APPLICATION OF ENERGY-SAVING AND GREEN ARCHITECTURE TECHNOLOGIES IN THE ARCHITECTURAL AND URBAN PLANNING DEVELOPMENT OF CITIES IN THE ARAL SEA REGION

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Abstract: This article highlights the issue of introducing energy-saving and green architecture technologies into the urban planning process in areas with ecologically sensitive and climatically challenging conditions, such as the Aral Sea region. Based on scientific sources, energy-saving, green infrastructure, and climate-appropriate architectural strategies are analyzed, and practical recommendations for the Aral Sea region are provided.

Keywords: energy efficiency, green architecture, Aral Sea region, urban planning, environmental design, sustainable development

Introduction.

Today, global environmental challenges, particularly climate change, resource scarcity, and intensifying urbanization processes, necessitate new approaches in urban planning practices. Ensuring sustainable urban development has become an urgent issue, especially in the ecologically sensitive Aral Sea region. Improving the living conditions of the population in this area, creating a healthy environment, and promoting rational use of resources are among the primary objectives of current urban planning policies.

The aim of this research is to scientifically study, analyze, and develop proposals for the effective implementation of energy-efficient and green architectural technologies in the architectural and planning formation of cities in the

Aral Sea region. Drawing on global experience, this article focuses on developing architectural and urban planning strategies suitable for this region, identifying existing problems, and exploring potential solutions.

Relevance of the research.

In recent years, the concept of sustainable development has been gaining significant importance in urban planning on a global scale. The practical significance of this concept is especially high for the Aral Sea region, which is recognized as an area of ecological disaster. Population growth, accelerated urbanization, and limited natural resources necessitate the introduction of new energy-efficient, environmentally friendly, and sustainable solutions in the urban planning process.

The ecological crisis resulting from the drying up of the Aral Sea has negatively impacted the socio-economic stability of the region. Currently, many cities and towns in the region face problems such as air pollution, water scarcity, soil erosion, and sharp continentalization of the climate. In such a complex ecological situation, creating a comfortable, ecologically balanced, and energy-efficient living environment for the population is an urgent scientific, creative, and practical issue.

At a time when the cost of energy resources is increasing year by year, economic efficiency can be achieved by reducing energy consumption for heating and cooling buildings. In this regard, the use of passive building cooling systems, solar energy, green roofs and walls, natural ventilation systems, and energy-saving building materials is of particular importance.

International studies show that the application of green architecture and bioclimatic design strategies in regions with hot and arid climates helps reduce heat stress, conserve water resources, and improve urban microclimates [1]; [3]. In particular, measures such as green areas based on xerophytic plants, multi-shaded spaces, and the alignment of street layouts with wind directions increase the ecological stability of cities.

Furthermore, the relevance of this topic is directly related to the priority directions defined in the "Concept for Sustainable Living and Socio-Economic Development in the Aral Sea Region" issued by the President on December 10, 2022. The Concept identifies the introduction of environmentally friendly technologies, the development of green infrastructure, and the creation of a favorable living environment as priority tasks.

Consequently, this research is not only relevant from a scientific perspective but also practically important, serving to shape modern and sustainable architectural approaches for the urban development of the Aral Sea region. Through this scientific inquiry, not only are problems revealed, but recommendations aimed at their solution are also developed.

Literature review.

Research conducted in various regions serves as an important scientific foundation for achieving energy efficiency and ensuring environmental sustainability in urban planning processes in hot and arid regions such as the Aral Sea area. In recent years, numerous international studies have focused on green architecture, bioclimatic design, and energy-efficient urban planning. The most relevant of these are analyzed below.

Approaches to bioclimatic architecture and ecological design.

In hot and arid regions, architectural design must be adapted to the environment. A study conducted by Riham Muhammed Gaber analyzed experiences of energy conservation, indoor comfort improvement, and microclimate management through bioclimatic design in North African areas such as Matmata (Tunisia), the M'zab Valley (Algeria), and the Siwa Oasis (Egypt). The study highlights that local traditional construction methods and passive ventilation systems can be reapplied in accordance with modern requirements [1].

Similar approaches are also outlined in the "Bioclimatic Landscape Design" concept developed by S. Attia and I. Duchhart, which recommends achieving

microclimate management through a three-layered approach (bioclimatic zones, thematic gardens, and intensive green areas) [5].

Green infrastructure and water resource management in urban planning.

In urban areas, green infrastructure plays a crucial role in reducing heat, maintaining atmospheric humidity, and conserving energy. A study conducted by Yang and Wang (2017) examined the potential for improving urban microclimates through green infrastructure and xeriscaping (water-efficient landscaping) using the example of Phoenix, USA. The research results indicate that a temperature reduction of just 1°C can lead to significant energy and water savings [3].

Additionally, a study by Ahmed Abi Ayad and colleagues investigated the impact of green and blue (water) infrastructure on indoor cooling energy consumption in Alexandria, Egypt. The highest energy savings (8.12%) were recorded with blue infrastructure [6].

Energy-saving urban planning strategies.

Farahat (1983, 1985) developed urban planning strategies aimed at energy conservation in arid regions. His recommendations suggest that constructing buildings with courtyards, developing mixed-use areas within walking distance, and implementing planning approaches that enable car-free mobility can significantly reduce energy consumption [7].

One of the most comprehensive recent analyses, conducted by Umoh et al., focuses on energy-efficient urban planning policies and practices. It identified the most effective approaches, including strict building codes, renewable energy integration, public transportation, and citizen participation [2].

Net-zero (zero energy) and passive house experiments.

In recent years, the construction of net-zero houses in hot regions has become increasingly relevant. A study by Trepci et al. examined passive design strategies

(compact form, shaded southern windows, minimally glazed western and eastern facades) developed by participants of the Solar Decathlon competition in Dubai and analyzed their impact on energy efficiency [8].

Ismaeil and Sobaih developed a net-zero housing project for the hot climate of Saudi Arabia, minimizing energy consumption through the use of solar panels and geothermal heat pumps [10].

Ways to solve the problem.

The main challenges in implementing energy-efficient and green architecture technologies in the architectural and urban planning of the Aral Sea region are:

Harsh climatic conditions - sharply continental climate, high temperatures, strong winds, low precipitation.

Scarcity of natural resources - shortage of water, suitable soil, and environmentally friendly building materials.

Energy inefficiency of traditional construction methods - approaches based on former Soviet-era standards are still widespread.

To address these issues, the following scientific and practical approaches are proposed:

Implementing bioclimatic urban planning principles.

The bioclimatic approach involves shaping architecture and urban planning in harmony with the environment. This reduces dependence on external energy resources, and the internal microclimate is naturally regulated.

Practical measures:

- positioning buildings in relation to wind directions.

- using shading elements on southern facades, and minimal windows on east/west sides.

- reintroducing the courtyard architectural style [7].

Applying passive design strategies.

Passive design technologies reduce the need for external energy sources. They aim to maximize the use of solar energy and limit heat loss.

Measures:

- thermal insulation of roofs and walls.

- thick walls and thermally inert materials (brick, earth).

- natural ventilation and heat-retaining ventilation ducts [8].

Planning green and blue infrastructure.

Green zones in cities stabilize the microclimate, while blue infrastructure provides a cooling effect along with water conservation.

Recommended solutions:

- Landscape design using xerophytic plants (xeriscaping).

- air humidification through artificial lakes and water gardens [6]; [3].

Integrating renewable energy sources.

Arid regions are rich in solar resources and have great potential for widespread use of solar energy.

Recommended solutions:

- local energy production using solar panels.

- solar water heaters and passive heating systems.

- creation of supplementary energy sources through wind turbines [10].

Suggestions and recommendations.

It is necessary to develop an urban planning model based on energy-efficient and green architectural technologies, taking into account the ecological, climatic,

and social conditions of the Aral Sea region. Below are the proposed measures to achieve this goal:

Develop a regional bioclimatic urban planning strategy.

Bioclimatic design facilitates natural cooling of interior environments in hot climates and reduces external energy requirements [5].

Recommendation:

Develop urban plans based on wind directions and solar radiation patterns.

Implement a system of courtyard buildings and shaded walkways.

Create a zoning system based on regional proportions of building density and height.

Develop water and energy-saving green infrastructure.

Microclimate management is possible through xeriscaping, rainwater harvesting, and blue infrastructure (water gardens) [3]; [6].

Recommendation:

- Plant species adapted to the local climate that require less water.

- Reduce heat stress with artificial lakes and architectural elements that provide shade.

Develop building standards based on solar energy utilization and passive design principles.

Net-zero houses and passive construction strategies reduce energy consumption in hot regions by 40-60% [8].

Recommendation:

- Utilize reflective roofs, small windows, and thermally inert materials (brick, concrete).

- Provide subsidies and tax incentives for the installation of solar panels and water heaters.

Conclusion.

A scientifically grounded, climate-appropriate, locally resource-based, and community-engaged strategic approach is essential for developing cities in the Aral Sea region in an energy-efficient and environmentally sustainable manner. Through the proposed measures, it is possible to achieve not only energy conservation but also ecological restoration, social prosperity, and economic stability in the region.

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