Concept of organizing autonomous architectural objects as new paradigm of habitat

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Abstract. The article is devoted to a relevant problem of determining ecological approaches to the formation of an autonomous architectural object as a new paradigm habitat. Introduction of ecological principles offers great promise for use in the architecture of research and development projects generating new ideas. This concept allows understanding the importance of and the need to find new trends in shaping the scope of architectural design. The purpose of the article is to identify the environmental formation techniques of architectural objects using autonomous energy supply. A leading approach to the study of this problem is based on the development of techniques for increasing energy efficiency of autonomous buildings with renewable energy. The study identifies innovative approaches to formation of autonomous architectural objects in the context of the preservation of the environment and energy saving. The materials can be useful to the theory and practice of forming the space habitat as they open completely new possibilities in architecture and construction.

1. Introduction
In architecture a progressive direction is developed assuming the application of new technologies when creating architectural objects. It is connected with a new view of environmental values and energy saving conservation. In many countries, this trend has been further developed, the so-called "autonomous house", which is an example of self-organization in environment formation.

To develop recommendations for the design of autonomous architectural objects, one should consider the use of environmental approaches in their formation. In addition, it is important to define modern concepts of formation of energy-efficient buildings, new types of energy for offline habitats, as well as the areas of application properties of autonomy in architectural and urban planning practice. Introduction of ecological principles offers great promise for use in the architecture of future R&D projects generating new ideas.

Using energy systems specific to the industrialized areas is unprofitable for relatively small settlements located far away from each other. The establishment of autonomous small power plants based on the use of renewable energy sources to supply local consumers has obvious advantages for such locations. This is especially relevant for some remote regions of the country that are not connected to a central power supply systems.

Development of the principles of designing energy-efficient buildings, as well as the creation of new building designs and materials in the context of autonomy attracted the attention of many architects and specialists. These results are provided in references [1-11]. In addition, their authors propose specific solutions and developments performed within the framework of this concept [12-22].
In this regard, the study examined alternative energy sources, provided ecological techniques of formation of architectural objects that best meet the requirements of energy saving when one creates autonomous artificial environment.

Such architectural objects include the use of devices that can capture, convert and transfer energy from renewable sources. This enables lower energy consumption of conventional sources, which increases the efficiency of such installations. In connection with the absence of an autonomous design methodology of architectural sites, the research is particularly relevant.

The main direction of scientific research is aimed at developing techniques for increasing energy efficiency of autonomous buildings with the use of various types of renewable energy and new energy technologies. In this regard, the authors set an objective of developing environmental formation techniques for architectural objects using autonomous energy supply.

2. Materials and methods
The problem of modeling self-adaptive environment is notable for its concept of novelty as a source of new ideas. The need to use the principles of self-adaptation of architectural objects is particularly acute when creating of autonomous environment. Complex technology and economic requirements for creating such architectural objects induce the search for new approaches and use as research methods:

- integrated design object as a system, a method of structural analysis and informational method. The consideration of the characteristics of autonomy of environment in depending on the renewable energy technologies would create a concept of architectural objects as a new paradigm habitat.

2.1. Bio-tectonic system in architecture
An alternative direction in architecture is related to the design, development and establishment of the autonomous bio-tectonic systems based on the use of renewable energy. This includes solar, wind, hydro, tidal, geothermal, biomass [1].

In the world practice, a large number of autonomous architectural objects that were designed and built based on different concepts of energy efficient and environmentally clean technologies. The difficulty lies in the fact that in the same building object, you can usually find an implementation of several different concepts that defined their own names [2].

So, for example, the concept of “high-tech building” is implemented in the object in which energy saving, quality of microclimate and environmental safety are achieved through the use of technical solutions based on know-how [3].

One of the emerging directions in architecture, a hi-tech style, with the main principle of harmony with nature, became the “bioclimatic architecture” with the inclusion of a set of design and technical solutions to ensure the building is comfortable for human life providing for the economical use of energy [4].

It also includes the concept of “healthy building”, in which the energy-saving technologies have technical solutions, while contributing to the improvement of a microclimate in premises and environmental protection. In addition, these objects are built with use of eco-friendly construction materials [5].

The concept of “eco-neutral building” is associated with resource-saving and low-waste, healthy and improved object, combining modern comfort with autonomous life support systems using renewable resources and processes wherever it is possible. This is achieved by the use of autonomous engineering systems in conjunction with a sound house construction design [6]. The category of energy efficient buildings also includes the concept of building “low energy consumption” and a “zero energy building” [7].

The principle of ecological balance between man and the environment illustrates the concept of “sustainable buildings”. The main purpose of the theory and practice of the construction of this concept is a comprehensive study of the building and the environment, their common environmental and energy status [8]. This includes the possibility of using clean renewable energy, water conservation, use and recycling of construction materials, as well as improving the quality of human habitat [9].
2.2. **Solar energy-intensive buildings and structures**

Such objects are designed for heat and refrigeration systems, hot water preparation or production of other kinds of energy through the capture and conversion of solar energy, which is one of the most attractive alternative energy sources. The development of the architectural trends for solar energy use takes place in two directions. On the one hand, as the use of heat-physical properties of the buildings to accumulate and store heat from the so-called “passive” energy collection system. On the other hand, it stipulates for the accommodation of special technological devices in the building at a so-called “active” energy collection system.

- In practice, in the design and construction of such buildings “passive” methods of gathering energy are being more frequently used [10]. Due to the fact that this experience is widely documented in the literature, it is advisable to focus on a forward-looking trend of “active” energy gathering [11]. This resulted in the emergence of projects of energy-intensive buildings with combined systems, giving a great variety in buildings formation [12].

- Among well-known constructive techniques used to improve energy activity autonomous buildings special attention should be paid to kinematic methods [13]. They use such principles as energy-intensive building rotation in a tracking mode for sun or other cyclical movements, increasing the capture and accumulation of solar energy, as well as use various types of protection fence transformation, rotating screens-reflectors, etc. [14].

- When using renewable energy, one can observe the formation of the conditions for an autonomous use of transformable mobile buildings in hard-to-reach areas. These types of buildings have large benefits especially in small remote towns located far from each other [15]. The formation of architectural objects using different systems of solar energy can solve not only economic and environmental problems, but also facilitate the search for new alternative approaches to the organization of environment [16].

2.3. **Wind energy-intensive buildings and structures**

In the regions with prevailing strong winds efforts are taken to use wind energy for improving the energy balance of buildings in order to save other energy sources. However, all of them are commonly reduced to the location of conventional one-purpose wind engines in the vicinity of a building or its structures. The modern idea of a wind-energy-intensive building is connected with the following additional feature designs to capture and convert wind energy into other useful forms of energy (electrical, thermal, mechanical, etc.).

The studies show that in this case it is possible to create autonomous energy self-sufficient system. Building practice have known urban planning techniques that increase the use of wind energy. For example, take into account the placement of the buildings in the area, the most secured wind energy, as well as their relative positions, reinforcing the overall aerodynamic effect.

When you create the wind-energy-intensive buildings using kinematic structures, you can use wall coverings, protective elements, skylights design screens and add-ins [17]. The overall effect can be enhanced by strengthening capacities or combined application in one building or their complex several energy-intensive systems.

2.4. **Hydro-energy-intensive buildings and structures**

The use of hydro-and geothermal energy, which is a renewable form of energy, much less-building and different seasonal or daily stability has not been yet widespread in practice, design and construction. The geothermal energy of low capacity is used for reducing thermal loads on the heating system of autonomous buildings during the heating season.

The design of such buildings has specific characteristics. The principle of poly-functionality when designing energy-intensive buildings hydrothermal type allows combining the water-intake design, heat transfer and circulating channels with designs of buildings. The most important practical task is to ensure increased waterproofing for the structures. The use of hydro-and geothermal energy in
autonomous buildings gives certain economic advantages compared to conventional architectural objects.

2.5. Bio-energy-intensive buildings and structures
The technology is based on the principles of the use of biogas as an end-product of a multi-step conversion of solar energy, initially assimilated in biological mass and then turned into gaseous fuels. Among the methods used in the development of bio-energy-intensive buildings and structures are distinguished: reactor blocks generate biogas (digester) and blocks the accumulation of end product (biogas) - energy carrier (gasholders).

The scope of bioenergy application is broad and varied: agriculture-livestock buildings, agricultural buildings in the processing of agricultural products and waste management; in chemical and bio-processing industries; in residential and public buildings. The first two areas of use has its own specificity associated with technological processes and are considered in detail in literature [18]. The relevance of the development of a bio-energy-intensive autonomous house stems from the fact that the cost of engineering equipment, as a rule, more than half of the total cost, and embedding engineering equipment of a factory to the present time is not made.

2.6. The integrated ecological systems
The idea consists in erecting architectural objects with fully managed engineering communications as a single center of managing equipment systems with microprocessors. They are programmed to independently select optimal operating modes depending on changing conditions [19]. Energy saving is realized through the systems capable of dosing the minimum amount of energy required to ensure the best conditions for the operation of the building at any moment [20]. The main components of this technology are ecology, safety, comfort, resource and online information environment that allow one to easily and efficiently manage the building [21].

An integrated system of managing autonomous buildings infrastructure provides for comfortable improvement of the diversity of the served functions of monitoring the status of the building as a whole and its various premises without any reconstruction works. Unlike standalone systems, an integrated system uses a common database that can be authentically used not only by life support subsystems, but also by any other device for building automated management [22].

The development of information technology is gradually changing the role of home in human life, transforming it into space where a human spends a larger part of work and past time. The main difference of a modern home lays in its intellectuality.

3. Results and discussion
Environmental approaches to the formation of autonomous architectural objects in this review identified the following directions:

- **Bio-tectonic system in architecture.** In the world of construction such as “high-tech building”, “bioclimatic architecture”, “healthy building”, “eco-neutral building”, building with “low energy consumption” and “zero energy building”, as well as “sustainable buildings”.

- **Solar energy-intensive buildings and structures.** The known constructive techniques intended for improving the energy activity of autonomous buildings include kinematic techniques which should be particularly considered. Autonomous mobile complexes witch using different systems of solar energy can solve not only economic and environmental problems, but also facilitate the search for new alternative approaches to the organization of the environment.

- **Wind energy-intensive buildings and structures.** Wind energy use is associated with providing an additional function to a building consisting in collecting and converting wind energy into other useful forms of energy to improve the energy balance of buildings in order to save other energy sources.

- **Hydro-energy-intensive buildings and structures.** Geothermal energy is used for reducing thermal loads on the heating system of autonomous buildings during the heating season.
Alternative energy use consists in the impact or the selection of thermal energy depending on its deficit or excess in the thermal balance of the building which gives certain economic advantages compared to conventional architectural objects.

- **Bio-energy-intensive buildings and structures.** The technology is based on the principles of the use of biogas as an end-product of a multi-step conversion of solar energy, initially assimilated in biological mass and then turned into gaseous fuels. Of greatest interest are bio-energy-intensive self-contained residential and public buildings.

- **Integrated ecological systems.** Maintenance of autonomous systems is ensured by central management with a single automated control, which allows monitoring the life-support systems, security systems, information systems, communication systems, systems uninterruptible power supply, scheduling and operation.

4. **Conclusion**

In the process of establishing autonomous and ecological constructions there is a trend for developing the interrelations of traditions and R&D advances, based on the strategic use of non-renewable energy sources, in architecture with the decrease of the negative impact on environment. This enables one to unleash the potential of architecture and best meet the needs of society.

**Practical significance** of the research is to advance knowledge for new approaches to architectural design. The consideration of the characteristics of autonomous use allows formulating the concept of architectural objects as a new paradigm habitat. The methodical basis obtained in the paper can be used when creating the latest techniques in practice, design and architectural education, with a view to the development and formation of new innovative approaches to the creation of environment.

Thus, the application of environmental principles in architecture of autonomous objects creates a new architectural language that is based on a combination of high energy technology and new materials. The main features of this language are: the autonomy from of urban infrastructure, the use of information technology and environmentally friendly materials, energy saving principles and self-control, psycho-social comfort environment, the use and study of the natural forms and processes.

A developing promising direction in the architecture advancement, applying new technologies when creating architectural objects, is associated with a new view on environmental values, environment and save energy conservation. It is necessary to conduct thorough analysis and systematization of the experience design of autonomous objects, both in architecture and related disciplines to build an integrated model of a resource savings space.

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