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Renovation Analysis of a Socialist Modernism Office Building–Case Study

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Abstract: Socialist modernist architecture in the Balkan has left a valuable legacy of remarkable buildings from this century, which brought a mixture of new experiences and local traditions. Unfortunately, after the 1990s, many of these buildings have been neglected, improperly treated, or abandoned. This paper focuses on the iconic socialist modernist office building "Rilindja" in Prishtina, Kosovo, which was built in 1979. In 2010, the building envelope was changed in the name of revitalization, without considering the energy aspect. The study aims to present energy performance analysis through cost-optimal renovation measures of the building envelope while restoring the architectural values before the last renovation. Using Archicad and EcoDesigner STAR, a BIM model was created, and energy analysis was conducted. The findings indicate that eighteen proposed energy efficiency measures can achieve a reduction in energy consumption for heating and cooling of more than 80% over the life cycle period of 20 years. The comparison before and after renovation considering restoring and preserving the inherent values, while integrating energy efficiency measures was necessary, as there is a lack of such studies in the general literature. Finally, the potential of restoring the collective memory through cost-optimal analysis is emphasized as an approach for similar cases.

Keywords: socialist modernism architecture; iconic building; building envelope renovation; energy saving; cost-optimal levels

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1. Introduction

The socialist modernist architecture built in Central and Eastern Europe in the twentieth century is known for its high percentage of energy consumption. In this sense, a significant change is needed to achieve the European energy and climate targets by 2050. More than 80% of these socialist modernist buildings have poor thermal performance and do not meet today's standards [1]. These buildings, most of them now known as symbols or icons of the cities, are at the same time responsible for enormous potential as well as specific attention and treatment. The requirements for the preservation of the values of these buildings, as well as the application of energy efficiency measures, are now considered to be quite challenging but at the same time very important for sustainability. Even though the unique socialist modernist architecture built in the twentieth century in Central and Eastern Europe is considered a source of existing and potential heritage due to the historical context in which it was created, this architecture still remains ambiguous for some countries [2]. After the Second World War, rapid industrialization and the need to have a roof over one's head were the main challenges during this period of time. This initiative comes as an endeavor and necessity for rapid progress together with the tensions of the Cold War and the confrontation between the Socialist and Capitalist Blocs [3]. As a result, in most European countries, mass-produced multi-story apartment blocks were

built on a massive scale [4]. The appearance of modern architecture at the beginning of the 20th century brought revolutionary changes in architectural design [5]. Pure and simple design without ornamentation began to replace the eclectic artistic expressions of past times [5]. The modernist tendency was adopted as the result of historical events. In 1955, the official moment of "useless stylistic elements" in architecture was abandoned by the decision of the Central Committee of the Communist Party of the Soviet Union [6] with the proposal of 'one flat per family' under the Khrushchev government. Therefore, most of the social housing was built and completed in the years 1950'–1980', especially in countries of Soviet Union [7]. In the first decade of the mass housing campaign alone (1956–1965), 13 million apartments were built [8]. As mentioned before, the architectural design of multi-story residential buildings is characterized by simplicity or a functionalist and utilitarian style. Those typically have flat façades with regularly spaced windows, balconies and a repetitive interior model. The design of these buildings is not focused on aesthetics in mind but on the "efficiency" of housing production and affordability [9]. In addition, these buildings are considered cheap housing, equal opportunities, and social security. Strict regulations and bold plans with limited economic opportunities led to the creation of separate but small apartments that people began to refer to them as "cages" [10], "ugly appearance" [4], "depressive architecture" [10], and "concrete landscapes" [11]. The dimensions of the apartments were minimal. Consequently, the typical living area for an apartment was 16 square meters for a one-room apartment and 40 square meters for a four-room apartment, while the room in the project designated as a bedroom for one person had a limited area of only 6 square meters [12]. Taking into account the time needed for the interior design, the prefabricated panels could be completed, and residents could move in within about a month and a half after the start of construction. Prefabricated panel blocks are referred to by many different names in most countries, such as "large-panel buildings" [9], "Panelki" [13], "common blocks", or "socialist lifestyle" [9]. However, even in the West or behind the Iron Curtain, the main reason was the rapid construction of housing to accommodate the growing urban population [14]. Therefore, their names differ from the technology of their construction which is prefabricated reinforced concrete several meters wide and high [9].

This article therefore shifts the focus away from socialist mass housing and concentrates on the iconic buildings of this period of time, namely public buildings. In contrast to residential buildings, public buildings are considered far greater freedom in terms of design and construction. At this time, the city center was considered the center of political activity. In this respect, the city's most important public buildings had to enclose the center, which had to be designed as a regular, central place for social and political gatherings. A tower always played an important role in the composition in order to be representative and create a landmark for the city center [15]. For this reason, many public buildings throughout Central and Eastern Europe have been constructed with an architecture that strongly expresses the principles of modern architecture. From this point of view, it is clear that Soviet practices are rejected as a reference point for future architecture [16] in socialist countries. The Monument to the Revolution of the People of Moslavina (Spomenik Revolucije Naroda Moslavine), Croatia, the "Arch of Freedom", Bulgaria—1978, and the Monument to 1300 Years, Bulgaria—1981 are just some of the monuments from this period that should be mentioned because such a revolutionary approach was already widespread and manifested itself in the public buildings as well. A modernist concept was also expressed in the completion of Alexander Platz in Berlin in 1969 [17].

During this period, many architects had the opportunity to use various references from all over the world in their countries. They also had the opportunity to demonstrate and apply their professionalism elsewhere. For this reason, there are different buildings built in different countries, but they have common features and elements in their design (such as the airport "Tallinn" [18], Estonia, the cinema "Rossiya" [19], Yerevan, Armenia, and the youth sports center "Boro and Ramizi" [20], Prishtina). In this context it is important that most public buildings, in this period, were built in regular geometric forms, with rational

functional solutions, clear volumes, and openings that were repeated evenly and without ornamentation, with a flat roof, open floor plans, etc. The main characteristic of socialist modernist architecture is the use of materials such as brick, steel, concrete, etc. according to their natural properties, in most cases using them without any covering. Although these materials are considered beautiful enough, they are quite energy inefficient from a sustainability point of view. Walls, roofs, ceilings, and floors were built without any thermal insulation or the windows only had one layer of glazing. For this reason, these buildings are not considered very environmentally friendly today. When it comes to the use of materials, there are different opinions about their properties and characteristics. For example, concrete as a façade material is considered 'ugly' and 'poor quality' [21]. However, there are also studies that consider this material as "concrete heritage" as a legacy of modernist architecture [2]. Furthermore, concrete prefabricated panels are considered iconic materials in some countries [8], as this material enabled reconstruction after the Second World War and modernization in the following decades [2].

On the other hand, some of these buildings are characterized by natural light, using large windows, skylights, and other design features that allow natural light to penetrate deep into the interior of a building, as well as functional interior design. For many of these reasons, the architecture of these buildings is considered controversial by many authors today. Some of them describe it as unusual and exciting architecture, a so-called "exotic appearance" [22] or "pure and dignified architecture until completion" [16] while [23] considering that Central and Eastern Europe are fading memories of the socialist era and are describing them as "decaying grey". The fact that socialist architecture is not perceived as cultural heritage by the wider public is also pointed out by [24]. After the fall of socialism, most socialist areas were found to be a "rejected" heritage or a kind of "ruined" spaces that had lost their functional meaning, symbolic significance, and any clear narrative [25]. Many of these buildings have been abandoned and left to decay, while others await demolition in the rapidly developing cities [23]. Thus, many iconic buildings of the socialist era were demolished because it was felt that the architecture of the communist era was not adequately integrated into a sense of continuous historical identity [26]. Some of these buildings that are now abandoned, destroyed, and almost forgotten are the Technicum Auditorium, Georgia, (1978) [27], such as the Neon Restaurant–before recreational center, România, (1957) [28], the Buzludzha Monument, Bulgaria, (1974) [29], the Cantin Cosmos, Romania, (1960s) [30], the Noroc Restaurant (Acum Cafeneaua Guguță), Moldova, (1979) [31], etc. The fact that buildings erected during the socialist era are being demolished and replaced by new ones is also evident in [32].

Various consequences, such as a lack of funding for renovation and negligent or ignored maintenance, brought attention to the socioeconomic implications of these buildings' continued physical deterioration [33]. However, the architecture of this era is considered distinctive, authentic, and of raw quality, unlike the hyper-precise architectural production of today [22] and it is not only for this reason that these buildings must be protected and preserved, but also because they represent an era of history, a collective memory and, above all, our culture in which we have grown up and developed. Furthermore, this can be defined as follows: "Buildings and monuments are a clear reflection of the social and cultural context of the socialist period and they are not represented in the history of world architecture" [34]. In the last decade, this modernist architecture has become an attractive topic for the younger generation [22] which especially increases activities around rethinking and revitalizing the modernist heritage and has become a global trend [25]. This is because many buildings have undergone advanced degradation processes over the decades, making repair or modernization work necessary [35]. Considering the fact that most of these buildings are almost 60 years old and still in use, the implementation of restrictive regulations and technical conditions, e.g., those with regard to energy standards and thermal comfort are also a part of the triggering process for the renovation.

There are some iconic buildings that have demonstrated successful renovation practices through a particular treatment approach to restoration, appropriate conservation, and

preservation of their historic values. One of them is a landmark of Croatian architecture, the Cube (Kockica) building in Zagreb. The flat roof and façade of the building were renovated, windows were replaced with aluminum profiles and triple glazing, while all the originally installed steel façade elements were preserved. All concrete elements of the façade were repaired, while at the same time, the building envelope was reconstructed as it was built in 1968 [36]. Another building is the Hala Olivia Gdansk in Poland, which was built in 1972. After the restoration work was completed, parts of the building were demolished and returned to its original form. Today, the building is as it was originally built [37].

Not all buildings have the same fate, the number of revitalization problems is considerable and most buildings have not only been renovated but have left nothing of their original design. One such building is the Tomis department store in Constanta, Romania (1973), where the main structure was preserved but new facades and superstructures were built [34]. Another building is the Banca Națională a Moldovei (1974) in Moldova, which radically changed the design of the building, both in the height of the building and in the general style [35]. Recently, the building of the "Enver Hoxha" Museum in Tirana, Albania (1988) was also transformed into a shopping center [38]. Another case is the Technical University of Moldova, where three pavilions were decorated with three murals on the theme "Ideology, Cosmos and Science", but after the renovation two of them were partially destroyed by covering them with thermal insulation material without taking into account the value of cultural heritage [39]. The reasons for the transformations are different and often arise from current interests, as in the case of the Turnul, Romanița (1986). City officials say that the building is blocked by new buildings on public land and for this reason, the demolition of this building is planned for within the next 10 years [40]. Sometimes, there are also "commercial motives", as in the case of the "Emilia Pavilion" in Poland, which was listed as a heritage building but was sold to a foreign company that managed to remove it from the heritage list. Now, it is being demolished and will be converted into a high-rise building [32]. Some of the other buildings were adapted for contemporary purposes. The Haus der Statistik in Berlin—a nine and eleven-story building—is being converted into accommodation for refugees [38], while in the case of the sports and concert complex in St. Petersburg, permission was granted for construction work to renovate it by a bogus company that exists without a single license [40].

In an effort to protect these buildings, many of these countries have launched initiatives for more than a decade to document and preserve them as the heritage of their countries. One example of this is BACU–Birou pentru Artă şi Cercetare Urbană (Bureau for Art and Urban Research), a research group that through an initiative seeks to raise public awareness of the need to protect the built heritage of modernist socialist architecture.

To summarize, the architecture of socialist modernism addresses essential themes such as history, collective memory, and heritage. There are also many buildings of this type in Kosovo. They are iconic and have been transformed for different purposes. At the same time, they are part of our heritage, and their fundamental architectural features and values should be preserved. Against this background, the article aims to shed light on the architecture of the former printing house "Rilindja" in Pristina, an administrative building built in 1979. It is proposed to renovate the building envelope because it is not only about restoring the collective memory and returning the building to its original appearance but also about its poor energy performance, even though the building does not suffer from any moisture or mold. Through the BIM model and dynamic analysis of the existing situation of the building, it was determined that there was a high need for heating and cooling due to the large, glazed area on the façade of the building. The dynamic analysis was also carried out for the project before the renovation in 2010, as the façade of the building had some vertical walls that helped to improve the overall energy performance.

In summary, the main objective is to restore the socialist modernist architecture of this building, to highlight critical features, and to show the possibility of integrating energy-saving measures. For these reasons, it is necessary to develop and find cost-optimal levels,

by proposing energy efficiency (EE) measures that reduce energy consumption while preserving the values of this iconic socialist modernist building.

Numerous papers deal with topics such as building renovation, cost optimality, and energy savings, but there is remarkably little literature that deals with the particular challenges associated with socialist modernist buildings and their values. The main contribution of the research is the proposed methodology to achieve a cost-optimal level of building renovation through better energy efficiency measures. However, the key point is the restoration of the values that buildings with such characteristics possess by restoring the collective memory and preserving their landmark status.

2. Methodology and Selected Case Study

2.1. Materials and Methods

As already mentioned, the renovation of similar iconic buildings is not easy, not only in Kosovo but throughout Central and Eastern Europe. The biggest challenge for most of these cities is how to deal with these socialist buildings and how to most efficiently integrate them into the new condition [25] because the modern socialist heritage is highly endangered and its evaluation and protection are the most appropriate measures to preserve the common good. This approach has not been easy, because sometimes the renovation processes have destroyed the identity and values that these buildings possessed. However, the architecture of socialist modernism can undoubtedly be seen as a period with high identity value. For this reason, a selected case study is used to show that the set goal has been achieved and to demonstrate that a drastic renovation is not the best and right solution. Restoring the values that this building had before was the best solution and the biggest challenge. The model is developed in four main phases: (1) input data collection model from the projects (initial and existing) designs and inspection in the location; (2) selection and development of these data; (3) defining renovation energy efficiency measures; (4) simulation of the data and finding their optimization.

Moreover, taking into consideration that the building before the renovation had a different appearance from how it is today, the paper initially analyzed:

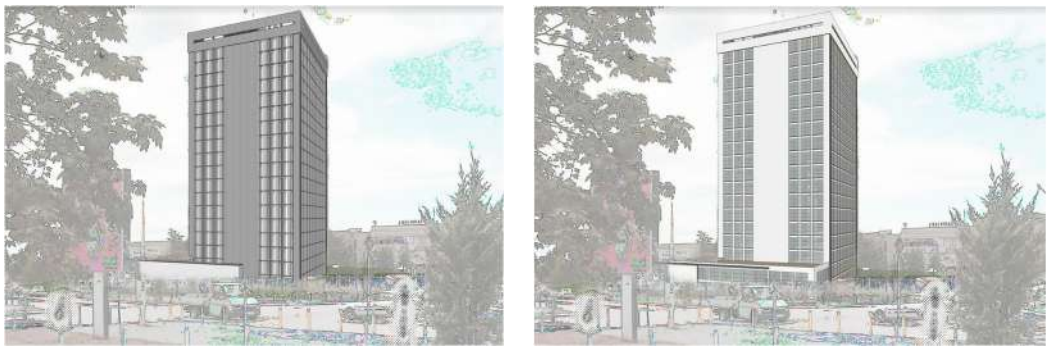
- The building before the renovation (case: initial project design) compared with the building as it currently is (case: existing situation). These two projects were analyzed and compared with a focus on energy efficiency, paying particular attention to the building envelope.
- The case of the 'initial project design' of the building is taken as a reference for the further application of the energy efficiency measurements.

It is important to mention that in order to achieve the EU's 2030 targets for reducing overall energy consumption, with a particular focus on the reduction of greenhouse gas emissions by at least 55%, many directives and the corresponding rules have been revised [41,42]. In this context, Kosovo, which is not yet a member of the European Union, has also adopted the law [43] in the field of building energy performance, which is partially in line with the EPBD [44]. Also in 2018, two regulations [45,46] were adopted that deal with information on the minimum requirements for calculating the energy performance of buildings and on the national methodology for calculating energy performance based on various standards such as the EN standard [47–50], etc. Despite this legislation, there are still no Energy Performance Certificates (EPC) for buildings in the absence of the national software for energy calculation. For this reason, the BIM model was initially created to proceed with the dynamic analysis for energy calculation while taking into account restoring the appearance of the building envelope.

2.2. Case Study and Narrative History of Building

The case study refers to the former "Rilindja" printing house in Prishtina, which is an administrative building that now houses numerous ministries. The building was built in 1978 and is located in the center of the city. There is a small park in the courtyard of the building, which is connected to the city's main street. The "Rilindja" complex consists

of the tower and the printing house, but for this study, only the tower of this complex will be discussed, as they also function as separate units. With the independence of the Republic of Kosovo, important developments took place, but at the same time the country was undergoing rapid changes in the administrative system, and these developments undoubtedly had also a direct influence on the inherited modernist architecture. In 2010, the building envelope was renovated and today, there is a different view of the building as shown in Figure 1.



(**a**) (**b**)

Figure 1. Printing House "Rilindja": (**a**) initial project design—original identity; (**b**) existing situation—after renovation.

Numerous studies, including those of [51–54], speak and describe this phenomenon, especially about the collective memory of the city of Prishtina. In particular, this research shows the identity, the history, the transformations of the city due to the burning, and the destruction of the city or in particular the well-known iconic buildings of Prishtina. These changes are the result of the last Kosovo war, which produced "emergency architecture" [51] that was later replaced by the "Turbo BOOM architecture of Prishtina" [52] by using building materials or components that were not compatible with the architecture or structure of the building, nor with the appropriate technology.

As a result of this situation, the lack of or insufficient inspection, Prishtina counted 45,000 illegal buildings in 2015. Buildings such as the Economic Bank of Kosovo (now the Government of the Republic of Kosovo), the Eximkos company, the Iliria Hotel, the Building of Technical Faculties of the University of Prishtina, the Grand Prishtina Hotel, and the Rilindja (now the Government of Kosovo) are some of these cases that have been altered from their initial design. As we have already mentioned, the building of the printing house "Rilindja" is one of these buildings that have changed the envelope. With its shape and volume, this building dominates not only its surroundings but also the entire city center. The architecture of the building was built from natural, white-colored concrete elements that influence the creation of a visual variety of facade elements [53,54]. These natural concrete elements are sometimes referred to in the literature as a brutalist architectural style. Based on the initial building's design project, the building envelope had no thermal insulation at all, and the windows were only with a simple double glazing. After the renovation, the ratio of windows to walls was increased to 42%, compared to 20% in the initial building. The glazed areas of the building envelope were expanded in all orientations, without taking into account measures to prevent overheating or shading. Although the building was additionally thermally insulated, it is worth noting that the opaque surface of the building façade was significantly reduced, which has a negative impact on the building's cooling requirements.

2.3. Building Description—Existing Situation

The tower of the "Rilindja" building has a size of 30.4 × 30.4 m, with a gross floor area of 19,490.4 m^2. Before the last renovation, the building had 17,923.61 m^2, while after 2010

it has 1566.79 m^2 more, as the last floor was added and the entire building envelope was changed, resulting in an increase in the total square meters. The total height of the building is 67.58 m, with 18 floors above the ground floor (before 2010 it was 17 floors). At the core of the building, there are four elevators and two pairs of stairs laid in opposite directions, made of reinforced concrete and covered by ceramic tiles. The main entrance to the building faces southeast. The building is an office landscape organized around the building core on the four sides and has natural and mechanical ventilation. The windows are not equipped with solar shading elements such as shading devices, internal curtains, or other horizontal elements. The building is equipped with natural and mechanical ventilation. The main characteristics of the building (before and after renovation) in terms of square meters, volume, shape thermal transmittance, etc. are listed in Table 1. The screenshot of the existing situation via Google Earth can be seen under Figure 2.

Table 1. Geometry characteristics of the initial and existing situation of the building.

Characteristic	Initial Building	Existing Building
Floors	B + G + 17	B + G + 18
Gross Floor Area [m^2]:	17,923.61	19,490.40
Treated Floor Area [m^2]:	16,476.75	18,017.61
External Envelope Area [m^2]:	10,835.07	10,981.16
Windows Glazing Area [m^2]:	2167.01	4754.53
Opaque facade [m^2]:	8668.05	6226.23
Glazing Ratio [%]:	20%	42%
Basement Floor Area [m^2]:	1789.12	1789.12
Roof [m^2]:	1721.77	1721.77
Ventilated Volume [m^3]:	58,300.29	59,955.89



Figure 2. Google Earth screenshot–existing situation [55].

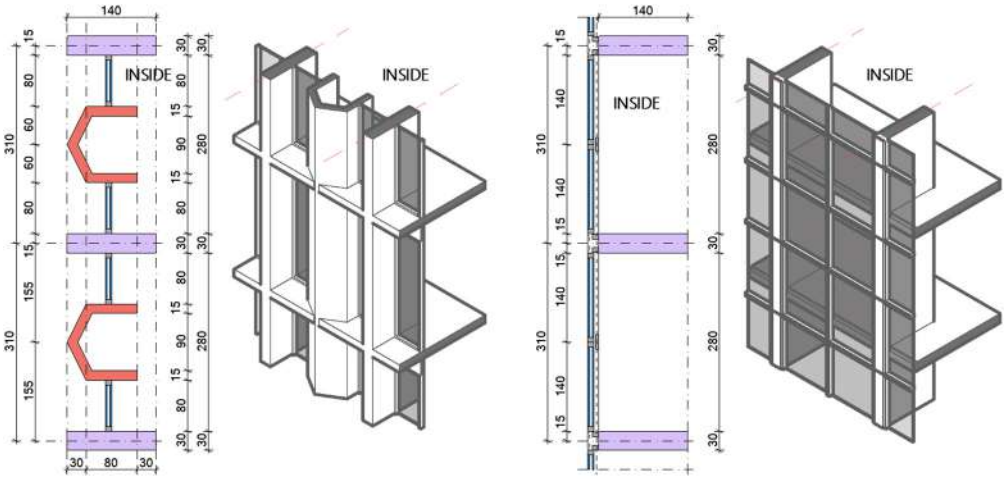
2.4. Initial Design Project—As a Reference Building

As previously mentioned, the initial design project is used as a reference building to test measures to achieve energy-saving targets with the main focus on the building envelope. In the following, characteristics of the main features of this building will be explained using information taken from the initial project design. Based on the design of this building, the massive walls in the core are made of concrete block material, while the partition walls are made of hollow clay blocks with a thickness of 10 cm as presented in Figures 3 and 4a. The inner organization remains the same as mentioned in the previous

Section 2.3. The outer walls of the building facade consist of natural concrete elements with different thicknesses throughout the building. Concrete blocks with thicknesses of 15, 20, and 30 cm are the walls that encompass mostly perimeter of the building while vertical elements in the facade consist of walls constructed of hollow clay blocks with a thickness of 10 cm. Table 2 depicts all the components of the building envelope for the case initial project design, including the wall types, their different thicknesses, surface areas, and thermal conductivity while in Figure 5, transmission losses are also presented.



Figure 3. Rilindja—Characteristic floor plan and its overall organization as it was initially designed.



(**a**) (**b**)

Figure 4. A façade details in floor plan and axonometric before and after the renovation of the "Rilindja" building: (**a**) initial project design—original identity; (**b**) existing situation—after renovation.

Table 2. Main characteristics of building envelope components such as surface area, U-values, and materials.

Building Envelope Components	Surface Area [m²]	Main Material	U-Value [W/m²K]
Walls_30 HCB	81.09	Hollow clay block	1.49
Walls_10 HCB	329.87	Hollow clay block	3.06
Walls_30 CB	3054.11	Concrete block	3.64
Walls_20 CB	1056.58	Concrete block	4.26
Walls_15 CB	3184	Concrete block	4.65
Roof	1721.77	Flat Concrete Roof	3.40
Windows	2158.08	Glass	2.65
Basement Floor	1789.12	Concrete	4.11

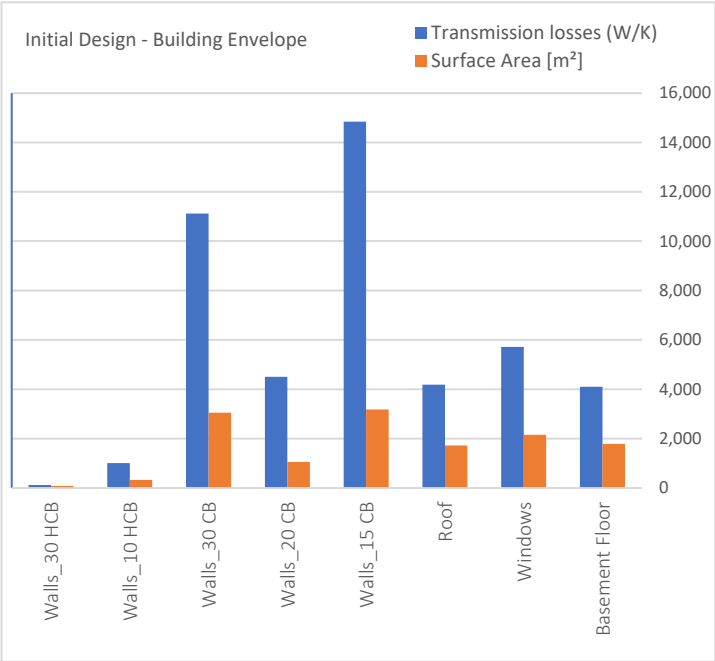


Figure 5. Main characteristics of building envelope components such as surface area and transmission losses.

Regarding thermal transmittance (U-values), there are significant differences between the initial design project, current building envelope components, and the current National Regulation for Minimum Requirements for the Energy Performance of Buildings [46]. A comparison of the thermal transmittance (U-values) shows that the values in the walls without thermal insulation are up to 4.66, which is about 13 times higher than the maximum value allowed by the national regulation, while they are about 11 times higher compared to the existing situation of the building.

In addition, the windows were simple double-layer glazing with a U-value of 2.66, which is higher than the maximum value allowed by current regulations (allowable U-window 1.7). Although the windows in the existing situation have permissible U-values according to the national regulation, the high proportion of windows ratio in the façade has led to an increase in cooling demand of more than 70% (compared to the initial design project) and has a major impact on the overall energy demand.

According to the Köppen classification, Kosovo belongs to climate types C and D, with the average hot climate in the summer months at 22 °C (72 °F) and the average cold climate being above −3 °C (27 °F). Considering these climatic conditions and the characteristics of the building, the aim is to explore the potential and possibilities for renovation while restoring the initial appearance of this building.

3. Proposed Energy Efficiency Measures and Global Cost

3.1. Possibilities for the Energy-Saving

The proposed measures aim to integrate the concept with higher energy efficiency by restoring the initial design of the Rilindja building and thus restoring the collective memory. These measures aim to reduce energy consumption, improve comfort, and minimize environmental impact. In addition, these measures can have a greater impact on this process, especially in the treatment of the building envelope elements. Adding thermal insulation materials on the building's external walls helps to prevent excessive heat losses in the winter period and at the same time solar gains thus preventing overheating in the summer period, consequently reducing the overall energy consumption of the entire building. Choosing a thermal insulation material is a challenge, particularly when it comes to increasing thermal performance by considering factors such as flammability, affordability, and durability of a material. The complexity becomes even more apparent when you consider that the chosen building is a city landmark, meaning that it is not that easy to return and preserve what was initially designed. Furthermore, insulating the external walls helps to retain heat within the building, which increases thermal comfort and helps to minimize the environmental impact by reducing the energy needed for heating and cooling.

Considering restoring the initial appearance of the building and at the same time achieving energy efficiency, the materials characteristics used in the external walls of this building are shown in Table 3 with their respective thicknesses.

- Hollow clay blocks with a thickness of 30 and 10 cm.
- Concrete blocks with a thickness of 30, 20 and 15 cm.

The "highlights" or "dark grey cells" in Table 3 display the condition of the building before renovation and reflect values of the initial project design, while the "light grey cells" present the existing situation of the building. Other values in the table represent the materials used in various thicknesses for different components of the building envelope. The U-values of the windows refer to the entire glass and frame component. In addition, the table contains values corresponding to all the different variants tested in the analysis to achieve a cost-optimal level of energy efficiency improvement.

In order to improve energy efficiency, it is proposed to provide the exterior walls with thermal insulation composite systems in various thicknesses. Thermal insulation that was used is lightweight, durable, environmentally friendly, recyclable, and economical. The problems with fire behavior can also be significantly mitigated by carefully selected material properties and applications. Taking all this information into account, the properties and applicability of these materials were analyzed in detail when selecting the insulation materials. On the other hand, the use of Thermolock Stucco Facade is proposed for the concrete strips (walls) in the facade of the building, in particular this material is proposed only for use in the concrete walls with 15 cm thickness (U-Wall-15 concrete block). Thermolock is a natural insulating and leveling material obtained by mixing various natural aggregates (pumice, perlite) with advanced technology, resulting in better quality and a more economical construction process. This material is considered a "new generation of building materials" as it is breathable, non-flammable, good insulator, lightweight, UV-resistant, etc., and has a thickness of 1–2 cm. In addition, this material is also suitable for interior walls [56]. Other examples of highly efficient materials are aerogel insulating plaster or cork plaster, which offer better insulating properties (low thermal conductivity) with less thickness than traditional insulation materials. However, these materials have not been used in this paper, but only mentioned as potential or suitable options for the same specific cases. Currently, there are numerous studies that have used these materials in different scenarios [57,58].

Extruded polystyrene (XPS) is used on the floors to the ground and roof due to its known application and advantageous properties including rigidity, low water absorption,

and compressive strength. XPS insulation is used in various thicknesses for different concrete slabs.

Table 3. Characteristics of the external walls along with various testing variants were analyzed for the building envelope. " Dark gray cells " show the condition of the building before renovation while " Light gray cells " present the existing situation.

Type	U-Value [W/m²K]	Building Material	Thickness of Thermal Insulation [cm]	Thermal Conductivity [W/mK]	Density [kg/m^3]	Specific Heat Capacity [J/kgK]
U-Wall-30 Hollow clay block	0.20	ETICS	18	0.042	15	1450
	0.28		12			
	0.39		8			
	0.62		4			
	1.49		0			
U-Wall-10 Hollow clay block	0.22	ETICS	18	0.042	15	1450
	0.31		12			
	0.45		8			
	0.78		4			
	3.06		0			
U-Wall-30 Concrete block	0.22	ETICS	18	0.042	15	1450
	0.32		12			
	0.46		8			
	0.81		4			
	3.64		0			
U-Wall-20 Concrete block	0.22	ETICS	18	0.042	15	1450
	0.32		12			
	0.47		8			
	0.84		4			
	4.26		0			
U-Wall-15 Concrete block	0.98	ETICS with finishing plaster TLC	2	0.06	333 (±10%)	1000
	1.45	ETICS	2			
	4.65	N/A	0			
U-Roof-20 Concrete block	0.17	ETICS	18	0.032	28	1450
	0.29		10			
	0.54		5			
	3.40		0			
U-Windows (glazing and opaque)	0.69	WT3A				
	1.58	WD2A				
	2.65	WS1				
U-Floor-20 Concrete block	0.36	XPS	8	0.032	28	1450
	0.47		6			
	0.67		4			
	4.11		0			

ETICS = External Thermal Insulation Composite Systems, TLC = ThermoLock Stucco Plaster, XPS = Extruded Polystyrene, WT3A = Aluminum window Triple-glazed Argon fill, clear, low E—Ultimate Aluminum Frame, WD2A = Aluminum window Double-glazed Argon fill, clear, low E—Premium Aluminum Frame, WS1 = Metal window double-glazed, clear.

3.2. Analyses of the Energy Efficiency Package Measures

To improve energy performance, while restoring the initial appearance of the building, about 18 combinations of energy efficiency (EE) measures were presented. The EE measures were implemented in the initial design project, where there was no thermal insulation, and the windows were simply double-glazed. Each component of the building envelope was treated separately. The initial building is presented as the weakest in terms of efficiency and this model has been used and continuously replaced by more advanced measures. These measures were proposed and combined until an economic optimum was achieved.

The proposed measures are presented in Table 4, where the types of walls are indicated on the left-hand side together with their thermal insulation and thicknesses. For example, for the 30 cm wall type (Hallow Block—HBC), thermal insulation is applied in different thicknesses (4, 8, 12, and 18 cm). The thicker the insulation, the lower the U-value of the wall, and the better the overall energy efficiency of the building. The 18 combinations of EE measures are listed on the right-hand side of the table. Each case is assigned an ID number. The measures applied to each building element are shown in the highlighted cells.

Table 4. Proposed energy efficiency measures.

Type	Building Material	Thickness [cm]	ID.1.6	ID.1.7	ID.1.8	ID.1.9	ID.1.10	ID.1.11	ID.1.12	ID.1.13	ID.1.14	ID.1.15	ID.1.16	ID.1.17	ID.1.17.1	ID.1.18	ID.1.19	ID.1.21	ID.1.22	ID.1.23
U-Wall-30 Hollow clay block (HCB-30)	ETICS	18																		
		12																		
		8																		
		4																		
		0																		
U-Wall-10 Hollow clay block (HCB-10)	ETICS	18																		
		12																		
		8																		
		8																		
		0																		
U-Wall-30 Concrete block (CB-30)	ETICS	18																		
		12																		
		8																		
		4																		
		0																		
U-Wall-20 Concrete block (CB-20)	ETICS	18																		
		12																		
		8																		
		4																		
		0																		
U-Wall-15 Concrete block (CB-15)	TI+TLC	2																		
		2																		
		0													X					
U-Roof	XPS	18																		
		10																		
		5																		
		0																		
U-Windows	WT3A WD2A WS1																			
U-Floor	XPS	8																		
		6																		
		4																		
		0																		
External Louveres Natyral ventilation Mechanical ventilation with heat recovery																				
Infiltration at 50 Pa [ACH]			1.86	0.76	0.60	0.60	0.67	0.76	0.62	0.62	0.63	0.63	0.63	1.06	0.59	0.58	0.68	0.64	0.64	0.64

legend: initial design; measures applied; existing situation; X Demolition

Some of these cases have the following characteristics:

- Case (ID. 1.6) represents the initial building design, showing that the walls, roof, and slabs had no thermal insulation, while the windows were simple and double glazed.
- The case (ID. 1.17.1) shows the existing building in its current situation. In this state, all walls (HCB, CB) of the building have 8 cm thick thermal insulation, while the CB_15 walls with a thickness of 15 cm were demolished due to the renovation of the building envelope (with signed "X" presented in Table 4). The roof and floor slabs are insulated with 5 and 4 cm thick XPS, respectively. In addition, the windows (U_{window} 1.58) are double-glazed aluminum windows with argon filling, clear, with low e—premium aluminum frames (WD2A).
- Case (ID. 1.11) represents walls CB_15 with 2 cm of thermal insulation and 2 cm more plaster TLC. In addition, the windows were replaced with triple-glazed windows—WT3A (triple-glazed aluminum windows with argon filling, clear, low e—ultimate aluminum frame). The other elements of the building envelope remained unchanged as in case (ID. 1.6).
- Case (ID. 1.16) represents the case in which the walls HCB_30-15 have 4 cm and 8 cm of thermal insulation. Walls CB_30-20-15 have 4 cm and 8 cm of thermal insulation added and 2 cm of TLC. In addition, 5 cm of XPS was added to the roof and 4 cm of XPS to the floor. Triple-glazed windows (WT3A) were also used.
- Case (ID. 1.21) has different thicknesses of thermal insulation that were applied to all walls depending on the orientation of the building. For example, insulation of 18 and 12 cm was applied to wall HCB_30, and the other walls were treated according to the same principle. Triple-glazed windows (WT3A) and mechanical and natural ventilation were also installed here.
- In case (ID. 1.23), each thermal zone was analyzed separately, and the specific requirements were changed for walls with the same characteristics in different orientations. The thickness of the thermal insulation in CB_20—E/S/W was added in 18, 12, and 8 cm in different facades. In addition, the windows were replaced with WT3A, and external louvres were added.

The combination of measures follows these steps:

- Initial project design case (ID. 1.6) is compared with the existing situation case (ID. 1.17.1).
- Case (ID. 1.17) is formed by the combination of the structure of the initial project design and the use of the same materials as in the existing situation, case (1.17.1).
- All other measures were applied to the initial project design case (ID. 1.6), resulting in a scenario case (ID. 1.7), a case (ID. 1.8) . . .case (ID. 1.23).

From these proposed measures, it is clearly seen that the U values have significantly improved compared to the situation before the energy renovation and the existing condition of the building. Furthermore, implementing these different measures for the reduction of energy consumption will result in significant cost savings over their lifecycle. Considering that this building can be a reference for similar buildings with the same characteristics, the implementation of the proposed measures would lead to significant energy savings for a large number of buildings.

Moreover, applying better thermal insulation and upgrading windows can significantly enhance the airtightness of the building envelope, resulting in decreased air infiltration. This reduction in air infiltration not only improves energy efficiency but also improves indoor air quality. As shown in Table 4, infiltration rates for the building structure are applied from 1.6 L/sm^2 (indicating high infiltration for initial building design) to 0.60 L/sm^2 (representing low air infiltration), with an average of 1.1 L/sm^2 for most measurements. Additionally, approximate infiltration rates for the windows are also considered.

Taking into consideration that the heating, ventilation, and air conditioning (HVAC) systems play a key role in ensuring indoor thermal comfort and air quality by controlling temperature, humidity, and air quality, it is necessary to have them for better overall energy performance of the building as presented in Table 4. According to the project, the

HVAC systems for the offices consist of internal controls to regulate and support the air circulation through air handling units (AHU) devices. Two fans will exhaust the air from the offices. A heat recovery system (run-around loop) will transfer the energy from the exhaust air to the fresh air. Cold and hot water pipes have been laid in the false ceiling to connect the terminal units so that the offices can be cooled or heated depending on the external conditions. In addition, chilled beam systems were installed in the offices, which are mounted in the ceiling. These are essentially air outlets that function like fan coil units without fans. They cool or heat by circulating cooled or heated water instead of air. In rooms such as meeting rooms, cafeterias, libraries, and storage rooms, the ventilation system consists of variable air volume (VAV) with a reheating coil and a temperature sensor. Meanwhile, a mechanical exhaust air system consisting of dedicated fans, a duct network, and exhaust air registers is used for toilets, cleaning rooms, and IT rooms. Although control devices or sensors for the building management system (BMS), smoke control systems, and indoor air quality are installed in the building, most of them do not work. However, for such cases, it is not enough to treat only the building's envelope. In order to achieve a higher energy performance, it is essential for the building to also consider the technical aspects. In this paper, the technical systems were not the focus, they were not dealt with, but it is presented as it was in the project and as it was mentioned above. Furthermore, Kosovo legislation stipulates that administrative buildings must achieve nearly zero-energy building standards (nZEB). To meet this requirement, the percentage of renewable energy generated on site compared to the building's energy consumption must be more than 25%. At the same time, all materials used must have significantly improved energy performance specifications that are at least 50% higher than the maximum permissible U-values (for example: If the maximum allowable U-value for a renovated wall is 0.35 W/m^{2}K, this U-value must not exceed 0.17 W/m^{2}K for nZEB buildings).

3.3. Thermal Zones (Blocks) and Their Characteristic

The building treated has 18 floors above the ground floor, with 12 floors for offices and the other floors for the ministers of the respective ministries. In order to calculate the energy consumption, some preliminary work had to be conducted. In developing a BIM model of the case study, the shape and geometry were determined along with all architectural features and attributes. Then, all areas were converted into thermal zones depending on which category they belonged to. By definition, a thermal zone is an area that is defined by its roof, walls, and floor and can be used as a basis for calculating heat loads.

All the thermal blocks were initially categorized in accordance with the appropriate categories or profile zones, taking into account the areas for offices, restrooms, staircases, storage rooms, etc. The values for the energy required for heating and cooling vary depending on the orientation of thermal blocks. Solar and dynamic analyses are carried out every hour throughout the year. The geometry of the building itself and the shading effect, and external louvres were taken into account, but external objects such as neighboring buildings, trees, etc. were not considered, nor was internal screening, as the focus was on renovation of the building envelope. In addition, inside the building, the minimum and maximum temperatures were determined for each thermal block, e.g., the landscaped office has an indoor temperature of 20–22 °C on weekdays (both for heating and cooling), the bathroom only has heating requirements, and the temperature is limited to 22 °C, the circulated and traffic areas has 20–22 °C, etc. For the purpose of the calculation, unheated zones are considered stairs, the basement as well as the attic under the raised roof, while the offices are examined as a single thermal zone. The calculations were also made for all occupancy (count 10 m^2 per capita) working from Monday to Friday (07–17) in accordance with the applicable local regulations, weekends are calculated but not holidays.

As can be seen in Figure 6, the most critical thermal blocks in terms of energy losses are compared with the initial building design and the existing situation of the building.

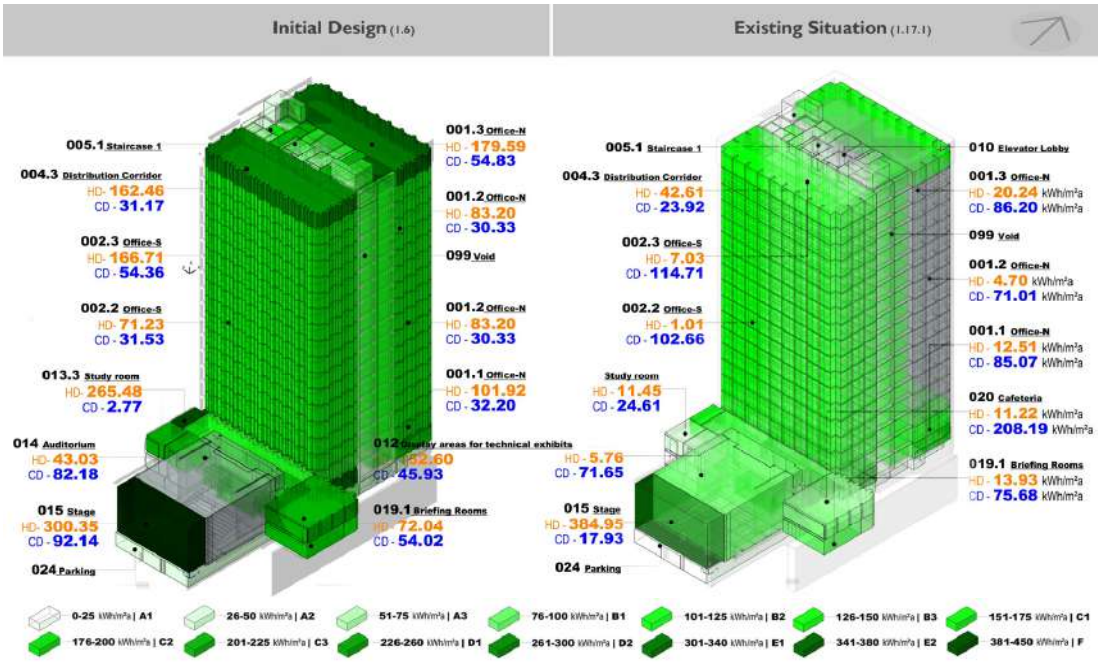


Figure 6. Thermal blocks, geometry, and energy consumption characteristics.

A BIM model was created and dynamic simulations of this building were carried out using the software ArchiCAD 26 [59] and the add-on EcoDesigner STAR [60]. As already mentioned, the climate in Kosovo [61] is continental, with warm summers and cold winters. The altitude of the building is 581 m, and the HDD and CDD of the degree days are 3379 and 1695, respectively. 42°39′32.7924″ is the latitude and 21°9′21.8412″ is the longitude and the average solar radiation is 450.47 W/m^2.

3.4. Cost-Optimal Levels-Global Costs

3.4.1. Cost-Optimal Levels

Considering that buildings account for 40% of final energy consumption and 36% of its energy is associated with greenhouse gas emissions [62], various legislation packages set out how Europe can achieve a decarbonized building stock by 2050 [41,63]. In this context, the cost-optimal level is defined in the EU Directive as "the energy performance level which leads to the lowest cost during the estimated economic lifecycle" and has to do with setting levels that take into account the various costs and energy saved. The methodology of the comparative framework established by the recast EPBD 2018 [64] amended the EPBD 2010 [44] requires the determination of global cost curves and primary energy through packages of EE measures. More specifically, the cost-optimal analysis should identify the packages of EE measures that minimize the global costs considering the entire lifecycle of the building. Although the EPBD requires that calculations are carried out according to national calculation methodologies harmonized with European standards, Kosova has legislation that is partially in line with the EPBD but has not yet approved national software for energy calculations. For this reason, a dynamic model was created for the energy analysis and cost-optimal analysis carried out in this study. The result, as depicted in the graphs, will determine the cost-optimal level. The primary energy consumption of the building is shown on the horizontal axis, while the global cost is presented on the vertical axis of the graph.

Figure 7, depicts in a clear and understandable way that by increasing the investment cost (the sum of all measures), the operating cost of energy will decrease. Each point on the graph represents an energy efficiency measure of renovation. The lower part of the curve determines the economic optimum for the combinations of measures that are considered as the minimum requirement for energy performance, while the lowest point corresponds to

the cost-optimal level of energy performance. Based on the EPBD recast, determining the minimum energy performance requirements for buildings, building units, and building elements through cost-optimal levels is a challenging task. It involves proposing and testing numerous combinations of EE measures, which requires many design decisions. The EE measures started with an overview of how the building was, case (ID. 1.6) and how it is in its current condition (ID. 1.17.1). Subsequently, the EE measures defined in the national regulations were applied and then proceeded with the combination of measures until the optimum energy solution was achieved. According to the European Commission, the proposed variants or packages of EE measures to determine the cost-optimal level should include at least 10 packages. In this research, 18 packages of EE measures have been proposed and applied for this purpose. The selection of energy and cost-optimal measures depends on various factors, such as the constructive system, available materials, climatic data, age of the building, and its use. Furthermore, this research aims to find the optimal options for the renovation of the office building "Rilindja" considering the energy consumption and life cycle cost (LCC) through the cost-optimal approach in order to obtain the most favorable renovation budget. Moreover, energy performance optimization and LCC are closely linked, as the chosen materials and renovation components have a direct impact on the LCC.

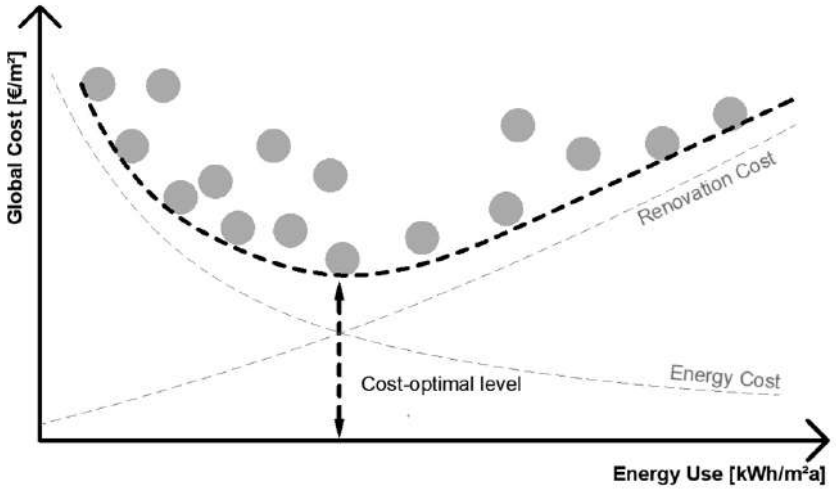


Figure 7. Schematic example for the determination of cost-optimal calculations for various packages.

3.4.2. Global Costs–Financial Calculation

The minimum energy performance requirements for buildings have to be specified and determined by the Member States in accordance with the requirements laid down by the European Commission [65]. The calculations have to ensure that they are comparable between these countries, as they must comply with the framework set out in the Directive. All calculation costs are considered as investment costs. In order to determine a life cycle cost analysis, the calculations can be performed in two ways: as a financial or macroeconomic calculation [66]. It is up to the Member States which of these two calculations they choose and compare with the national minimum standards [67].

For this research we chose a financial calculation method, as all relevant prices are taken from market conditions, including all applicable taxes like VAT, which includes, among other things, the cost of electricity, network fees, energy taxes, and VAT. The calculation methodology is applied in accordance with the Guideline [68] accompanying the regulation no. 244/2012. All costs such as initial investment costs, annual costs, and energy costs are based on the calculation from the starting year 2023.

The equation of Global Cost can be written as the following:

$$C_g(\tau) = C_I + \sum_j \left[\sum_{i=1}^{\tau} (C_{a,i}(j) \times R_d(i)) - V_{f,\tau}(j)\right] \quad (1)$$

$C_g(\tau)$ means global cost (referred to starting year τ 0) over the calculation period;
C_I initial investment costs for measure or set of measures j;
$C_{a,I}(j)$ annual cost during year i for measure or set of measures j;
τ is the calculation period;
$V_{f,\tau}(j)$ residual value of measure or set of measures j at the end of the calculation period (discounted to the starting year τ 0);
$R_d(i)$ means discount factor for year i based on discount rate.

The global cost is estimated in terms of net present value (NPV) for each measurement developed for each year throughout the calculation period. The calculation of the global cost considers the initial cost of the investment (CI) and the annual costs for each component, until the end of the calculation period (τ). So, the global cost (Cg) is calculated by adding the sum of all initial investment costs to the sum of annual costs. These costs for each year have been deducted from the discount rate, while replacement and maintenance costs are not considered because their lifetime seems to be equal to the calculation period. This procedure is repeated for each within the calculation period. The calculated period is set for 20 years as it is defended for administrative buildings, specifically offices. The discount rate has been chosen to be 4% for sensitivity analysis and to compare costs and benefits for this particular calculation period. The lifespan of the building envelope elements is equal to the calculation period.

In order to perform this research, two local companies have provided the sale pricing of various construction materials, including transport, installation, and VAT. The final price of electricity includes 1 kWh = 0.081 EUR, a fixed fee of 2 EUR, and VAT of 8% based on local distributions. The current prices, the calculations for materials, and the construction process are presented in Table 5.

Table 5. Price and types of materials used in the building envelope.

Type	U-Value [W/m²K]	Building Material	Thickness of Thermal Insulation [cm]	Price [€/m²]
U-Wall-30 Hollow clay block (HCB)	0.20	ETICS	18	53.13
	0.28		12	43.13
	0.39		8	38.13
	0.62		4	28.13
U-Wall-10 Hollow clay block (HCB)	0.22	ETICS	18	53.13
	0.31		12	43.13
	0.45		8	38.13
	0.78		8	35.00
U-Wall-30 Concrete block (CB)	0.22	ETICS	18	53.13
	0.32		12	43.13
	0.46		8	31.25
	0.81		4	24.38
U-Wall-20 Concrete block (CB)	0.22	ETICS	18	53.13
	0.32		12	43.13
	0.47		8	31.25
	0.84		4	24.38
U-Wall-15 Concrete block (CB)	0.98	Thermal insulation + TLC	2	23.13
	1.45		2	20.00

Table 5. *Cont.*

Type	U-Value [W/m²K]	Building Material	Thickness of Thermal Insulation [cm]	Price [€/m²]
U-Roof-20 Concrete block (CB)	0.17	XPS	18	56.88
	0.29		10	50.00
	0.54		5	37.50
U-Windows (glazing and opaque)	0.69	WT3A		237.5
	1.58	WD2A		187.5
	2.65	WS1		125
U-Floor-20 Concrete block	0.36	XPS	8	42.50
	0.47		6	39.38
	0.67		4	35.63

ETICS = External Thermal Insulation Composite Systems, TLC = ThermoLock Stucco Plaster, XPS = Extruded Polystyrene, WT3A = Aluminum window Triple-glazed Argon fill, clear, low E—Ultimate Aluminum Frame, WD2A = Aluminum window Double-glazed Argon fill, clear, low E—Premium Aluminum Frame, WS1 = Metal window Single-glazed, clear.

4. Results and Discussion

4.1. Current Energy Consumption

To illustrate and compare the current energy consumption, calculated by Archicad 26 software and EcoDesigner STAR, Figure 8 depicts the delivered energy for the building as it was originally designed before 2010, case—initial project design (a) (ID. 1.6), and for the existing building as it is now after renovation, case—existing situation (b) (ID. 1.17.1). The energy simulations are analyzed, examined and compared for both cases. The specific annual energy required for heating and cooling is evaluated for both case (a) and case (b) in order to assess the building envelope in terms of its energy efficiency. Due to the different properties of the building envelopes, the buildings examined show large differences in energy needs. The results have shown that the delivered energy calculated for the useful floor area for the building case (initial project design—ID. 1.6) is 124.12 kWh/m^{2}a, while 91.64 kWh/m^{2}a was calculated for the case (existing building—ID. 1.17.1). The specific energy needs for case (ID. 1.6) is 37.05 kWh/m^{2}a for cooling and 87.07 kWh/m^{2}a for heating, while case (ID. 1.17.1) requires 70.15 kWh/m^{2}a for cooling and 21.50 kWh/m^{2}a for heating. The calculations for these two cases are also given in Figure 9. In this research, the building envelope was studied in detail, while the HVAC systems and lighting were calculated as shown in the project design. As shown, the high energy consumption values in case (ID. 1.6) are due to the lack of thermal insulation and the simple double glazing of the windows on the building envelope. In case (ID. 1.17.1), on the other hand, the high g-value of the double layer of glazing and the fact that the façade of the building has about 43% glazed area are considered high solar gains, resulting in a higher cooling needs than heating needs, although Kosovo has a continental climate, which is not common for the relatively cold winters.

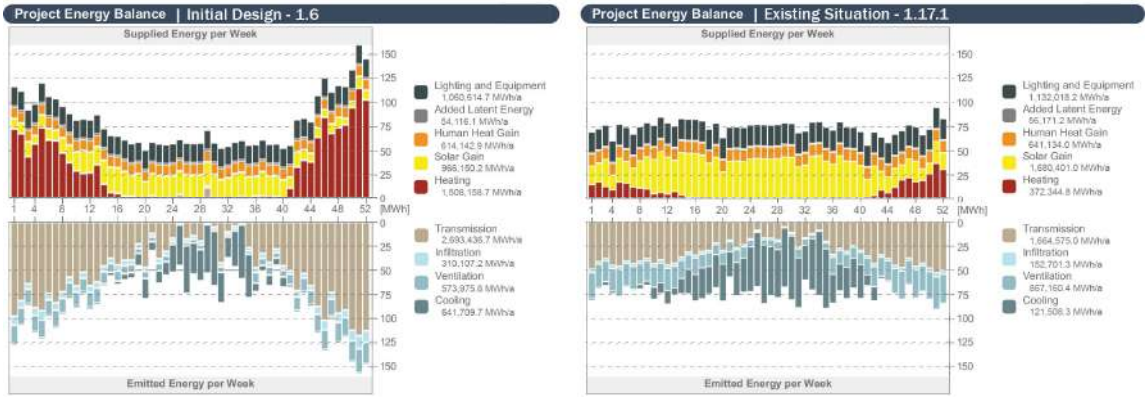
The lighting and equipment as well as the human gains are shown differently in Figure 9, as the calculations were carried out for square meters and the initial design case (ID. 1.6) has a total of 1566.79 m^2 less than the existing situation case (ID. 1.17.1).

Based on the above results and as a contributor to the preservation of the collective memory, the dynamic energy simulations as well as the proposed energy efficiency measures were applied to the building project according to the initial project design (ID. 1.6). This model is also used as a reference building for further calculations and comparisons.



(**a**) (**b**)

Figure 8. Comparison of the building characteristics between the: (**a**) initial design case (ID. 1.6); and (**b**) ex-isting building case (ID. 1.17.1).



(**a**) (**b**)

Figure 9. Energy balances of "Rilindja" (**a**) initial project design; (**b**) existing situation, presented by EcoDesigner STAR.

4.2. Results of the Calculations for the Same Building with Different Energy Efficiency Measures

Figure 10 shows the results of the energy simulation for various energy efficiency measures applied to the "Rilindja" building. As explained in Section 4.1, the assessments were carried out not only for the cases (ID. 1.6—initial project design) and (ID. 1.17.1—existing building) but also for the eighteen other variants proposed for the energy renovation of the building envelope to determine the specific annual energy need for heating and cooling. The results show that the differences are between 26% and 75% for heating. In the following, most of the results are expressed in kilowatt-hour (kWh) for the delivered energy, and at the same time, the savings are given as a percentage.

If we compare the case (ID. 1.6) with the case (ID. 1.17.1), we can see that after adding the thermal insulation on the building envelope and replacement of the windows with more advanced ones, the total energy consumption has dropped to only 32.5 kWh/m^{2}a, which corresponds to a percentage reduction of 25.39% compared to the initial design. The energy for heating has decreased from 87.07 to 21.50 kWh/m^{2}a which corresponds to about 75% savings. However, as some walls in the façade were demolished and the glazing area was doubled (see Section 4.1), the cooling needs have increased from 37.05 kWh/m^{2}a to 70.15 kWh/m^{2}a. Nevertheless, this result comes at a high construction cost, as the entire

building envelope has undergone a radical transformation and at the same time, the floor area has been added.

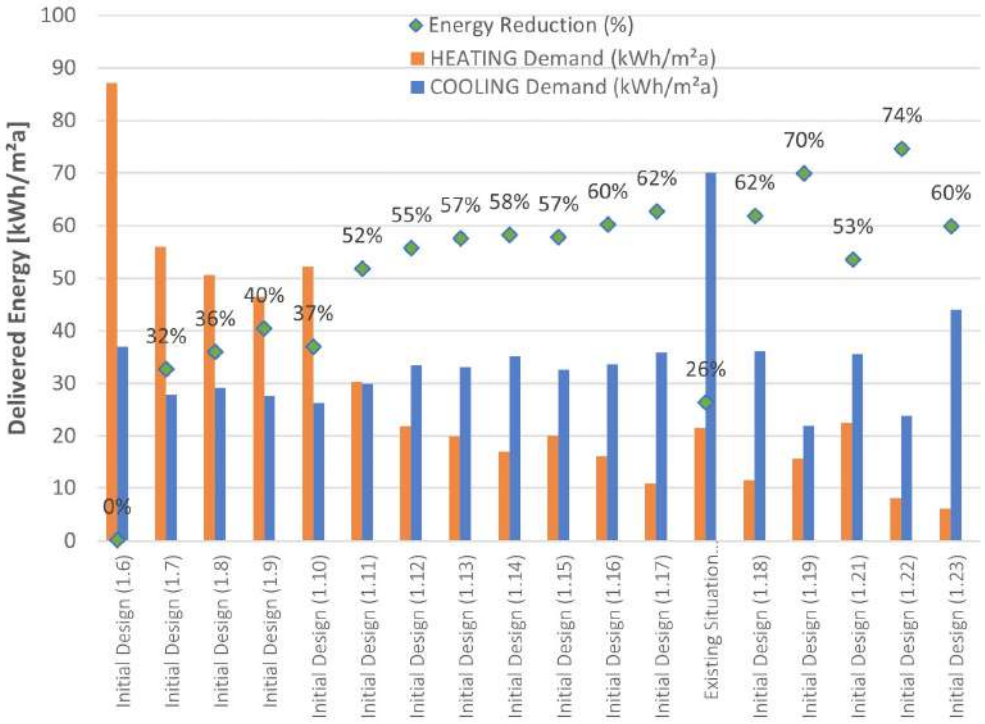


Figure 10. Different energy efficiency measures with their specific annual heating and cooling delivered energy.

It is important to mention that most of the thermal transmittance coefficients of the building envelope are more than 20% above the maximum permissible value for the case (ID. 1.17.1) compared to the national regulations [46].

On the other hand, if we apply all the materials of the existing building into a case (ID. 1.17) and compare the results with the case (ID. 1.6), we can see that the energy savings for heating are up to 62.39%. From this, we can conclude that the energy efficiency measures proposed in case (ID. 1.17) lead to higher energy savings than in the case of the existing building (ID. 1.17.1). Therefore, the application of these EE measures would not only preserve the appearance of the building but also provide greater benefits in every other aspect.

Only small investments were made in the renovation of this building, such as the combination of energy efficiency measures in case (ID. 1.11) by adding only 2 cm of thermal insulation in the walls, especially in the vertical elements of the façade, and also replacing the windows with triple glazing (WT3A). Therefore, the delivered energy would be reduced by more than 51% compared to case (ID. 1.6), resulting in a delivered energy consumption of 60.19 kWh/m^{2}a. The 2 cm thickness of thermal insulation was added to preserve the building envelope, especially the vertical elements/walls of the façade (CB_15).

However, it is important to mention that 2 cm thermal insulation with a simple finishing plaster does not provide good energy performance. Therefore, ThermoLock Stucco Façade, a much more advanced plaster with a thickness of 2 cm, was chosen for the combination of measures in the case (ID.1.19). This material has demonstrated better heat retention properties and is a good insulator and breathable, among other qualities. Other elements of the building envelope were thermally insulated in accordance with the combinations of measures described in the previous section. The result is an energy saving for the heating needs of 15.78 kWh/m^{2}a or 81%, while the energy saving for cooling is the most favorable at 21.45 kWh/m^{2}a, which corresponds to a saving of 40.7% compared to the case (ID. 1.6).

As already mentioned, in the case (ID. 1.22) each thermal zone was analyzed separately, and the specific requirements were modified for walls with the same characteristics but different orientations. In addition, natural ventilation and external louvers were added. The results showed that this combination resulted in a total delivered energy of 31.91 kWh/m^{2}a or a saving of 74.14% compared to the case (ID. 1.6).

4.3. Cost-Optimal Level and Results from the Global Cost

After performing the energy simulations, the cost-optimal results are addressed. Figure 11 shows the result of these analyses, two curves represented in the graph representing an energy cost (orange color) and renovation cost (blue color). When these two curves intersect, this is the lower part of the diagram or the cost-optimal scenario, specifically the combination of measures (ID. 1.19), with a corresponding global cost calculation of 37.26 EUR/m^2. The diagram shows that the scenario with the higher energy prices increases global costs, while the lower point of the diagram corresponds to a lower energy value, which represents the level of the cost-optimal case. As other points begin to rise (blue curve) above the upper left corner of the diagram and the other dropdown (orange curve) in this case the global costs increase, while energy savings (in this case, delivered energy) also increase. From a financial perspective, the most efficient and lowest-cost renovations represent optimal options, while the more extensive renovations approach the nZEB targets and lead to higher costs.

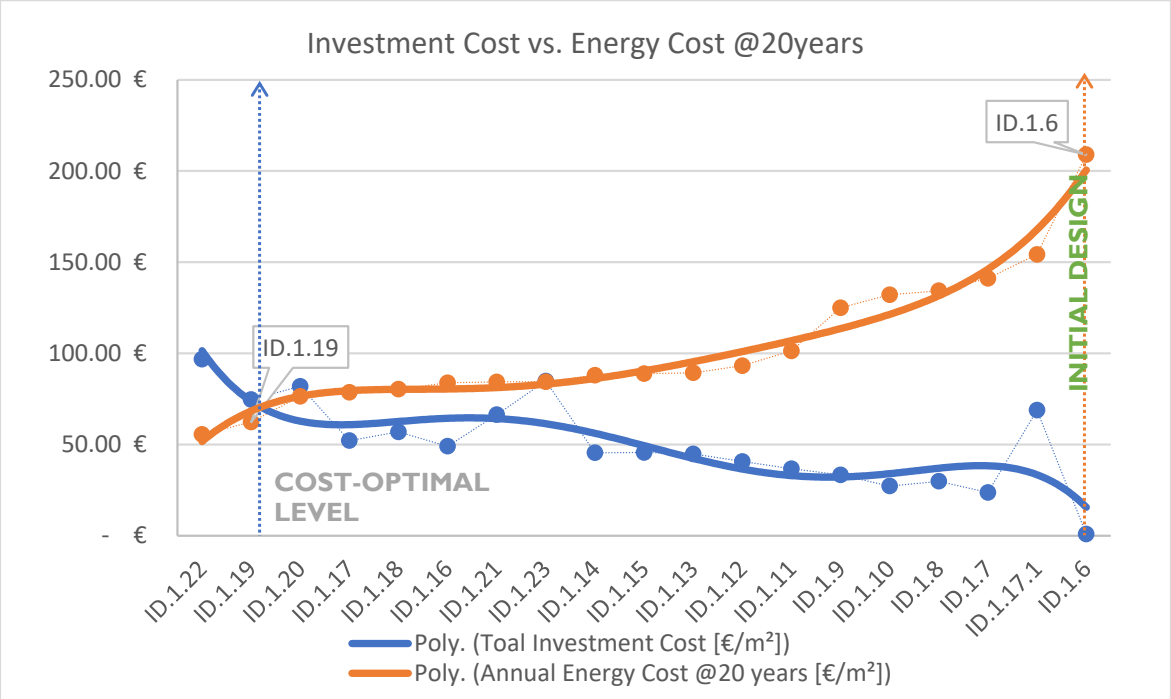


Figure 11. Cost-optimal level.

The combination of measures has led to low overall global costs (ID. 1.19). The investment in the building envelope is not considered to be very high as it does not include the internal technical systems. The low price was also influenced by the use of ETICS, as it does not involve high investment costs for the overall application.

The U-values of the insulated elements in the building envelope are within the permissible values according to Kosovar legislation [46], with the exception of the CB_15 walls, where even a plaster with better energy performance was applied. The U-value of these walls is higher than the maximum permissible value because the vertical elements/walls

of the façade cannot be thermally insulated any further, which means that it is not possible to use higher thickens of thermal insulation as there is technically no space available.

Although this plaster has a higher price compared to the basic plaster, its application contributes significantly to energy savings, so it is worth considering. The largest investment was made in the windows, as the building envelope has a large, glazed area, which is beneficial for solar heat gain in the winter months.

For the sake of brevity, the primary energy was analyzed after all calculations of the energy efficiency measures in order to determine the cost-optimal level. Figure 11 shows the cost-optimal level of delivered energy, while Table 6 shows results of delivered energy converted into primary energy and the potential savings for eighteen EE measures. A significant reduction in total primary energy can be achieved as a result of different energy resources. For example, for case (ID. 1.19), up to 69% savings can be achieved compared to the initial building design or more than 74% savings for case (ID. 1.22). Various energy resources have been assigned as distinct values for primary energy factors used in the conversion of delivered energy to primary energy, as have been set in the Regulation [45]. For the conversion into primary energy, the value of factor is used about 1.2 (lignite), since more than 85% of electricity in the Republic of Kosova is generated by using lignite as the primary source of electricity [69,70]. As there are no solar or photovoltaic systems installed in the building, only non-renewable sources were utilized in the primary energy conversion. It is also important to mention that the building of Rilindja is connected to the district heating network of Prishtina, which means that instead of burning the fuel lignite with high emissions, the waste steam of the power plant is used to generate heat for district heating [71]. For this reason, this converted factor was used as it was considered potentially suitable.

Table 6. Delivered and primary energy results for 18 different measures from cost-optimal level.

Case	Delivered Energy [kWh/m²a]	Primary Energy [kWh/m²a]	Reduction of Primary Energy [%]
ID. 1.6	124.12	148.95	
ID. 1.7	83.84	100.61	−32.45
ID. 1.8	79.78	95.73	−35.73
ID. 1.9	74.24	89.09	−40.19
ID. 1.10	78.49	94.19	−36.76
ID. 1.11	60.19	72.23	−51.51
ID. 1.12	55.37	66.44	−55.39
ID. 1.13	53.04	63.65	−57.27
ID. 1.14	52.27	62.73	−57.89
ID. 1.15	52.78	63.34	−57.48
ID. 1.16	49.81	59.78	−59.87
ID. 1.17	46.69	56.02	−62.39
ID. 1.17.1	91.64	109.97	−26.16
ID. 1.18	47.70	57.24	−61.57
ID. 1.19	37.73	45.28	−69.60
ID. 1.21	64.48	77.38	−48.05
ID. 1.22	31.91	38.29	−74.29
ID. 1.23	50.14	60.17	−59.60

To show that investments in energy efficiency are worthwhile, it is important to consider not only the energy savings but also the payback period. A payback period of 20 years was calculated using the methodology based on guidelines [68] accompanying the regulation for this type of building. We can conclude that the building would not have needed such a drastic transformation of its envelope if all these energy-saving options had been considered during the renovation (before 2010). These proposed measures would not only have saved energy but could also preserve the identity of the building.

5. Conclusions and Further Work

The aim of the study is to restore the value of the former printing house "Rilindja", an iconic building in Prishtina from 1978, while identifying and determining the cost-optimal renovation solutions to improve energy performance and achieve better thermal conditions in this building. It is important to mention that there is currently a lack of comprehensive analysis of this kind in the literature. There is so much literature on improving the energy efficiency of buildings, but restoring the values of a socialist modernist building is not very common, especially in Europe.

The analyses are carried out on the basis of scenarios of energy losses from the building envelope. The simulations were analyzed for a life cycle of 20 years in a continental climate zone where summers are hot and winters are cold, so the need for heating and cooling is high. Eighteen energy efficiency measures were proposed, taking into account both the building's initial design project (ID. 1.6) before the renovation (before 2010) and the existing building, case (ID. 1.17.1). These measures were analyzed and tested to determine the optimum balance between energy performance and financial aspects.

The building model based on the initial design (ID. 1.6) was used for the development of energy efficiency measures as it has the potential to significantly reduce energy consumption while preserving the collective memory of this iconic city building. The best option in the case is (ID. 1.19), which corresponds also to the cost-optimal level. In this case, the delivered energy for heating is 29.58 kWh/m^{2}a, which represents an energy saving of 81%, while the delivered energy for cooling is 28.7 kWh/m^{2}a.

From the results of the research, it can be concluded that:

1. The proposed measures for the renovation of the building through the cost-optimal solution, have the ability to reduce energy by more than 60%:
2. Ad hoc investments are not a cost-optimal solution.
3. In the case where we have integrated existing materials, as present in the existing building, into the building envelope of the initial building design, this would result in an energy and budget saving of about 50% compared to the case (ID. 1.6).

The measures proposed for the renovation of this building were carefully selected to improve the overall energy performance of the building by calculating the life cycle costs with the lowest possible investment. The methodology used in this case study can also be applied to similar renovation cases. However, it can also be applied to new buildings with the same climatic conditions and similar characteristics such as shape, size, orientation, etc.

Considering that heating, ventilation, and air conditioning (HVAC) and lighting systems are responsible for more than 25% of the total energy consumption in office buildings, optimizing the right HVAC system should be considered for further work to improve the energy performance of this building even further. In addition, the inclusion of renewable energy sources (RES) must be considered to meet the standard and be part of the nearly zero energy building—nZEB. Although, it is necessary to continue taking measures to improve energy performance in this building, the results have shown that only a cost-optimal level can reduce around 70% of the overall energy consumption. These results can be seen as a first step towards achieving the EU's ambitious targets for increasing energy efficiency and decarbonization by 2050. Considering that it is undoubtedly a challenge to reduce carbon emissions to zero, future work should take into account the planning of ZEB policies to archive targeted strategies. Therefore, concrete actions and close collaboration between stakeholders, researchers, architects, engineers, and citizens are needed.

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