

The Necessity of Energy-Efficient Buildings, Their Development History, and their Application in Uzbekistan

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Abstract:

General Background: The global shift toward energy efficiency has necessitated the development of energy-efficient buildings, driven by concerns over energy security, economic sustainability, and environmental conservation. The construction sector is a major energy consumer, contributing significantly to global energy demand and carbon emissions. **Specific Background:** Following the 1974 energy crisis and the rising depletion of non-renewable energy sources, many countries prioritized energy-saving technologies in building design. European nations and developed economies have actively promoted energy-efficient construction, integrating renewable energy sources such as solar, wind, and geothermal energy into modern building practices. Uzbekistan, with its growing population and increasing energy demands, has recognized the need to enhance energy efficiency in construction. **Knowledge Gap:** While substantial progress has been made in energy-efficient building design globally, Uzbekistan faces challenges in fully adopting advanced construction methodologies and integrating renewable energy solutions. The lack of systematic implementation strategies, regulatory frameworks, and local expertise hinders the widespread adoption of energy-efficient buildings. **Aims:** This study examines the historical development, necessity, and current state of energy-efficient buildings in Uzbekistan, emphasizing strategies for implementing international best practices in local construction. **Results:** The findings highlight that Uzbekistan's energy consumption in buildings remains significantly higher than in developed countries. Government initiatives and policies have been introduced to promote energy efficiency, but outdated infrastructure and limited access to innovative construction materials impede progress. **Novelty:** This study provides an in-depth analysis of Uzbekistan's energy-efficient building sector, exploring policy implications, technological advancements, and practical applications. **Implications:** The research underscores the urgent need for Uzbekistan to adopt global best practices, enhance

regulatory policies, and invest in research and development to promote sustainable construction and energy conservation.

Keywords: energy-efficient buildings, energy-saving technologies, renewable energy, sustainable construction, Uzbekistan, building regulations, carbon emissions, energy conservation.

Introduction: In many countries around the world, the emergence of energy- efficient buildings and structures was primarily triggered by certain events that took place in the 1970s.

One of these events was the energy crisis that occurred worldwide in 1974. The main cause of the crisis was that oil-exporting countries (mainly Arab states) at that time, aiming to raise the price of oil, reduced their oil extraction volume by 5%, which resulted in a 70% increase in its price. No one could guarantee that such or even worse events would not recur. Following this energy crisis, some countries that were not members of the Organization of Petroleum Exporting Countries (OPEC), particularly European nations, began to worry about their energy security and independence. This, in turn, led to the development of various energy-saving technologies and the construction of energy-efficient buildings [1-2, 4-7].

Secondly, our expert scientists concluded that if we use non-renewable, conventional energy sources (oil, gas, coal) to meet current demand, their reserves may last only another 100–150 years [2,4–7].

Thirdly, by the end of the 20th century, the rapid development of all sectors of the national economy—marked by the construction of numerous large-scale manufacturing enterprises and skyscraper residential buildings—and the extensive utilization of all non-renewable energy sources became evident.

Fourthly, the rapid increase in the population in some countries—especially in those located on the continents of Asia and Africa—has also led to a day-by-day increase in the global demand for energy resources and necessitated the implementation of measures to address this issue.

For example, if we consider the current population growth solely in the Republic of Uzbekistan, the country’s population is increasing by 800,000 to 1,000,000 people per year. With such growth, the population of Uzbekistan may exceed 60 million by the year 2050.

In almost all countries worldwide, the majority of the total energy consumption in national economies comes from conventional, non-renewable energy sources such as oil, gas, coal, and others. In many countries, these sources account for an average of 70-90% of total energy consumption. These figures indicate that our economy is currently developing primarily through the use of non-renewable, depleting traditional energy sources. Furthermore, considering the various energy crises that occur globally, it becomes even more evident that the topics of energy efficiency and energy conservation are of great importance and urgency for the sustainable development of our economy. In short, all the information provided highlights the necessity of increasing the share of alternative and renewable energy sources, such as hydropower, solar, wind, and geothermal energy, in national economies. At the same time, it is crucial to use both renewable and non-renewable energy sources wisely and efficiently.

All newly constructed buildings today must be energy-efficient. This is because approximately 40-50% of total energy consumption is attributed to residential buildings. In recent years, the increasing scarcity of energy resources and their rising costs, along with the depletion of traditional non-renewable energy sources (such as oil, gas, coal, and others) due to population growth and the rapid development of various sectors of the national economy, have made it essential to construct buildings that use energy resources efficiently. Energy-efficient buildings refer to structures that,

based on the latest advancements in modern technology, ensure economical and rational use of energy resources throughout their operation. The main principle of designing such buildings is to maintain an optimal indoor temperature without relying on heating and ventilation systems by maximizing airtight insulation and utilizing alternative energy sources. The energy efficiency of a building is primarily achieved by minimizing heat loss without compromising the final outcome and ensuring rational use of thermal energy in all energy processes.

Literature Review. In the design and construction of energy-efficient buildings, significant contributions have been made by Swedish scientist Eje Adamson, German scientist Wolfgang Feist, American researcher David Orr, British architect Norman Foster, Russian scientists Y.A. Tabunshikov and I. Bashmakov, and Uzbek scientists R. Avezov, E.A. Nasonov, R.Yu. Marakayev, E.A. Shipachyova, S.A. Khodjaev, M.M. Zokhidov, and others. In particular, Y.A. Tabunshikov's monograph titled "Energy-Efficient Buildings," published in 2003, provides detailed information on famous energy-saving and energy-efficient buildings constructed worldwide between 1972 and 2003. Additionally, Russian scientist I. Bashmakov was awarded the International Nobel Prize for his extensive scientific research on improving the energy efficiency of buildings.

Analysis and Results: The first energy-saving and energy-efficient buildings began to appear in the 1970s. Examples include: A six-story administrative building constructed in 1972 in Manchester, Sarthe innovative energy-saving "EKONO-HOUSE" – a six-story, two-section administrative building built in Otaniemi, Finland, between 1973 and 1979. These buildings incorporated solutions to minimize heat loss: Reduced the surface area of exterior walls, with some buildings designed in a cubical shape Decreased the glazing area (down to 10%) Flat roofs painted in light colors to reduce solar radiation absorption No windows on the northern sides of the buildings Installed vertical and horizontal sun protection devices Solar collectors and geothermal installations placed on the roofs. Thanks to these measures, the heat and electricity consumption in these buildings was several times lower than that of other buildings constructed in the same period in Finland and the USA [1-4].

Between 1975 and 2000, the construction of various types of modern energy-efficient buildings developed rapidly in many countries. This trend became particularly widespread in European countries such as Denmark, Austria, Sweden, Germany, Switzerland, the United Kingdom, and France.

In Russia, the average energy consumption of older buildings was around 600 kWh/m² per year. However, after the introduction of SNiP 23-02-2003 "Thermal Protection of Buildings", the energy demand of newly constructed buildings was reduced to 350 kWh/m² per year. The construction costs of such energy-efficient buildings were 8-12% higher than those of conventional buildings. However, the additional expenses required for building these energy-efficient homes paid off within 7-10 years

In European countries, under similar conditions, the annual energy consumption of energy-efficient homes is around 120-150 kWh/m².

From the examples mentioned above, it is clear that the primary goal of constructing modern, energy-saving, and energy-efficient homes based on new (pilot) project designs is to determine the overall efficiency of energy savings. This is achieved by implementing architectural and engineering solutions focused on reducing energy consumption in both these pilot buildings and all future constructions within this new direction.

As we mentioned earlier, considering that the economies of most countries in the world are currently operating with 70-90% of their energy resources coming from non-renewable resources such as gas, oil, coal, and others, in the coming century, not only will the reserves of these resources be depleted, but the various gases and waste products (especially carbon dioxide emissions) released when these organic substances are used as energy sources can pollute the environment and pose a threat to the life of humanity and the animal world.

Currently, the depletion of non-renewable energy resources, the increasing pollution of the environment, and the changing climate of our planet are some of the most urgent issues facing specialists. The construction of modern, energy-efficient, energy-saving, and low-energy-demanding environmentally friendly buildings could be part of the solution to this problem.

In Uzbekistan, significant efforts have been made to save non-renewable energy resources, reduce their negative impact on the environment, increase the types and volumes of renewable energy sources, and improve the energy efficiency and energy-saving of buildings.

Within the framework of the “Improving the Energy Efficiency of Social Sector Buildings in Uzbekistan” project, in 2012, grand opening ceremonies were held for eight modern energy-efficient pilot facilities, including schools and medical centers, in the Andijan, Kashkadarya, Navoi, Fergana, Tashkent regions, and the Republic of Karakalpakstan.

The energy consumption of buildings in Uzbekistan is 2.5 times higher than in developed countries, and by 2030, the country’s energy demand is expected to increase by another 2.5 times (equivalent to 61.2 million tons of oil). These figures call for raising all the buildings being constructed and reconstructed in our country to the level of energy-efficient buildings.

In Uzbekistan, 50% of the total energy consumed by the economy (equivalent to 24.1 million tons of oil) is used by buildings alone. Many buildings were constructed during the Soviet era, and their service life has already expired. They do not meet current requirements at all. Due to outdated engineering communications, poor exterior insulation, and other problems, energy consumption in buildings has significantly exceeded that of developed countries.

In Uzbekistan, 39% of the greenhouse gases released into the atmosphere are attributed to buildings. These data clearly show that the focus of measures to improve energy efficiency and reduce energy consumption should be on buildings.

In the Republic of Uzbekistan, considerable efforts have been made to expand the use of renewable energy sources, reduce their negative environmental impact, conserve traditional and non-traditional energy resources, and construct energy-efficient and energy-saving buildings

In the Resolution No. 4422 of the President of the Republic of Uzbekistan, dated August 22, 2019, on “Urgent Measures to Improve Energy Efficiency in Economic Sectors and the Social Sphere, Implement Energy-Saving Technologies, and Develop Renewable Energy Sources,” issues such as conducting energy audits in business entities, developing renewable energy sources, and supporting innovative measures for the introduction of energy-saving technologies have been outlined [1].

Starting from January 1, 2020, based on the Presidential Decree No. 5577, dated November 14, 2018, it has been established that residential construction projects must be equipped with energy-efficient and energy-saving building materials [2,5].

The Presidential Resolution No. 4779, adopted on July 10, 2020, titled “Additional Measures to Improve Energy Efficiency in the Economy and Reduce Dependency on Fuel and Energy Products Through the Involvement of Available Resources,” outlines the need to improve the thermal protection of buildings, implement energy-saving technologies, and introduce renewable energy source systems in multi-story residential buildings. These measures aim to reduce energy needs for heating and cooling in buildings across all regions of the republic during 2020-2022 [2,5]

In his speech at the international summit held within the framework of the “Abu Dhabi Sustainable Development Week” platform, established in 2008, on January 14, 2025, President of the Republic of Uzbekistan Sh.M. Mirziyoyev stated that by 2030, 54% of the total energy sources used in Uzbekistan will come from renewable, non-traditional energy sources, and that the volume of greenhouse gases released into the atmosphere will be reduced by 35%.

In recent years, a clear example of the work being carried out in Uzbekistan on designing and constructing energy-efficient buildings of the new generation is the development of the working project for the reconstruction of the CVT National University in collaboration with the Tashkent Institute of Architecture and Building Design (Toshuyjoy LITI) and the University of Cambridge in the United Kingdom. The annual energy demand for heating in this building was 44.5 kWh/m², which is not much higher than the energy consumption rates of “low-energy homes” being built in European countries. Many similar examples of designing and constructing energy-efficient buildings in Uzbekistan in cooperation with foreign countries can be cited.

Conclusions and recommendations: The scientific research conducted on energy-efficient buildings can be summarized and expressed as follows, with additional points included:

- Studying the most modern and advanced experiences accumulated in developed foreign countries regarding the design, construction, and use of energy-efficient buildings, and analyzing the data obtained from this research to implement them in the development of related activities in Uzbekistan. It is an urgent task to develop specific scientific proposals and practical recommendations for this purpose.
- Holding various scientific conferences to study advanced foreign experiences in the design, construction, and use of energy-efficient buildings, and investigating the prospects of applying them in Uzbekistan’s conditions, as well as making presentations in mass media, organizing seminars, training sessions, and roundtable discussions with the participation of foreign experts, preparing pilot projects, and carrying out other promotional activities will yield good results. When constructing new modern buildings, it is necessary to use model projects that incorporate energy-saving methods, technologies, and energy-efficient construction materials and structures.
- It is advisable to limit the construction of buildings that do not meet modern energy efficiency requirements and to reconstruct existing ones in accordance with energy-saving standards. The building’s energy consumption can primarily be reduced by: increasing construction density, orienting the building considering the horizon and the main direction of the wind, properly selecting the building’s shape, floor heights, room dimensions, building width, facade segmentation, and compactness, choosing the right thermal insulation and heat-resistant materials for external barrier structures, properly selecting glazing for the facade, organizing thermal protection for the basement and underground parts of the building, determining the building’s humidity and air regimes, designing the room layout, selecting appropriate points for air intake from the outside, and planning migration routes.
- Windows should be designed with strict adherence to the climate zone of the building’s location within the republic, minimizing their surface area and number to the extent possible (without violating specified regulatory requirements), and avoiding placement on the north side.
- Based on advanced European practices, it is recommended to minimize the surface area of the building’s external walls as much as possible, and to design the building’s shape in smooth surfaces such as cubic, circular, cylindrical, or other similar forms.
- The roof’s type and slope should be designed considering the geographic latitude, weather conditions, and the angles at which sunlight falls during different times of the year, with the use of light-colored materials being preferable.
- The main indicator of energy efficiency for new generation energy-efficient buildings is primarily determined by the amount of heat required for heating the building (which is closely related to the thermal conductivity coefficient of the building’s envelope, the average air exchange rate, the compactness of the building’s shape, the glazing of the facade, and several other parameters). Additionally, energy-efficient use in buildings is achieved through efficient consumption of energy resources and automation of processes.

- Currently, the energy consumption of buildings is a key indicator in determining the quality of modern designs, but ensuring microclimatic conditions in the building's rooms remains a primary criterion

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