Integration of Recreational Spaces into Living Buildings
Considering Ecological Aspects

I V Zhdanova¹, N A Kalinkina¹, I V Chernysheva¹

¹Architecture of Residential and Public Buildings Chair, Academy of Architecture and
Civil Engineering, Samara State Technical University, Molodogvardeyuskaya str., 194,
Samara, 443001, Russia

E-mail: zdanovairna@mail.ru

Abstract. The main goal of this article is to explore the modern approaches to solving
problems of energy saving and environmental pollution by introduction recreation areas to
the residential buildings. Reviewed the popular elements of green building - green roofs
and vertical greening in residential buildings. Also, identified the advantages of greened
roofs, studied the different types of roofs and various types of plants. The author considered
vertical gardening and constructions (such as – suspended systems, modular lattices, metal
mesh). The examples of foreign houses using vertical gardening confirm this type of
landscaping as a unique. They can create new favorable spaces in an urban environment.
So we can conclude that using of green roofs and vertical gardening is very relevant
nowadays. They make urban accommodation more comfortable, increase aesthetic conditions of urban
environment and they have good effect on human health.

1. Introduction
In connection with the industrialization of society, urban growth, population growth and the
development of all modes of transport, the energy saving problem has become very actual. The
population growth in urban areas leads to consolidation of buildings, which affects the comfort of
human habitation [1-5]. The development of all kinds of transport causes the environmental pollution.
The total volume of emissions in 2017 is 32.1 million tons. 17.5 million. tons emitted by stationary
sources (neperevodizhymi technological units) and 14.6 million tones - mobile sources (road and rail)
[6, 7]. One of the most rational way to solve the problem of environmental pollution is the use of
recreational spaces. The number of recreational spaces decreases in modern cites. That is why we must
search the new ways to create green spaces. They reduce air pollution and have a positive effect on
energy efficiency [8, 9]. The modern technology creating and restoring recreational areas can change
the ecological situation. Compensate for the lack of recreational spaces in cities can, for example,
 impose on the roofs of houses, as well as vertical greening [10, 11]. Currently, these types of
landscaping become an increasingly popular element of ecological construction.

2. Materials and methods
At the beginning of the 21st century the environmental problems and gardening of recreational spaces
become very topical. This article is based on the works of Barsova P.v., Bragina V.i., Vergunov A.l.,
Virsing In A.a. Voronin, Gollwitzer, Zhdanov, I.v., Kvasov V.a., Nefedov, A.f., Novikov N.v.,
Maximov, O.g. Merzhanov B.m., Meshcheryakova S.y., Mikulina E.m., Ozhegov S.s., V.a. Rudakov, Symonds, J., Sirocinskaja As, Titov N.p. Introduction of the design and construction methods of integrating recreational spaces in residential buildings will improve their consumer properties, improve environmental quality and raise comfortable conditions in buildings. This research has some tasks: to summarize the international experience of formation of recreational spaces in residential buildings with consideration of use in cold climates, to reveal the architectural planning methods of organizing recreational spaces. The subject of study in this article becomes the methods of greening in residential houses.

3. Results

Roofs covered with plants or green roofs were used in antiquity. In Scandinavia there was a tradition to cover roofs with grass or turf. The structure of green roof has several advantages. Firstly, in winter a green roof acts as thermal insulation, it does not let the ceiling freeze due to the additional layers. Secondly, roofs can warm up to 50°C in summer, but vegetation lowers the temperature, thus the temperature in dwellings also gets much lower. Thirdly, a green roof possesses a good sound insulation. Fourthly, a green roof absorbs moisture rather effectively. More than 60% of rainfall evaporates into the environment, the rest 40% is absorbed by the roots of the plants. And finally, plants on a green roof produce oxygen and serve as a rest place [11]. This creates comfortable and aesthetic conditions for life saving charges on electricity and central heating.

Nevertheless, green roofs have got some disadvantages. The weight of a green roof makes additional loading on the construction which needs to be considered before the beginning of the installation. A high level of humidity is created, this demands some additional waterproofing before the installation of a green roof. Microorganisms, chemical substances and the root system affects the waterproofing material. The selection of definite plants and their cultivation in special conditions are needed.

There are two types of turfs: extensive and intensive. With extensive green turf the size of a plant cover varies from 30mm for moss and 150mm for a lawn. The following kinds of plants are used: grassy and those which cover the ground (stonecrop, sedum, thyme, rejuvenate, meadow grass, fescue, plantain, cerastium, saxifrage, cloves, crocus, daffodil, scylla, muscari and others). Intensive turf lets plant little vegetation as well as bushes and trees. The necessary size of the cover for vegetation planting makes 150mm, for bushes it reaches 1 metre [12]. Types of plants for intensive turf are trees and bushes (maple ginnala, tatar maple, silverberry, short quince, rowan tree, cranberry high, Tunberg barberry, low birch, common hawthorn, white dogwood, Canadian spruce, prickly spruce, fir spruce, table-mountain pine, white cedar, horizontal juniper and others). One of the methods of building greening can also be by placing flowerpots with plants onto open terraces. Vertical greening is planting vegetation on vertical surfaces with the help of various constructions – hanging systems, modular arrays, nets made of metal ropes. Building greening has assumed recognition and is spread worldwide, even in countries with cold climate where plants can lose their aesthetic attraction in winter. Thus, it is especially relevant to use green roofs and vertical greening in a city with a lot of buildings.

The research is limited by considering international experience of green roofs structure and vertical greening in inhabited buildings. 10 previous years were taken into consideration. The usage of various technologies of the green environment restoration are offered for examination. They are situated on definite constructions abroad in moderate climatic zone or judging by natural conditions are close to moderate climate with winter temperatures below 0°C.

For example, the effect of unification of a national park with an inhabited building of a variable number of storeys is 79&Park (Swiss, Stockholm, arc. BIG, 2018). The construction was built in moderate sea climate where temperatures go below 0°C in winter. The cellular structure of the house lets each flat have its own open green terrace made by intensive type where planting of trees and little bushes is available (figure1A) [13].
One more example of a house of a variable number of storeys with an inner yard and a view of the bay is Sorenga Block 6 (Norway, Oslo, arc. MAD arkitekter, 2015) built in moderate cold climate with winter temperatures up to -5°C. The inclined structure supposes that each flat has got either a balcony or a glassed recessed balcony. It can also be a green terrace. Lean-to green turf was constructed by the extensive type (figure 1B) [14].

One of the examples of using vertical greening with the help of hanging structures is House 152Elizabeth (USA, New York, arc. Tadao Ando, 2014). The construction is built in humid subtropical climate with an average temperature of -2°C in conditions of tough building. The building represents a house-insert. The biggest green wall in New York with the size of 17 metres high and 30 metres wide covers the total of the southern front part (figure 2A). Vegetation for planting in hanging flowerpots were selected considering changes during the whole year, for example, English Ivy, Virginia Creepers, Jasmine Clematis and Climbing Hydrangeas [15]. The inclusion of vertical greening in modular arrays is used in House Upper Eastside Townhouse, (USA, New York, arc. Michael K Chen Architecture, 2017). The blocks of vegetation consist of various local forest plants, the usage of which is agreed with partnership of botanists SUNY. Some plantations are under the threat of disappearing because of climatic changes, they are used in blocks of vegetation for the first time with the purpose of their spread in gardening as an experiment (figure 2B). On the roof exploited there is always a rest zone for inhabitants with intensive greening of the turf and flowerpots in which small trees grow [16].

Figure 1. Examples of roofs of residential buildings (A-intensive type B-extensive type).

Figure 2. Examples of vertical greening of residential buildings (A-hanging systems. B-modular lattices).
The usage of vertical metal ropes on which vegetation is held can be examined taking as an example apartment complex Stadthaus M1 (Germany, Freiburg im Breisgau, arc. Barkow Leibinger, 2013). The apartment complex was built in conditions of moderate climate, in winter the temperature does not go under -4°C (figure 3).

One of the most important tasks of the complex was to realize the architectural concept with energetic standards. Solar batteries were installed on the roof of a house for energy saving. The heating and conditioning of air is realized through integrated waterproof tubes. Thus, the coefficient of the heat loss has decreased by 30% in inhabited placements. Low technological facades save energy as well as charges. Vertical metal ropes on the southern part are installed. Active vegetation grows on them giving shade in summer months. Two types of plants are mainly used: climbing rose and grapes. The ropes do not touch the facades that does not let the plants destroy building materials [17].

![Figure 3. Example of using vertical steel cables.](image)

The analysis of the leading world experience of designing and construction of living complexes has demonstrated that the usage of the green turf and vertical greening finds its application in different climatic zones, even in moderate climatic zone and close in natural conditions to the moderate climate. Herewith the decrease of winter temperatures below 0°C is not an obstacle for the use of building greening as special plants are selected. They are resistible to winter temperatures taking into account changes of the exterior during a year.

4. Discussion
This research has revealed the main techniques of greening in residential buildings in cold climates - intensive and extensive type of roof construction, vertical greening using suspension systems, modular lattices and metallic cables (with the active use of the climbing roses and grapes). The analysis of the theoretical framework and international experience of formation of recreational spaces allow to compile and systematize the basic techniques that improve environmental properties. This provided an opportunity to highlight the method of "environmental improvement" used to improve consumer properties of a residential building, environmental qualities, comfort level living and improve the architecture of the buildings. This method aimed at developing energy and eco-efficient solutions and based on respect for the principles of urban development. The main directions are: environmental improvement – the use of savings and an increase the number of natural elements in the structure of the building, the use of alternative energy sources on the roofs and facades; recycling- the accommodation spaces for installation the resource reuse system (figure 4).
The results of this research can be used in the experimental design and in the preparing of tasks for students. This article shows that the use of recreational spaces in residential buildings makes it possible to create a comfortable environment, increases the attractiveness of the cities, and has a fine effect on human health.

5. Conclusions
So, in modern cities, the accommodation of green spaces in residential buildings improves comfort and environmental performance of apartments [18-20]. And also they optimize the urban organization, functional, microclimatic options of entire cities. The use of green roofs and vertical gardening in modern Russian constructions based on the experience of foreign countries.

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