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Sustainable Strategies of Urban Planning

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Abstract

Ecosystem degradation and environmental urban development create a new trend in the context of global ecological crisis. This trend involves the need to shift urban facilities to sustainable development, which in turn is linked to the necessity to modernize urban environment in the view of comfort, economy, and ecological compatibility. The design of sustainable cities plays a natural catalytic role for change and improvement of the environment quality. This paper analyses sustainable development strategies and methodological principles of sustainable architecture in particular, which served as a basis to define a set of core principles of establishing architectural solutions of energy-efficient buildings such as urban, architectural and planning, design concepts as well as the principles of the use of renewable energy. The project of energy-efficient school in Gaziantep, Turkey, being the sustainable architectural model, was used as an example to show the application of the methodology and demonstrate the comprehensive integration of engineering, architectural and energy-efficient solutions into the facility in question.

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1. Introduction

Sustainable development of contemporary cities is the urgent task aimed at creating beautiful, healthy, and ecological city satisfying completely the residents' needs. The objective is to be achieved by both residents and city officials throughout the entire country as well in order to ensure a better quality of life of people and of urban environment, and to provide the balance between the city and natural environment. The relatively recent world's cities movement towards sustainable development started only at the end of the twentieth century. Within the UN

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system, there were established structures contributing to the shift to sustainable development such as UN-HABITAT human settlements centre, Urban Environment Forum (UEF), United Nations Environment Programme (UNEP) and others [1].

Up to the middle of the twentieth century, no initiatives were taken for greening human activity despite the first warning signs like environmental pollution, overpopulation [2], deforestation and water pollution. It was in the second half of the twentieth century when humanity faced the problems of the depletion of core nonrenewable resources and the emergence of a number of signs of global ecological crisis. Humanity started pondering the question of ecologization and the necessity of major changes in ways of being and acting, or the necessity of shifting to sustainable development [3].

The idea of sustainable development is unique and innovative and requires rethinking of the approach to the environment: a man should realize the limited nature of resources and the necessity to conserve them for supporting the needs of future generations [4]. Countries around the world need ecological crises to be resolved, thus the idea of the overall shift to the path of sustainable development is relevant and important.

2. Challenges facing sustainable architecture

With the adoption of ecocentric thinking people start identifying ecological compatibility with economy [5]. It is economy that will allow us to make the life green and shift to the path of sustainable development. The transition process to sustainable development results in a number of problems. First, there is a need to replace the conventional anthropocentric thinking by the ecocentric one. Second, sustainable development is impossible in war and inequality. Third, humanity needs to develop new ecological technologies that will replace non-ecological ones. The main problem is to develop strategies of shifting to sustainable development since this is a complex process related to the involvement of an increasing number of researchers to study the problem [6].

Construction and design have achieved remarkable results in sustainable development. Green buildings design and green construction, for example, are aimed at the search for an architectural solution in cooperation with trained engineers in various areas. In turn, it will contribute to the development of a more integrated approach to create sustainable architecture [7]. Accordingly, some specialists like landscape architects, architects, engineers, urban designers and planners play a significant role in achieving sustainable development in cities and countries and in creating appropriate conditions for higher quality of life.

3. Sustainable strategies of urban planning

To create sustainable cities one needs to reduce the area of human-induced land, to turn a large part of developed and polluted territories into their natural state. However, the ordinary recovery of land can be complex or even impossible due to the growth of urban areas and population [8,9]. There is still possibility to replace this recovery by sustainable construction, by making urban areas green that would allow creating brand new biopositive facilities related to nature, accepted by it and included into natural ecosystems. The nature will take biopositive objects (building, structures, settlements, countries) as natural objects that will gradually lead to achieving sustainability, rectifying the imbalance and preventing the human-induced destruction of nature [10]. Hence, there is the challenge of sustainable development of cities and ecologization of resettlement places.

Design and planning of residential areas and neighbourhoods are a major challenge when creating a favourable urban environment. The challenge is based on the principles of integrated approach to different demands: social, architectural, artistic, economic, sanitary and hygienic. Social demands are aimed at constructing network and placing buildings in order to create favourable conditions for their convenient use. Architectural-artistic solutions are aimed at single spatial composition of an area with the surrounding landscape. Economic demands include rational utilization of area territories [11]. Sanitary and hygienic demands are of more interest in terms of creating sustainable urban areas: establishing favourable insulation and air conditions over the whole area as well as the protection of buildings from external noises. The control of air conditions is carried out through various ways of building up areas that create windshields towards strong winds. The length of the windless region depends on the length-height ratio in a building and on its location towards prevailing wind (see Fig. 1).

Fig. 1. Diagram of windless regions casting with a building's front located perpendicular to the wind current: 1 – zone of the decrease in wind speed by 70%, 2 – zone of the decrease in wind speed by 60%, 3 - zone of the decrease in wind speed by 30%, 4 - zone of the decrease in wind speed by 40% [11].

4. Methodological principles of sustainable architecture

Sustainable architecture is the architecture that unites time and architecture and represents the unity of aesthetic, socio-economic, engineering and technology, natural and ecological demands based on the principles of sustainable development. The completeness of the implementation of these demands is determined according to the requirements of rating systems to evaluate the sustainability of the habitat [12,13].

Architects and engineers single out two approaches to the development of eco-sustainable architecture. The first approach is based on the introduction into architecture the newest technological innovations in energy efficiency [14], intelligent building management and usage of the newest materials. The second one involves both the application of architectural and spatial solutions influencing power consumption and resource-saving and the maximum utilization of natural rather than mechanical modes of operation of engineering systems [15].

The concept of sustainable development facilitates developing new principles and methods of architectural engineering. Energy efficient architecture of a building can be attributed to such methods. Based on the analysis of foreign and domestic experience of designing energy efficiency residential buildings, one can generate a number of demands [16, 17]:

- Urban needs: design of enclosed yard areas; arrangement of buildings in accordance with the orientation under direction; landscaping;
- Ecological needs: use of environmentally sound materials; zero-discharge operational cycle of a building enabling to preserve the environment (reducing the carbon dioxide emission into the atmosphere); use of alternative energy sources for building engineering; maximum vertical gardening usage in warm climate;
- Architectural and planning needs: design of compact form of a plan and avoidance of irregular facade; stylobate floor lay-out to reduce the wind load on the adjacent territory; use of buffer zones in a building from adverse directions; design of big-framed buildings (heat loss reduction due to the reduction of building envelop area); calculation of optimal relationship of building envelop area and that of a building; calculation of optimal relationship of building envelop area and that of window openings in order to reduce power inputs;
- Constructive needs: use of effective thermal insulation materials and structures when erecting a building; use of three-layered building envelops; use of local construction and finishing materials when erecting a building;
- Engineering needs: use of both passive and active alternative energy sources systems in buildings; use of mechanical exhaust system of ventilation with air disposition by thermal pumps for the needs of hot water supply system; use of hot water supply system with local decentralized water preparation in the basement plant room;
- The provisions above enable one to highlight a core set of principles (Table 1) of establishing architectural solutions of energy efficient buildings - urban, architectural and planning, design concepts as well as the principles of the original renewable energy usage [18].

Table 1. Set of core principles of establishing architectural solutions.

Cluster of principles	Principles
Urban	Principles of the selection of building location taking into account: climatic conditions, locality, existing site development in the area of the supposed construction.
Architectural and planning	Compactness of shapes of a building, specification of general architectural and planning building concept, specification of inner layout of a building, architectural and compositional principle.
Design	Principles of the selection of: wall facing construction, roof construction, facing materials, glazing of a building (spaces, structures, light opening location) and sun protection.
Principles of the use of original renewable energy	Principles of the usage of: solar energy, wind energy, bioenergy, earth's heat energy; secondary energy.

The spheres where sustainable architecture is developed and formed are: scientific researches, pilot projects, normative regulation and support, educational activities, design and construction and life cycle monitoring. The activities of specialists from these areas facilitate the process of establishing and developing sustainable architecture with each area possessing its own methodology and problem-solving procedures in establishing sustainable architecture.

5. Application of methodological principles in architectural design

One can refer to the project of energy-efficient school in Gaziantep, Turkey to illustrate the usage of the above-described methodology of sustainable architecture principles in the design of buildings. The project in question was created by the authors of the paper for the international contest of energy efficient projects in 2014 and won the first prize at the regional stage. The school building was designed taking into account the climatic conditions of the built-up area, orientation under direction and the function of the building as well.

One of the major distinctive features in terms of energy efficiency is the building embedment by half a floor that contributes to the unity of architectural space and surrounding landscape. The unity is achieved by means of organizing green roof, which smoothly passes from the ground level to that of the second floor and serves as the recreational area for pupils. The considerable glass area needed for the comfort learning process is balanced by the sun light protection system - mobile blinds and permanent sun protective tents made of light structures. These tents located under zenithal lanterns protect the building from overheating and support solar panels with necessary bending angle. The outer escape gallery with vertical greenery is located around the perimeter of academic buildings thus shading classrooms in warm climate (Fig. 2).

Provisions are made for plenum and exhaust ventilation system with forced air heating in the building. The system includes rotary generator with efficiency no less than 85% allowing heating (cooling) the fresh supply air locally by exhaust air. In addition, for the initial heating (cooling) of supply air, it passes through ground heat exchanger where the ground delivers its energy thus reducing costs on heating (cooling) of supply air (Fig.3).

For short-term supply air heating to reach specified characteristics, the heat preheater with heat carrier circulating from public accumulating heat tank for hot water supply, heating and ventilation system is used. The given tank is the heat-insulated reservoir heated by thermal pump, which receives heat from exhaust air and/or from the system of solar cell batteries (solar collector) located on the roof of the building with circulating heated antifreeze there (Fig. 4). Local energy supply of heat pump and other electrical equipment is provided by solar panels generating

electricity, which after being converted in the current inverter, enters power lines (Fig. 5). Both heat carrier for the system of heating and hot water to satisfy system needs for water consumption are received from public heat tank.

Fig. 2. (a) green roof and building embedment by half a floor; (b) escape gallery with vertical greenery

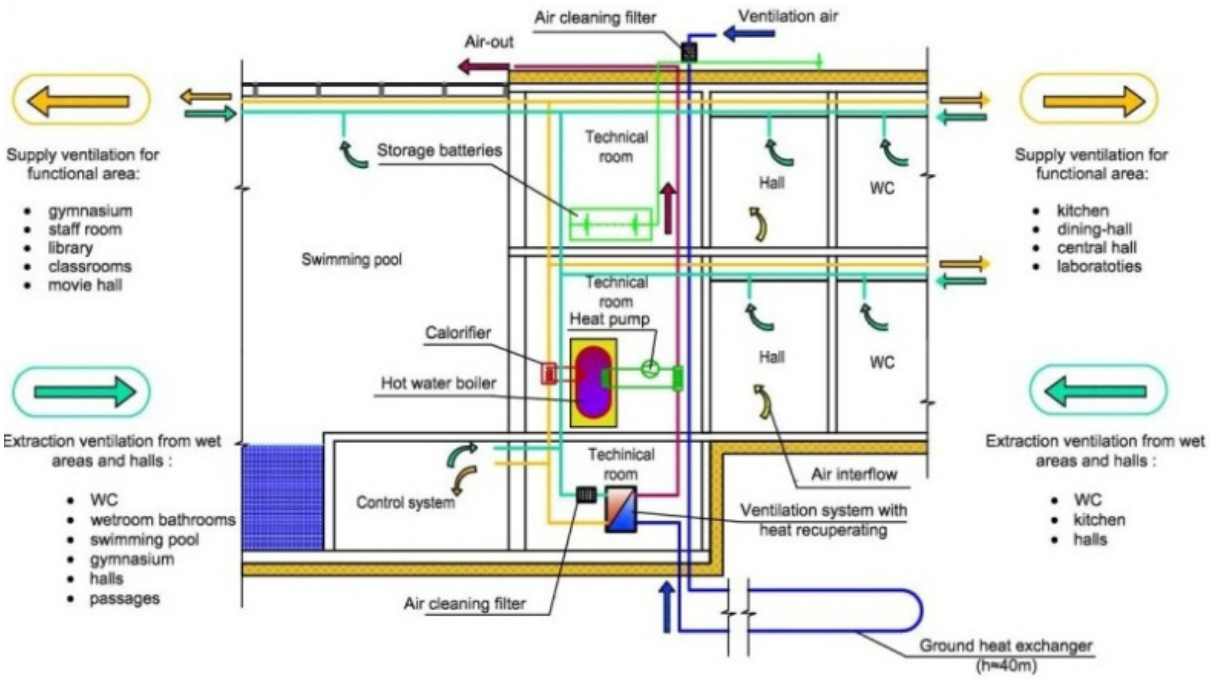

Fig. 3. Model of ventilation with recuperative heat exchange

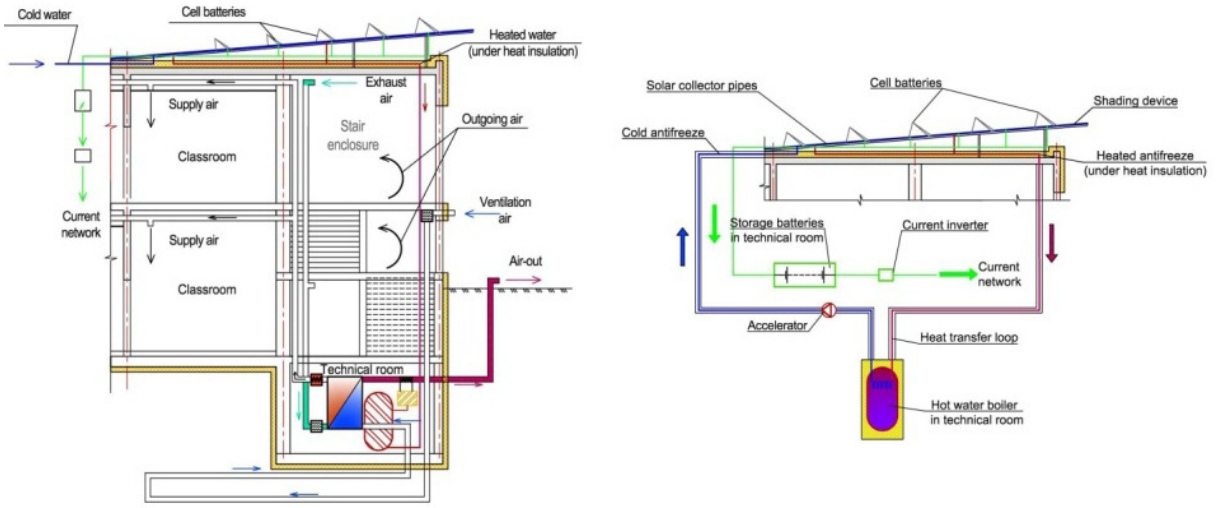

Fig. 4. (a) Model of engineering systems with recuperative heat exchange; (b) Model of solar system

Turkey, like all southern areas with hot climate and dry summer, uses decorative and paddling pools, fountains, and sprinkling-watering utilities along with green plantations in order to humidify air in the yards. Utilizing the given methodological principles proved by calculations allows recognizing the project of energy efficient school in Gaziantep to be the demonstration of sustainable architecture.

6. Conclusion

At the forefront in a sustainably developed country, there is the problem of creating comfortable, ecological, aesthetically beautiful and sustainable architectural environment. Green buildings and engineering projects fit perfectly ecosystem, which perceives them as natural constituents. This environment provides people with high quality of life and is found to be in ecological balance with natural environment.

Sustainable architecture deals with all problems relevant to ensuring sustainably urban development, namely:

- Basic principles of sustainable architecture: ecologization of buildings and structures; integration of energy efficient, spatial arrangement and engineering principles into the design process [19] resulting in the necessity of on-going cooperation of specialists from various fields to perform a project as a whole;
- Sustainable architecture produces benefits: social, ecological, and economic [20]. Sustainable urban planning allows reducing negative impact on the environment, minimizing the natural resources consumption and increasing the utilization of renewable resources and wastes and their minimization, reducing operational costs,
- Utilization of green materials in building energy efficient structures with the possibility of their further wasteless recycling.

Sustainable urban development requires integrated approach, which is expressed by the diversity of urban planning organization, namely, in the form of the following cluster: residential area - neigbourhood - building. A separate urban planning unit includes varied methodological principles of building sustainable architecture.

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