The Influence of Alternative Energy Means on the Architectural Shaping

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***Abstract* —** The alternative energy sources are considered to be the main environmental influence on the traditional regional architecture, considering that the physical appearance of the traditional architecture is based basically on the human interaction with the surrounding environment, his adaptation to it, and his best utilization of it. This is makes this architectural image special and significant. This research will look into two aspects.1) The theoretical aspect that review the importance of studying the effect of the characteristics of alternative sources on shaping the elements of vernacular architecture, it also inspect the importance of studying the nature and characteristics of these elements and their integration with environmental, social and esthetical sustainability standards. 2) The practical aspect conducts a practical analyses of several regional buildings samples from the Sheki region (Azerbaijan Republic) to study the effect of alternative energy sources for analyzing and discovering the effect of these variations in enriching the sustainability within the reguonal architecture in each country, and their effect in generating the vernacular architectural form.

The positive and negative factors of the integration of alternative energy in the structure of buildings are identified and the degree of their influence on the process of architectural formation is estimated.

***Keywords*—** Alternative energy, residential and public buildings, building structure, integration, solar panel.

1 Introduction

Recently, the use of alternative and renewable energy sources has become one of the most pressing problems of today due to the depletion of hydrocarbon resources and their negative impact on the environment. Obviously, in addition to reducing waste emissions into the environment, it is necessary to significantly develop alternative and renewable energy sources. The situation in this area is very dynamic for some developed countries, for example, in France, nuclear energy long years ago has turned from an alternative to the main source of energy. Solar, nuclear, wind and hydropower are important directions. Undoubtedly, the future belongs to renewable solar energy. Solar energy is inexhaustible, environmentally friendly, and does not produce harmful waste. Solar energy, following nuclear power, is currently experiencing a renaissance, which is associated with tightening environmental standards and an increase in the need for electricity [1-3].

The pace of development of alternative energy in Azerbaijan is extremely low in comparison with the leading industrial countries of the world. In some branches of non-traditional energy, the total energy production in Azerbaijan is hundreds and even thousands of times lower than similar indicators in developed countries. The process of developing renewable resources is proceeding very slowly. However, in recent years, the government of Azerbaijan, when developing strategies for modernizing the economy has set the main task
of energy saving and energy efficiency, the solution of which is entrusted to alternative and renewable energy.

In recent years, there has been a transition to environmental standards, including in construction. This allows us to speak about the formation of a new ecological architecture.

To achieve a competitive level about foreign colleagues, Azerbaijani architects and designers also need to take a huge step towards mastering engineering and technical and scientific base in the field of energy - saving and energy efficiency.

The integration of alternative and renewable energy resources into the structure of the building significantly improves its energy and environmental performance. However, this process often turns out to be technically difficult and not economically justified. For this reason, the development of energy-efficient buildings requires a special approach to the design process. The introduction of alternative and renewable energy resources into the structure of the building requires special safety work, which greatly affects the space-planning decisions. And improving the energy efficiency of the system of an energy-active building depends on the form of its material structure. Thus, speaking about the integration

of alternative and renewable energy into the structure of a building, a special approach to architectural shaping is required. An important task is the competent synthesis of architecture and alternative or renewable energy, which requires a skillful and advanced scientific experience and approach [4]. Thus it is necessary to use the latest computer-aided design systems. Only the development of advanced technical tools will lead to the development of ecological architecture, which will preserve the ecology and resources of our planet for future generations, and also form a new ecological consciousness in the current generation.

Today, the world scientific experience has a significant amount of materials on the problem of integrating alternative and renewable energy resources into the structure of buildings. Most of the research work is of an engineering and technical nature, without touching upon the problems of architecture, including the process of shaping.

In this paper, we clarify the ways that alternative energy sources contribute to shaping the form of vernacular traditional architecture within the Sheki-Zagatala region of Azerbaijan, and define how vernacular architecture achieved sustainability through being environmentally responsive to a specific location in a specific period time. Literature review on the topic showed a lack of scientific indicators about the effect of natural energy resources in creating the image of an environmentally responsive vernacular architecture within the Sheki-Zagatala region. While there is a large body of literature regarding environmental sustainability in vernacular architecture in general, there are limited studies regarding the effect of natural energy resources in creating the image of an: environmentally responsive vernacular architecture within the Sheki region in specific. Moreover, there are limited studies about the character and image of vernacular architecture in the Sheki-Zagatala region.

The purpose of this work also was to identify the positive and negative factors of the integration of alternative and renewable energy resources into the structure of buildings and to assess the degree of their influence on the process of architectural shaping.

The object of the study was residential, public and traditional regional buildings with the integration of alternative and renewable energy resources into their structure.

2 Vernacular architecture

The word "vernacular" comes originally from the Latin word: Verna, which means the traditional or the local. Vernacular architecture is the architecture that prevails at the whole society in a specific time concerning its culture and context [5]. Many terms had been used to refer to vernacular architecture, as Rudofsky mentioned in his book Architecture without architects [6]. Oliver [7] proposed defining vernacular architecture as the successful result of an architecture that corresponded rationally to the available local building materials, climate conditions and cultural needs. He also mentioned that there isn't any clear definition of vernacular architecture, though it can be possibly a mix of architectural and human about time, geography and history. Another famous author on vernacular architecture defined the vernacular architecture as the result of the total integration of many variables such as; society, culture, environment, building materials, and geographic location; as it is the product of processing all those variables together [8].

Vernacular architecture is a reflection of how many civilizations across the world historically lived in their local environments [9], it is a reflection of how cultures adapted and utilized the natural sources provided to them in a specific region, which resulted in generating a unique architectural image from one region to the other. While at the same time succeeded in providing the basic sheltering needs from the weather conditions, resolving climatic problems, integrating social functions, and also added physical and aesthetical special appearance [10]. All of that is considered the prime motivators that resulted in the formation of different shapes of vernacular architecture across the world as a whole, and across different locations within a region, like the Sheki-Zagatala region included in this study.

Vernacular architecture is the architecture that provides harmony to each element of its buildings, urban fabric, environment, building materials, culture, and climate [11], in other words; Vernacular architecture is sustainable, But is it is important to mention here that sustainability measures are different from time to time, our present time criteria for sustainability might be different from that naturally found in vernacular architecture, so we need to keep in mind that we are talking about a specific time in which those vernacular forms emerged and how conveniently they provided human comfort to their users within their context in the past so we can learn from vernacular sustainability experiences [12].

3 Alternative and renewable energy in the structure of buildings

The concept of means of alternative and renewable energy includes a complex of engineering and technical means for receiving, processing, transforming and distributing energy between consumers based on energy

resources of various types of alternative and renewable energy.

Solar energy is one of the most promising energy sources, since the sun is practically inexhaustible, absolutely safe, and affordable energy source. The total amount of solar energy supplied to the Earth's surface per year is not only many times greater than the energy of the world's reserves of oil, gas, coal, uranium and other energy resources, but almost ten thousand times more than modern energy consumption. Currently, more and more countries are planning large-scale use of solar energy in their energy programs.

The direct conversion of solar energy into electricity is widespread in world practice and is considered one of the main tasks of the energy sector in developed countries. Under the 1997 Kyoto Protocol, construction began on large-scale alternative energy plants in the EU and the US.

The basis of solar panels (SP) is the solar cell (SC) semiconductor material that directly converts sunlight into electricity. With a small demand for electricity (less than 500 W of power), the installation of a joint venture is preferable to other types of energy.

The joint venture is easier to install compared to wind turbines. They take up less space, are more reliable in providing energy, do not require a mast, and are practically invisible from the outside on the roof. There is no need to use a crane or transport construction materials by trucks. You just need to properly position and fix the panels on the roof. The ideal location for a private consumer is the roof of the building, preferably facing south. Thus, on a roof area of $5 \times 5 m^2$, about 4 kW of solar power can be accommodated. Ground placement is also possible, but in this case a large open area is needed. In practice, land-based placement is more common in industrial power generation projects.

Quality solar panels can easily withstand any weather conditions, even hail. The only maintenance required is to clean the surface of snow and dust from time to time, which can significantly increase productivity. There are also systems that can turn the solar array to follow the sun during the day, thus increasing energy production by up to 50% of stationary generation.

A distinctive feature of the entire class of solar cells is that the process of converting solar radiation energy into electrical energy occurs inside the solar cell and does not require the use of any moving parts or natural fuel. Moreover, no waste is generated during the conversion process. Moreover, from the point of view of the time scales of human evolution, the Sun is an unlimited source of energy.

The need for portable power sources is increasing. In our life, thanks to technological progress, there are constantly emerging devices with which it is difficult for us to part, even for a short period of time. Due to the need to use different types of electronics, the problems of its power supply are becoming more acute. New generation solar panels are lightweight and reliable batteries that are designed to recharge and power batteries for various devices.

Unfavorable factors in the operation of energy facilities were identified, which are divided into the following: factors of constant action such as noise, vibration, electromagnetic and radiation, temporary factors with a certain cyclical nature as harmful emissions, transportation of raw materials and waste, potential factors of a single nature such as fire and explosion hazard the possibility of a man-made accident.

Additional positive factors for the operation of alternative energy in the structure of buildings are independence from network failures, a careful attitude of the consumer to energy costs, the possibility of self-service and personal technical control of the energy system by the consumer and the possibility of selling excess energy.

All buildings, according to the nature of interaction with alternative energy facilities, are proposed to be divided into two groups: buildings with power plants located outside their material and structural structure, and buildings with power plants located in their material and structural structure. In the first group, it is necessary to distinguish buildings that use transported energy, as a rule, through energy or heating networks, from a remote power generating unit, and buildings with separate power plants, in the immediate vicinity, and, as a rule, aimed at supplying energy to this particular building. Installations of this kind do not affect the space-planning solution of the building and its material-constructive structure, acting as a peripheral element. However, together they form a single functional complex. The second group includes buildings that use power plants as peripheral devices. Power generating plants here act as additional engineering and technical elements that do not affect the volumetric planning solutions of buildings and their structure as a whole. Also, the second group includes technical buildings in the structure of a production facility. Such buildings in themselves fulfill a secondary functional purpose, not being an independent object, and are completely subordinate to the operation of a power generating installation. Of the greatest importance for this work are objects that are also related to the second group, in which power plants form their material-constructive structure. Such buildings, by and large, form a single whole with an energy-generating facility, forming a functional synthesis.

The productivity of a photovoltaic system is highly dependent on the climatic context in which it is located. The amount of electricity produced is, in fact, directly proportional to the availability of solar radiation and, to a much smaller extent, inversely proportional to the working temperature of the cells. It is therefore extremely important to define the correct inclination and orientation of the modules, to maximize the incident radiation and favor heat loss. At the latitudes of EAC countries, the optimum tilt angle is 0° (horizontal), but up to 15° there is no significant decrease in production. Hence the fact that, contrary to what is generally proposed for higher latitudes, it is not appropriate to put PV panels on the walls, or as overhangs for windows shading the south or north facade since they would remain in the shade for half the year.

Architectural integration represents an interesting opportunity for photovoltaics, with very promising growth prospects, even in strictly economic terms. The installation of the modules on the building envelope provides a variety of advantages, such as the use of the land surface already occupied by buildings. To obtain the best performance of a photovoltaic system, whether integrated into the building envelope or not, careful planning is necessary. The modules must be located in such a way as to intercept the maximum possible solar radiation, avoiding shade produced by trees, surrounding buildings, or parts of the building itself.

Ventilation of modules, by leaving a gap between their bottom surface and the roof or other building components on which they are mounted, is an important prerequisite to avoid lower performances than expected. When the modules are mounted on a roof, care must be taken not only to leave a ventilated gap but also to increase the roof insulation, to avoid a significant heat flow due to the panels' relatively high temperature reaching the indoor environment.

4 Case studies

The present research aims to advance green energy consumption by integrating energy conversion schemes into buildings, as an inherent part of architectural construction. The realization of such tasks implies adjustment of external shapes of buildings. Particular solutions depend on the chosen types of renewable energy sources, geographic location, and environmental conditions. The novelty of suggested solutions is based on the principle of preliminary crowding of solar radiation.

This part of the research will adopt an analytical descriptive approach, where will present case from common vernacular dwelling typologies found in the Sheki-Zagatala region and describe how each case's forms and features are responsive to the alternative energy in their context in a way of providing environmental sustainability measures and human comfort to the users.

As a prototype of the traditional is caravanserai (figure 1) that originated in the XVIII-XIX century and is found in several places within the Sheki region. This type Yuxari Caravanserai consists of a linear plan house where all spaces open up to a loggia that is placed on the elevation facing direct sun radiation, this form especially responds to the sun factor by shading it – preventing overheating in summer where the sun is high and obtain solar energy in winter where the sun is low.

a)

b)

Figure 1. Sheki Caravanserai a) Yuxari Caravanserai, b) Ashagi Caravanserai

The roof here is mostly no flat, made of wooden beams that are covered with sticks and mud for insulation. As for building materials they are local brick or stone depending on what is available in the location, if brick they are usually covered in plaster for protection and insulation, the structure of the building depends on stone columns, this is why no massive walls are needed to carry the roof. For such a design of the building, it is convenient and profitable to install solar panels on loggias and roofs.

4 Conclusion

The alternative energy sources are considered to be the main environmental influence on the traditional regional architecture, considering that the physical appearance of the traditional architecture is based basically on the human interaction with the surrounding environment, his adaptation to it, and his best utilization of it. This really makes this architectural image special and significant.

All buildings, according to the nature of interaction with alternative energy facilities, are divided into 2 groups as buildings with power plants located outside their material structure and buildings with power plants located in their material structure.

Modern alternative energy has an extremely wide range of different engineering and technical means, therefore each separate direction for integration into the building structure should be considered separately.

The positive and negative factors of the integration of alternative energy in the structure of buildings are identified and the degree of their influence on the process of architectural formation is estimated. Due to the absence of unfavorable performance characteristics, it is advisable to use many alternative energy techniques in the structure of buildings.

The theoretical aspect reviews the importance of studying the effect of the characteristics of alternative sources on shaping the elements of vernacular architecture, it also inspects the importance of studying the nature and characteristics of these elements and their integration with environmental, social and esthetical sustainability standards. The practical aspect conducts practical analyses of several regional buildings samples from the Sheki region (Azerbaijan Republic) to study the effect of alternative energy sources for analyzing and discovering the effect of these variations in enriching the sustainability within the reguonal architecture in each country, and their effect in generating the vernacular architectural form.

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