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Review Paper

Green Architecture and Environmental Sustainability: Analysis of Projects Using Renewable Energy Sources

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ABSTRACT

The article considers the theoretical foundations of green architecture in historical retrospect and in perspective, and practical implications of its development globally. The main directions of energy saving in the design and operation of green buildings are highlighted, including not only rational architectural planning and corrections according to climatic conditions, but also at first glance not quite implicit factors such as ventilation and natural lightening. Some examples of appropriate solutions implementation are described. Particular attention is paid to the consideration of certification standards for green building in the context of the analysis of green architecture projects. Moreover, the phenomenon of greenwashing in green building is covered briefly, with outlining possible ways of its reducing. It is emphasized that although green certification of construction is a sound driver of enhancing environmental sustainability of projects, it, at the same time, contains a significant pitfall – a loophole for greenwashing, and this fact requires specific attention of both market participants and regulators.

HIGHLIGHTS

- The rapid growth of the global green buildings market, projected to reach around USD 1,169.29 billion by 2032, highlights a significant shift towards environmentally sustainable architecture, reflecting a shared commitment to reducing the environmental impact of construction and promoting energy efficiency.
- Despite the promising trajectory of green construction, the industry faces challenges, particularly the risk of greenwashing in certification processes, emphasizing the need for standardized, measurable parameters such as energy efficiency to maintain investor confidence and ensure the genuine environmental impact reduction of construction projects.

Keywords: Energy efficiency, green architecture, green building, sustainability, green certification, greenwashing

In the modern world (late 20th – early 21st centuries), researchers call the world-view problem of understanding the essence and goals of development one of the most pressing problems. The harmfulness of the development of industrial-market civilization has become obvious the rapid development of it has led to the degradation of the natural basis of society’s life and a growing shortage of vital natural resources. Since the 80s of the 20th century,

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designers have used the term "green" architecture, which reflects the substantive side of the ideology aimed at creating an environmentally friendly environment for humans (green building). "Green" buildings and complexes are an example of the organic unity of technically advanced systems and elements of natural nature (not so much plants, but rather energy-efficient systems without harmful waste, creating the potential for an environmentally friendly environment). A new vector for the development of urban space was formulated by the UN Commission on Sustainable Development and indicates the humanization of the living environment the choice of an environmentally safe future (Cajes, 2021). "Green" buildings are the result of a reorientation of approaches to buildings design, the use of technologies for the reproduction of energy resources, which make it possible to design buildings that are energy-saving, functional, comfortable, with minimal negative impact on the environment.

The concept of architecture of energy-saving buildings has become relevant in modern architecture in recent decades. When designing energy-saving buildings, attention is paid not only to the efficient use of energy, but also to the reduction of energy costs in the entire cycle of their operation.

Examples of implemented "green" projects are very diverse. These are the School of Art and Design in Singapore, the Chicago City Hall building, the Academy of Sciences in California, the exhibition hall in Bonn, GENO Haus in Germany, The Solaire, the New York Oasis House, the Historial de la Vendée Museum in France, a government building in Japan in Fukuoko (Goede, 2016). A special direction is dynamic architecture based on the principles of energy conversion. Italian architect David Fischer proposed a completely new concept from a tectonic point of view, "Dynamic Buildings," which has such advantages as fast construction, energy autonomy and high efficiency.

A large number of European cities use hybrid systems that provide apartment buildings with heat and electricity. According to the designers, a "green" building should consume a minimum amount of external energy. Therefore, one of the main tasks of "green" construction is the introduction of alternative energy sources. In this regard, the concept of "energy efficiency" is introduced. The ideal facility from an energy efficiency point of view is one that is self-sufficient. And this requirement is implemented using alternative sources. These include solar panels and wind generators, geothermal pumps, biomass energy and biosewage residues. Wind turbines, for example, are usually placed on the roofs of buildings.

Eco-development was first discussed in the United States in the late 70s during the energy crisis, and a few years later European architects became seriously interested in it. Technologies and concepts such as self-heating, cooling due to solar radiation, renewable energy sources, super-insulation, energy-efficient devices, and bionic architecture were forced to emerge. At the end of the 80s, the concept of eco-development became a worthy alternative to traditional design and construction and was firmly entrenched first in Germany, the Netherlands and Scandinavia, and then "captured" America and Canada. Currently, eco-development has become widespread in Europe and 60% of all new projects are "green", while entire eco-cities have begun to be built in Dubai and China (Goede, 2016).

According to Precedence Research (2023) data, "The global green buildings market size was estimated at USD 474 billion in 2022 and is projected to hit around USD 1,169.29 billion by 2032, registering a CAGR of 9.50% during the forecast period from 2023 to 2032". Green building market share current state and projection is presented in Fig. 1 below.

Fig. 1: Green building market size 2022 to 2032 (USD billion) (Precedence Research, 2023)

There are many large buildings in industrialized countries that embody the concept of sustainable Green architecture, which reduces the environmental impact, including the Conde Nast Tower (48 floors) in Times Square in New York. This tower is one of the first examples to apply the principles of sustainable green architecture, and they used almost every technology imaginable to save energy. The building used special quality glass that allows natural sunlight to pass through and retains heat and ultraviolet rays from the outside of the building.

In recent decades, with the participation of architects, builders, engineers, various public and government organizations, world standards for eco-development and methods for environmental assessment of real estate have been developed. They are usually applied voluntarily, but taking into account market realities. Based on the standards, the facility' environmental efficiency and its environmental impact are assessed, and based on the assessment results, the building is awarded a certificate.

In a scientific sense, the development of green architectures relies not only on the latest relational technologies, but also on the best combination and arrangement of these technologies, or the so-called exploratory combination of technologies. But in actual operation, green buildings are mainly built on the basis of some existing mature and cost-effective technologies, which is called practical technology combination.

No matter what technology is used, green building is always based on the 3R principle ('reduce, reuse, recycle'). Many successful projects have shown that green buildings are not that difficult to implement. Studying the experience of such projects, their benefits, as well as challenges and concerns is a very relevant scientific and practical task in the light of deepening and improving the concept of sustainable development.

MATERIALS AND METHODS

The research methodology is based on the study of literature on the topic of work, as well as project materials, followed by systematization and generalization of the research results. The methodology and research methods consist of analyzing and summarizing scientific research in the field of energy-saving architecture of buildings, normative and recommendatory literature, design materials in the aspect of the area under study. During the research process, methods of a systems approach, stakeholder theory, forecasting, methods of analysis and synthesis were used.

Literature Review

In response to the first energy crisis of the 1970s, corresponding to the "oil shock", "solar" houses, "passive" or "active", appeared. According to the architectural concept, they were created to receive, store, and distribute natural energy. Due to the climate problems of the 80s (holes in the ozone layer, the greenhouse effect), solar houses became bioclimatic, integrating the comfort of residents, energy saving and environmental protection. This was determined both by the features of the architecture and the technical equipment used (Sowinski, 2017).

Since 1980, two trends began to develop in parallel: so called low tech and high tech. Proponents of low tech, driven by a desire to maintain voluntary simplicity in their lifestyle, are convinced that an economic recession in developed countries is inevitable. They often practice the use of local natural materials and advocate the conservation of resources and the development of traditional skills. High tech, supported by industrial development, mainly focuses on energy optimization through the use of sophisticated materials and 'high' technical solutions (Jodidio, 2018).

Over time, a third path emerged between them, a more pragmatic one, which puts people at the center of attention. This is "eco-responsible" architecture that takes into account economic and environmental issues, affirming the social responsibility of the architect and urban planner towards future generations. The developers of such architectural objects show respect for nature and take bioclimatic aspects into account. Optimized urban planning, architectural, structural and engineering decisions are made based on comprehensive analysis.

The concept of sustainable development emerged as a result of combining three main aspects of design: social, economic, environmental. Reconciling these different perspectives and translating them into concrete actions that are the means to achieve sustainable development is a task of enormous complexity, since all three elements of sustainable development must be considered in a balanced way. Rather, sustainable architecture can be understood as a balance between newly discovered bioclimatic principles, local building traditions linked to the context and original innovations that reduce resource consumption. This goal can be achieved through interdisciplinary and integrated design based on a holistic approach (Nuffida, 2015).

Early definitions of low carbon architecture emphasized the balance between the needs of people, architecture and climate. In recent years, low carbon architecture has begun to be mentioned in the context of energy efficiency and sustainability (Tabb, 2014). Therefore, low carbon architecture can be defined as a theory based on ecology with simultaneous sustainable development of the economy, society, and architecture.

Speaking about the diversity of terminology, one can note the connection of their content not only with the development of technology, but also with changes in the architecture assessment system. The environmental crisis that occurred more than half a century ago made to think about the irreplaceability of energy resources. In the construction sector, this has found expression in reducing costs for heat and power operations of buildings and structures. Now energy can be saved at all levels: heating, air conditioning, ventilation, water supply. As a result of the use of energy-saving technologies, so-called "passive" or "smart" houses have appeared, which require virtually no external energy.

The next stage was the evolution of energy-efficient buildings in relation to reducing the negative impact on nature and human health. The use of environmentally friendly materials, the application of safe technologies in the construction of the building, and the efficient use of energy and resources came to the fore. At this stage, the passive house is replaced by an active one. An active home not only provides itself with energy, but also accumulates excess generated energy, which can be used for other needs. The pinnacle of green building development is sustainable architecture, which allows for the creation of complex projects that meet human needs while preserving the environment throughout the entire life cycle of the building. Researchers talk about an evolution in the building industry from energy-efficient architecture to green architecture and then to sustainable architecture (Achraya *et al.* 2020).

It is interesting to analyze the interpretation of the term "sustainable architecture". Many definitions have an economic, social or technological slant. A number of experts see the task of sustainable architecture as "creating a living environment that is worthy of modern requirements and satisfies future generations" (Graff, 2018). This definition implicitly includes an idea of the goals of architectural activity, but does not specify qualitatively new ways to achieve them. In contrast, other scholars call sustainable architecture a set of architectural and engineering solutions that ensure high performance of the human environment and the preservation of ecological balance (Bonenberg & Kaplinski, 2018). At the same time, the normative and methodological basis of sustainable architecture is the rating system for assessing the human environment, a set of architectural, engineering, environmental, economic, and other requirements for the human environment, allowing a quantitative assessment of its quality (Aliamin, 2021).

In general, to create modern construction projects according to the rules of ecological construction, which has received the name "green" in international practice, it is necessary to comply with the following basic norms and rules: resource conservation, preferential use of renewable energy sources (sun, wind, groundwater, energy of rivers and seas), minimizing the negative impact on the biosphere and the organic inclusion of constructed objects in the natural landscape, the use of environmentally friendly materials, the production and disposal of which does not harm the environment (Gou, 2020). As one can see, energy efficiency and a focus on renewable energy sources rank first in this list.

In a review of the world theory of "green" architecture, the following main areas of energy saving in the design and operation of buildings can be identified (Jodidio, 2018):

1. Application of rational architectural, planning and design solutions taking into account climatic conditions to save energy.
2. Use of modern technologies and utilization of renewable energy sources to obtain clean energy.
3. *Building orientation:* This factor plays a major role in the design of energy efficient buildings. The purpose of rational orientation and relative position of buildings is protection from light, heat and wind discomfort. At the same time, a comprehensive system

for assessing insolation can be based on three main factors: sanitary and hygienic, architectural and planning, and technical and economic.

4. *Building Layout and Shape:* By optimally designing the building shape and location with passive solar utilization, the building can benefit from natural ventilation and lighting to create comfort while increasing the energy efficiency of the building.
5. *Natural ventilation:* Air exchange conditions in a building have a direct impact on people's health, feeling of comfort and vitality. From the point of view of human physiology, the most important things in ventilation are the purity of the air, the nature of its movement, as well as the indirect effect of ventilation on temperature and humidity. Ventilation is divided into three types according to its purpose: "health ventilation" maintains air quality, replacing indoor air with fresh outdoor air; "thermal comfort ventilation" creates thermal comfort by intensifying the process of heat exchange between the human body and the environment; "structure cooling ventilation" cools structures when the indoor air temperature becomes higher than the outdoor air temperature. In some cases, ventilation increases temperatures inside a building when the light-colored exterior surface and the thermal resistance of the wall prevent the absorption of solar radiation.
6. *Natural lighting:* indoor lighting is formed from two components: natural light from the sky falling into the contours of the light opening; and natural light reflected from the opposing (screening) light opening of the building. Daylight is undoubtedly the highest quality light source. It provides the most realistic color reproduction. It is believed to improve mental and physical health. The use of natural lighting or daylighting technologies in buildings is unoriginal. However, creative high-tech approaches make the process more efficient, economical and easy to implement. Thus, wisely planned natural light projects produce astonishing energy savings that cannot be ignored.
7. *Use of buffer space:* One of the main architectural elements to improve natural ventilation and increase the thermal efficiency of a building is the buffer space in the building. Using a buffer zone to store solar heat while ensuring its good thermal insulation properties is also an energy saving method. Buffer space, which involves the use of various unheated (or partially heated) utility rooms around the house, can be an atrium, sunwell, courtyard, greenhouse on the south side, verandas on the east and west, etc. Currently, the atrium has a multi-purpose purpose. Being the basis of the volumetric-spatial structure of the building, the atrium is a space limited from the external environment, around which blocks of residential and office premises are concentrated, receiving daylight from it. The use of buffer space in a building has been widely developed, and recently this idea has attracted the attention of architects. Among the immediate phenomena that must be taken into account when constructing a buffer space, the following can be identified: engineering and technical: convenient maintenance in different seasons; functional and planning: loss of useful space of the building; thermal engineering: increased heating costs during the cold season.

In addition, greening roofs and walls helps reduce the temperature inside the building in summer and retain heat in winter, i.e., reducing the cost of air conditioning and heating; moreover, is directly related to increasing the environmental sustainability of the urban environment.

RESULTS

One of the key requirements for buildings and architectural structures in urban areas is currently environmental safety. Being a multidimensional term, safety of this kind is associated not only with a specific type of activity, but also with its result. As a result, the scope of this concept includes both the permissible level of negative impact of natural and anthropogenic environmental hazards on the urban environment and residents, as well as a set of measures aimed at reducing the harmful consequences of citizens' own activities. This reduction should be achieved by the use of renewable energy sources, as well as environmentally friendly building materials. The tasks of environmental safety are the most important for state, regional, and municipal government, construction and architecture in all countries.

Green architecture reinforces and embraces the close relationship between the environment and the economy, and the reason for this is that the impact of urban activities and buildings on the environment has clear economic aspects, and vice versa. Energy consumption, which causes an increase in electricity bills, is closely related to the phenomenon of construction, that occurs due to the fact that a large number of air conditioners use up energy, unlike natural ventilation. Waste of construction materials during the implementation of the project causes additional costs and at the same time leads to environmental pollution. They contain high percentages of toxic and harmful chemicals. Thus, environmental solutions and methods that provide sustainable green architecture lead at the same time to the achievement of countless economic benefits at the individual and societal level. For example, in the United States of America, buildings alone consume (65%) of total energy consumption and cause (30%) of greenhouse gas emissions. The importance of integrating the practices and applications of green sustainable architecture is clear.

The principles of green construction are specifically evident in buildings that are partially buried in the ground (Fig. 2). The use of earth protection can not only significantly reduce energy consumption under normal conditions, but also reduce dependence on fuel supplies, especially in harsh winter conditions. One of the important problems that must be solved when designing recessed houses is energy saving. To achieve both the energy efficiency of a building and the comfort of living, a number of basic requirements must be met, including: determining the type of building, choosing a construction site, determining the most effective orientation, architectural, planning and constructive solution. Particular attention should be paid to landscaping. The location of a buried building is determined based on topographic, geological, and hydrogeological conditions. The main requirements for the site are: the presence of dry, not prone to erosion, preferably sandy soils; low groundwater level; the presence of suitable terrain; low relative air humidity (Krstic *et al.* 2017).

The protective thickness of the soil determines the energy-saving effect of buried buildings. Compared to above-ground buildings, houses buried in the ground do not actually need air cooling in the summer due to heat transfer through the enclosing structures of the soil filling. In winter, soil filling significantly reduces heat loss due to the additional thermal resistance of the soil filling. Its subsequent landscaping allows increasing the number of green spaces, improving the microclimate of the building and the urban landscape. A semi-buried building located on a slope allows for the greatest visual contact with the surrounding natural space, in contrast to buildings on flat terrain (Krstic *et al.* 2017).

Buried houses built using "green" technologies significantly reduce environmental pollution, and if certain conditions are met, they will be able to

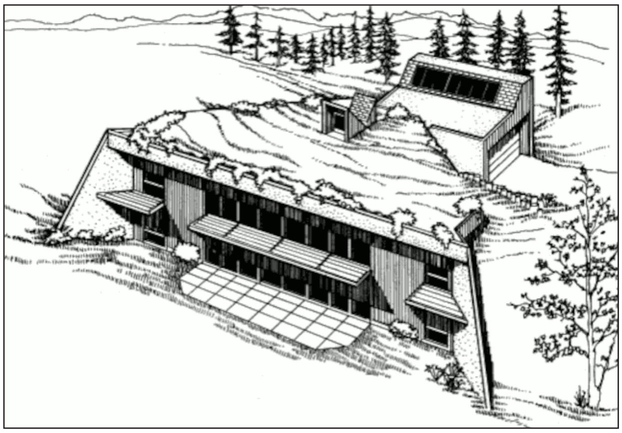

Fig. 2: Partially buried building

independently meet their own needs for energy sources, without using external power sources. Also, in urban conditions, buried houses help restore and preserve flora and fauna, improve the quality of the surrounding urban environment, that is, they contribute to the protection of nature.

DISCUSSION

With increasing urbanization and increasing consumption of natural resources, the need for environmental design is growing faster. An actively developing environmentally sustainable architectural and urban planning environment, taking into account the requirements of environmental standards in construction, is becoming an important direction. It is characteristic that in developed countries the real estate market has changed significantly. For reconstructed, existing, and new buildings, an environmental certificate is required for rent and sale as an indicator of quality and reduction of operating costs. The environmental rating, confirmed by the certificate, primarily shows a reduction in the facility's pressure on the environment by reducing the consumption of energy and natural resources.

In total, approximately 12 "green" standards are used in world practice: Green Star in Australia, CASBEE in Japan, GOB AS in China, DGNB in Germany and others. However, due to their specificity, these standards are not applicable to foreign markets and are used only within these countries accordingly. Therefore, Belgium, Holland, Spain and France, having their own standards, still cooperate with the English corporation BRE Global, which in 1990 developed and implemented the world's leading BREEAM Europe and BREEAM international. The second most popular standard is the LEED standard, developed in the USA. When assessing green standards, as a rule, general parameters are used: location of the building, energy and water consumption, properties of building materials, indoor environment. A distinctive feature of each standard is the assessment mechanism and the system for assigning points according to parameters. The core reason underlying less widespread use of the LEED standard in the world is that it has a clear structure and is focused only on strict compliance with American standards, while the BREEAM requirements, in turn, are more flexible and easily adaptable to the construction features of any geography. The popularity of the latter has long left the UK: special versions of BREEAM have been developed for Germany, Spain, Norway and Sweden. Today, more than 200,000 projects around the world have undergone voluntary certification, and more than a million buildings are registered to undergo the procedure.

The environmental assessment process, for example, in accordance with the BREEAM standard, includes the following: preliminary assessment of the site; connecting an appraiser; registration of an object on the site; preparation of evidence base; sending evidence for verification; pre-certification; obtaining a preliminary certificate; final verification of the evidence base; receiving the final certificate. Adjustment factors are used: in each country, weighting factors are established starting with the first project and all subsequent projects certified to BREEAM during the life of the current version. The determination of adjustment factors is influenced by location, culture, economy, climate, and work practices (Yudelson, 2016).

The LEED environmental assessment process consists of the following steps: selecting the required version of LEED; registration of the building with the Green Building Certification Institute (GBCI); engaging an accredited professional (optional); preparation of evidence base; preliminary check for technical recommendations on loans (on-line system with electronic sample documents); correction of comments; completion of construction; final check; obtaining a certificate (Yudelson, 2016).

In terms of the number of environmental requirements, the Japanese CASBEE system is very detailed. CASBEE, compared to other systems, differs in that the assessment is based on an environmental quality indicator (or QUD). This indicator takes into account the future impact of the planned urban development project on the environment (emissions into water, soil and atmosphere, other types of pollution). This impact is referred to as environmental loading (or LUD) (Pham, 2021). The developers of this system tried to balance the impact of all aspects of sustainable development and therefore created the most progressive rating system, focusing on environmental issues.

It should be noted that the energy efficiency of a building is one of the key components of any green construction and is considered along with all other requirements of green standards. However, this is the most difficult point to implement, which is confirmed by empirical data. In particular, in the No and Won study (2020, p. 1), it is stated that "although interest in and the importance of green building certification have increased, it is difficult to determine how much less energy the buildings actually consume after obtaining sustainability related certification, such as LEED in the USA, and G-SEED in Korea".

At the same time, in the research on Japan data, based on the number of certifications by CASBEE, DBJ Green Building Certification, LEED, BREEAM, and WELL Building Standard in Japan from 2018 to 2021, Nakamura (2022) claims that J-REITs account for the highest percentage of green building certificates per year, followed by mostly private funds and real estate developers. Notably, the percentage of certification acquisitions by private investors is increasing year after year, climbing from 8% in 2018 to 30% in 2021. The number of corporations obtaining certificates is also increasing. The above is illustrated in Fig. 3.

Of course, eco-development standards are designed to increase the efficiency of water and energy consumption, improve the quality of the internal environment of premises, control the emission of harmful substances into the atmosphere, and ensure the economic well-being and social health of the population.

For example, the Australian studio Koichi Takada Architects presented a project for a residential building, which they named Urban Forest. The architects plan to make it "the greenest residential building in the world". Along with vertical gardening, the project also incorporates other sustainable design principles. The 30-storey building in Brisbane includes 392 apartments, a two-level rooftop garden and a public park on the ground floor. Organically shaped columns will fill the park like tree trunks, referencing both traditional Queensland raised dwellings and Le Corbusier's pillars. 1,000 trees and 20,000 plants representing the local flora will be planted on the stepped façade. The building is aiming for 6 stars, the highest rating in Australia's Green Star rating, equivalent to LEED Platinum. The vertical garden will be an active component of the green building. It will increase biodiversity and improve the ecology of the city, as well as protect the residents of the house from the sun, wind and rain. Solar panels installed on the building will become a source of renewable energy, and the garden will be watered using collected rainwater and treated wastewater.

However, the growing popularity of green certification in construction has given rise to the phenomenon of green washing. A. Muggleton (2023) tries to explain the deep reasons of greenwashing phenomenon occurrence. All 'Green Building'

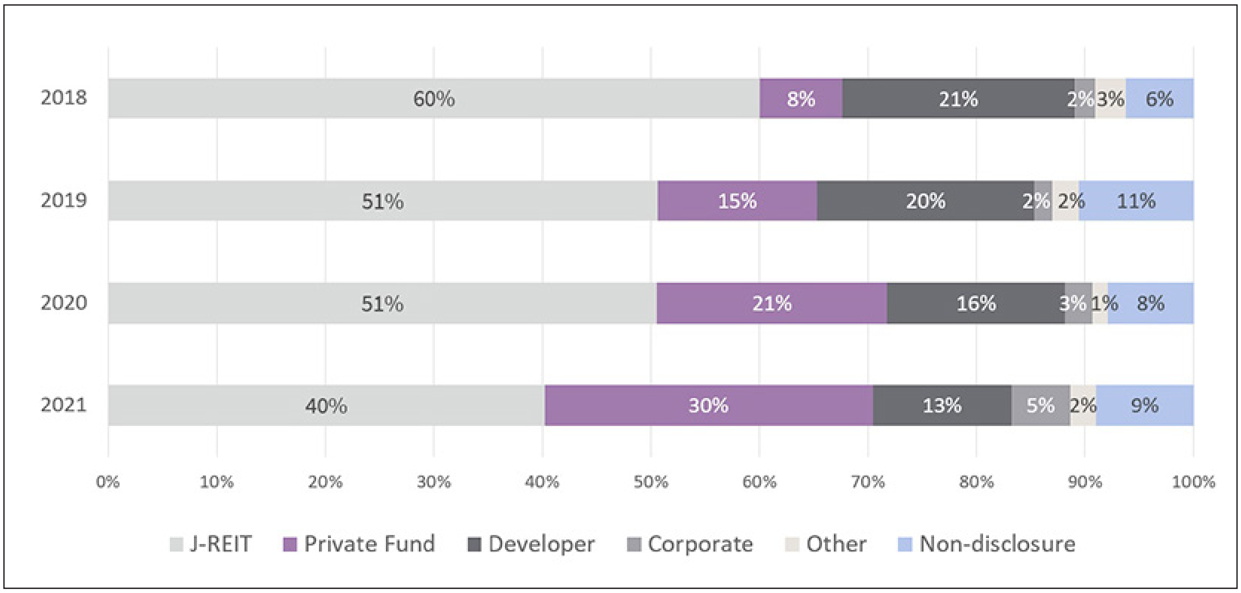

Fig. 3: Certificate acquisition ratio by applicant type (2018-2021) (Nakamura, 2022)

projects begin with high hopes, enthusiasm, and marketing bluster, - he says. Then came the harsh reality of finances, ROI, and design fatigue. When a new 'Green Building' is built, leased, and operational, the architectural goals and marketing hype are rarely validated. After all, in this day and age of social media and big marketing budgets, "talk is cheap" and "integrity is expensive". The concept of greenwashing is one symptom of this problem. It is the practice of making deceptive or unfounded claims about the environmental benefits of a building, its systems, and equipment. Using just green roofs or solar panels to demonstrate the sustainability of a building or development might be linked to a greenwashing technique in architecture. While green roofs and solar panels have many benefits, especially in metropolitan areas, they do not guarantee that a new project will exceed sustainability criteria. This is especially apparent when other crucial considerations such as energy efficiency and the use of environmentally hazardous materials and construction systems are overlooked.

The current industry standard for building and building systems performance verification is the analogue practice of building commissioning. The aim of this exercise is to ensure that a building's systems are designed, installed, tested, and operated to meet the owner's operational needs.

While it can in fact be effective when executed by an expertly-qualified practitioner, this method is often fraught with challenges due to misaligned incentives, contractual ambiguities, and a shortage of competent personnel. Also, as currently practiced by a large number of providers, building commissioning remains an analogue, people-centric specialism. It is time for the industry to advance, in particular, moving to smart technologies. It is also advisable to manage the development of green construction based on the implementation of a value-oriented approach, in which the competent management of the interests of stakeholders, and even the joint creation of value, are carried out.

CONCLUSION

Green construction, without a doubt, is today a fast-growing trend and a "no alternative" vector for the development of the construction industry and related industries (production of building materials, etc.). At the same time, energy efficiency is a key parameter of real "greenness" of the construction project. This is also true in the context of sustainable development goals, among which resource conservation is one of the priorities. However, at the same time, green certification in the construction industry is characterized by the risk of a high degree of "profanation" of certification greenwashing, which already in the near future may reduce investor confidence in green construction projects, and therefore worsen the access of promising projects to investment financing. In this context, namely the energy efficiency of buildings, as an indicator that can be quite clearly and unambiguously measured, that can become the basis for effective interaction with stakeholders (economically interested in high energy efficiency indicators) both in the process of assessing and certifying the project, and during the operation of the constructed building.

REFERENCES

Acharya, D., Boyd, R. and Finch, O. 2020. *From principles to practices: Realising the value of circular economy in real estate*. Arup and Ellen MacArthur Foundation.

Aliamin, Y. 2021. Pathways toward Sustainable Architecture: Green architecture and circular built environment. *IOP Conference Series: Earth and Environmental Science,* **794**. https://doi.org/10.1088/1755-1315/794/1/012155

Bonenberg, W. and Kaplinski, O. 2018. The Architect and the Paradigms of Sustainable Development: A Review of Dilemmas. *Sustainability,* **10**(1): 100.

Cajes, A. 2021. *Philosophy of sustainable development: A critique*. Alsalca Research and Analysis Services.

Goede, D. 2016. *Green building fundamentals: A concise summary of LEED*. Lulu.com

Gou, Z. 2020. *Green building in developing countries: Policy, strategy and technology*. Springer.

Graff, S. 2018. *Organic architecture and the sustaining ecosystem*. Frank Lloyd Wright Found.

Jodidio, P. 2018. *Green architecture*. Taschen America.

Krstic, H., Bogdanovic, V., Vaspv, M. and Protic, I. 2017. Buried buildings as an example of architecture that strives to be energy efficient. *Facta Universitatis – Series Architecture and Civil Engineering,* **15**(3): 403-413.

Muggleton, A. 2023. What is 'greenwashing' in sustainable building practices? *Construction Week*. https://www.constructionweekonline.com/business/insights/what-is-greenwashing-in-sustainable-building-practices

Nakamura, A. 2022. Growth of green building certifications in Japan. *JLL*. https://www.jll.co.in/en/trends-and-insights/research/growth-of-green-building-certifications-in-japan

No, S. and Won, C. 2020. Comparative analysis of energy consumption between green building certified and non-certified buildings in Korea. *Energy,* **13**: 1049.

Nuffida, N. 2015. On architecture and energy: The concept of (generating) form through adaptation. *Procedia – Social and Behavioral Sciences,* **179***:* 154-164.

Pham, T. and Nguyen, T. 2021. Green Building Certification as a Policy to Promote GreenBuilding - A Study of Singapore, Taiwan, Australia, UK, US and Lessons for Vietnam. *Int. J. of Sustainable Construction Engineering and Technology,* **12**(3): 135-141.

Precedence Research, 2023. *Green building market*. https://www.precedenceresearch.com/green-buildings-market

Sowinski, S. 2017. *A history of sustainable architecture: Design fundamentals*. Eco Press.

Tabb, P. 2014. *The greening of architecture: A critical history and survey of contemporary sustainable architecture and urban design*. Ashgate Pub.

Yudelson, J. 2016. *Reinventing green building: Why certification systems aren't working and what we can do about it.* New Society Publishers.