Agreement (SAA) [12], WB6 countries are required to transpose or adopt, if full transposition is not possible, the European Union acquis. The Energy Performance of Buildings Directive (EPBD) [13], revised in 2018, is the most prominent legislation regarding energy efficiency in the building sector, which sets clear definitions and targets with a distinction between private and public buildings.

Public buildings in the Western Balkans generally exhibit poor performance in energy efficiency assessments. The average energy consumption in public buildings is anticipated to exceed double the EU requirement, rendering them very inefficient, given that more than 60–70% of these structures were built over 60 years ago with no regard for energy efficiency [1,2]. Except for Albania, more than 70% of public sector buildings currently employ district heating systems or fossil fuels, predominantly coal and gas. Renovating

these buildings increases energy efficiency, alleviates fiscal burdens, and enhances indoor comfort and health, while concurrently showing governmental leadership and engaging in the private and residential sector, leading by example [1].

Efforts to enhance building energy efficiency globally and regionally utilize various metrics. However, in the Western Balkans, the evidence remains fragmented and non-comparable due to data weaknesses. Most studies focus on legal and EU *acquis* alignment as well as governance [14–20], while offering limited analysis of market structure and finance. Performance and stock analyses of public buildings are generally confined to single-country, subnational, or typology-specific buildings [21–28]. *Odyssee-Mure* [16] connects policy inventories to top-down indicators of efficiency outcomes. However, neither offers a composite readiness assessment specific to public buildings for the region, nor systematically encodes quantitative near-zero-energy building (nZEB) thresholds, operational energy efficiency agencies, or funds. In this article, we will introduce the Public Building–Energy Efficiency Readiness Index (PB-EERI) to evaluate how legislative specificity, institutional capacity, financing mechanisms, energy market conditions, renovation guidelines, and societal awareness collectively influence the readiness of Western Balkan economies to enhance energy efficiency in public buildings. The index serves as an operational diagnostic to identify the presence of enabling conditions, determine the most significant gaps, and prioritize policy efforts accordingly.

This study presents a novel approach by integrating, within a single transparent metric, (i) the existence of laws, quantifiable legal obligations, nZEBs, Energy Performance Certificates (EPCs), and renovation guidelines, as well as operational capacity and financial viability, (ii) market feasibility (a renewable energy sources mix and primary energy factors), (iii) the renovation needs of public buildings according to the efficiency performance of the existence stock, and (iv) societal awareness. The awareness pillar is both central and novel. By utilizing harmonized RCC data, this article quantifies public and business awareness, actions, and intentions, thereby ensuring that the index accurately reflects the importance of stakeholder comprehension in the success of renovating initiatives for public buildings.

2. Theoretical Framework

The importance of energy efficiency and the correlation between energy efficiency and energy consumption savings are not unquestionable among academics. Numerous studies suggest that energy efficiency may lead to an overall rise in energy usage. The “Khazzoom–Brookes” postulate asserts that if energy costs decrease due to enhanced efficiency, a nation’s economy will grow, leading individuals and businesses to desire or demand greater consumption, a phenomenon referred to as the rebound effect [29,30]. Research demonstrating this rebound effect includes [31–45].

Meanwhile, extensive research indicates that energy efficiency decreases the energy required for associated tasks, hence resulting in a direct reduction in energy consumption and costs over time. Some of this research also assesses the environmental impact resulting from reduced energy consumption. An extensive body of literature [46–53] finds no evidence of rebound effects. Their research has concentrated on the building sector, concluding that energy efficiency improvements in buildings neither elevate overall residential energy consumption nor are they cost-prohibitive, resulting in an annual energy consumption decrease of 12–21%. Sorrell and Dimitropoulos [54] contend that empirical methodologies based on pricing elasticities may exaggerate the rebound effect. Considering these findings, global energy organizations and research entities have urged nations and governments to prioritize cleaner and more economical energy alternatives, emphasizing the importance of energy efficiency as the first fuel [3,4].

No studies have assessed the comprehensive impact of measures and policies of energy efficiency in public buildings; renovations are needed according to the existing public building stock and awareness of society in Western Balkan countries. Research on the Western Balkans typically examines the advancements in energy efficiency initiatives within the context of the Green Agenda, addressing their implementation and the degree of alignment with EU countries or directives [55–60]. The Western Balkan area has commenced preliminary advancements in establishing fundamental policy frameworks to improve energy efficiency in buildings. These initiatives are primarily driven by international commitments, including the Energy Community Treaty, the Paris Agreement, and the Sofia Declaration [61–63]. Considering these pledges, regional countries are endeavoring to align their energy efficiency regimes with European Union requirements, particularly focusing on the Energy Performance of Buildings Directive (EPBD) [13].

A primary proposal for the region is to expedite the formulation and implementation of legislation and policies that emphasize energy efficiency, especially within the building sector. This should encompass the development of renovation methods for existing structures, investigating the viability of efficient cogeneration and district heating/cooling systems, and creating specialized finance mechanisms and financial models to facilitate implementation.

Expected final energy savings vary depending on whether a building is newly constructed or an existing structure, defined as one built prior to 1990, and are also contingent upon the relevant legislative framework. For existing public buildings, implementing the European Union's Cost Optimal Level for primary energy yields an average energy reduction of almost 60%. Nonetheless, utilizing the objectives specified in the amended 2023 version of the EPBD [13] results in a substantial improvement in savings, reaching almost 81%. In new structures, the anticipated ultimate energy savings are roughly 13% in reaching the Cost-Optimal Level (EU-COL) and may attain up to 44%, in accordance with EPBD regulations [2].

When assessing the status of the energy market, international organizations typically employ composite indicators focused on various significant and prioritized themes. Effective general energy legislation and specific energy efficiency legislation can facilitate cost-efficient energy savings in the building sector while also providing significant additional advantages by improving the energy performance of buildings and appliances [64,65]. These additional benefits, frequently equivalent in economic value to direct energy savings, encompass enhanced health outcomes, improved job productivity resulting from improved indoor conditions, and increased energy affordability, which elevates overall living standards [66]. International reports globally indicate that all countries do and should prioritize the legal framework as the foundation of every policy effort. For the case of Western Balkan countries, we can assess the application and transposition of the EU *acquis* into their national legislation, as five of these nations are EU candidate countries, while Kosovo (this designation is without prejudice to positions on status, and is in line with UNSCR 1244 and the ICJ Opinion on the Kosovo declaration of independence) is a potential candidate country. The Energy Community Secretariat report [67] discusses energy efficiency in the building sector, highlighting the regulatory framework in this area and benchmarking it against the standards in the EPBD [6,13].

Under the European Green Deal [10] initiated by the European Commission, European Union countries have started the Rehabilitation Wave [68] by introducing near-zero-energy buildings (nZEBs). Near-zero-energy buildings require that all new constructions, starting in 2020, achieve high energy efficiency with minimal energy requirements, predominantly met from proximate renewable energy sources. Simultaneously, the current residential and public structures will experience substantial enhancements in energy efficiency. The

EU *acquis* mandates the annual rehabilitation of at least 3% of buildings owned by public bodies. The concept and the energy requirements for nZEBs have been analyzed in recent research around Europe [69,70]. Despite not being EU member states, Western Balkan countries have voluntarily included the 3% renovation-rate element into their national legislation to line with the *acquis*. This alignment allows us to benchmark their legal frameworks for energy efficiency in public buildings against these measures. Nevertheless, not all countries have adopted the same aim. In accordance with their capacities, they have chosen a lesser percentage, as exemplified by Bosnia and Herzegovina and Montenegro [2].

In addition to the legal framework established by national legislation, countries' energy efficiency is constrained by the current state of their energy markets, which vary significantly among the nations of the Western Balkans. The fuel mix available in each country for energy consumption significantly influences energy efficiency regulations in the broader market, and particularly within the construction sector, as studies indicate that renewable energy sources facilitate more efficient energy usage. This is particularly applicable in the construction sector, as the electrification of heating and cooling, two activities that constitute most of the energy consumption in buildings, enhances the potential for implementing energy efficiency policies by substituting gas or fossil fuels with advanced technologies powered by electricity from renewable sources [71–75]. Moreover, the notion of energy-efficient buildings in Europe was amended by the Energy Performance of Buildings Directive EU/31/2010 in 2018 [13].

According to Alam et al. [76], a theme analysis of focus group conversations revealed 23 unique barriers to energy efficiency in public buildings. The procedure was categorized into four principal stages typically observed in public building renovations: (1) assessing building energy performance, (2) obtaining financing, (3) overseeing procurement processes, and (4) promoting awareness of energy efficiency. The awareness component emerged as a crucial factor, highlighting the importance of stakeholder comprehension in the success of retrofitting initiatives.

Global research on energy efficiency in public buildings has examined many metrics of energy efficiency. In the context of Western Balkan countries, the options are severely constrained due to a lack of data. No prior evaluation of comprehensive energy efficiency for public buildings has been conducted. No studies have assessed the comprehensive impact of measures and policies of energy efficiency in public buildings. Renovations are needed according to the existing public building stock and awareness of society in the Western Balkan countries. The scientific literature is fragmented; numerous studies focus on legal/EU *acquis* alignment and governance aspects [14–20,67], while a few also address market structure and financing opportunities. Performance and stock evaluations are generally confined to a single nation, subnational regions, or certain typologies [21–28]. Societal awareness of energy efficiency in the building sector, its advantages, perceived obstacles, and readiness to engage, has been largely overlooked in previous research and rarely assessed uniformly across the region. Since 2023, the RCC Balkan Barometer modules [77] have offered comparable, cross-country indicators of public and business awareness, self-reported actions, and intentions concerning energy efficiency, facilitating the first regional assessment of attitudes and engagement that can be aligned with policy and market developments.

The fragmentation, coupled with the absence of routinely reported energy demand and consumption data for publicly owned buildings, constrains comparable assessments across the region, particularly about the current efficiency status of the public stock and the extent of rehabilitation requirements. Data regarding the energy demand or consumption of buildings owned by public entities is unreported for certain countries. The sole metric available for estimating renovation needs in public buildings to attain energy efficiency is

the “average primary energy consumption in kilowatt-hours per square meter of building area per year.” This statistic has demonstrated use as it can be compared with the Cost-Optimal Level (COL) for European Union nations or the stipulations outlined in the Energy Performance of Buildings Directive EU/31/2010 [13]. The Cost-Optimal Level methodology for EU countries specifies that the energy requirement for the non-residential sector is 140 kWh/m² per year for new buildings and 180 kWh/m² per year for existing structures. The EPBD specifies that the standard for the non-residential sector is 85 kWh/m² per year, without differentiation between new and existing buildings. Given that the EPBD is excessively ambitious and the status of rehabilitation requirements in the Western Balkans is shown unfavorably in this article, energy efficiency will be evaluated using the EU COL approach as a benchmark.

The requirement for initial financial investments might hinder energy efficiency initiatives. For the case of Western Balkan countries, there are no data to conclude on the status of financial readiness to achieve energy efficiency in the general energy market or, particularly, in the specific building sector [67]. The presence of Energy Efficiency Funds is included in the legal framework; nevertheless, no practical, quantitative measures can be derived from the available data. The Western Balkans predominantly depend on international grants and loans, which are often inconsistent and project-based. Conversely, the private sector provides loans for energy efficiency without preferential interest rates and does not distinguish between various energy efficiency measures.

On the awareness theme, as the public (individuals and businesses) gains greater awareness of energy efficiency, it can indirectly influence governmental policies through intensified attention, augmented media attention, and more robust activism. This collective consciousness frequently manifests as an increased demand for governmental initiatives, including the implementation of new legislation, the acquisition of financial resources, and the enhancement of public infrastructure with energy-efficient technologies [76]. Government institutions function under a specific degree of public scrutiny. They are anticipated to substantiate the allocation of public expenditure not solely on the grounds of efficiency and cost-effectiveness, but also in relation to overarching societal ideals, such as equity, fairness, and the common good. The exposure of public bodies and their work to residents frequently impacts their decision making, especially for energy efficiency improvements in their buildings and their other activities [76,78,79].

3. Materials and Methods

This article evaluates the readiness of Western Balkan economies to enhance energy efficiency in public buildings by developing a composite indicator, the Public Building Energy-Efficiency Readiness Index (PB-EERI), for Albania, Bosnia and Herzegovina, Kosovo, Montenegro, North Macedonia, and Serbia. The PB-EERI aggregates five thematic pillars: (1) the energy efficiency legal framework, (2) energy market conditions for energy efficiency, (3) public building renovation needs, (4) societal awareness, and (5) business awareness for energy efficiency.

The theoretical framework derives from the application of composite indicators in numerous studies and reports to illustrate the status of energy or energy efficiency, as well as the implementation of measures and policies within a country or for comparative analysis among a group of countries [16,67,72,80]. The data utilized are uniform across countries by ensuring comparability. The World Bank, Eurostat, Public Opinion Balkan Barometer 2024, and Business Opinion Balkan Barometer 2024 [81–83] are databases used that employ a uniform approach across all nations. All data processing and analysis were conducted in Microsoft Excel (2021).

The PB-EERI indicators and sub-indicators were selected based on the evidence gaps and recurring determinants identified in the theoretical framework and the literature review. Legal framework indicators, including the existence of energy efficiency, renewable energy and performance buildings laws, an nZEB definition, energy and renovations strategies, the existence of an energy efficiency fund and agency, public-sector renovation targets, and renewable energy trajectories, highlight the importance of transposition and governance emphasized in studies of the Western Balkans and assessments of the EU acquis [14,19,67]. The comparison of legal readiness among countries proved challenging due to the national-level nature of legal documents, since various measurements and policies are articulated and quantified in different ways. For the purposes of this paper, we ensured the utilization of sub-indicators that are accessible for all Western Balkan nations and that align with the legal requirements established by EU directives, since all these countries are endeavoring to align their national legislation with the EU acquis and the pertinent EU legislation regarding energy and energy efficiency.

Energy market conditions, including buildings' share of final energy, primary energy consumption per capita, renewable energy share, and the primary energy factor, reflect the fuel mix and energy market characteristics that influence the feasibility and benefits of building sector efficiency. This aligns with research connecting electrification and renewable energy to improved energy efficiency outcomes for buildings [3,16,73]. Renovation needs are represented by region-comparable available measures. In the absence of direct metered data for public buildings, we utilized harmonized proxies that align with European standards, such as primary energy measured in kWh/m² per year and the total area of existing public buildings per capita, to indicate renovation needs [2,23]. Successful retrofits are conditioned upon citizen engagement and policy adoption. The novelty of this paper includes the sub-indicators related to societal and business awareness [82,83] that monitor adoption rates, perceived barriers, availability of green finance, and expectations for transition. These elements have been consistently recognized as essential facilitators in public-building retrofit research, particularly during the financing/procurement and awareness phases [76,78,79].

The methodology for developing this indicator adheres to the OECD's *Handbook on Constructing Composite Indicators* [80], published in 2008 on variable selection, normalization, weighting/aggregation, and fundamental robustness assessments. Table 1 presents the hierarchy of indicators, sub-indicators, and their corresponding weights. We adopted a two-stage weighting. The total of the indicators' weights equaled 100%. In each indicator, the weights of sub-indicators totaled 100%. We used expert/BAP-style allocation with an a priori indicator design supported by policy relevance, adhering to the OECD's Step 6 guidance on weighting and aggregation [80,84]. We further verified the rank stability of the results under $\pm 20\%$ perturbations of pillar weights.

Table 1. Implementation indicator structure and weighting.

No.	Indicator Name	Weights ¹
1	Energy Efficiency Legal Framework	25%
1.1	Definition of zero/near-zero-energy buildings in national legislation	20%
1.2	Public building renovation target annually in %	20%
1.3	Existence of law on energy performance of buildings	15%
1.4	Existence of law on energy efficiency	10%
1.5	Existence of updated national energy and climate plan	10%

Table 1. Cont.

No.	Indicator Name	Weights ¹
1.6	Long-term renovation strategy	10%
1.7	Dedicated energy efficiency fund	5%
1.8	Agency for energy efficiency	5%
1.9	Relative increase in renewable energy share from 2023 to 2030 target	5%
2	Energy Market Conditions for Energy Efficiency	20%
2.1	Share of energy consumption in building sector	40%
2.2	Primary energy consumption per capita (kWh/person)	20%
2.3	Share of renewable energy in gross final energy consumption	20%
2.4	Average global primary energy factor	20%
3	Public Building Renovation Needs	30%
3.1	Average annual current primary energy—kWh/m ² in existing public building inverse	40%
3.2	Total area of existing public building per capita—m ² /capita	30%
3.3	Average annual current primary energy—kWh/m ² in new public building inverse	30%
4	Society Awareness About Energy Efficiency	12%
4.1	Share of individuals who have installed solar panels for household consumption	35%
4.2	Share of individuals who have used energy-efficient household appliances	30%
4.3	Share of individuals that report concerns about rising energy costs in households	15%
4.4	Share of individuals who report concerns about rising energy security, including electricity availability in households	15%
5	Business Awareness About Energy Efficiency	13%
5.1	Share of businesses that predominantly use renewable energy	20%
5.2	Share of businesses that perceive that availability of green finances and incentives under favorable conditions (such as energy efficiency loans) will influence their business decisions in the coming year	20%
5.3	Share of businesses that perceive that rising costs of energy and materials will influence their business decisions in the coming year	20%
5.4	Share of businesses that perceive carbon taxation, CBAMs (Carbon Border Adjustment Mechanisms), and ETSs (Emissions Trading Systems) will influence their business decisions in the coming year	20%
5.5	Share of businesses that believe that the green transition will have a positive implication on their businesses	10%
5.6	Share of businesses that are aware of the circular economy and its principles	10%

¹ Indicators and weights prioritize (i) availability in harmonized, cross-country datasets covering all Western Balkan economies; (ii) alignment with EU energy and energy-efficiency directives (acquis); and (iii) relevance to energy efficiency in public buildings. Source: Authors' compilation (2025).

The normalization procedure applied for the sub-indicators was min–max so that the values would fit in the range [0, 1] by applying Equation (1) for each sub-indicator s_i and country c . Direction $\in [+1, -1]$ represents a switch that indicates whether a higher value is preferable (+1) or a lower value is preferable (−1). The lack of outlier values favored the use of min–max procedure. To control outliers, the median absolute deviation (MAD) method was used, as recommended in small samples [85,86]. For those sub-indicators benchmarked against EU targets, the “distance to a reference” procedure was used, as explained in Equation (2).

$$z_{s,c} = \frac{x_{s,c} - \min(x_s)}{\max(x_s) - \min(x_s)} * direction_i + 0.5 * (1 - direction_i) \quad (1)$$

$$z_{s,c} = \frac{x_{s,c} - x_{s,c=\overline{EU}}}{x_{s,c=\overline{EU}}} \quad (2)$$

For the aggregation method, the summation of weighted and normalized sub-indicators, as shown by Equations (3) and (4), was used, since the data complied with all the requirements. This linear aggregation method is the most used in the creation of composite indices, as it addresses the multidimensionality of sub-indicators and allows flexibility and adaptability in normalization methods. Another benefit is the easy interpretability and comparability that it offers [80].

Indicator score:

$$z_{i,c} = \sum_{s \in i} w_{i,s} * z_{s,c} \text{ where } \sum_{s \in i} w_{i,s} = 1 \quad (3)$$

Composite index score:

$$PB - EERI = \sum_i w_i * z_{i,c} \text{ where } \sum_p w_p = 1 \quad (4)$$

4. Results and Discussion

The evaluation of the PB-EERI in the Western Balkans demonstrated significant differences in energy efficiency readiness in public buildings, as shown in Figure 1. These findings are broadly aligned with evaluations presented by the Energy Community Secretariat [16,67], which, although not directly comparable in methodology, reveal similar performance patterns and challenges.

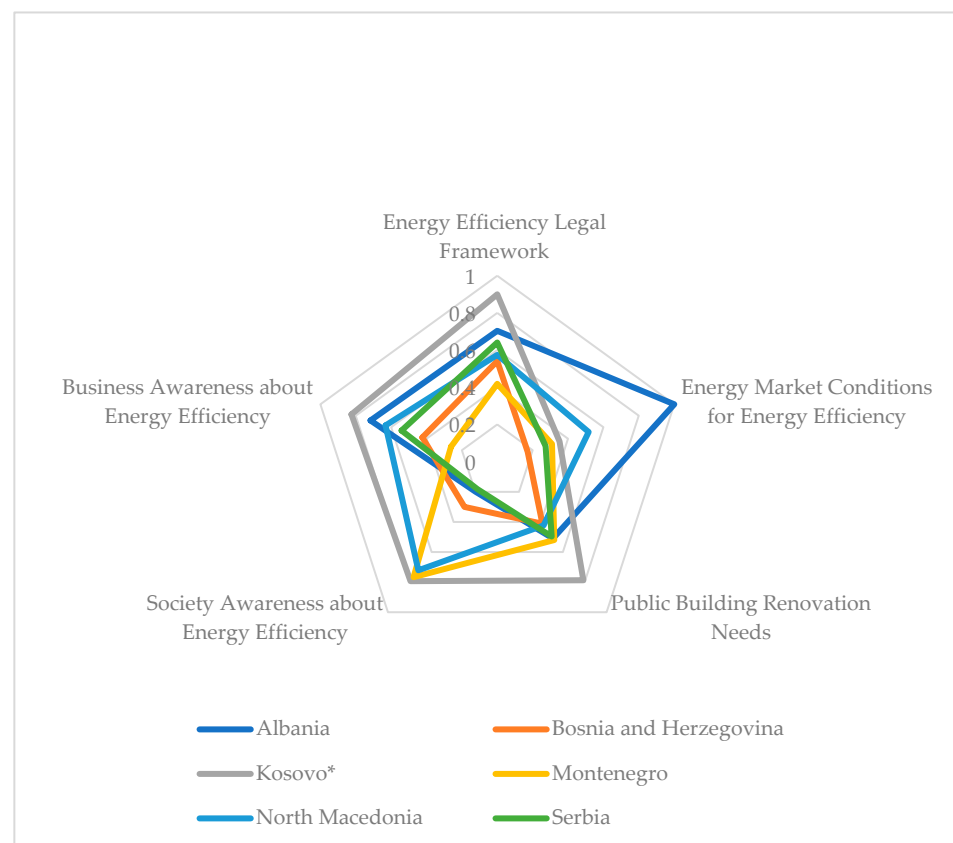


Figure 1. Multi-dimensional assessment of public building energy efficiency readiness for Western Balkans (PB-EERI). * This designation is without prejudice to positions on status and is in line with UNSCR 1244 and the ICJ Opinion on the Kosovo declaration of independence.

Kosovo excelled in nearly every category, thus scoring an index of almost 72%. Energy market conditions for energy efficiency was the only dimension where Kosovo scored a

low performance due to limitations imposed by its fuel mix. The legislation of Kosovo is the most comprehensive, as it provides explicit definitions of nZEBs and establishes quantifiable and precise standards for achieving them. Further information is required on generating prospects for market energy to sustain energy efficiency.

With an overall result PB-EERI of 63%, Albania performed strongly in the market conditions for energy efficiency dimension, primarily due to its capacity to generate electricity from renewable sources. Despite a robust legislative framework, public knowledge remains somewhat low, although business awareness is quite high. Probably due to elevated legal obligations that impose financial strain, firms tend to exhibit greater awareness.

North Macedonia exhibited an index of 54%, characterized by elevated levels of public and business awareness. Society should exert pressure on governments to enhance the application of EU standards and advance their renewable energy markets. Ambitious targets have been established to enhance energy efficiency in the energy sector. The proportional rise in the share of renewable energy from 2023 to the objective for 2030 is about 98%, the highest among all countries.

Montenegro and Serbia had a similar performance, scoring 44.7% and 45%, respectively. Montenegro possesses adverse conditions for the development of an efficient energy market. The need for public renovations is substantial, although the annual public buildings renovation rate is at 1%. The proportional rise in the share of renewable energy from 2023 to the 2030 target was the second lowest, at over 22%. Serbia ranked among the lowest in terms of public and business awareness. The circumstances and parameters in the energy market do not significantly enhance energy efficiency, while the objectives established to tackle these challenges lack sufficient ambition.

The PB-EERI index for Bosnia and Herzegovina was 39%. The legal framework is often inconsistent among its two entities due to its divided governmental structure. The parameters for energy efficiency in the energy industry are severely constrained due to a significant dependence on fossil fuels. The anticipated growth in the share of renewable energy from 2023 to the 2030 objective was the lowest at nearly 19%. The renovation rate of public buildings was set at 1% below the EU requirement, even though the public renovation needs are high.

4.1. Energy Efficiency Legal Framework

The energy efficiency legal framework assesses the existence and functionality of legislative and institutional requirements for energy efficiency in public buildings in the Western Balkans. The indicator includes (i) the transposition depth of the EPBD and the specificity of nZEB definitions, (ii) the existence and operational status of a specific energy efficiency agency and fund, and (iii) the presence of public-sector renovation obligations.

Albania demonstrates a relatively developed framework established by the Law on Energy Efficiency (No. 124/2015), the Law on Energy Performance of Buildings (No. 116/2016), and the Law on Renewable Energy Sources (No. 24/2023). The provisions of the EPBD have been adopted, establishing a required EPC regime for both public and private buildings. The National Energy and Climate Plan (NECP) 2021-2030 for Albania establishes a target of 54.4% of gross final energy consumption derived from renewable sources by 2030. This target signifies a 23% increase from the ultimate energy consumption in 2023. The increase is somewhat moderate, given the advantageous conditions for renewable energy in Albania and the nation's dedication and prioritization within its energy plan. The target share of renewables is set for various industries, but excluding the building sector. However, while the idea of nZEBs is mentioned in legislation, it still lacks quantitative criteria (e.g., kWh/m²) and properly defined national indicators. The Agency for Energy Efficiency (DCM No. 852/2016) formalizes institutional capacity by

overseeing technical verification and licensing. Albania has yet to establish a dedicated energy efficiency fund, relying instead on the state budget, international financial institutions, and commercial credit lines for financing. Renovation rates are clearly defined: 3% annually for central government buildings and 2% for municipal structures until 2050. Collectively, these characteristics indicate a medium–high score in the energy efficiency legal framework dimension, with the primary deficiency being the lack of nationally mandated nZEB performance standards [87–91].

The performance in Bosnia and Herzegovina is mitigated by structural fragmentation, since energy and building efficiency regulations are established at the entity level, resulting in inconsistent adoption and implementation between Republika Srpska and the Federation of BiH (FBiH). Both institutions have implemented fundamental energy and renewable energy source legislation, along with minimum energy performance standards for buildings, although neither has established a clear, quantifiable definition of near-zero-energy buildings (nZEB). Energy performance certificates for buildings have been established, but the consistency of implementation and enforcement is lacking. Legislation anticipates the establishment of an energy efficiency agency and an Energy Efficiency and Environmental Fund. However, the fund's complete operationalization is contingent upon the enactment of secondary legislation and the availability of stable financial sources. The principal strategic document regarding energy, the NECP in BiH, establishes a national objective of 43.6% of final energy consumption derived from renewable sources, reflecting an increase of nearly 20%. This target is relatively moderate given the current proportion of renewable sources in gross final energy consumption. A 1% yearly renovation commitment for public buildings has been established, and the FBiH has implemented a long-term renovation strategy extending to 2050. The interplay between these issues leads to a low-to-medium performance in the energy efficiency legal framework dimension, attributable to definitional discrepancies, administrative duality, and postponed implementation [92–96].

Kosovo's operational tools and precise legal alignment allow it to achieve high performance in the energy efficiency legal framework dimension. The Energy Efficiency Law (No. 06/L-079), the Energy Performance of Buildings Law (No. 08/L-242), and the Renewable Energy Sources Promotion Law (No. 08/L-258) collectively implement the EPBD with significant precision, incorporating a clear definition of nZEBs based on quantitative performance criteria. Energy Performance Certificates are obligatory for both public and private buildings and are integral to compliance protocols. The institutional framework is solid. The Kosovo Agency for Energy Efficiency is operational, and the Energy Efficiency Fund prioritizes municipal/public facilities and private-sector initiatives. Renovation requirements for central government buildings have been intensified to 3% annually starting in 2024, in accordance with the EPBD standard. The targets have been incorporated into the NECP/Energy Strategy 2021–2030, with a significant enhancement in the share of renewable energy sources [97–100].

Montenegro meets the essential requirements of its legal framework but needs further enhancement in key areas. The Law on Energy, Law on Energy Efficiency, and Law on Energy Performance of Buildings have incorporated essential EPBD elements, and an EPC system has been established. Nonetheless, the nZEB idea is cited without quantitative benchmarks; instruction is based on an outdated secondary law that offers methodological and qualitative requirements instead of obligatory numeric performance criteria. There is no independent energy efficiency agency. Responsibilities are managed by the Directorate for Energy Efficiency within the Ministry of Economy, which limits specialization and the execution of long-term programs. The public-sector renovation goal is established at 1% annually, which is very small in comparison with its regional neighbors. The adoption of the 2024 NECP and the 2030 Renewable Energy Sources target indicates significant

advancement; however, Montenegro's absence of nZEB thresholds and an institutional framework continues to prevent a higher rating [101–103].

North Macedonia's framework integrates essential elements of the Energy Efficiency Directive and the EPBD into its NECP and other energy legislation, while lacking a separate, independent EPBD building law. An EPC system is compulsory, and the NECP introduces the concept of nZEBs. Nevertheless, the precise thresholds and indicators are unclear. The stipulation that new residential structures attain a minimum Energy Performance Building Class C (about 90 kWh/m²/year) represents progress, but it is not expressly defined as the nZEB standard across other building categories. An Energy Agency operates inside the Ministry of Economy, whereas the Energy Efficiency Fund has been proposed but is not yet functional. The annual renovation requirement for central government buildings is 1%. A target of 38% renewable sources in final energy consumption has been established, effectively doubling the current figures [104–106].

Recent amendments to Serbia's Law on Energy Efficiency and Rational Use of Energy and the Law on Renewable Energy (both from 2023) demonstrate a strategic commitment to efficiency and renewable energy; nonetheless, measures relating to building regulations are insufficient. The regulatory stipulations for energy performance certifications apply to both public and private buildings. Procedures for evaluating building performance exist, but a specific EPBD building statute with defined nZEB thresholds has yet to be established. The Directorate for Financing and Promoting Energy Efficiency operates as an effective national energy efficiency agency, and a budgetary Energy Efficiency Fund is active with consistent public appropriations. The renovation requirement for central governmental buildings is established at 3% annually, and the NECP sets certain quantitative renovation criteria [107–109].

4.2. Energy Market Conditions for Energy Efficiency

The current state of the energy market among the WB6 countries reveals disparities [1,110,111]. This arises from the variation in energy sources based on the available and utilized natural resources, as well as the distinct sectors of the economy, despite all six predominantly relying on the service sector. One of the most critical metrics regarding energy efficiency in buildings is the proportion of energy consumption attributed to this sector. Eurostat [1] provides values for the “residential” sector and the “services and non-specified” sector, as shown in Figure 2.

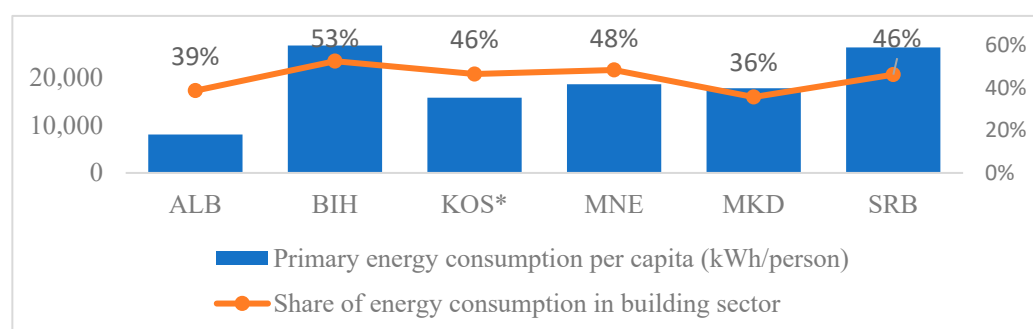


Figure 2. Primary energy consumption and share of building sector energy use in Western Balkans, 2023. * This designation is without prejudice to positions on status and is in line with UNSCR 1244 and the ICJ Opinion on the Kosovo declaration of independence.

In this context, there are no data regarding the proportion of consumption allocated to public buildings. However, the overall numbers are somewhat suggestive of general building efficiency. In 2023, the lowest values were recorded in Montenegro and Albania, despite

Montenegro exhibiting the largest value added from services in its economy. Nonetheless, the residential sector was more significant in this number.

Albania exhibited a higher proportion of renewable energy in both consumption and production, as shown in Figure 3, due to its advantageous natural resources, demonstrating greater energy efficiency. In 2023, the proportion of renewable energy in Albania's power output, including exports, was 102%, thereby contributing to the achievement of the renewable energy source target [112]. This significantly influences energy efficiency in buildings, as electrically powered buildings can implement more efficient technologies and heating systems, hence reducing gas emissions, which is another criterion for near-zero-energy buildings. In certain countries, this number may decrease to as low as 26%, as in North Macedonia.

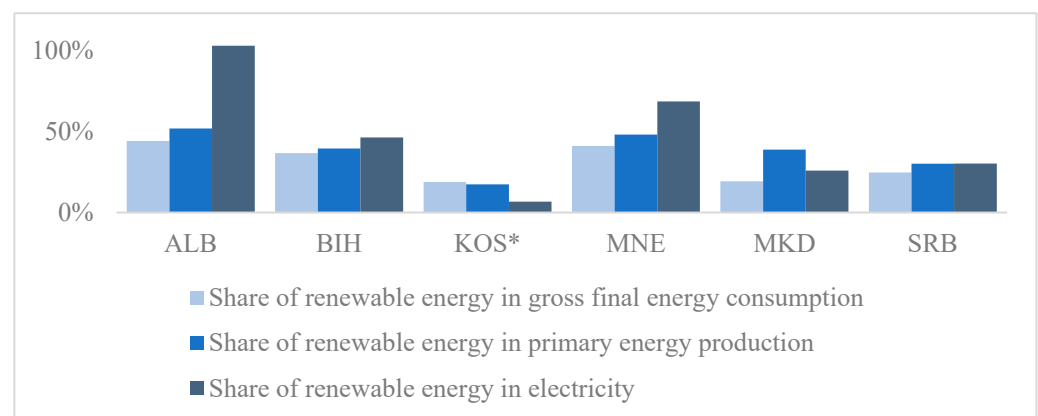


Figure 3. Renewable energy shares in final consumption, primary production, and electricity in the WB6, 2023. * This designation is without prejudice to positions on status and is in line with UNSCR 1244 and the ICJ Opinion on the Kosovo declaration of independence.

The absence of data restricts us from assessing mostly general sub-indicators related to energy market opportunities for achieving energy efficiency in the building sector. The final sub-indicator assessed was the average primary energy factor shown in Figure 4. Albania, ranking the lowest, demonstrated a clean energy mix, little conversion losses, and a substantial dependence on hydropower, indicating prospects for enhancing energy efficiency in the broader energy market and, specifically, within buildings. Montenegro exhibited the largest dependency on fossil fuels, suggesting significant losses in the transmission grid and demonstrating the worst inefficiency in meeting energy efficiency metrics [2].

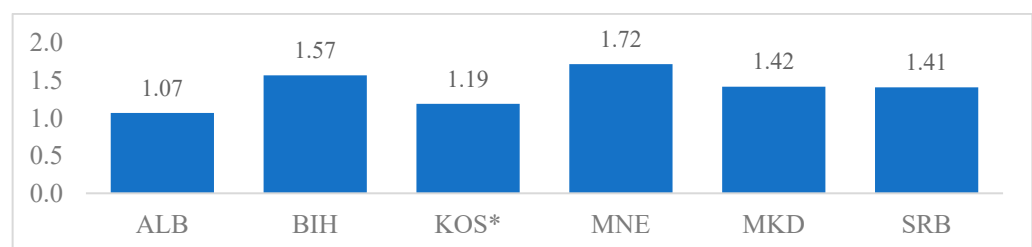


Figure 4. Average primary energy factors in Western Balkans, 2023. * This designation is without prejudice to positions on status and is in line with UNSCR 1244 and the ICJ Opinion on the Kosovo declaration of independence.

4.3. Public Building Renovation Needs

Public buildings in the Western Balkan countries are distinguished by their significant energy inefficiency. The average energy consumption in public buildings is projected to be at least double the EU standard, making them very inefficient, as over 60–70% of

these buildings were constructed over 30 years ago with minimal consideration for energy efficiency. Excluding Albania, over 80% of public sector buildings presently utilize district heating systems or fossil fuels, primarily coal and gas. The third theme of the composite index pertains to the renovation requirements for public buildings. The UNDP [2] assessed the range [minimum, maximum] of primary energy consumption in kilowatt-hours per square meter per year, contingent upon the year and public building type in the WB6. These values were subsequently compared with the European Union's COL methodology (180 kWh/m² for existing public buildings and 140 kWh/m² for new public buildings) and the EPBD standard of 85 kWh/m².

Albania possesses the lowest primary energy consumption standards for both existing and new public buildings, as shown in Figure 5. The primary energy consumption needs significantly exceed EU regulations, indicating potential for energy reduction through energy efficiency policy actions. Even though primary energy consumption in existing public buildings is low, Albania possesses a substantial existing public stock. The per capita total area of public buildings in Albania is significantly elevated, over double that of Bosnia and Herzegovina, which ranks second highest. Kosovo exhibits the lowest rate [2].

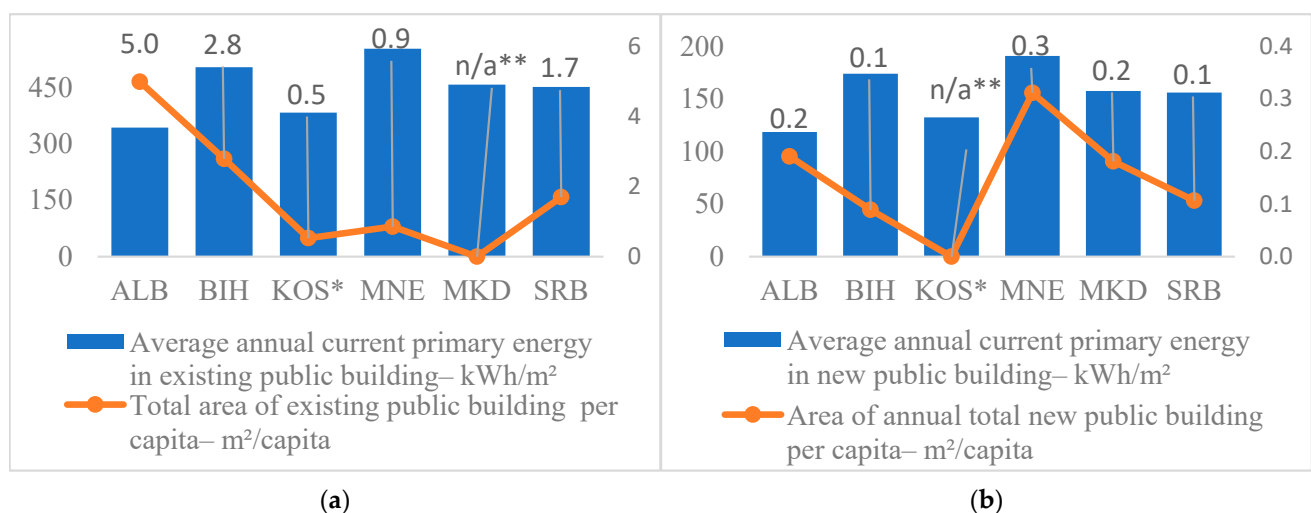


Figure 5. (a) Energy performance and building stock intensity in existing public buildings; (b) Energy performance and building stock intensity in new public buildings. * This designation is without prejudice to positions on status and is in line with UNSCR 1244 and the ICJ Opinion on the Kosovo declaration of independence. ** Data are absent.

The new buildings have reasonably low primary energy use, closely aligning with the EU COL approach, although they still fall short of EPBD norms. However, the annual inventory of new constructions is rather low for all WB6.

4.4. Society Awareness About Energy Efficiency

Public awareness of energy efficiency is most pronounced in North Macedonia and Kosovo, as shown in Figure 6. Individuals express awareness regarding escalating energy expenses and energy security. These individuals indicate elevated levels of personal initiatives to enhance energy efficiency in their residences, along with individuals from Montenegro [82]. This may be attributable to the substantial dependency of these two countries on fossil fuel sources in comparison with their neighbors [1].

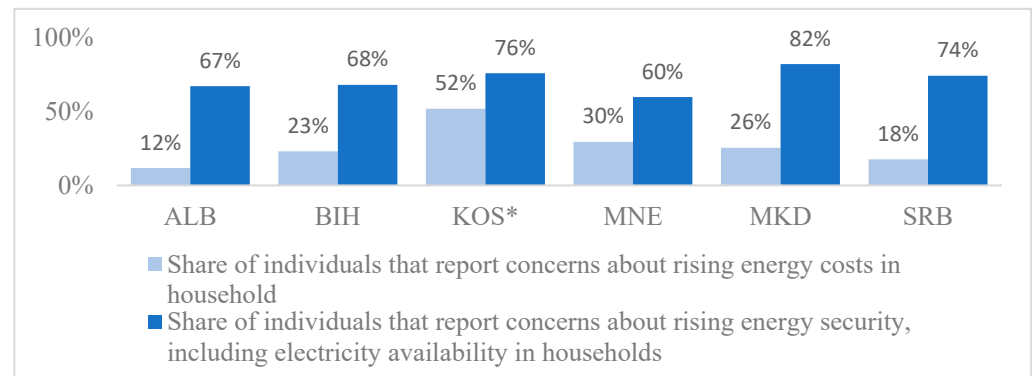


Figure 6. Public perceptions of rising energy costs and energy security in Western Balkans, 2023. * This designation is without prejudice to positions on status and is in line with UNSCR 1244 and the ICJ Opinion on the Kosovo declaration of independence.

In the Western Balkans, approximately 13.5% of government and public administration employees report utilizing energy-efficient household appliances, ranking second after employees in transportation and distribution logistics. Additionally, nearly 28% of these employees indicate that they have installed solar panels for residential use [82]. Figure 7 shows the adoption of energy-efficient measures in Western Balkan countries.

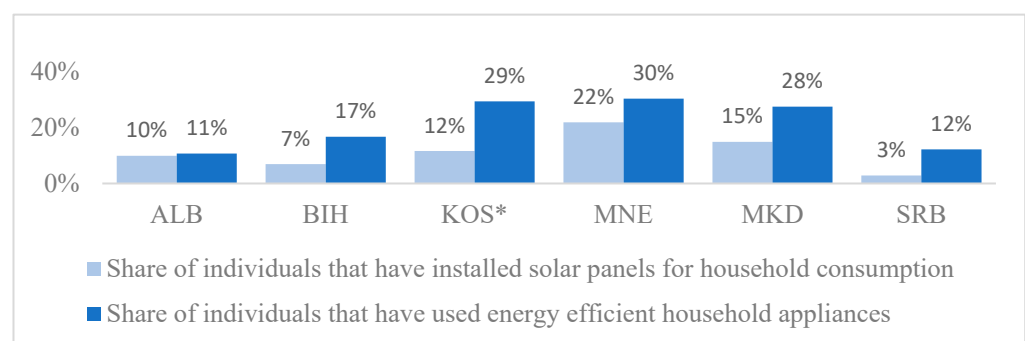


Figure 7. Adoption of energy-efficient measures in Western Balkan households, 2023. * This designation is without prejudice to positions on status and is in line with UNSCR 1244 and the ICJ Opinion on the Kosovo declaration of independence.

A more pronounced disparity is evident between rural and urban regions. Over 12% of urban residents indicate having installed solar panels for domestic use, in contrast with under 1% of rural residents. This remains applicable to energy-efficient household equipment, despite respondents citing growing energy costs as their primary concern, with 73% of the urban population and 69% of the rural population expressing this sentiment. This highlights a financial limitation in rural areas [82].

4.5. Business Awareness About Energy Efficiency

Business Opinion Barometer [77] data indicate that business awareness, understanding of energy efficiency, and larger energy transition challenges are rising across the Western Balkans, even with significant variance among countries. As shown in Figure 8, a considerable proportion of businesses indicate that escalating energy expenses and material costs will influence their future choices, with percentages surpassing 60% in Kosovo and North Macedonia, in contrast with merely 19% in Montenegro [83].

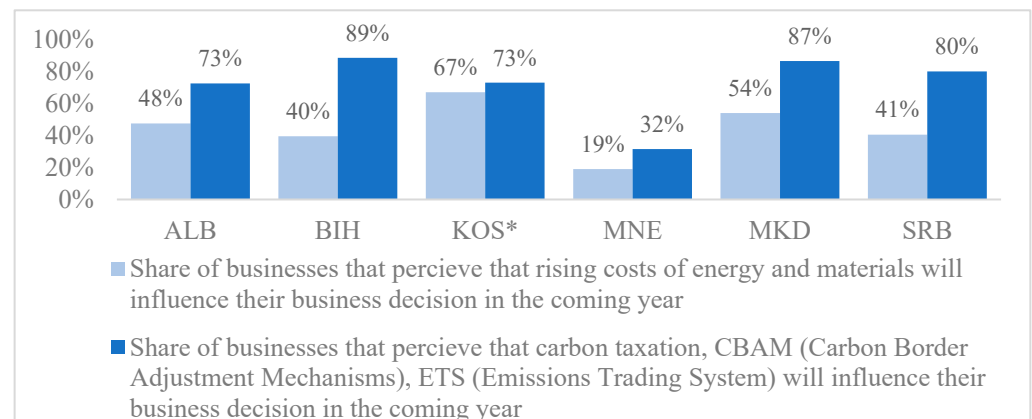


Figure 8. Business perceptions of energy costs and climate regulation impacts in the Western Balkans. * This designation is without prejudice to positions on status and is in line with UNSCR 1244 and the ICJ Opinion on the Kosovo declaration of independence.

In Bosnia and Herzegovina, just 7% of firms predominantly utilize renewable energy sources, whilst in Serbia, the figure is 10%. In contrast, Montenegro demonstrates a greater proportion, at 20%, and Kosovo follows closely, with 19%, as shown in Figure 9. These findings underscore a paradox: despite enterprises' growing understanding of risks associated with energy price volatility and EU climate policy, this awareness does not consistently result in proactive investments in energy efficiency or the adoption of renewable energy. This gap indicates that although awareness is essential for change, it must be augmented by more robust financial incentives, clearer regulatory frameworks, and supportive systems to expedite the transition of businesses to sustainable energy practices and to advocacy for more energy-efficient governments [83].

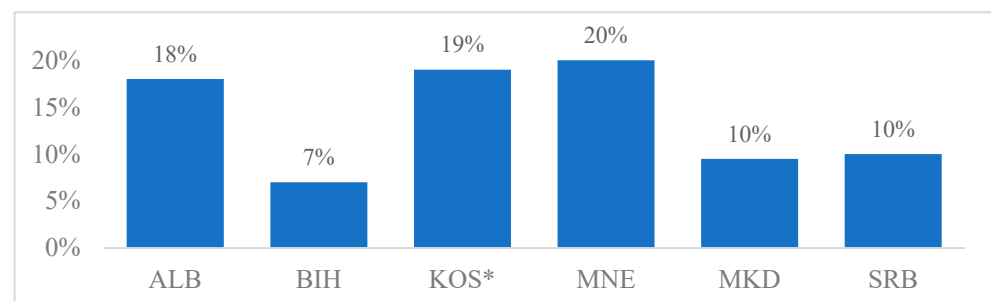


Figure 9. Share of businesses predominantly using renewable energy in the Western Balkans, 2023. * This designation is without prejudice to positions on status and is in line with UNSCR 1244 and the ICJ Opinion on the Kosovo declaration of independence.

For all WB6 countries, data indicate that 56% of businesses with solely foreign ownership are aware of the circular economy and its principles, in contrast with merely 35% of businesses with domestic ownership. Women in leadership and managerial roles appear to significantly influence the understanding of circular economy practices and energy efficiency in companies. As the number of women in leadership roles increases from zero to five, awareness rises from 31% to 49%. Furthermore, it is demonstrated that enterprises comprising a sole individual or family members exhibit diminished awareness compared with corporations [83].

5. Conclusions

This study evaluated the Public Building–Energy Efficiency Readiness Index (PB-EERI) to evaluate how legislative specificity, institutional capacity, financing mechanisms, renova-

tion guidelines, energy market conditions, and societal awareness collectively influence the readiness of Western Balkan economies to enhance energy efficiency in public buildings. The index serves as an operational diagnostic to identify the presence of enabling conditions, determine the most significant gaps, and prioritize policy efforts accordingly.

The Public Building–Energy Efficiency Readiness Index (PB-EERI) exhibits significant variation throughout the Western Balkans, with total scores ranging from around 39 to 72% and concentrating around the mid-0.5s. The findings reveal systematic differences in most indicators’ performance. The legal framework indicator significantly influences variation between countries. Higher scores are observed where EPBD transposition incorporates explicit, quantitative nZEB thresholds, where mandatory EPC regimes are effectively implemented, where dedicated implementing bodies are established, and where public-sector renovation obligations are enforced with specific timelines, such as the case of Kosovo and Albania. The energy market conditions are also very heterogeneous, where Albania and North Macedonia have the best performance. Cleaner power mixes and reduced primary energy factors consistently enhance readiness by facilitating technical nZEB compliance. Across the Western Balkans, public building renovation needs present broadly similar performance, with the notable exception of Kosovo. This is conditioned on an aging and extensive public stock that the countries of the Western Balkans have inherited.

Business awareness generally surpasses public awareness and is more homogeneous between Western Balkan countries, reflecting firms’ need to comply with obligations and remain accountable to their consumers. Societal awareness about energy efficiency is more uneven. On the one hand, in Kosovo, which is heavily dependent on coal, its citizens report higher awareness and a great propensity to adopt efficiency measures. In Albania, despite possessing a relatively clean, hydroelectric power mix, public awareness appears low. This is possibly due to the low perceived energy emissions and relatively low energy tariff.

Energy efficiency in public buildings, praised as the “first fuel”, should be prioritized beyond mere compliance with EU regulations and regarded as a fundamental component of sustainable development and energy security in the Western Balkans. To attain the 2030 objectives, it is essential to implement near-zero-energy building standards and standardized legislative frameworks, with the development of dependable statistics systems, resilient finance structures, and enhanced enforcement capabilities. Ultimately, the PB-EERI emphasizes that success relies more on the capacity to transform formal strategies into concrete repair programs, quantifiable objectives, and reliable monitoring systems.

A constant challenge in the region is the lack of regular, reliable, and comprehensive statistics on the energy sector. Governments frequently lack the comprehensive data necessary to formulate and execute long-term energy efficiency initiatives. The disparity is especially pronounced in the public building sector, where the public building inventory is predominantly antiquated, where approximately 35–45% was built prior to 1990, yet thorough energy statistics are still lacking.

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