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ENSURING THE ECONOMIC AND ENVIRONMENTAL DEVELOPMENT OF THE ARCHITECTURE AND CONSTRUCTION INDUSTRY: THEORETICAL CONCEPTS AND APPLIED DEVELOPMENT PATHS

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In order to ensure the sustainable development of the architecture and construction industry, the economy and the state as a whole, it has been proven that it is necessary to develop environmental awareness. Environmental awareness contributes to the preservation of natural resources, the solution of environmental problems, the promotion of innovation and the strengthening of competitiveness. It is only through the combination of environmental principles and effective management strategies that we can create a future that is beneficial to both our economy and nature. The study aims to define theoretical concepts and applied ways of economic and environmental development of architecture and construction. The main idea of the economic efficiency of architecture and construction consists in promoting the construction and reconstruction of architectural objects through the introduction of cost-effective technologies and solutions. This includes using alternative energy sources, energy-efficient materials and heating and cooling systems, and rationalising space to optimise usage. Such measures will bring economic benefits to owners and occupiers of buildings by reducing energy consumption and energy costs. There will also be a positive impact on the environment through the reduction of carbon emissions and other pollutants. The "passive house" concept is the subject of analysis. It is noted that there has been a significant increase in interest in the construction of passive houses from secondary materials such as concrete, glass and metal. In Germany, in particular, there are special plants that process this type of waste and use it for the production of building materials for energy-efficient houses. According to the authors, systemic factors need to be considered when designing economic, organisational and technological support for installing energy-efficient buildings. The energy-economic model of energy consumption in the construction and operation of building structures includes the following important factors: natural and climatic factors, which determine the environmental suitability of the area and the energy costs for maintaining sanitary and hygienic parameters in the building premises; microclimate, which depends on the optimal thermal, air and light conditions created by the enclosing structures. The conclusions state that the efficient use of limited resources and the use of environmentally friendly technologies are at the heart of the economic approach to sustainable development. This includes optimising how raw materials get extracted and processed, creating environmentally friendly products and waste management. An integrated approach and cooperation between all stakeholders – government, companies, organisations and the public – is needed to ensure the economic and environmental development of the architecture and construction industry. Modernising processes and using innovative technologies is one of the ways to achieve this goal. This will ensure sustainable industry growth, efficient use of natural resources and balanced social development.

Key words: economics, architecture, construction, passive house concept, green technologies, energy and economic model, energy efficient house.

Relevance of the paper. The rapid greening of the economy that has been taking place in various countries of the world over the past two decades is the result of the growing awareness of the scientific community of the limited resources of the planet, the threat of environmental degradation to future

generations, and the need for business to consider society's demands for environmental protection and more efficient use of primary resources in production.

Ukraine has also been an active participant in this process. Environmental initiatives are developed, supported and put into practice by the government and civil society organisations. For example, the Green House concept is widely used. It involves the use of energy-saving technologies, renewable energy sources, waste sorting and other environmentally friendly solutions in construction.

Considering the impact of consumer behaviour on the environment is also important. Awareness-raising campaigns and environmental education can help reduce the use of plastic products and energy, and change people's attitudes towards choosing environmentally friendly goods and services. Environmental awareness can also be raised through decentralised activities such as the opening of eco-centres, birch groves, parks and squares.

In addition, active government support is needed to implement environmental and economic policies, including creating favourable conditions for the development of eco-enterprises, promoting the use of renewable energy sources and overcoming energy dependency.

Overall, the key factors in overcoming the environmental crisis and achieving sustainable development are environmental action, partnerships between business and society, education and government support. A positive impact on the environment and a living space for future generations can be achieved through the interaction of all these parties.

Attention to environmental issues and the preservation of the natural environment in urban development is also important. The creation of spaces that contribute to the preservation and sustainable development of natural ecosystems should be the focus of architects and urban planners. Such spaces should be environmentally friendly and create comfortable conditions for residents, giving them access to nature and green spaces.

Developing and implementing sustainable urban development strategies based on energy efficiency, renewable energy, water management and waste management is also important. The implementation of such strategies will reduce the impact of the urban environment on climate change and will contribute to the conservation of natural resources.

In general, urban development requires attention to environmental issues and sustainable development, and environmental awareness should become an ongoing task for all citizens. Only by working together will we succeed in creating an eco-friendly and comfortable urban environment for future generations.

Environmental awareness is therefore an important prerequisite for the development of architecture, construction, business and government. It helps to conserve natural resources, solve environmental problems, stimulate innovation and strengthen competitiveness. An important task for long-term economic success is therefore the development of environmental awareness among the population and the economy.

The purpose of the study is to identify theoretical concepts and applied ways of economic and environmental development of the architecture and construction industry.

Analysis of recent researches and publications initiating the solution of this problem, relied upon by the authors. Various aspects have been studied and presented in the works of Ukrainian and foreign scientists. These include L. Musina, A. Yamchuk, T. Kvasha [1]; G. Yablonska [2]; M. Klymchuk [3]; O. Stepanenko and V. Dubrovska [4]; T. Kishchenko, L. Gusarova, N. Bolila [5]; O. Tkach [7]; O. Shpatakova [8]; V. Lisenko [10]; G. Ratushniak, Y. Bix, A. Lyaliuk [11]; P. Makarenko, O. Kalinichenko, V. Aranchii [12]; S. Tsyhychko [13]; V. Chala, Y. Orlovska, A. Glushchenko [14]; A. Bilyk [15]; S. Hryn, Y. Irklienko, V. Manankova [16].

Material and findings. Nature is a system with limited energy and raw material resources, which also has a limited capacity for waste and pollution assimilation. Inefficient use of primary resources, water and air can lead to their depletion and limit the livelihoods of a growing population. Accelerated economic growth and industrialisation in many countries in recent decades has increased global demand for resources and put pressure on natural resources [1, p. 74].

The paradigm of economic efficiency in architecture is that theoretical, methodological and practical measures should influence both the process of managing and implementing an architectural object and the architectural object itself in terms of spatial organisation and its suitability for living. Conservation of resources will be achieved by introducing energy-efficient or passive buildings into the practice of construction and reconstruction of existing social infrastructure facilities. The energy efficiency of buildings will be improved by harmonising national legislation with European Union standards.

An innovative construction concept aimed at creating buildings with the highest level of energy efficiency was presented by scientists W. Feist and B. Adamson [10] in 1988. The researchers' main objective was to reduce heat loss and minimise space heating costs. This resulted in the concept of the "passive house" being born.

The study by M. Klymchuk gives a few definitions of its essence. According to the researcher, it is a building with low energy consumption that provides comfortable living conditions without the use of active heating or air conditioning. In addition, it is environmentally friendly and comfortable for the occupants, with optimal humidity levels. Such a building is energy efficient and is in line with the criteria of sustainable development [3, p. 364–365].

The design of a house is one of the most important problems in construction, experts O. Stepanenko and V. Dubrovska [4] point out. The cost of construction is reduced if the building is properly designed. In particular, in the context of energy efficiency, the concept of "passive house" is a promising research. Passive houses cost 15 kWh/m² per year to operate. Energy consumption in the residential sector would be reduced by 92% if all buildings in Ukraine were built as passive houses. In addition, total energy consumption in Ukraine would be reduced by 14,75% if 50% of all buildings in Ukraine were renovated and built as passive houses. This shows how important it is to apply the principles of energy efficiency and passive construction in order to reduce energy consumption.

The current state of general economic trends in architectural science and practice at the global and national levels is analysed in order to develop the theoretical foundations of architectural science and determine its place in the scientific and practical environment. The current scientific and practical directions related to the economics of architecture will be evaluated, and the scope of the scientific interests of the independent scientific direction of "economics of architecture" will be determined. Furthermore, it formulates the concept of the general economic basis of architectural objects.

An important aspect of the construction of civil buildings is their energy efficiency. An economic assessment of the results of the implementation of design, construction and engineering solutions that ensure the standard level of energy consumption is the basis for making such solutions. This assessment includes indicators relating to the economic efficiency of individual design measures, the construction project and the structure of the energy-saving programme. It allows us to select the best technologies and solutions that ensure the optimal balance between investment and energy savings. It also ensures the standard level of energy consumption in the building.

There are therefore three classes of low energy buildings: energy efficient, low energy and zero energy. Specific aspects of the use of energy and technology in a building are described by the qualification groups "passive building", "smart building", "intelligent building" and "high-tech building". In particular, in order to ensure low energy consumption from traditional sources, a "passive building" uses unconventional energy sources. A "smart building" is automated. It uses high-tech equipment to make the building more comfortable for people. Information technology is used to optimise heating and air-conditioning processes in an "intelligent building". A "high-tech building" uses technical solutions to achieve energy savings and microclimate quality [5, p. 58].

Implementing a low energy consumption system in residential construction is done in two stages: a construction stage and an operation stage. Architectural, planning and design solutions, engineering systems and the installation of energy, heat and water measuring and control devices are used at the stage of construction, reconstruction or technical re-equipment of buildings. At the operation and maintenance stage, it is important to comply with the established standards, regulations and technologies for the operation of technical equipment and building structures. In addition, the construction industry can subcontract to third parties and select the best suppliers of building materials and equipment. This has a significant impact on the economic aspects of construction. Given the use of modern innovative solutions and materials in construction activities, it can be argued that construction companies are actively applying energy-saving technologies, modern thermal insulation materials and advanced equipment developed in other industries.

Since 2021 the construction of energy-efficient buildings that can produce more energy than they consume from renewable sources has been one of the European Union's strategic priorities. New building standards regulate the installation of equipment in buildings based on the Triple Zero concept. This allows them to avoid drawing energy from the municipal grid and avoid harmful emissions into the atmosphere. Triple Zero, the concept of "three zeros", is the latest conceptual approach to building that minimises primary energy consumption and

environmental impact. The author of this approach, V. Zobeck [6], is a well-known architect. He combines all the know-how with modern requirements for comfort and environmental friendliness of buildings. The essence of the "Triple Zero" concept is the following: 1. Zero energy consumption – a building's energy production from renewable sources must be at least equal to its energy consumption. 2. Zero emissions – the building should not contaminate the atmosphere with harmful emissions (e.g. CO2, VOCs, etc.).

A passive house is a combination of methods and technologies for achieving high levels of energy efficiency and comfort for the occupants. The main components of such a house include the following [16]:

1. High thermal insulating properties: the walls, roof and floor of the house have very effective thermal insulation, which significantly reduces heat loss.

2. Energy efficient glazing: to keep heat in and keep cold out, the windows in the passive house have triple-glazed, low-energy glass and well-insulated frames.

3. No thermal bridging: a passive house has a well-designed construction that avoids thermal bridging – places where heat can enter or escape by crossing insulated layers.

4. Hermetically sealed: the house is completely sealed, which keeps the heat inside and prevents the cold air from coming in from the outside.

5. A highly efficient system for recovering heat: a passive house uses a ventilation system with heat recovery, which allows fresh air to be brought in from the outside and heat to be recovered from the exhaust or used air.

Passive houses are built using environmentally friendly materials such as wood, stone or brick, which have a positive impact on the environment and provide a healthy place to live.

More recently, the use of recycled materials such as concrete, glass and metal in the construction of passive houses has become increasingly popular. In Germany, for example, there are special plants that process this type of waste and use it to make building materials for energy-efficient houses [7, p. 169]. Such an approach to construction allows the rational use of available energy and reduces dependence on natural fuel resources. This is becoming increasingly important as these resources become scarcer and energy prices rise. In addition, low-energy buildings offer a high level of comfort and environmental friendliness for the occupants and for the public spaces. As a result, in the context of resource conservation and sustainable development, such projects are becoming increasingly attractive.

It is clear that there are a number of factors that have an impact on the concept of energy efficiency and its development. The socio-political factor is one of them. It is determined by supranational and national approaches, as well as by the level of societal demands. The economic factor also plays an important role and is determined by the price parameters for using energy resources. The environmental factor influences the decision to switch to renewable energy and to achieve zero climate impact. The investment factor develops energy efficiency by creating new energy producing facilities and technologies. Equally important is the energy factor, which has to do with the understanding of the needs of society, government and business [8, p. 73].

The construction sector under study implements energy efficient standards and technologies that reduce the consumption of materials, energy and human resources. In this context, approaches such as passive house technology are being used. These provide comfortable living conditions with minimal environmental impact through special designs and the use of renewable energy. The concept of energy-efficient buildings and premises is also being implemented. This is specifically designed for commercial properties, including IT infrastructure such as co-working spaces. In addition, energy-efficient residential buildings and residential complexes are also being developed. Government and businesses are increasingly focusing on energy efficiency in building and construction, as it brings significant economic and social benefits and helps reduce negative environmental impacts.

A significant reduction in the use of materials, energy and human resources is achieved by introducing new approaches to architecture and construction. This applies both to the process of designing and building, and to the creation of architectural objects at various hierarchical levels. New approaches are enabling the efficient use of resources, the reduction of costs and the improvement of the sustainability of architectural solutions. Methods such as social housing, using green technologies, building energy efficient and reducing waste are becoming more common. Advanced methods also include using modern technology and information systems to optimise processes. All this contributes to a more sustainable and efficient architecture and construction environment.

To reduce costs and protect the environment, there is growing interest in recycling construction waste. Manufacturers are developing specialised equipment for the process, and steady improvements in the technology are making it possible to achieve high recycling rates and significant profits. There are more than 400 construction waste processing plants in Germany alone. There are two main principles for the organisation of the recycling of heavy construction waste and substandard construction products around the world: waste processing in special landfills and waste processing at the point of generation (on the construction site). Important aspects of the first option are the production of a clean and fractionated product and the effective solution of environmental problems. In addition, waste transport costs can be reduced by increasing the capacity of the crushing and screening complex. On the other hand, the second option requires special environmental protection measures. It may also require the shutdown of the crushing plant. In addition, the second option does not provide for a deeper level of processing and does not have a permanent logistics and marketing system [9, p. 222–223].

Therefore, the system-forming factors should be considered in the methodology of economic, organisational and technological support for the installation of energy-efficient enclosing structures, taking into account the specific conditions of their further operation. The energy-economic model of energy consumption of natural resources and results of human activity in the construction and operation of enclosing structures includes the following main factors:

– natural and climatic, which formulate the territorial improvement of settlements and the consumption of resources and energy to ensure sanitary and hygienic parameters in the premises of buildings and structures;

– microclimate of premises with optimal thermal, air and light conditions, which is formed by the parameters of enclosing structures, i.e., a rational ratio between the size of transparent and opaque enclosing structures and their thermal insulation properties;

– features of building and enclosing structures made of energy-efficient materials;

– compliance with the requirements of regulations and standards on building energy efficiency;

– use of renewable energy sources and efficient energy saving;

– rational use of natural resources and reduction of energy consumption during building operation;

– consideration of individual needs of building users and ensuring their comfort;

– use of intelligent control and monitoring systems to optimise energy processes.

Sustainability of buildings means the ability of a building to perform over time in terms of durability, thermal performance and technical performance, with efficient use of energy resources. Eco-friendliness guarantees a reduction in the negative impact on the environment during the entire life cycle of a building, through the use of energy sources that do not emit harmful emissions and through the rational use of non-renewable and alternative energy sources, in particular to ensure optimal sanitary and hygienic parameters in the premises. Thus, one of the key principles of sustainable development in architecture and construction is to ensure that buildings are sustainable and environmentally friendly.

The introduction of innovative thermal insulation technologies based on the principles of sustainable development is therefore a key step towards ensuring the economic and environmental development of the building and construction industries [11, p. 207]. These new approaches are necessary to solve economic, environmental, technical and technological problems, as the world is facing a shortage of energy resources. It is necessary to consider the cost of energy used at different stages of production in each economic sector. The reduction of energy consumption involves the optimisation of managerial, organisational and technological factors, taking into account all factors that affect structures during their life cycle [12, p. 9].

The efficient use of limited resources and the application of environmentally friendly technologies are at the heart of the economic approach to sustainable development. This includes optimising the extraction and processing of raw materials. It also includes creating environmentally friendly products and managing waste. However, there are questions about which types of capital should be conserved (physical, natural, human) and to what extent they are interchangeable. There are also issues related to valuing these assets, in particular environmental resources [13, p. 15]. For the architecture and construction sector, this is particularly relevant. Current economic conditions point to significant problems associated with ageing housing. The development of energy efficiency in buildings and the impact on the microclimate are key priorities. These are encouraging scientists to find effective solutions to reduce energy

consumption and address environmental issues at various levels. One of the most promising areas for energy efficiency and a major consumer of energy resources is the architecture and construction sector. Both in the production of building materials and in the operation of finished buildings for various purposes, this industry faces the problem of rational energy use [14, p. 9].

For example, A. Bilyk [15] proposes a way to increase the efficiency of construction by reducing the carbon footprint and increasing the efficiency of buildings. Steel and building construction can switch to more environmentally friendly alternatives instead of using carbon-based materials that have a large carbon footprint. For example, the use of recycled materials, such as scrap metal, instead of primary iron ore could be an option. Using scrap can significantly reduce CO2 emissions. One tonne of scrap can save up to 740 kg of coal. In addition, the environmental impact of steelmaking processes can be reduced by using energy from more sustainable sources.

The steel production network in Ukraine is well diversified and localised. This helps to improve the life cycle parameters of steel products. The efficiency of rolled product mixes and the use of high strength steels are particularly important. So far, Ukraine does not produce its own rolled I-beams from high-strength steels. However, the physical and mechanical properties of the steel can be improved by applying the latest technologies. In addition, due to the wider range of plates and their cutting, welded sections are more cost-effective despite longer production times and higher costs.

In particular, the use of profiles and recycled elements in buildings can be applied depending on the specific project situation. Using composite solutions can help reduce metal consumption by 20–30%, thus reducing the emissions associated with using metal in the building frame. The use of perforated girders and variable section girders can help reduce emissions by reducing metal consumption and building height, resulting in lower running costs. The amount of metal required and therefore the associated emissions can be reduced by allowing for limited plastic deformation in structures. This can lead to a 10–12% reduction in steel consumption, contributing to lower environmental and economic costs over the life cycle of the building.

It is also worth noting that the use of standardised building elevations is a common design strategy, allowing structures to be selected based on section strength and maximising the benefits of using high strength steels. To reduce the carbon footprint and increase cost-effectiveness, extensive optimisation of the frame or its components can be carried out at the early stages of construction.

Conclusions. Thus, one of the most important tasks in the modern world is to ensure the economic and environmental development of the architecture and construction industry. This is driven by the need to ensure sustainable economic growth, to respect natural resources, to reduce negative environmental impacts and to create comfortable places for people to live. The architecture and construction industry faces many challenges due to the rapid development of cities and population growth. Creating efficient and innovative solutions for the design, construction and operation of buildings is a key aspect of the industry's economic development.

The use of energy-efficient technologies and materials in construction is one of the economic aspects. This helps to reduce heating and cooling costs, reduce energy and water consumption and reduce atmospheric emissions. Both building owners and society as a whole benefit economically from such solutions.

An important aspect of sustainable development in the architecture and construction industry is the sustainable use of natural resources. This includes reducing waste and using recycled materials, as well as minimising the negative impact of construction on natural ecosystems. Sustainable use of natural resources also means implementing the circular economy, where materials and resources are re-used or recovered.

To ensure the economic and environmental development of the industry, it is also important to improve the design, construction and management of buildings. The use of digital technologies, such as the Building Information Model (BIM), can reduce costs and improve the quality of building design and management. Such tools can also contribute to the efficient use of resources, the reduction of waste and the improvement of energy efficiency.

Therefore, ensuring the economic and environmental development of the architecture and construction industry requires a comprehensive approach and the cooperation of all stakeholders – government, companies, organisations and the public. The sustainable growth of the industry, the conservation of natural resources and the balanced development of society can be ensured through the modernisation of processes and the use of innovative technologies.

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ЗАБЕЗПЕЧЕННЯ ЕКОНОМІЧНОГО Й ЕКОЛОГІЧНОГО РОЗВИТКУ АРХІТЕКТУРНО-БУДІВЕЛЬНОЇ ГАЛУЗІ: ТЕОРЕТИЧНІ КОНЦЕПТИ ТА ПРИКЛАДНІ ШЛЯХИ РОЗВИТКУ

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Доведено, що розвиток екологічної свідомості є необхідним для забезпечення сталого розвитку архітектурно-будівельної галузі, економіки та держави загалом. Екологічна свідомість допомагає зберігати природні ресурси, вирішувати екологічні проблеми, сприяє інноваціям і зміцненню конкурентоспроможності. Тільки шляхом поєднання екологічних принципів з ефективними управлінськими стратегіями можемо створити майбутнє, що буде вигідним і для нашої економіки, і для природи. Мета дослідження – визначити теоретичні концепти та прикладні шляхи економічного й екологічного розвитку архітектурно-будівельної галузі. Визначено, що основна ідея економічної ефективності архітектури та будівництва полягає в тому, що будівництво та реконструкція архітектурних об'єктів повинні бути просунуті шляхом упровадження економічно ефективних технологій і рішень. Це передбачає використання альтернативних джерел енергії, застосування енергоефективних матеріалів і систем опалення й охолодження, а також раціональну організацію простору для оптимального використання. Такі заходи дозволять зменшити споживання енергії та знизити витрати на її забезпечення, що приведе до економічної вигоди для власників і користувачів архітектурних об'єктів. Окрім того, це також позитивно вплине на навколишнє середовище, зменшить викиди вуглецю й інших шкідливих речовин. Проаналізовано концепцію «Пасивний будинок». Зазначено, що зацікавленість у побудові пасивних будинків із вторинних матеріалів, як-от бетон, скло та метал, значно зростає. Зокрема, у Німеччині існують спеціальні заводи, які переробляють такі відходи, використовують їх для створення будівельних матеріалів для енергоефективних будинків. На думку авторів, методологія економічного й організаційно-технологічного забезпечення влаштування енергоефективних конструкцій будівель повинна враховувати системні чинники. Енергоекономічна модель витрат енергії під час будівництва й експлуатації конструкцій будівель передбачає такі важливі чинники: природно-кліматичні, які визначають екологічну придатність місцевості й енергетичні витрати на підтримання санітарно-гігієнічних параметрів у приміщеннях будівлі; мікроклімат, який залежить від оптимального теплового, повітряного та світлового режимів, створюваних огороджувальними конструкціями. У висновках зазначено, що економічний підхід до стійкого розвитку орієнтується на ефективне використання обмежених ресурсів і використання екологічно-збережувальних технологій. Це включає оптимізацію видобутку та переробки сировини, створення екологічно прийнятної продукції й управління відходами. Для забезпечення економічного й екологічного розвитку архітектурно-будівельної галузі необхідно використовувати комплексний підхід і співпрацю всіх зацікавлених сторін – держави, підприємств, організацій і громадськості. Один із способів досягнути цієї мети – модернізація процесів і використання інноваційних технологій. Це допоможе забезпечити стале зростання галузі, ефективне використання природних ресурсів і збалансований розвиток суспільства.

Ключові слова: економіка, архітектура, будівництво, концепція «Пасивний будинок», екологічно-збережувальні технології, енергоекономічна модель, енергоефективний будинок.

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