Vol. 11, 2022, 147-154

DOI: 10.17512/bozpe.2022.11.17

Construction of optimized energy potential

Budownictwo o zoptymalizowanym potencjale energetycznym

ISSN 2299-8535 e-ISSN 2544-963X

Energy efficiency in the architecture of the eastern countries: traditions and innovations

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Abstract: Architecture, as a science and practice of forming the environment, sensitively responds to the challenges of modernity – technological, economic, etc. One of the urgent challenges is environmental, the concern of which is formulated in many international acts, including the UN Sustainable Development Goals until 2030. Methods of neutralizing the negative impact on the environment in modern conditions are costly and consist of energy-intensive technologies. Architecture has been built since ancient times on the principles of consistent inclusion of artificial structures in the environment: in different countries there are traditional methods of protection from adverse climatic factors through the use of architectural planning and structural techniques. Demonstration of the possibilities of traditional ways of forming a comfortable environment in the countries of the East, as well as their interpretation in modern energy-efficient practice of architecture and construction is given in this article.

Keywords: energy efficiency, architecture of the countries of the East, traditions, innovations, architectural and planning organization

Please, quote this article as follows:

Abdrassilova G., Danibekova E., Energy efficiency in the architecture of the eastern countries: traditions and innovations, Construction of Optimized Energy Potential (CoOEP), Vol. 11, 2022, 147-154, DOI: 10.17512/bozpe.2022.11.17

Introduction

The modern term “energy efficiency” embodies a centuries-old strategy of adapting architecture to various natural and climatic challenges, using the rational formation of the structure of buildings in order to effectively use both environmental resources and planning solutions. In cold or hot climates, people protected their buildings from the negative effects of cold wind, heavy rainfall, solar overheating

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by erecting thick walls, sloped roofs, sun protection devices and deep loggias. What is more, these buildings were focused on keeping warm in winter, cool in summer, provided ventilation of the buildings, and were built from eco-friendly local materials (adobe, wood, brick, stone). In the architectural history of the countries of the East, there are many examples of adapting buildings to the climate by using traditional construction techniques. It is especially important to return to the study of these adaptive technologies in the context of the United Nations Sustainable Development Program (The 2030 Agenda for Sustainable Development), aimed at improving the environmental situation on our planet (https://sustainabledevelopment). Undoubtedly, the combination of traditional and innovative methods of rational use of all types of energy is an opportunity for the consistent development of the anthropogenic and natural environment.

1. Research methods

The research methods are based on the study of materials about the architecture of the countries in question, the identification of traditional methods of protection from adverse factors and the creation of a comfortable living environment. The analysis of the experience of construction in the conditions of a sharply continental climate arid zones allows us to identify relevant energy-positive, economical architectural techniques for implementation at the present stage, which meets the UN Sustainable Development Goals.

2. Results and discussions

One of the oldest inventions of nomadic peoples living in the territories of modern Kazakhstan, Altai and Mongolia is the yurt. This lightweight mobile prefabricated and portable dwelling, which has a wooden frame and felt covering, traces its history back to the Bronze Age and the Scythian period, and is still popular not only in these countries, but also far beyond their borders. Mobility, protection from negative natural factors have made the yurt an irreplaceable type of dwelling for nomadic and semi-nomadic peoples (Maidar & Purveev, 1980).

The yurt had an aerodynamic shape of a semi-dome resistant to strong steppe winds. The structures of the yurt included: a lattice-bearing skeleton (kerege), domed poles (uyk), and a crowning round element (shanyrak) (Murzagaliyeva, 2019). The entire structure was covered with felt carpets, and the interior was decorated with elements. The heating of the yurt was carried out at the expense of the hearth located in the center of the room; ventilation – due to artificial traction through the upper round hole – shanyrak. The hearth was used for both heating and cooking (Fig. 1).

The yurt was especially well adapted to the sharply continental climate with cold winters and hot summers. For example, nomads roamed year-round in a variety of natural landscape conditions of the Kazakh steppes at winter temperatures

(in the northern and eastern parts) as low as –20°C, –30°C with strong winds and blizzards and sultry summer (in the southern and western parts) with an average temperature of up to +29°C with winds and dust storms.

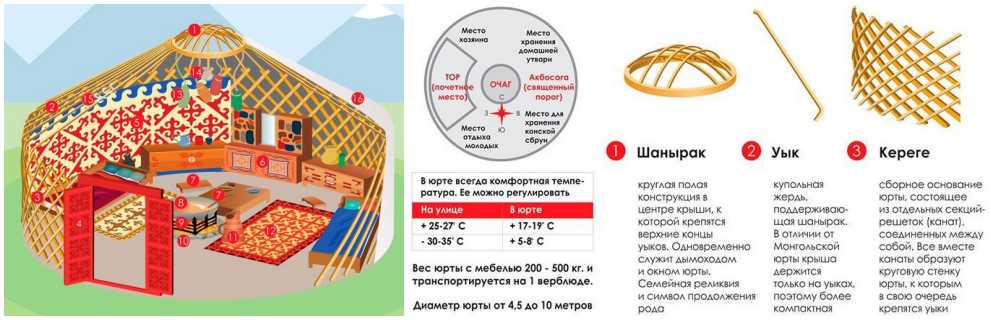

Fig. 1. The structure of the yurt (https://welcome)

The ingenious simplicity of the yurt represents the quintessence of energy efficiency in the traditional architecture of nomads. A rational attitude to nature is expressed in an optimal zero architecture that does not cause any harm to the environment. Energy efficiency in nomadic architecture was achieved through the use of natural building materials (wood, animal wool); an efficient heating and air conditioning system.

In the stationary structures of the countries of the East, in the conditions of a hot climate, in the process of historical development, traditional construction methods were formed, including: matching orientation to the directions, watering and landscaping of the territory, the device of aivans – open galleries to ensure optimal air movement in the premises, etc. Such adaptability to extreme climatic conditions was formed through the use of energy-intensive technologies.

The original construction techniques of the centuries-old experience of traditional architecture, which were conditioned by local raw materials and successfully solved the problems of comfort of architecture, include traditional engineering structures and building elements in the regional conditions of Central Asia: kyariz, ayvans, badgirs, yahchals, etc. With the help of these structures, the problems of overheating of premises, ventilation, dry air, etc. were solved.

For example, a kyariz or a qanat is a complex hydraulic structure consisting of a main well – a reservoir for the flow of underground foothill water, a number of shaft-like wells and ventilation holes with underground galleries and water ducts (Akishev & Baipakiov, 1973; Murzagaliyeva, 2020; Saeidian, 2013).

The urgent need for the construction of kyariz in the historical and geographical region of Central Eurasia and Asia, which included in the XIX-XX centuries the territories of modern Kazakhstan, Kyrgyzstan, Turkmenistan and Uzbekistan, according to historian and orientalist V. Bartold (1869-1930), were conditioned by the agricultural form of management of the semi-nomadic population in arid climate (Bartold, 1914). The desert lands of Morocco, Algeria, Libya, Afghanistan, Crimea, Armenia, Azerbaijan, Iran, Southern Kazakhstan, Uzbekistan are characterized

by evidence of the existence of irrigation system channels tens of kilometers long. The complex of the Shirvanshahs Palace (Baku, Azerbaijan, XII-XVI centuries) can be considered an example of the successful use of the kyariz in providing water for drinking and technical needs.

The appeal to the experience of vernacular architecture in the form of irrigation technology, which has already been tested in appropriate climatic conditions, can be attributed to one of the possible ways to solve environmental problems of the habitat in arid zones.

Another problem of living in arid areas was the adverse sanitary and hygienic conditions of cooling of protecting structures and temperature in closed spaces. The urgent need for air circulation in the regions of the Anterior and Central Asia was solved by architectural and planning methods, building materials and elements aimed at creating comfortable living conditions.

In the vernacular architecture of the countries of the East, the required constant movement of air masses was achieved by means of vertical air exchange under the influence of the heat pressure of the communicating spaces of courtyards and terraces of the "aivans" type or by deepening some rooms below ground level (Askarov, 1988; Firsanov, 1982; Khayalina, 2008).

The problems of an energy-saving method of heating in a sharply continental climate (summer – sultry with cool nights, winter – cold) were solved by the method of "underfloor heating": by installing a hearth ("yer-uchak") with chimneys built under the raised part of the floor of sleeping areas.

Such rational methods of maintaining an optimal temperature balance solved not only the problems of a comfortable indoor climate, but also influenced the plasticity of the architectural image with pronounced regional characteristics as elements of shaping. Especially active elements in the spatial environment of settlements in a number of Eastern countries are badgirs and yahchals, which demonstrate the adaptation of authentic architecture to the specifics of the local climate and landscape.

Badgirs are an ancient energy-saving air conditioning system, built mainly in the Middle East, Central Asia, including Southern Kazakhstan (Voronina, 1982). The characteristic expressive abris of quadrangular (sometimes six – octagonal) massive towers rising above the general environment formed the basis of the silhouette of ancient settlements. The rationality of the principle of operation and simplicity of execution did not require additional energy consumption: the spent hot air in the room was replaced by cool air by capturing even a low wind flow, cooling in the provided water tanks and directing it in the right direction using holes in the walls of the structure.

Yahchal (Persian – "ice pit") is a unique ancient cone-shaped structure with underground spaces where water is frozen in winter and stored in summer, creating "refrigerators" in desert conditions. The special shape of the aboveground part facilitated the movement of air masses by pumping warm streams and bringing them up.

The construction experience of buildings, as well as the considered engineering and technical structures of the countries of the East can be characterized as an additional opportunity to adapt architecture to local natural and climatic conditions in

a harmonious synthesis of the achievements of modern energy-efficient construction technology.

For architecture, along with engineering solutions to ensure the comfort of facilities, the artistic image of structures is important. In solving energy and environmental problems, architecture strives to achieve the artistic integrity of the image of buildings and their accordance with the natural or artificial environment. Energy-efficient elements of buildings are used to create expressive forms, increasing the symbolism of architecture.

A unique example of eco-friendly design and construction is Masdar City, a project of a high-tech green city with simultaneous consideration of the specifics of the local climate, culture and traditions, being developed in Abu Dhabi, UAE, the completion of which is scheduled for 2025-2030. The new city will be the first eco-settlement built on the principles of using renewable energy sources with zero impact on the ecological framework of the planet.

To achieve the regional character of this high-tech settlement, the architects took into account the local cultural context and traditional construction experience when forming images and silhouettes. For example, a scheme of space organization was applied, which became widespread during the construction of ancient cities in the Middle East, Central Asia and other territories with a hot climate. This helps to reduce solar radiation, promotes adaptation to specific climate conditions: houses were designed very close to each other, thereby reducing the surface area in order to protect against overheating. A significant role in this is played by huge shadow shelters over the open spaces of Masdar City, which are also auitable for placing solar panels (Fig. 2).

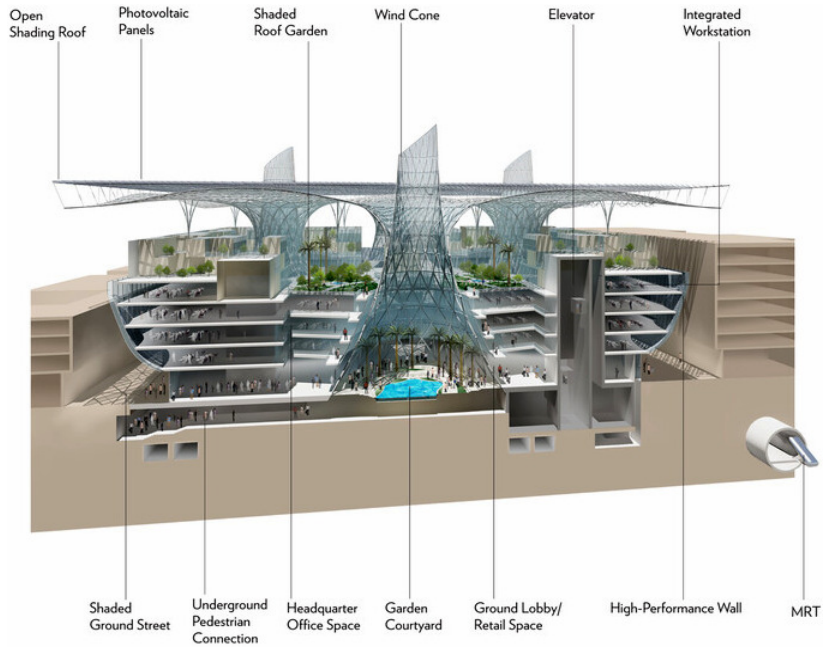

Fig. 2. Masdar City, UAE. Section fragment (https://royaldesign)

The architecture of Masdar City uses traditional engineering methods and adaptations, compositional forms and artistic elements. The surfaces of terracotta walls, enclosing structures of loggias and shade shelters are covered with a fantastic pattern of traditional ornament. Original unique images have been formed in the city and a comfortable microclimate of the spatial environment is being created.

The problems of ventilation and regulation of air temperature were rationally solved through the use of already proven methods in similar climatic conditions: the construction of part of the structures below ground level and the ancient energy-saving air conditioning system of the badgir type. The spatial environment of the city has become more active due to the volume of modern high-tech wind towers with a dynamic silhouette, which provide active aeration of air in the hot landscape.

Modern technologies make it possible to build structures in a hot and arid desert with a high level of comfort, minimal energy consumption and no emissions into the environment. Sustainable development specialists initiate various proposals to eliminate emissions and minimize energy consumption.

In 2022, the construction of the BEEAH Group Headquarters, designed by Zaha Hadid Architects (ZHA), was completed in the desert landscape of Sharjah (UAE). A high-tech object in the style of lifeless dunes looks like a fantastic alien ship. The building repeats the relief pattern of and fits into the existing environment. The construction materials and technologies, used in the construction of the structure, and engineering equipment respond to the principles of the strategic priority of the BEEAH Group, which deals with energy efficiency, environmental education, and waste monitoring, etc.

Reducing energy consumption, which means neutralizing the negative impact of the BEEAH Group Headquarters building on the environment, is facilitated by: reinforced fiberglass panels that prevent overheating of the interior space; cooling of enclosing structures; sewage filtration; solar farm-generators with Tesla batteries; an intelligent building management system that regulates energy consumption. This object shows the amazing dynamics of the development of energy-efficient technologies in the architecture of the countries of the East: from ancient methods to modern innovative techniques.

The use of traditional methods and techniques of energy-saving construction is also becoming widespread in the modern practice of Kazakhstan (Fig. 3): architects include in their projects the principles of "grounding" part of the building, air conditioning on the principle of aivans and badgirs, solar collectors, orientation to favorable points, etc. (Abdrassilova & Tuyakaeva, 2016).

As an example, the authors of the Friendship House of the historical and Cultural center "Ancient Taraz" (2014-2015, Taraz city, Kazakhstan), architects Eskander Baitenov and Galym Issabayev, were guided by both the principles of energy-efficiency and regional design (Fig. 4). In their project, a modern interpretation of the dome shape of a moble nomad dwelling (yurt) in combination with engineering devices such as a recuperator (heat exchanger) contributes to the creation of an optimal microclimate of the interior space. At the same time, in addition to the analogy with the traditional form of the mobile dwelling of nomads, the authors applied modern interpretations of the decorative design of the facades of the

medieval architectural monument “Babaji-Khatun”, small architectural forms characteristic of this region, shading, landscaping, watering of the territory (Baitenov & Issabayev, 2016).

Fig. 3. Museum complex project. The ancient sanctuary Ak-Bauyr. Kazakhstan (arch.: E. Baitenov, G. Issabayev) (https://www.zakon)

a) b)

Fig. 4. a) House of Friendship “Kone Taraz”. Taraz, Kazakhstan (arch.: E. Baitenov, G. Issabayev) (https://strategy); b) Interior of the House of Friendship “Kone Taraz”. Taraz, Kazakhstan (photo kindly provided by architect E. Baitenov)

This made it possible not only to solve the problem of emissions into nature, but also to become an example of architecture characterized by recognizable regional features – appropriate for this context of climate, building traditions and culture. The result of the design and construction of the House of Friendship “Kone Taraz” showed that a purposeful appeal to the traditional experience of using alternative sources in solving energy efficiency problems reduces the likelihood of using standard global forms and, on the contrary, contributes to the formation of a sense of recognizable spirit of the place among the local population.

Conclusions

The study of economical and environmentally positive methods of traditional construction in a sharply continental or hot climate makes it possible to implement “folk” energy-intensive technologies that can increase both the energy and artistic-figurative efficiency of the architecture of buildings and structures.

Analysis of techniques and methods of heating and ventilation of buildings shows that they meet the requirements of architecture sustainability – reducing negative impacts on the environment, conservation and protection of earth resources through the use of alternative energy sources. It is especially important to return to the study of these adaptive technologies in the context of the United Nations Sustainable Development Program (the 2030 Agenda for Sustainable Development), aimed at improving the environmental situation on our planet.

Thus, the traditional experience of forming a comfortable living environment in the countries of the East can become a source of new ideas with new functional content, material and technological support. This is also demonstrated by the latest buildings adapted to the climate, combining traditional and innovative methods of rational use of all types of energy for the consistent development of the anthropogenic and natural environment.

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