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IMPROVING ENERGY EFFICIENCY IN BUILDINGS THROUGH THE USE OF PANORAMIC GLAZING

The purpose *of this study is to highlight how panoramic windows can significantly enhance energy efficiency in interior spaces. The aim is to identify and discuss the main benefits and disadvantages of these windows, as well as their classification according to the destination of the respective space.*

Methodology*: the study was based on extensive bibliographic research, analyzing various sources such as books, articles and specialized publications in the field of architecture and energy efficiency. The author evaluated and interpreted the data and results obtained, organizing them logically to provide a coherent presentation of the topic.*

Results. *The effective utilization of panoramic windows offers numerous benefits for enhancing energy efficiency indoors, including improved thermal insulation, optimized utilization of natural light, efficient control of solar radiation, and promotion of natural ventilation. Despite associated drawbacks such as thermal losses and maintenance costs, proper classification and climate adaptation can maximize energy efficiency and indoor comfort in buildings.*

Scientific novelty*. The study explores the energy efficiency of buildings through the optimization of panoramic windows across various climatic and cultural contexts, employing advanced technologies in thermal insulation and solar control. Results, derived from exhaustive research and empirical data, underscore the advantages of these windows in enhancing the energy efficiency of buildings.*

Practical significance*. The study highlights the multiple practical advantages of panoramic windows, such as improving thermal insulation and solar control, leading to energy savings and increased indoor comfort. The efficient use of energy through these windows not only reduces CO2 emissions but also protects the environment, promoting responsible resource consumption and contributing to societal progress through ecological innovations.*

Keywords: *architectural design, natural ventilation, window classification, interior comfort, natural lighting.*

Introduction. For the elaboration of this study, the author focused on the analysis of the advantages and disadvantages of using panoramic glazing in the energy efficiency of modern buildings. These defining windows for Contemporary Architecture, have a long history and fit perfectly into today's urban landscape. In the context of the current concerns regarding the conservation of resources and the reduction of the impact on the environment, the use of panoramic glazing becomes an essential strategy for optimizing the energy performance of buildings. They not only provide a modern appearance, but also contribute significantly to lower energy consumption and improve interior comfort (Fig.1, 2). Thus, the study aims to highlight the multiple benefits brought by the efficient use of energy and to identify the specific advantages associated with panoramic glazing in the energy efficiency of interior spaces.

Analysis of Previous Research. To complete the analysis of previous studies on the efficient use of panoramic windows for energy efficiency in interior spaces, several relevant scientific publications from the last 5-10 years are highlighted. Researchers such as Lee E. S., Selkowitz S. E. [7] evaluated the thermal and visual performance of dynamic shading systems, while Liu X., Wu Y. [8] studied the impact of electrochromic windows on energy savings. A detailed study by Razaei S., Shannigrahi S., Ramakrishna S. [13] emphasized the potential of panoramic windows to reduce energy consumption by improving thermal insulation and optimizing natural light usage. Shannigrahi and Ramakrishna also addressed future trends in

Fig. 1. Cleveland Clinic Lou Ruvo Centre for Brian Health. 2005-2010. Las Vegas, Nevada, USA. Architect, Frank Gehry

Fig. 2. Galleria Departament Store, Gwanggyo, South Korea. 2016-2020. Architects: OMA

building energy efficiency, highlighting the importance of innovative technologies for panoramic windows.

Furthermore, Wang X., Li Q. [15] investigated the performance of panoramic windows under various climatic conditions, showcasing the variability of energy efficiency based on geographical location and specific building characteristics. These studies provide a comprehensive understanding of the benefits of panoramic windows for building energy efficiency, covering aspects such as energy-saving potential, thermal and visual performance of dynamic shading systems, the impact of electrochromic windows, and future trends in this field. These references can be integrated into the existing analysis to support the presented arguments, thus contributing to a deeper understanding of the subject.

Based on the previously examined aspects, the present study focuses on an unexplored question: how can panoramic windows be optimized to improve the energy efficiency of buildings across diverse climatic and cultural contexts? This question is addressed through the analysis of insulation technologies, solar control, and interior design, tailored to the climatic specifics and cultural preferences of different regions. The aim of the study is to make significant contributions to understanding how panoramic windows can be utilized to create buildings that are more energy-efficient and comfortable, tailored to the diversity of geographical and cultural contexts.

The results of the research study. Efficient use of energy brings multiple benefits. By reducing CO2 emissions, the climate is protected and the air is kept clean. Energy efficient technologies also reduce dependence on energy imports and associated costs. Promoting responsible and sustainable consumption of resources that contribute to the preservation of the environment. Ecological innovations stimulate the progress of society. Moreover, energy efficient technologies provide comfort at low energy consumption, and their implementation can create jobs and reduce energy poverty. These benefits underline the importance of efficient use of energy and bring significant advantages in the economic, social and technological fields. Panoramic glazing can bring multiple benefits in terms of improving energy efficiency in indoor spaces (Tab. 1).

Table 1

Benefits of using panoramic glazing in the energy efficiency of interior spaces

Benefits	Properties
Improved thermal insulation	Modern panoramic windows are made with advanced thermal insulation technologies [2], improving daylighting systems thus reducing heat loss and the need for additional heating.
Use of light	The ability of panoramic windows to allow the penetration of natural light reduces the dependence on artificial lighting [3], contributing to significant savings in electricity (Fig.3a, 3b).
Solar control	Panoramic windows can be equipped with solar control technologies to minimize heat absorption and harmful solar radiation, thereby reducing the need for additional cooling in summer [4].
Natural ventilation	Some types of windows allow air to circulate indoors, improving air quality without the need for additional air conditioning systems, thereby reducing the energy consumption associated with them.

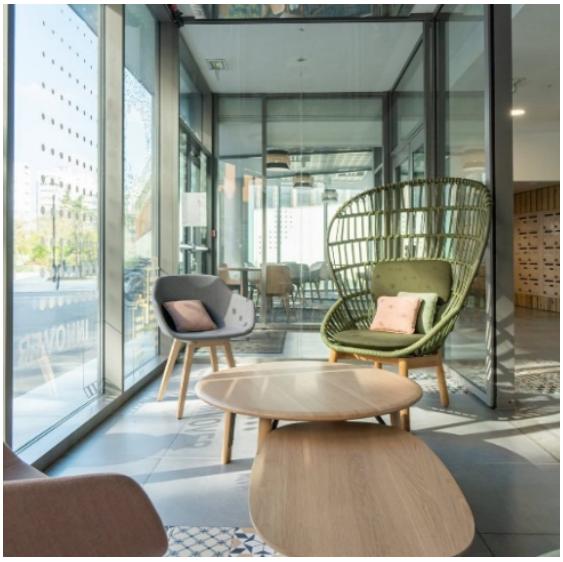

Fig. 3a. *Use of light.* RIVP Headquarters 2022. The reception of the Nord Express building on rue Renee Boulanger

Fig. 3b. *Use of light.* 3379 47th AVE NE, Seattle, WA 98105

Key factors influencing the thermal insulation of panoramic windows include the quality of the glazing, the material and quality of the frames as well as the proper sealing. Rational selection of windows and correct installation can contribute to significant savings on heating and creating a comfortable environment inside. By opening panoramic windows for natural ventilation, air quality can improve significantly, reducing the need for additional fans and air conditioning systems. Solar control – an essential element that brings significant electricity savings. Although panoramic glazing offers many advantages in terms of natural lighting, aesthetics and connection with the external environment, there are also some disadvantages in terms of energy efficiency (Tab. 2).

Table 2

Disadvantages of panoramic glazing in energy efficiency

Aspects	Inconveniences
Thermal losses	Panoramic windows, especially those that are not equipped with advanced thermal insulation technologies, can be weak points in terms of thermal insulation of the building. They can allow significant heat loss during the cold season, which can lead to increased energy consumption for heating.
Increasing solar heating	In summer or in hot climates, panoramic glazing can allow excessive penetration of solar radiation, which can lead to overheating of the interior of the building [4]. This may increase the need for additional cooling, leading to increased electricity consumption.
Protection against UV radiation	Standard panoramic windows can allow ultraviolet (UV) radiation to enter the interior, which can lead to discoloration and damage to furniture, flooring and other interior items exposed to sunlight.
High maintenance costs	The maintenance and repair of panoramic windows can be more expensive than conventional ones, especially in the case of problems such as internal condensation, damaged seals or manufacturing defects.
Safety and security	Panoramic windows may be more vulnerable to accidental cracking or intrusion especially when compared to solid walls. They may require the installation of additional safety measures, such as the use of safety glass or the installation of security systems.

The specifics of panoramic glazing in terms of improving energy efficiency in indoor spaces may vary depending on the geographical location, the destination of the building or space (Tab. 3).

Table 3

Classification of energy efficiency by space destination, panoramic glazing

Types of buildings	Aspects of the use of panoramic glazing in buildings
Residential	Panoramic glazing provides a balance between thermal comfort and natural brightness. Use of thermal insulation technologies for winter (reducing heat loss) and solar control for summer (minimizing over heating) [13]. The design can be adapted to create a pleasant and aesthetic environment.
Commercial and office	In these spaces, panoramic glazing is designed to maximize natural brightness and create an open and welcoming environment. They can be equipped with solar control technologies in order to reduce the need for additional cooling and improve visual comfort. Thermal insulation characteristics can also be integrated to achieve thermal comfort.
Institutional and public	Panoramic glazing is designed to create a comfortable and pleasant environment for users in institutions and public spaces. The use of advanced thermal insulation and solar control technologies ensures optimal thermal comfort and reduce energy consumption. The integration of additional safety features protects users and goods (Fig. 4a, 4b).
Industrial and commercial	Panoramic glazing is used for natural lighting and ventilation, reducing dependence on artificial lighting and air conditioning systems. Solar control and thermal insulation technologies optimize energy efficiency and ensure a comfortable working environment for employees [12].

Fig. 4a. Coney Island Hospital, Brooklyn, 2021

Fig. 4b. Tours Duo, Paris, France, architect Jean Nouvel, 2021

By classifying panoramic windows according to the destination of the respective building or space, it can be ensured that they are optimally designed and used to improve energy efficiency and interior comfort according to the specific needs of users (destination) and activities carried out in these spaces [5], geographical positioning (Tab. 4). In general, however, panoramic glazing is designed to optimize natural light and provide a panoramic view [15], thereby improving the quality of the interior space experience.

Table 4

Panoramic windows and climate: solar and energy control strategies

Aspects	Description aspects of the use of panoramic windows in buildings
Climate and local temperatures	Panoramic glazing can be designed and installed differently depending on the local climate and temperatures. In regions with predominantly hot or temperate climates, the focus may be on solar control to reduce warming.
Sun exposure	Sun exposure can influence the design and location of panoramic windows to value solar energy capture or minimize over-heating of interior space. In regions with high sun exposure, it is important to use solar radiation control technologies to limit the negative effects of excessive heating [2]. In regions with reduced sun exposure, glazing with improved insulating properties for energy efficiency can be used.
Natural ventilation	Panoramic windows can be designed to facilitate natural ventilation, allowing air to circulate freely in the building and ensuring a healthy and comfortable indoor environment. In regions with mild and temperate climates, the use of natural ventilation can be an effective way to cool the building during the warm season [3]. In regions with more extreme climates, ventilation systems can be designed to maximize energy efficiency and thermal comfort.
Solar energy capture capability	Panoramic glazing can be equipped with technologies to capture and use solar energy, helping to reduce energy consumption and increase the energy efficiency of the building. In regions with high sun exposure and high temperatures, solar energy capture technologies can be adjusted to reduce the need for air conditioning systems, thus helping to save energy and reduce associated costs. In contrast, in regions with more moderate climatic conditions, similar technologies can be adapted to provide additional benefits, such as natural lighting and thermal comfort [8], having a positive impact on the quality of life inside buildings.

In predominantly hot or temperate climates, panoramic glazing is designed to maximize solar control, reducing excessive entry of solar radiation and heat into the interior during the summer. In regions with a cold climate, panoramic glazing is designed to value thermal insulation and reduce heat loss during the cold season. This may include the use of glass units with triple glass or with thermal protection film, which reduce heat transfer through the windows. The windows could also be designed to maximize the capture of sunlight and the building during the day to help passively heat the interior space, thus reducing the need for additional heating.

Design and role of panoramic glazing in interior architecture. The design and role of panoramic glazing in contemporary interior architecture represent an essential topic in researching and understanding how these elements shape both the aesthetics and functionality of modern buildings. These expansive glazing, emblematic of contemporary design, seamlessly integrate with urban landscapes and bring a multitude of advantages to interior spaces.

The study of interior design in implementing panoramic glazing provides a synthesis of important aspects addressed [11], starting with the various shapes that glazing can adopt. From curved, rectangular, round, oval, or triangular shapes to customized or irregular shapes, each shape brings unique possibilities to interior design, influencing the overall look of the space.

In parallel, it presents the various types of panoramic glass [2], including fixed, sliding, folding, or pivoting glazing, each type having its advantages and disadvantages depending on the users' needs and available space (Fig. 5a, 5b).

The color options for panoramic glazing are diverse and adaptable to fit any project [10]. It is necessary to emphasize the importance of selecting suitable colors, as they can contribute to the overall appearance of the building and the atmosphere and functionality of the interior space [1] (Tab. 5).

Panoramic glazing can be harmoniously integrated into the interior design of a home or a space with various purposes. They can serve not only as functional elements but also as aesthetic focal points, contributing to the creation of modern and spacious aesthetics.

Fig. 5a. Putna Monastery, Romania, 2024 (Author's photo)

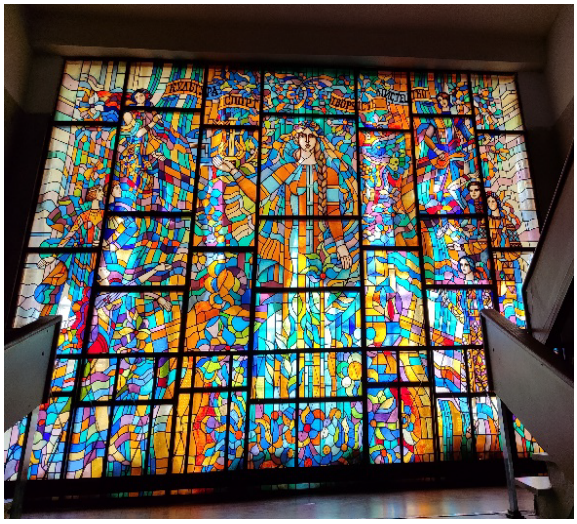

Fig. 5b. Kyiv National University of Technologies and Design (KNUTD), Ukraine, 2024 (Author's photo)

Table 5

Color options for panoramic glazing

Color type	Description	Examples
Transparent	Allows an unobstructed view of the exterior landscape.	Transparent or tinted glass windows.
Colored	Adds an interesting design element to a room.	Windows with neutral or vibrant colors.
Decorative patterns	Personalized with artistic or textured patterns.	Windows with decorative patterns.
Reflective-E	Treated with Low-E technology to reduce heat transfer and create energy efficiency [9].	Reflective or Low-E technology glass windows.
Customized	Adapts to aesthetic preferences and individual needs [6].	Customized glazing according to the owner's or project's preferences.

Conclusions. The study emphasizes the importance of panoramic windows in contemporary architecture and the optimization of building energy performance. The analysis shows that these windows offer multiple benefits, such as improved thermal insulation, efficient use of natural light, and solar control, thus contributing to reduced energy consumption and enhanced interior comfort. Although there are some disadvantages, these can be managed through the use of advanced technologies and the adaptation of window design to specific climatic conditions and the building's purpose. Panoramic windows are not only functional elements but also aesthetic ones, contributing to the creation of a modern and spacious environment within buildings. Various design options, including shapes, types, and colors, allow for the harmonious integration of panoramic windows into contemporary interior design.

Future research should focus on expanding existing knowledge and identifying directions for further studies. It is important to explore innovative technologies for panoramic windows that offer more energy-efficient and long-term sustainable solutions. Evaluating the performance of these technologies under different climatic conditions is crucial for optimizing their use. Additionally, investigating the impact of panoramic windows on the health and well-being of occupants is essential to ensure complete benefits for users. Developing and discussing design options for panoramic windows will encourage their adoption in construction projects, contributing to the creation of more sustainable and energy-efficient living and working environments.

Panoramic windows represent a promising solution for improving energy efficiency in modern architecture. Future research should focus on expanding existing knowledge, exploring innovative technologies, evaluating performance under different climatic conditions, and investigating the impact on the health and well-being of occupants. These directions will contribute to advancing the field and promoting the efficient and sustainable use of panoramic windows.

Confirmation

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ПІДВИЩЕННЯ ЕНЕРГОЕФЕКТИВНОСТІ БУДІВЕЛЬ ШЛЯХОМ ЗАСТОСУВАННЯ ПАНОРАМНОГО СКЛІННЯ

Метою дослідження *є висвітлення можливостей панорамних вікон у підвищенні енергоефективності внутрішніх приміщень, ідентифікація та обговорення основних переваг і недоліків цих вікон, а також їх класифікація відповідно до призначення відповідного простору.*

Методологія*. Дослідження базувалося на обширних бібліографічних дослідженнях, аналізі різноманітних джерел, таких як книги, статті та спеціалізовані публікації в галузі архітектури та енергоефективності. Автор оцінював та інтерпретував отримані дані і результати, логічно організовуючи їх для надання зв'язного викладу теми.*

Результати*. Ефективне використання панорамних вікон може принести багато переваг з точки зору покращення енергоефективності внутрішніх приміщень. До цих переваг відносяться краща теплоізоляція, оптимізація використання природного світла, ефективний контроль сонячної радіації та сприяння природній вентиляції. Однак також важливо враховувати пов'язані недоліки, такі як тепловтрати, збільшене сонячне нагрівання та високі витрати на обслуговування. Класифікуючи панорамні вікна відповідно до призначення простору та пристосовуючи їх до конкретного місцевого клімату, можна максимізувати енергоефективність та внутрішній комфорт в будівлях.*

Наукова новизна*. Дослідження висвітлює важливість ефективного використання панорамних вікон у покращенні енергоефективності будівель, надаючи докладний та документований взгляд на їх переваги та обмеження.*

Практична значущість. *Інтегруючи панорамні вікна у будівельні проекти, можна досягти значного збереження енергії та покращення внутрішнього комфорту, що є важливим кроком у реалізації більш сталого та енергоефективного середовища для проживання та діяльності.*

Ключові слова: *архітектурне проектування, природна вентиляція, класифікація вікон, внутрішній комфорт, природне освітлення.*

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