Ecologically Dependent Architectural Space as One of the Main Objects of Study in Higher Architectural School

P Kazantsev

1Architecture and Urban Planning Department, Far Eastern Federal University, 8 Sukhanov Str., Vladivostok, 690900, Russia

E-mail: pal-antvlad@yandex.ru

Abstract. The restoration of the source ecosystems lost during the urban development of the territory is due to the formation of spatial cells that are friendly to the elements of an ecosystem. Thus, education and research in sustainable architecture has to be focused on studying the principles and ways of forming an “ecologically dependent architectural space”, starting with obvious dependencies. Five levels of such a program can be as follows: 1. Principles and methods of forming a climate-oriented architectural space (entry level); 2. Architecture and renewable energy engineering systems interconnection; 3. Green systems in architecture, including city farms and algaetecture; 4. Transformable architectural forms and adaptive landscape design to the dynamics of weather and climatic conditions; 5. The specifics of architecture and urban design integrating natural ecosystems (graduate level). Graduation level main attention is focused on the study of water sensitive urban design and related concepts, as well as the concepts of renovation of the littoral marine zone. One of the obvious outcomes of experience is the need for a specialized educational program “sustainable architecture and design” in a higher architectural school.

1. Introduction
These days, the architecture in Russia is viewed as a professional activity not related to ecology. The topic of environment conservation and sustainable development and eco-architecture coexists in absolute isolation from each other. Ecological architecture in Russia has not been recognized as a very efficient way of forming a sustainable and environmentally friendly human habitat. As a result, the issue of increasing energy efficiency in buildings is viewed only from an engineering technology point of view which could be resolved by efficient insulation, interior climate control and energy conservation methods in residential and commercial buildings. Outside of these ideas, the variability of the sizes and configurations of space as a method of achieving the sustainability of an urban environment is excluded.

2. Theory and method
It is a well-known fact that the vernacular architecture of various climatic zones was contextual, the forms of buildings and the typology of urban spaces corresponded to local climatic conditions. Vernacular architecture was formed during thousands of years by trial and error and has always been context-conscious and environment-dependent – complying with the requirements of the climate, terrain and natural resources at inhabited area by humans for centuries.

Today when planning for the resources saving and creating the thermal comfort of a sustainable urban environment, we can use the properties of urban spaces, landscapes and single buildings external
and internal forms to change the wind and insolation regime. Similarly, the introduction of renewable energy engineering systems into the architecture of buildings and the urban space limits on the shape of buildings and space to increase the effectiveness of these systems [11].

The placement of green systems, including systems based on photobioreactors (algaetecture) on facades, roofs and in the interior of buildings, should also take into account the need to create normal conditions for the vegetation of for the vegetation of plants and microalgae. Which also affects the shape of the buildings, which must provide these favorable conditions. Water sensitive urban design is also impossible without transforming the architecture of buildings and urban spaces [8, 14].

So, in general, the restoration of the source ecosystems lost during the urban development of the territory is due to the formation of spatial cells that are friendly to the elements of an ecosystem. The space of the city should not only be adapted to the needs of its residents, but equally to the elements of restored ecosystems [9]. Thus, to ensure sustainable development, education and research in sustainable architecture has to be focused on studying the principles and ways of forming an “ecologically-dependent architectural space” [3] by looking into the peculiarities of its development in the context of regional conditions.

3. Structure of the educational program and research

It can be suggested that the structure of the ecologically dependent architectural space education and research should be as follows:

1. Principles and methods of forming a climate-oriented architectural space (passive solar architecture, entry level): Analysis of annual wind and insolation changes, levels of precipitation and humidity; researching the possibility of adapting to them using architectural means, e.g. by changing the geometry of open space and volumes, applying the bioclimatic landscape design, rationalizing the exterior envelope design, and interior space-planning solutions.

2. Architecture and renewable energy engineering systems interconnection: Dependence of the building and space architecture on integrated active and passive systems by utilizing renewable energy sources. Primarily, solar power for domestic hot water and heating supply, photovoltaic systems and wind power generators; performance of these systems is often directly correlated to the chosen architectural solutions.

3. Green systems in architecture: Study of peculiarity of indoor and outdoor vegetation systems of buildings, including city farms, photobioreactor-based systems (algaetecture). First off all, dependence of the building form on the selected method of vegetation in local climate are considered. Architecture of buildings is viewed as a means of forming a comfortable microclimate for outdoor and indoor vegetation systems and the feedback should also be taken into account.

4. Transformable architectural form and adaptive landscape design: The possibilities of architectural form and landscape design are being investigated as a means of ensuring the sustainability of the urban environment to the dynamics of weather and climatic conditions, including based on forecasts of global climate change.

5. Integrating natural ecosystems urban design (graduate level): Methods and techniques for transforming the architecture of buildings and urban spaces in order to restore the original natural ecosystem or its individual elements. Including both the basis of ecosystem restoration in the urban environment, the methods of Water Sensitive Urban Design, and the methods of ecological renovation of the marine littoral zone, should be taken into account.

4. Experience and results

The practice of studying the basics of sustainable architecture and urbanism over 25 years has made it possible to draw some conclusions [3]. Initially, the basics to this course were introduced in 1992-99 and explained the specifics of the monsoon climate in the south of Russian Far East at middle latitudes. Specific characteristics include a high contrast of the horizon sides, microclimate features of the indoor and outdoor spaces depending on the direction and intensity of climatic factors [4] (Fig.1). In the Southern part of the Eastern Russia, the academic process also has to consider the fact that the vernacular
architecture of the tribes that used to inhabit Primorye, Primur'ye and neighboring regions of Manchuria was almost erased by the Mongolian invasion about 600 years ago. In 19th century Russian pioneering explorers and settlers didn’t consider the distinctive features of the local climate and relied on the construction principles and techniques typical to the European part of the Russian Empire. Therefore, the lecture part of the course focuses on the theoretical fundamentals of modeling a comfortable architectural environment influenced by the vector and related climate factors.

Design of “simple” bioclimatic form (section 1) – a solar pergola-solarium for a daycare remains as a basis for the introductory part of a series of course labs. A minimal functional load of the form allows students to concentrate on studying the possibilities of regulating the summer and winter insolation and wind patterns. Currently, the students have switched from physical modeling to 3D modeling and further studying of its characteristics via simulators of insolation and wind using the student version of Flow Design Autodesk software. Developing project requirements in 1990s, the author used the principles suggested by A.V. Yakovlev [15]. The assignment “Sun Clock Square” is a simplified version aimed at consolidation of the knowledge of the annual solar coordinates (Fig. 1).

Figure 1. Modeling of the architectural form taking into account the annual course of the wind and insolation regime - from simple to complex.
Project “Country Townhouse” or “Passive solar eco-house” exposes students to the potential of the greenhouse effect for the Primorye region and integration of active solar and wind systems into residential building design (section 1, section 2) (Fig. 1, 2). As much as possible, project design development is complemented with field trips. These days it is a competed single-family Solar SB dwelling with passive solar heating, built between 2014-2016, which was the first eco-house in Russia of straw bale “Ecococon’s” construction with passive solar heating. However, 2007-2009 Prototype Build Program for academic and research purposes was not fully realized due to the reorganization of the FEFU, which resulted the first built experimental Eco-Module Solar-5M being located in a remote area unreachable to the students.

*Figure 2. Study of the impact of climate on the architecture of low-rise buildings (Oksana Gubanova).*
Study of vegetation systems as part of public buildings was partially resumed in the “Green Retail Mall” and “School” design (section 3). Integration of the “urban farm” is one of the project requirements. Experiments of young instructors of “Green design studio” allow students to study design characteristics of “urban farms” in the region. The assortment of plants for the formation of green systems in the architecture of southern Primorye is also studied by Alexandra Shiyan [10], (Fig. 3).

**Figure 3.** Urban farms - a hypermarket farm design (Alexandra Kolomoets) and experiments on the FEFU campus (project “Tochka rosta” by Egor Van Ho-Bin, Yana Marus, Ekaterina Frolova, Daria Burdina).

In 2005, Project “Ecological Tower” was introduced into the 5th year of Environmental Design Program – a high-rise energy-efficient building located in city’s downtown (section 3, partly section 4). The original idea by Ken Yang [13] was chosen as a methodological foundation for this project. A similarity of climate conditions (monsoon of Eastern Asia) combined with a dramatic latitude difference (between the tropical area and moderately-cold Primorye) allowed students to find common features in the architecture of the Primorye region without replicating Yang’s ideas, thus encouraging them to develop their own creative side. In addition to the information on passive and active solar systems and windbreak methods, the students studied the methods of vegetation in the urban environment and integration of rainwater collecting systems into their design solutions (more than three months of fogs and wind-driven rains in the region). The problems and possibilities of collecting atmospheric moisture in the region were experimentally studied at the meteorological station “Busse hill” [2].
Figure 4. The concept of the ecological skyscraper of Ken Young in a temperate monsoon climate (Ekaterina Movchan and Maxim Malygin).

A greater proportion of residential and urban design in the 4th year of study and among graduates, allow a deeper study of the peculiarities of forming a sustainable living environment in the regional context (sections 1 to 5). According to the principles of ecological urbanism, a comfortable urban environment for residents is formed primarily through the preservation and restoration of the original natural context, and the inclusion of natural systems in the urban environment \[9\]. It is this approach that ensures the stability of the anthropogenic environment to weather and climate changes, provides citizens with clean water and air resources, and contributes to the formation of a favorable temperature and humidity microclimate of buildings. The basis for the formation of a sustainable model for the development of the urban environment, with natural systems integrated into the space of the city, is the restoration of the hydrological cycle close to the natural one in an urbanized area \[14\]. Therefore, the main attention in this case is focused on the study of water sensitive urban design and related concepts, as well as the concepts of renovation of the littoral marine zone \[2,5,7\].
In these projects, section 4 remains the least studied. So, the methodology of the architecture transformable according to the seasonal and daily course of weather elements and the dynamics of climate change still needs to be developed. Preservation of the unique city landform, the use of renewable energy sources and building materials, development of urban farms, provision of social sustainability - is also included in the range of assignments solved by students in course and graduation projects (Fig. 5.1., 5.2, 5.3.).

5. Discussion

Inclusion in the design tasks of the requirements for the formation of a resource-saving environment significantly increases and complicates the range of tasks to be solved in the training project. And, while maintaining the previous evaluation criteria, green projects often lose to classical course and diploma work. It must also be taken into account that these requirements for the formation of a sustainable environment are not included in the compulsory curriculum of architectural design. One of the obvious outcomes is the need for a specialized educational program “sustainable architecture and design” in a higher architectural school. Perhaps the basis of such a program should be one of the green standards, such as the most attentive to the requirements of the integration of natural ecosystems Living Building...
Challenge certification [5,12]. The results of inclusion of “sustainable projects” in the standard curriculum are limited to successful projects of the most talented students, and do not give a permanent and obvious positive result for all participants in the “green course” now.

Figure 5.2. Water Sensitive Urban Design for Diomid bay, general view (Marija Surova).
Figure 5.3. Regenerative architecture for urban river renovation, general view (Yana Marus).
6. Conclusions
In the standard program of architectural education, the requirement to form an ecologically dependent architectural space can be considered no more than an optional or optional burden of the project. Whereas today it is more than obvious that space of the city should not only be adapted to the needs of its residents, but equally to the elements of restored ecosystems. The experience of implementing the standards of green architecture in educational design showed that, while maintaining the current criteria for evaluating student projects, environmental education in an architectural institution cannot go beyond the scope of the experiment. While the five-step sequence of sustainable spaces study can be recognized as noteworthy.

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