Reorganization of industrial territories in the context of urban development

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Abstract. The area of Saint Petersburg is about 144,000 hectares, industrial areas occupy 24% of urban lands. The historical center of the city is surrounded by the so-called "gray belt", which is a zone of industrial enterprises that are unsuitable for further use for their intended purpose and that have come to an emergency condition. It was formed in the following way: enterprises were moved to the outskirts of the city, and when the development of the residential zone within the "belt" became impossible, urban development continued beyond its borders. This type of industrial development is typical of most large cities over 200 years old. Many foreign cities and towns of Russia, to varying degrees, have faced the problem of reorganizing such territories. St. Petersburg continues to develop and accept new residents, but it needs an urgent transition from extensive growth to building a model of sustainable urbanization and improving the quality of infrastructure. The purpose of this work is to provide research results that consider the effectiveness of methods for reorganizing industrial areas in urban development by the example of one of the buildings of the "gray belt". The research object is located on the territory of a residential area under construction. The results of the project showed the effectiveness of greening the roof and facade of the building in order to increase its energy efficiency, reduce water consumption and compensate for insufficient gardening at home (this problem is especially relevant for the central districts of the city).

1. Introduction
The issue of reorganizing industrial territories in an urban environment will become more urgent every year. In this regard, the greatest interest in Saint Petersburg is caused by the so-called "gray belt". A significant number of pre-revolutionary and Soviet industrial buildings in Saint Petersburg did not find new use during the post-industrial development. Now, it represents the territory of abandoned and unused industrial facilities surrounding the historic center of the city [1]. There is a constant replacement of "green", recreational areas on the territory of apartment residential buildings without a suitable infrastructure. The city needs an immediate transition from extensive growth to building sustainable urbanization models.

The aim of the study is to formulate proposals for the reorganization of an industrial building, located in the Moskovsky district of Saint Petersburg, taking into account the environmental aspects. The object of study is a 19th century gas-holder (currently Planetarium No. 1), located on the embankment of Obvodniy Canal and being part of "the gray belt". The relevance of the research topic depends on the lack of systematic approach to the processes of old industrial territories reorganization.
and sustainable urbanization in general, and also on the absence of practical recommendations for compensatory greening of urban spaces due to a lack of free territories [2].

A great number of industrial architecture monuments are located in the northern part of the Moskovsky district. The main interesting objects are the refrigerator of the cold storage facility of “Ice Manufacturing Plant”, and the group of gas-holders of the “Capital Lighting Society”.

The “Capital Lighting Society”, which owned the wet-type gas-holder complex, provided the city with gas for street lighting in the 19th century. The complex consisted of four towers that were erected in the period from 1858 to 1884. By the end of the XX century gas-holders were used as storage facilities, and in the main gas-holder there was a temporary parking lot. Since the spring of 2019, Planetarium No. 1 has been located in the main gas-holder, which is currently the largest private, commercial planetarium in Russia. The Planetarium hosts exhibitions of movie series about space by Yota Lab specialists (the open laboratory is located in a historic building beside), organ concerts, an ice rink on the territory of the remaining three gas-holders, scientific and cultural events, and a multimedia projection art museum.

2. Environmental certification

The renovation of industrial structures should be carried out not only for the rational usage of urban areas but also taking into account the impact on the environment, consumption of natural resources, and the influence on human health. This direction in construction is called "green building". The tool for the introduction, dissemination, and maintenance of the quality of the green building is the environmental certification of buildings and constructions. Thus, the first proposal for reorganization of the object is the environmental certification in construction. The most acceptable option for an object is standardization according to the BREEAM International In-Use system due to the fact that the assessment system is applicable to various types of buildings at different stages of the life cycle. Moreover, it has a scheme for adapting the regulatory documentation of the Russian Federation, has more flexible rules for preparing reporting documentation for compared with the equally prevalent LEED system, and adapts to the socio-economic conditions of the country [4].

The second proposal for the reorganization of the object was roof greening, which allows solving the problem of compensatory planting in conditions of a lack of free urban spaces. According to BREEAM In-Use [5], the reorganization is assessed in 9 main directions. Roof landscaping is an added benefit to certification and gains points in areas such as “Health and Wellbeing”, “Energy”, “Water”, “Resources”, “Resilient”, “Land Use and Ecology”.

3. Extensive roof greening

As part of the environmental certification, a project of extensive roof greening was prepared in more detail.

An extensive green roof is a roof with additional layers of special soil substrate and planting material. Access to the extensive roof is not provided for visitors. This type gives a minimum load on the building structure (the average value of the load on the building structure with an extensive type of roof greening is around 170 kg/m² then with an intensive type − 350 kg/m²).

On the top of the roof structure, in that case on rubberoid, the following layers are sequentially laid: anti-root protective film, moisture-accumulating mat, anti-slip protective mesh, to which anti-slip thresholds, special soil substrate, and ground cover plants are attached. Also, gravel fill protects the structural elements of the roof from vegetation germination. Due to the complex configuration of the domed roof, the standard set of layers for roof greening had to be modified. For the further estimate of green roof construction, recommendations from the Sayan Group were used. The company is a certified representative of the German company Optigrün in Russia [6]. The estimated limiting weight of the system with the maximum water content is 100 kg/m². The shear load is transmitted through the mesh and is applied to the top of the dome. The drainage system is carried out by waterproofing the roof into the gutter.

It is recommended to use various types of sedums as planting material for extensive gardening. The
main advantages are drought resistance, undemanding to the soil, frost and wind resistance, as well as decorative properties. Various cereals and mosses are also used for extensive landscaping. For the conditions of Saint Petersburg, the following species were selected: Sedum acre "Minus", Sedum album "Coral Carpet", Sedum spurium "Purple Carpet", Sedum kamtschaticum "TakahiraDake", Sedum floriferum "Weihenstephaner Gold", Sedum middendorffiana, Sedum ewersii var. haplophyllum "Rose Carpet", Sedum sexangulare, Saginasubulata (Irish moss).

Green roofs promote a building's energy efficiency [10, 11]. At the moment in the Russian Federation, there are no methods for calculating the effectiveness of roof greening. The most significant environmental and economic benefit factor is improving the energy efficiency of the building, as evidenced by the weight of the regional Energy criterion of the BREEAM technical guidance and the focus of tax incentives from the state. GOST R 58875–2020 [7], which is the main governing document in Russia for the construction of green roofs, takes into account only empirical evidence of environmental benefits. The calculation of the increase in energy efficiency was made according to the methodology specified in the regional methodological document “Recommendations for ensuring the energy efficiency of residential and public buildings” [8] and the set of rules “Thermal performance of the buildings” [9]. The calculation is based on the increase in the heat transfer resistance of the building after extensive greening of the roof. At the same time, climatic and energy characteristics were taken into account as initial data to ensure energy efficiency requirements in the design, construction, and commissioning of public buildings on the territory of Saint Petersburg.

Results showed that heat loss through the roof of the gas-holder is 28168,572 kWh/year. Total thermal resistance of the gas-holder roof layers is 7.119 W/m² · °C and after using extensive greening – 7.277 W/m² · °C. The heat loss of the building through the roof after greening will decrease by 20.65%. The annual energy savings after greening the roof, which can be calculated without an energy audit, is 5210.45 kWh annually.

4. Results and discussions

The proposed method does not contradict the existing Russian regulatory documents and complies with foreign environmental standards in the field of construction and maintenance of buildings. Even taking into consideration that the object is a monument of history and culture, all actions for its reorganization are regulated by Federal Law No. 73 [3]. Any work concerning the object can be carried out upon providing evidence that they are necessary for its preservation and reconstruction and obtaining permits from the Committee for State Control, Use and Protection of Historical and Cultural Monuments. Moreover, technical, author's, state supervision in the field of protection of cultural heritage objects is carried out over their implementation.

Requirements for environmental impact assessment of capital construction project documentation are mandatory. There are also requirements to reduce energy consumption for newly created buildings and structures. Otherwise, the environmental certification of buildings and structures is a voluntary initiative and does not have significant financial support or impact from the government.

For this project, a SWOT analysis was carried out, which demonstrates the sustainability of the project, risks and opportunities. The main risks include:

1. negative impact on the vegetation layer and the roof structure of environmental factors;
2. disruption of the functioning of the green roof due to a disturbance of construction technology, errors in construction calculations, improper selection of plant material and uncorrected planting care throughout the entire life cycle of the green roof;
3. changes in the legislation in the field of construction, ecology, protection of cultural heritage landmarks;
4. dependence on foreign policy conditions (for example, restriction on the supply of foreign equipment, the imposition of sanctions), since the equipment and most of the raw materials are foreign manufacturers.

Risks will be minimized by:

1. elimination of errors in construction work or installation technology, carrying out a calculation
of the load;
2. take into account the structural features of the building (outlet to the roof of air exchange systems), its location relative to the cardinal points and adjacent buildings;
3. avoiding saving money on the substrate (do not use simple soil), selecting a substrate with a low carbonate content;
4. use of moisture-collecting drainage mats instead of cellular drainage layers;
5. use of disease-resistant plant species. Avoid planting plants in large "spots";
6. fulfillment of all labor protection requirements provided for when working at height (provide employees with all necessary individual protection means).

Conclusion
Environmental certification in construction makes it possible to assess not only the impact of a building, structure or territory on the health and well-being of its users, but also its impact on the urban environment from the standpoint of environmental factors. With BREEAM certification, an object at all stages of its life cycle is considered as part of the overall urban structure, and not as an isolated object. At the same time, the project for the environmental certification of the building and the greening of the roof will pay off to a greater extent by attracting foreign investors, advertising and reducing the operating costs of the building.

The main social and environmental positive factors of the roof gardening project are:
1. Compensatory greening and building energy efficiency.
2. Reduced heat loss in the building.
3. Reduced noise pollution.
4. Reducing the load on the storm sewerage and preliminary treatment of storm drains.
5. Increased service life of roofing elements.
6. Improving air quality, maintaining biodiversity.
7. Reuse of urban land previously occupied for some construction.

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