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The Architecture of Public Buildings as Transformative Model Towards Sustainability

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ABSTRACT

Problem Statement: After the era of socialist modernism in Macedonia, the transition process of the newly independent state inevitably affected and still transforms the architectural heritage. The monumentality of modern architecture in Yugoslavia was determined by its specific typology and spaciousness. Such characteristics are becoming vulnerable while facing certain challenges between sustainability and the building's formal aspects and appearance. The reflection of these challenges can be observed through the architectural transformation based on heating demands, influenced by social, economic, and digital capitalism. In these processes, the other aspects of architectural physics are often neglected (thermal, acoustic, etc), which becomes an issue in terms of the building's performance and sustainability, and the building's energy efficiency implementation in its entirety. The problem area of this research is the redefining approach of the architectural practice which strives toward sustainability. Moreover, there is a lack of approaches based on a joint strategy between architecture transformations and architecture physics in a holistic manner.

Purpose of Study: The main aim is to understand the transformation process, from the architecture of monumentality to the architecture of segregation, where energy consumption is the driving factor and is directly related to the economy market.
Therefore, the purpose of this paper is to Investigate the interrelation between the architectural transformation process and the discipline of building physics reflected in the energy efficiency strategies.

Methods: The research is focused on public buildings, built in the period of social modernism in Yugoslavia, that have transformed their facade and materialization. This study investigated the reasons that drive the transformation processes. In that direction, the research method covers chronological data of the energy efficiency strategies by discussing their plans and actions and uses an analytical approach that recognizes the transformed models into sustainable architecture as evidence of the tendencies toward a sustainable economy of the built environment.

Findings and Results: The expected results of the research will determine the main driving economic and social factors of the transformative processes and will elaborate on the transformed model's sustainability.

Conclusions and Recommendations: The research will conclude the necessity of collaboration between architecture transformation and building physics, which indicates the architectural characteristics of sustainability.

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Introduction

The concept of sustainable energy is integral to sustainable development, wherein energy plays a crucial role in social, economic, and environmental advancements [1]. For energy to contribute to sustainability, it requires adopting an overall social and political strategy that will contribute toward reducing energy consumption [2]. Building upon Aristotle's philosophy, which asserts that living organisms should be recognized by their actions and reactions to the environment, Kaltenbrunner argues that not all sectoral fields of action align completely with sustainability. One or two measures alone are insufficient for genuine sustainable building [3].

The architectural heritage from the period of Socialist Yugoslavia faces specific challenges regarding energy sustainability. The main drivers for transformation are energy efficiency strategies, often implemented without consideration of the building's physics. Aspects like humidity, sound, and light, reflecting the architectural characteristics of sustainability, are frequently overlooked. Transformations in the building's structure are primarily driven by heating demands, influenced by the imperative of energy sustainability and economic benefits.

In the subsequent sections, this paper delves into the transformation of three public buildings in Skopje, North Macedonia: The Youth Cultural Center and both high schools "Orce Nikolov" and "Josip Broz Tito." Through a qualitative research method, the study

adopts an analytical approach to assess the physical and aesthetic aspects of the buildings facade interventions. The proposed method provides a qualification of the influences of transformation, regarding building performance and sustainability. Hence, the research hypothesis embodies the transformative process of the building's envelope as a means of qualifying the values and quality of the architectural transformation.

The first part of the research provides an overview of energy efficiency strategies in North Macedonia and outlines the activities involved in their realization. This part elaborates on the reasons that triggered the transformative processes from existing to new architectural expression. Given the varying grades of building skin transformation, the subsequent section raises concerns about the quality of the outcomes. The conclusion serves as the final segment, summarizing the key observations derived from the research.

Economic Models of the Built Environment

The main goal in the energy efficiency strategies of the Macedonian municipalities is the reduction of electricity costs, primarily through interventions in public buildings. That goal is driven by the idea of reducing costs in order to improve services and quality of life.

According to the strategies the potential for increasing energy efficiency is through the reduction of costs and energy consumption by improving the internal conditions in the buildings. These measures are applied through interventions on the buildings, mostly aimed at the building's skin, that is, through full or partial reconstruction [4]. However, such processes are not always implemented successfully, due to institutional, legal, and economic barriers [5]. Moreover, the interventions on built facilities often lead to transformations that do not align with the architectural physics of the objects, neglecting architectural characteristics for sustainability.

The reasons for the incomplete implementation of energy efficiency strategies for existing public buildings are related to financing or the source of finance. Additionally, high interest rates on development projects and the legal status of the facilities hinder progress. While the legal and economic aspects of energy efficiency strategies prevail, the qualities related to architecture are often overlooked. No strategy thus far has included in its program these architectural qualities and how they would impact the architecture of public facilities.

Skopje's Strategies for Energy Efficiency

The strategies of the city of Skopje for promoting and encouraging energy efficiency are directed towards facilities under the city's jurisdiction. Specifically, these include facilities within the education sector, public enterprises, fire protection facilities, and cultural facilities. Buildings detailed as case studies within these strategies are The Youth Cultural Center (MKC), and both high schools "Orce Nikolov" and "Josip Broz Tito" [5-6].

Concerning the energy consumption of these buildings, strategies for partial interventions have been established to enhance energy efficiency conditions. The improvement of energy efficiency is perceived through the prism of energy savings, incorporating characteristics such as financing and savings, social and health benefits, adherence to European norms and standards, enabling comfort, health, and airflow.

The tendency of this economic model is to reduce energy consumption and the associated costs to achieve economic benefits. This involves implementing measures distributed in action plans scheduled for each year separately. The measures refer to interventions such as replacement of windows, insulation of the floor, wall, roof, installation of heating pumps, installation of photovoltaic collectors, etc. [7].

The focus of this research is on buildings subject to the strategies of the City of Skopje, which concurrently stand out as architectural heritage from the period of socialist modernism in Yugoslavia. These facilities have undergone transformations and interventions aimed at improving functionality and energy efficiency. They remain the subject of future strategies aimed at further increasing their energy sustainability.

Transformative Processes

The transformative processes are part of the strategies for energy efficiency that have been implemented for the last 20 years. The economic models are coming up with the budget requirements in the context of the strategic plans of the Government of the Republic of Macedonia and the Ministry of Economy dealing with issues related to energy, energy efficiency, and the use of renewable energy sources [4]. The building's transformations, serve as examples of the tendencies toward a sustainable economy of the built environment.

The three case studies reveal the consequences of the economic models, resulting from ad-hoc solutions and a lack of a disciplined approach. In these instances, the transformed building facades become products solely designed for economic income-generating purposes. This hypothesis undergoes examination through a qualitative method employing analytical approaches such as graphic analysis, data tables, and commentary on the achieved results of these interventions

The research approach is elaborated along three lines of inquiry. First given is an elaboration of the importance of the building physics development, followed by a brief written overview of the three cases and their transformation, and a graphic illustration of the building's skin interventions. Second, is the data table with an observation of the the positive and negative outcomes of the implemented economic model toward greater energy efficiency of the buildings. In the final segment are discussed the results of the graphic and tabular display.

Building physics as a discipline is vital in defining the formal, technical, and technological (Schittich,2006) aspects of the building's skin development [8]. To understand it better, one needs to understand the means by which it occurs. The building skin characterizes the material, functional, and structural aspects of architecture. Building's skin rests on functional grounds such as: passive, active, cooling, and ventilated [9]. Furthermore, the building skin entails two functions: protective and regulatory. The protective function represents the resistance to weather conditions, while the regulatory function refers to the regulation of the internal climatic conditions. The structural narrative on the other hand is associated with the technical and technological characteristics. It specifies the gradation in structure in the building skin by separating the primary, and secondary. At that stage, the development of the architectural detail plays a crucial part in the performativity of the building. Connections and joints are also significant in the detailed development of building skin [10]. Besides the functional and structural, materialization is also considered an integral part of the process. Building physics as a discipline and architectural detail as a tool combined represent a unified approach in the development process. Accordingly, heat,

light, sound, and humidity as aspects of building physics are an integral part of the development process.

Youth Cultural Center Skopje (MKC) was built in the period between 1970 and 1972, as a facility for the promotion of culture, cultural and scientific achievements of young people. The facility has been operating successfully over the years, with a rich program of cultural and scientific activities. The building belongs to late modern architecture in Yugoslavia, with a refined functional plan and basic materials such as concrete, which emphasize its natural form. Its purpose primarily contains a strong social component. The building will undergo several transformations in terms of its appearance, but the most significant is its reconstruction in 2011, which will also experience a makeover of its stylistic expression [11]. The reconstruction is aimed at improving the functionality of the building, but also increasing its energy efficiency through interventions such as: an energy-efficient facade, new audio and lighting equipment, renovation of the domes and interior of the Planetarium, replaced roof, floors, doors, windows, and radiators (Figure 1, 2 and 3).

Figure 1: Youth Cultural Center – Original Façade
source: https://marh.mk/mkc-skopje/

Figure 2: Youth Cultural Center – Reconstructed
source: https://frontline.mk/

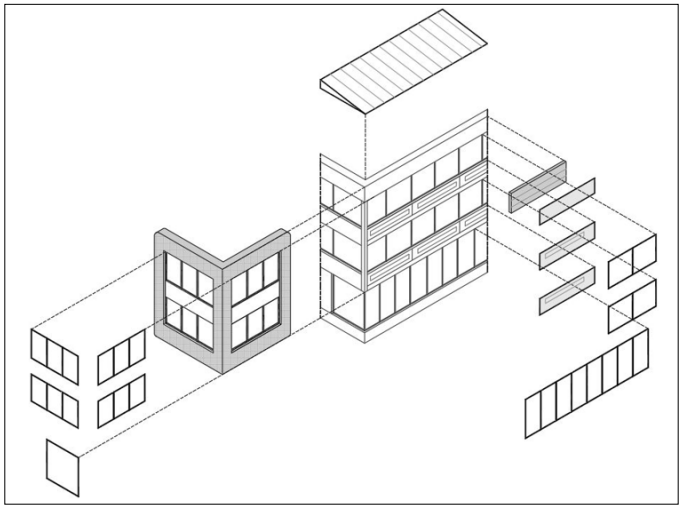

Figure 3: Youth Cultural Center – Illustration of Building's Skin Transformations.
source: authors, 2023

High School "Orce Nikolov" was built in the period between 1969 and 1971 and is an educational facility. The building belongs to the post-earthquake reconstruction of Skopje and represents one of the symbols of modern architecture in Yugoslavia. Its appearance has strong architectural characteristics under the influence of brutalism, reflecting as well the Macedonian regional modernism. The building's materialization is characterized with concrete in combination with facade brick. In 2016, the building was reconstructed with the aim of improving energy efficiency by up to 30% [6]. The interventions refer to the replacement of doors and windows, repair and insulation of the roof, insulation of the facade walls from the inside, as well as insulation of the porch ceilings. In 2018, new interventions were noted, such as energy improvement of the building within the Program for Energy Efficiency of City Institutions 2018-2020 [12]. In this process, insulation (styrofoam) was applied, but only on the constructive elements, which at the same time represented the characteristic architectural appearance of the concrete facade (Figure 4, 5 and 6).

Figure 4: High School "Orce Nikolov"– Original Façade source: https://marh.mk/

Figure 5: High School "Orce Nikolov"– Reconstruction source: https://marh.mk/

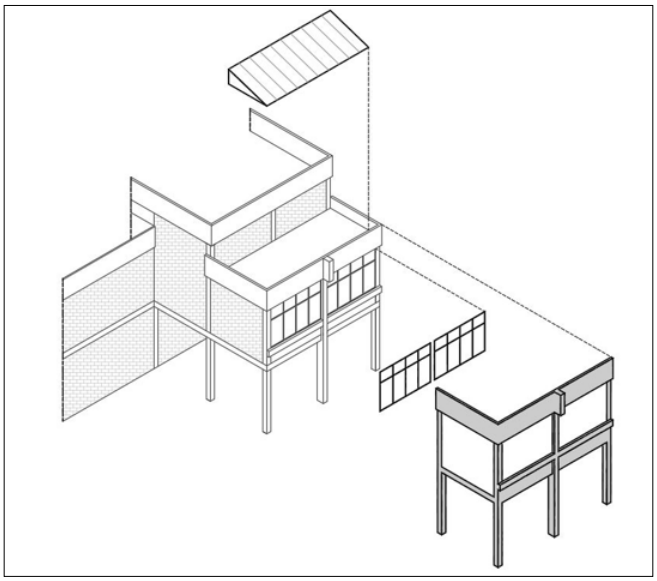

Figure 6: High School "Orce Nikolov"– Illustration of Building's Skin Transformations. Source: authors, 2023

The facility "Josip Broz Tito" High School was built in the period from 1970 to 1971, with stylistic expressions strongly influenced by brutalism. Materials such as concrete and facade brick prevail in the materialization of the building. The first reconstruction of the building was done in 2012, according to the Energy Efficiency Study, with the aim of saving energy and funds, as well as minimal emission of CO2 into the atmosphere [6]. The interventions refer to covering the building's facade with insulation (styrofoam), installing new PVC windows, and insulating the roof. The next interventions were made in 2018, within the 2018-2020 Program for Energy Efficiency of City Institutions, with the reconstruction of the facade and external windows. The floors, classroom doors, and parts of the atrium have been renovated (Figure 7, 8 and 9) [12].

Figure 7: High School "Josip Broz-Tito" Original Facade **Source**:https://josipbroztito.edu.mk

Figure 8: High School "Josip Broz-Tito" Reconstruction source:https://josipbroztito.edu.mk

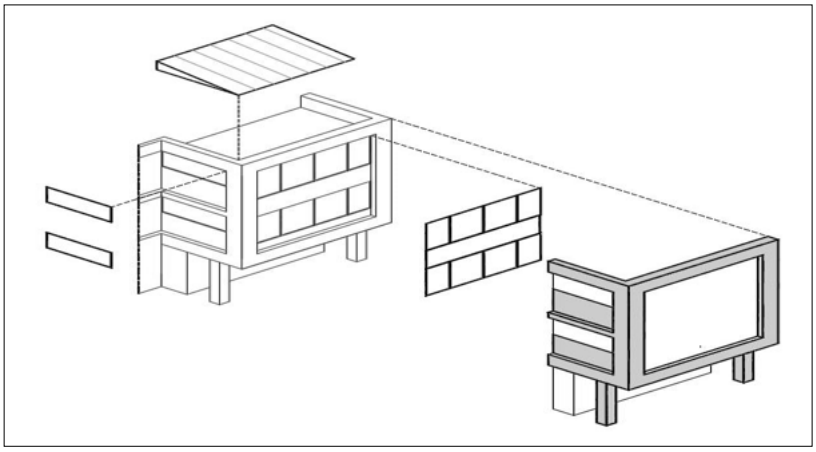

Figure 9: High School "Josip Broz-Tito"- Illustration of Building's Skin Transformations.
source: authors, 2023

Table 1: Mapping Activities and Assessing Outcomes

Building	Year of intervention	Type of intervention	Positive outcomes	Negative outcomes
Youth Cultural Center Skopje (MKC)	**2011**	Installation of new facade: – adding thermal insulation; -using new materials.	Increased heat resistance	Issues with sound permeability and humidity. Reduction of visual qualities and facade uniqueness.
		New equipment	Reduction of energy consumption	Increase in finances
		Roof installation: - adding thermal insulation; -using new materials	Reduced thermal conductivity	Frequent roof maintenance
		Windows replacement	Greater sealing	Space ventilation and increased air humidity
High School "Orce Nikolov"	**2016**	Replacement of doors and windows	Greater sealing	Space ventilation and increased air humidity
		Roof installation: - adding thermal insulation; -using new materials	Reduced thermal conductivity	Frequent roof maintenance.
		Adding thermal insulation from the inside: -using new materials.	Relatively increased heat resistance	No change in exposed structural elements – possibility of thermal issues
	2018	Adding thermal insulation on the facade at the exposed structural elements: -using new materials.	Reduced thermal conductivity	Reduction of visual qualities and facade uniqueness.
High School "Josip Broz-Tito"	**2012**	Installation of new PVC windows	Greater sealing	Space ventilation and increased air humidity. Loss of architectural cohesiveness and reduction of the building value.

	2018	Installation of new facade: – adding thermal insulation; -using new materials.	Increased heat resistance	Issues with sound permeability and humidity. Reduction of visual qualities and facade uniqueness.
		Roof installation: - adding thermal insulation; -using new materials	Reduced thermal conductivity	Frequent roof maintenance.
		Complete facade reconstruction.	Increased heat resistance	Increased dynamics of activities

Following the results of the graphic and tabular display, a discussion is initiated where the problem statement becomes evident. There is a deficiency in providing a comprehensive solution to issues concerning architectural physics. Taking Orce Nikolov High School as an example, interventions occur frequently, approximately every two years. Thus, when considering the dynamics of intervention from the perspective of architectural physics, it becomes apparent that the absence of establishing a complete framework leads to the repetition of procedures within a very short timeframe. Apart from the shortcomings associated with treating architecture from the standpoint of architectural physics, an additional problem arises concerning the temporal dynamics of interventions and the maintenance of buildings.

A similar case is observed in Josip Broz Tito High School. Architectural interventions are spaced four years apart, and the shortcomings identified in the 2012 interventions were addressed in 2018. Another problematic aspect is that changes directly related to the discipline of architectural physics are only perceived from a thermal perspective. This limited focus results in overlooking problems related to sound transmission and condensation, which are linked to humidity.

Furthermore, from the detailed cases, various problematic areas are evident in both past and present strategies for energy efficiency. These issues refer to an obvious and direct reflection of strategies through transformativeness, an approach with partial solutions and short-term measures. These approaches also result in the dispersion of consumer entities. Additionally, beyond the challenges identified in the specific framework, issues related to architectural physics are also apparent. These include:

- Problems related to air humidity and their impact on wall diffusion resistance and roof surfaces (inappropriate installation of thermal insulation leads to humidity-related problems).
- The resolution of issues solely related to heating (in terms of heat and thermal aspects) gives rise to problems in sound and acoustics, affecting the transmission of sound through air environments and construction surfaces.
- A disciplinary issue arises when architectural physics is perceived solely through energy issues related to heat. Addressing only one aspect (heat) results in problems affecting the entirety (sound, humidity, light, cooling, etc.).

Therefore, the necessity of collaboration between architectural transformation and building physics is increasing, providing the architectural characteristics of sustainability.

Conclusion

Progress toward sustainability and performance is fundamental in architecture. The environment and the effects it brings are visible in the technical, technological, and tectonic characteristics of the building's skin. Therefore, better approaches should be developed, where issues related to energy efficiency must be perceived from the point of architectural physics.

Furthermore, it is necessary to emphasize the need to understand the cultural development of humanity, a topic that is part of energy, energy consumption, and benefits, and it is necessary to include the consequences of development ideas.

Decapitalization through the built environment could be a solution resulting from the shortcomings of initial ideas related to financing and savings. These approaches will include different interests, as opposed to the current legal and economic ones, enabling an integrated approach to solving problems related to the physics of existing buildings.

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