УДК 72.02

DOI:10.30857/2617-0272.2024.2.5

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ENERGY AND ENVIRONMENTAL EFFICIENCY OF CONTEMPORARY INTERIOR DESIGN UNDER GEOCLIMATIC CHANGES

The aim *of the paper is to determine the means of energy efficiency in interior design and classify them according to the type of room and the comfort needs of contemporary society.*

Methodology*. The research methodology initially proposes an analysis, deduction and synthesis of the scientific works developed until now in the direction of energy efficiency in the field of architecture and construction. Based on them, a deduction from general to particular of the materials and practical solutions used in the interior design is elaborated.*

Results. *The research results highlight practical solutions and recommendations for ecological and energy-efficient interior design. The recommendations are classified by types of materials used in the interior design but also by design solutions in accordance with the type and purpose of the room. The scientific results obtained demonstrate the role and importance of eco-design in the current conditions of climate change and ecological degradation detected in the natural environment. The recommendations provide for the development and promotion of eco-design in the specialized field as a means of energy efficiency and conservation of the natural ecosystem. The proposed solutions are argued by describing the opportunities and advantages of ecological materials for human life and quality of life. They are also argued by identifying the protection processes of the natural ecological system. The results of the research determine the Eco-design solutions through the major contribution in the reduction of toxic waste, the gradual cleaning of the natural ecosystem, the increase of energy efficiency in homes and the provision of interior comfort.*

Scientific novelty *of the material lies in the structuring and classification of ecological design solutions in people's ordinary homes. Determining and identifying the function of eco-design and its role in ensuring the energy efficiency of the indoor environment.*

Practical significance *of the study is argued in the section "Eco-design. Eco solutions in interior design" which describes ecological solutions and materials for contemporary interior design.*

Keywords: *interior design, sustainability, energy efficiency, ecology, sustainable development.*

Introduction. The energy and ecological efficiency of buildings is an increasingly frequent concern in the environment of scientific and practical research around the world. With the geo-climatic changes that started at the end of the 20th century and continue until today, alarming consequences are recorded on the natural and human environment. In this context, the design of buildings and interior spaces aim to adapt to climatic conditions, contribute to increasing energy efficiency, increase the quality of life and reduce the destruction of the natural ecosystem. Ecological design must take into account the exploitation of natural resources and the technological development of solutions in such a way as to enhance the current and future natural potential of nature. Their effective solution consists in creating the optimal concept of sustainable development in the three general directions: economic, ecological and social-cultural.

Analysis of previous research. Climate change conditions the deterioration of the environment and the cyclical phenomena of nature. One of the causes of climate change is the emission of gases (CO2, methane, ozone, etc.) into the atmosphere following the burning of the fuels used. As scientists claim, the emission of CO2 is the main cause of the increase in the temperature of the Earth's atmosphere, and the interaction of people in stopping or neutralizing these emissions is absolutely indispensable [5, p. 9].

Analyzing the connection between buildings and climate change, we find that they

are interdependent: 1) buildings contribute to the production and emission of gases influencing the climate change process; 2) climate changes have an impact on buildings through air quality, thermal comfort, acoustic comfort, etc. that affect user behavior; 3) building users increase comfort conditions, which in turn cause additional energy consumption. In this process, there is a need to intervene by creating measures to control energy consumption, but also to preserve and conserve natural resources, which will later lead to the reduction of gas emissions [5].

In this context, it is important to develop a strategy to mitigate the causes of global warming and to adapt buildings to climate change. This represents one of the most important directions of action, because it primarily targets the environment and the quality of human life. Based on this consideration, it is necessary to approach the field of architecture and construction through sustainable design [17], which provides for a fair socio-ecological process and a common ideal [17].

Energy efficiency in simpler terms means getting more out of less. Efficient use of energy can provide us with a good level of comfort by consuming less natural resources or producing less toxic waste for the environment. According to the EU Energy Labels we know "an easy-to-understand and easy-to-use code system that helps identify the energy efficiency of many household devices and appliances" [6]. Energy labels propose a set of methods, solutions and investments, which are applied in the technological process to reduce energy consumption while ensuring comfort. Energy efficiency measures are a means of achieving sustainable energy supply, reducing greenhouse gas emissions and increasing security of supply [17]. EU legislation on energy efficiency has evolved significantly in recent years. In 2023, "the energy efficiency objective, namely the objective of reducing the EU's final energy consumption, was increased to 11,7 % by 2030" [7].

In this context, building specialists carry out a project in order to obtain, under the law, the building permit for the buildings and, with the assumption of the responsibility of meeting the minimum energy performance requirements, a study can be requested on the possibility of using alternative high energy efficiency systems. Depending on their feasibility from a technical, economic and environmental point of view, new economic and operational safety performances can be established. [20, p. 83-95].

For this purpose, construction specialists assume the role of providing residents with a healthy, pleasant and comfortable living environment, independent of external, meteorological and acoustic conditions. The reduction of energy consumption in the operation of buildings is related to the quality of the indoor and outdoor environment [10]. They are the result of a complex of factors that determine the characteristics of construction, design, location, climatic conditions, installations, etc. Energy efficiency measures must positively influence air quality or comfort in the building [11]. Thus, several energy efficiency measures or strategies determined by thermal insulation were established. They provide for: 1) the application of an additional layer over the waterproofing layer at the roof level; 2) applying a layer of mineral wool on the inside of the floor; 3) as well as a polyurethane foam layer on the inner face of the floor or a polystyrene thermo-system covered with a plaster layer of organic material. The same thermo-system can also be applied to the inside of the wall. The application of a layer of thermal insulation made of plasterboard can also be used here. The solution of replacing the old facade with the double-glazed double-peau" or PVC facade with double-pane windows is also known. They can be supplemented with ventilation device and window covering solutions to avoid overheating [5, p. 10].

Energy efficiency measures contribute to the quality of the indoor environment, which as

is known – is the major component of the quality of life. The comfort of the built spaces and the health of the inhabitants depend a lot on the quality of the indoor air. The problem of air quality arises from the presence of many chemical pollutants, which are part of our environment. They are found in food, water, air, building materials, furniture, installations, equipment, maintenance products, etc. Also harmful are physical pollutants, resulting from excessive humidity, dust, artificial fibers, chemical elements, gases with radioactive properties, electric and magnetic fields, etc. [14; 19]. Likewise needlethe biological pollutants present in microbes, viruses, bacteria, odorous substances of organic origin such as mites, cockroaches, plants, molds, etc. also have a negative effect [8]. Knowing the sources of pollutants favors the intelligent decision to minimize emissions through source control, ventilation and cleaning [3].

In general, the perception of interior comfort includes thermal, visual and acoustic factors, of which the most related to energy efficiency is the thermal and visual factor. 1) Thermal control must be achieved by adjusting the optimal temperature, humidity and air movement speed, in accordance with the type of room and people's activity. Here it is necessary to foresee human contact with too cold or too hot surfaces inside, but also the air currents that can be created. 2) Visual control is achieved through the management of light sources, which must be adapted to the needs of the activity in the interior space. It is recommended to calculate the power of artificial, natural lighting during the day and night in such a way as to ensure sufficient lighting and avoid too high light contrasts. 3) Acoustic control is ensured by the finishing materials of the space but also that of the furniture and included pieces of various textures and materials. The admissible noise level must be correlated with the type of activities carried out in the indoor space [5].

Statement of the problem. The efficiency of energy consumption in the operation of buildings cannot be separated from the quality of the internal environment, which also has an influence on the external one. All these are the result of the series of factors originating from the constructive, architectural, organizational characteristics of the location, climatic conditions, installations and of course the behavior of the users [2].

The purpose of the present work is to investigate, structure and classify the possibilities of building energy efficiency and ensuring optimal life comfort, reducing the negative impact of waste on the climate or the natural environment [1]. The objectives of the study include: describing the solutions and methods of increasing energy efficiency in accordance with the regulations and their qualification standards known worldwide; technological progress in the design of eco-design through optimal solutions and materials in the energy efficiency of buildings and the protection of the natural ecosystem; classification of practical eco-design solutions in various types of rooms; documenting and promoting eco-design in the specialized field as a means of energy efficiency and conservation of the natural ecosystem.

Results of the research. In the environment of interior design, a series of typologies or styles of plastic approach to space are known based on a "low energy" planning, which integrates ecological, sustainable design solutions and technological progress in order to reduce energy dependence [4]. This process starts from the execution and operation phase through the building envelope system to reduce heating, ventilation and air conditioning costs [20, p.20]. An optimal solution in this sense is the incorporation of photovoltaic cells in the roof plan, which reduce the energy requirement for heating by using solar input. At the same time, the system provides for the reduction of fuel consumption, the use of natural lighting, natural ventilation, the use of computerized building control systems [9]. They have a positive impact on people by increasing performance and productivity,

improving health, reducing depression and encouraging communication.

To ensure a comfortable indoor environment in terms of climate, several solutions are proposed, including induced ventilation [19]. This reduces the temperature in the interior spaces with minimal energy consumption. The system provides for the creation of a space at interior levels, often under a glazed roof, and the arrangement of openings on the perimeter of the building. These are often operable windows, which through the natural movement of air create natural ventilation. The system acts as a chimney for air removal. Another solution to ensure comfort is the method of heating water with systems based on solar energy. The method has solar collectors that generate energy for heating water for domestic consumption, but also for space heating equipment.

Windows make a considerable contribution to the energy efficiency of houses [22]. They can reduce or intensify the climatic effects of the environment through economic possibilities or low costs, while the glass itself is harmless to human life. The windows with reduced emission (low-e), ensure neutralization of the noise from outside and offer a high level of thermal insulation. At the same time, the geometry of the windows plays an important role in the way solar energy is used. The shape, size and location of the windows determine the solar input and natural lighting inside. Glazed surfaces must be planned depending on the type of space and the activities that will be carried out inside.

All solutions or methods concerned with energy efficiency are dependently linked to nature, environment and earth [20, p.20]. The durable connection of houses to the earth provides more complex protection. Partially buried buildings ensure stable temperature control in their interior spaces, thus saving energy and providing protection to the building from outside air temperature fluctuations. Horizontal windows can be placed on the roof of these buildings for added light, heat or other conveniences. Another favor of these houses is the use of trees or other plants that provide natural shading that reduces the direct fall of sunlight on the western and southern facades.

Recently, researchers in the field are increasingly analyzing the concept of "Active House" which refers to buildings that offer major comfort and healthy living conditions, without producing a negative impact on the climate. These houses provide a generous supply of natural light and fresh air to the residents, and the materials used are of natural origin or are compatible with human life. Also, the active house is energy efficient, and the energy requirement is provided by renewable energy sources, provided by an energy production system [4].

Eco-design is a trend of great importance in the sphere of energy efficiency and the promotion of natural resources [22]. Eco-design tends to happily combine the demands of the natural environment and the consumption demands of man. The ecological approach in design is, first of all, the creation of products in cooperation with the environment, as well as the reduction and complete elimination of the negative impact on the environment through the use of alternative resources and energy, as well as environmentally friendly recyclable materials and renewable processes. Eco-design acts as a conscious or intuitive response to natural changes, manifested through the creativity of objects and spaces [16]. This direction in interior design is defined as an optimal practice in solving social problems and protecting the natural environment from the consequences of its pollution. From this point of view, the tasks of Eco-design include ensuring ecological purity through construction and finishing materials, design objects, production and consumption processes, etc. Eco solutions in interior design the same order also includes the problem of waste disposal, ensuring the well-being of the environment, and of different spheres of human activity.

Choosing the right materials to design the interior architecture of a space is one of the

most important factors in terms of sustainability [2; 13; 17; 18]. The most common materials used in eco-friendly interior design are wood or wood panels, glass, metals, and plasterboard. They can form a finished surface or be the basis of the finish. When choosing this type of material, we must take care to have boards that contain formaldehyde-free resin residues. Such panels represent the efficient and minimal use of wood for the production of quality furniture and panels in different sizes. Glass has average life cycle energy consumption as it is obtained from nature and is non-toxic and recyclable. Metals are characterized by higher energy and it is recommended to use recycled metals that reduce losses and contribute to raw material savings [20, p. 32]. Drywall has very low energy consumption and is a good insulator. However, the biggest problem is the waste generated after installation or dismantling.

An analysis of construction products involves monitoring the product from raw material to the end of its use. Thanks to it, the long-term costs of materials can be determined. The life cycle of materials is a vital aspect in addressing sustainability issues. The impact of each step of the production process from raw, to collection, production, distribution and installation of materials to end use and disposal. The life cycle of a material can be divided into three phases (Fig. 1): Pre-construction, Construction, Post-construction.

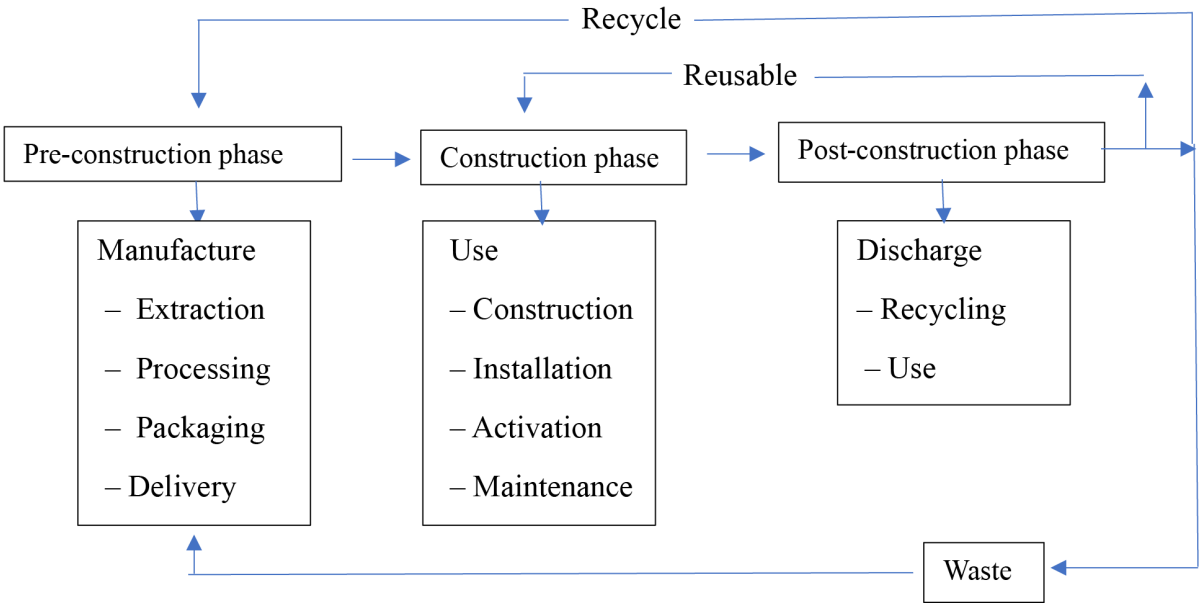

Fig. 1. Diagram of the life cycle of a material

The combination of materials with a homogeneous surface and objects with a pronounced texture looks attractive. Walls can be covered with wooden panels, cork, fabric wallpaper, finishing stone, plaster or water-based paint. Images with photo backgrounds, stone inserts, pebbles, wooden panels, or frescoes are welcome. White walls can be safely combined with dark shades of wood, black or bright green. By decorating a part of the wall with the same tiles as the floor one can create a single harmonious space.

The walls can be decorated with paper wallpaper decorated with floral motifs or with cork panels in support of Eco ideas. Plaster, painted or whitewashed, is also a perfectly durable wall covering. It is advisable to avoid synthetic paints, it is ideal to use paints based on linseed oil, emulsions with natural pigments or water-based vegetable dyes. In addition, it is recommended to use varnishes based on water

or natural oil without additives and products with beeswax and resin [20; 26]. Recycled paper wallpaper is also suitable for wall coverings, and clay-based mortars are the least harmful.

There are many options when choosing flooring materials. Natural floor coverings include coverings such as wood, bamboo, ceramic, stone or smooth cork underlays. Also carpets made of wool, cotton or vegetable fibers. However, recycled rubber, vinyl and carpets are increasingly being used. The materials that are considered the best from a sustainable point of view are cork, local stone, plant fibers and wood. From an economic point of view, the convenient material is concrete, which provides an excellent lining. Laminate is a popular solution that can create an imitation of wood, this finish is cheap and easy to install. The best material for flooring is parquet or parquet board. Ceramic tiles are also a good flooring option. It is not recommended to use linoleum or granite because they are often radioactive. For the ceiling, you can use wooden panels, or wooden paneling, beams, or painting in a light shade. They can be combined with different ceiling levels with directional lighting.

Eco-friendly fabrics have never belonged to the "rich" category of people because they are associated with rural life through their texture, texture and appearance. Followers of Eco-design believe that undyed natural fabrics even have a different energy. Natural fabrics such as linen or wool are suitable for windows. The unbleached natural canvas can be used for furniture upholstery. This can also be used for tablecloths or other home accessories. Textile materials in the bedroom are selected for the design of the bed and upholstered furniture so that they are in harmony with each other.

Lighting is another important element in achieving environmentally sustainable interiors [21]. The use of efficient lighting sources is one of the important criteria in sustainability. Another consideration in interior lighting is the maximum use of daylight. The energy used in the indoor lighting environment captures approximately 40-50% of the total energy used in the building. Luminaires can be "invisible", by incorporating them into furniture, construction, etc. with the intention of creating a light flow that complements the daylight. For a more decorative role, the lighting fixtures can have textile or vine shades, with elements in the form of branches or animal horns. The interior can be decorated with original lamps and floor lamps made of wood, metal, fabric, or rice paper. In these interiors, the idea of decorating the ceilings with huge chandeliers with crystal details is abandoned, and they opt for built-in spotlights or chandeliers as simple as possible. The lamps must emit a warm spectrum with a yellowish shade of light. The most suitable are incandescent bulbs. In addition, background or hidden lighting that emphasizes the ecological design of the interior is recommended. ECO LEDs are much more economical than classic electric bulbs and are very widespread [20, p. 30]. They also have a longer lifespan and are resistant to vibrations.

The palette used in decorating ecological homes involves natural shades. This range will emphasize the naturalness of the materials. Both calm and the most pronounced tones found in nature are used: green - the color of grass; shades of brown, from the color of beige-golden sand to the shade of tree bark; yellow, orange – for bright accents or fresh blue tones [15]. A common trend is the jungle theme that involves the use of rich green hues. In this design, bamboo stems are often used, decorative palms and alpine plants. For more freshness and ventilation, blue and silver tones are used. The pure white color is real, refreshing and expands the interior space. Bright floral shades (red, orange, yellow) are applied in certain areas or as decorative elements to enliven the design [12].

The image of ecological design can be completed by the decoration of leafy plants arranged in ceramic pots (ficus, palms, ferns, lianas, etc.) completed with sea pebbles, or other decorative forms. A beautiful decoration of the ecological interior can be aquarium with fish, spacious and well decorated. A wonderful

addition to the Eco interior is a fireplace with a wood fire, which provides a pleasant environment. A living green wall is quite suitable for an Eco interior. It is equipped with planting tanks, drainage systems, irrigation and lighting. Their well-established function ensures the active growth of plants over the entire area of the wall. This greenery exudes a feeling of harmony with nature and fills the room with freshness and oxygen.

Phyto-design is the solution that actively introduces plants into interior design, taking into account their biological compatibility, ecological characteristics, ability to improve indoor air quality. Phyto-design or floristic design also deals with the creation of plant compositions from flowers, leaves, branches, roots, stones, such as the Japanese art of "ikebana", the practice of landscaping and the creation of winter gardens. Green walls are also used – the so-called vertical gardening, which can be easily cared for.

For an Eco interior, wooden furniture is the most suitable, with a simple massive construction, imitating natural forms. Tables, chairs made of natural wood with traces of saw cuts with a solid tree trunk are suitable. The texture of the trees should dominate the interior, and its processing should be minimal. Sometimes smooth woodworking is also welcome for finer pieces. A type of furniture according to the Eco style is made of vines, bamboo, etc. Chipboard and MDF furniture is not suitable for the Eco interior, as it contains substances harmful to humans. The choice of furniture in an ecological interior is made in accordance with its basic principles: convenience, simplicity, naturalness. The shape of the furniture is determined by straight, simple geometric lines, without unnecessary elements and details. Large living spaces imply the use of large interior details, therefore beds, tables, sofas can be massive. For the bedroom, you can choose a large wooden bed or even an iron bed. Some of the synthetic materials used in the production of furniture have a large amount of toxic gases. Therefore these materials cannot be recycled. This is one of the important issues in the sustainable realization of eco-design.

Emerging from the needs of the natural and human living environment, eco-design becomes an important direction of development in the field of interior design and is recommended in the professional educational sphere. In this context, the plastic approaches of the young generation of specialists who describe new ecological design concepts are relevant (Fig. 2 a, b, c)

a b c

Fig. 2. Fragments from the eco-design projects carried out by the students of the Technical University of Moldova: a – interior design of the children's room, author Demian Mihaela, 2023;
b – living room interior design, author Bunduchi Mariana, 2021;
c – interior design of a company reception, author Stafie Artur, 2022.

The interior architecture must suit the needs of the users and create the most comfortable space for living and working. The problem of global pollution covers every aspect of our lives, including the comfort and well-being of interior design. Sustainability must be present in the design of interior architecture to minimize adverse effects on our living environment [16]. Through his major decisions in the creation of interior design, the designer plays a decisive role in the sustainable realization of the interior design project [8]. In the conditions when geo-climatic changes increasingly threaten humanity, the most effective solution to stop natural degradation, energy efficiency and protect human life is Eco-design. This is the optimal solution in regulating temperatures, providing lighting, harmonizing man with nature, saving natural resources and purifying the air. Understanding the importance of energy efficiency and Eco approach to space is a positive step towards saving humanity and the entire ecosystem.

Conclusions. Energy efficient and environmentally friendly interior design is concerned with creating a harmonious space which mainly relates to the materials used, the technical engineering solutions and the quality of the elements included in the interior. Eco-design is a complex systems approach that takes into account the natural, social and economic spheres. Energy efficiency is demonstrated by the eco-design approach, for which we offer some recommendations:

1. Source and technology of materials - natural materials, recycled materials, living elements, plants, natural fibres, fabrics and others.

2. Correct and efficient choice of materials according to the scope of use:

a) Walls – clad with wood paneling; cork; stone; ceramic; stone inserts; brick; fabric wallpaper, paper wallpaper; water-based paints; living wall (from greenery); b) Flooring – solid wood flooring; recycled hardwood; bamboo, ceramic; stone; recycled metal tiles, recycled glass tiles; eco-friendly carpets; linoleum from oxidised linseed oil; cork (from oak bark); c) Ceilings – wooden panelling; wooden panels; beams; water-based paints; lime; painting with natural pigments; fabric or paper wallpaper; ceramics; decoration with sisal ropes or ropes; dome-shaped ceiling; d) Furniture – made of wood; items made of vine stalks, bamboo; natural stone or marble countertops; recycled materials such as newspapers, used fishing nets, recycled materials; e) Textiles – organic cotton; linen fabric; wool; hemp; natural silk; bamboo fabric; sofa fabric; unbleached canvas; f) Lighting-natural; textile lampshades; vine lampshades; floor lamps made of wood, metal, fabric, rice paper, lamps with a simple and discreet design, LED light; e) Decorative objects – decorative deciduous plants in ceramic pots; baskets made of hashish; fruit pots; simple carpets on the floor; fish tank; g) Color range - natural shades; nature tones of grass-green, shades of brown, sandy beige-gold to dark brown bark tones, yellow, orange – for accents or fresh shades of blue and green; pure white used to extend the space.

3. Use of Eco materials in accordance with the type of room.

4. Energy efficiency through intelligent and efficient organization of the interior space with the use of lighting, heating, water consumption, insulation and ventilation systems.

Eco design has an immediate effect on our lives and the whole ecosystem. The energy efficiency and eco-efficiency of contemporary interior design is easily adaptable to recent geo-climatic changes and can positively influence people's living environment. The given study opens new possibilities for further research in the directions of building and architecture, energy efficient materials and equipment, industrial and furniture design.

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ЕНЕРГЕТИЧНА ТА ЕКОЛОГІЧНА ЕФЕКТИВНІСТЬ СУЧАСНОГО ДИЗАЙНУ ІНТЕР'ЄРУ В УМОВАХ ГЕОКЛІМАТИЧНИХ ЗМІН

Мета *статті – визначити засоби енергоефективності в дизайні інтер'єру та класифікувати їх відповідно до типу приміщення та потреб комфорту сучасного суспільства.*

Методологія *дослідження заснована на аналізі наукових робіт, розроблених до цього часу в напрямку енергоефективності в галузі архітектури та будівництва. Використано метод дедукції для аналізу практичних рішень, використаних в дизайні інтер'єру.*

Результати *дослідження висвітлюють практичні рішення та рекомендації щодо екологічного та енергоефективного дизайну інтер'єру. Рекомендації класифіковані за типами матеріалів, які використовуються в дизайні інтер'єру, а також за дизайнерськими рішеннями відповідно до типу та призначення приміщення. Отримані наукові результати демонструють роль і значення еко-дизайну в сучасних умовах зміни клімату та екологічної деградації, що виявляється в природному середовищі. Рекомендації передбачають розвиток та популяризацію еко-дизайну в спеціалізованій сфері як засобу енергоефективності та збереження природної екосистеми. Запропоновані рішення аргументуються описом можливостей і переваг екологічних матеріалів для життя людини та якості життя, а також виявленням процесів захисту природної екологічної системи. Результати дослідження визначають рішення еко-дизайну через основний внесок у зменшення токсичних відходів, поступове очищення природної екосистеми, підвищення енергоефективності в будинках і забезпечення внутрішнього комфорту.*

Наукова новизна *статті полягає в структуруванні та класифікації екологічних дизайнерських рішень у звичайних помешканнях людей; визначення та виявлення функції еко-дизайну та його ролі в забезпеченні енергоефективності внутрішнього середовища.*

Практична значущість *полягає в запропонованих екологічних рішеннях та матеріалах для сучасного дизайну інтер'єру.*

Ключові слова*: дизайн інтер'єру, стійкість, енергоефективність, екологія, сталий розвиток.*

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Цитування за ДСТУ: Platon L. I. Energy and Environmental Efficiency of Contemporary Interior Design Under Geoclimatic Changes. *Art and design*. 2024. №2(26). С. 54–64

https://doi.org/10.30857/2617-0272.2024.2.5

Citation APA: Platon, L. I. **(2024)** Energy and Environmental Efficiency of Contemporary Interior Design Under Geoclimatic Changes. *Art and design*. 2(26). 54–64.