Green Technologies in Production and Construction

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Abstract: It is believed that the main cause of global warming is technological progress. Technospheric human activity leads to an increase in the content of greenhouse gases in the atmosphere due to the increasing combustion of fuel, which is a factor that increases the temperature. Climatic anomalies provoke social cataclysms. The most important task at the present stage is to reduce global risks and improve people's safety. An effective tool to improve the sustainability of the environment is the construction of "green" buildings. This article provides an analytical review of the current focus of work in the field of "green" construction in Russia and in foreign countries. The basic principles of "green" construction, the conceptual foundations of buildings with low energy consumption are considered. It is shown that "green" roofs and "green" facades are important elements in the formation of an environmentally sustainable architecture of energy-saving construction. The problems of increasing energy efficiency during thermal renovation of building facades are considered. The principles of rating assessment in "green" construction are considered. The results obtained are of great practical importance. Systematization and generalization of data on "green" construction allow us to outline further ways to improve the energy efficiency and environmental safety of buildings and structures in solving the urgent problem of increasing the sustainability of the living environment in urban planning and architecture.

1 INTRODUCTION

Starting from 1974, after the global energy crisis, a direction appeared in the world construction practice, called “construction of energy-efficient buildings”, and the scientific foundations for the design of such buildings began to be created quite intensively, which not only have not lost their relevance to this day, but are in demand in which is constantly increasing. Since the 1980s, special attention has been paid to the environmental safety of the home and the quality of indoor air. The following pattern is formulated: among energy-efficient technologies, priority is given to those that improve the environmental safety of the home. Since the late 1990s, the requirements for energy efficiency and environmental friendliness have been supplemented by requirements that protect the environment from destruction (Surowiecki, 2021). The development of "green" standards began in the 90s of the last century. Currently, the number of "green" standards applied in international practice to buildings (design, construction and operation) is several dozen. The choice of assessment criteria, as well as the actual rating assessment of buildings, is different. It is worth noting that they were developed taking into account national characteristics and were initially used in the country of origin, and then began to be used around the world. In technically developed countries, rating systems for assessing the quality of design and construction solutions for buildings according to the criteria of energy efficiency, ecology, comfort, and resource saving have become widespread. Among the most advanced national rating systems, it should be noted the American one - LEED (The Leadership in Energy and Environmental Design), the English one - BREEAM (Building Research Establishment Environmental Assessment Method), the German one - DGNB (Surowiecki, 2021). The relevance of socio-economic and technological factors in the development of "green building" in Russia is beyond doubt. As well as the

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need to create our own national "green standards" and a rating system that meets our regulatory and methodological framework, national priorities of the economy, energy, and the environment, taking into account the significant climatic and resource differentiation of the country's regions.

As follows from the data presented, the scale of the use of digital tools in the framework of the greening of industry remained relatively small in these years. Nevertheless, it is impossible not to note the expansion in all areas of the "green" agenda in the pandemic period of 2020, which has sharpened the issue of environmental friendliness in many activities of manufacturing enterprises. The survey showed that industrial enterprises were most interested in such areas as improving energy efficiency (growth from 17% in 2019 to 22% in 2020), improving the efficiency of water use and raw materials (from 13 to 16%), as well as waste disposal (from 12 to 15%). At the same time, if the last two areas showed average growth rates in 2020 (by 3 p.p., respectively), then the increase in the number of enterprises involved in improving energy efficiency using digital technologies (by 5 p.p.) in 2020 was one of the maximum among all directions. In general, these results indicate that at the moment, from the point of view of greening, the resource component and energy efficiency, along with waste disposal, remain the main priorities in the industry (Evangelista, 2020; Surowiecki, 2021).

At the same time, although the areas related to environmental efficiency were significantly less represented in the sample, they gradually gained popularity. Thus, in 2020, compared to the previous period, the number of enterprises using digital technologies as part of the development of the electric transport fleet increased by 5 percentage points (from 2 to 7%), and the number of enterprises implementing digital technologies increased by 3 percentage points. technologies for creating clean and safe energy (from 4 to 7%). Relatively little attention was paid to improving the efficiency of greenhouse gas and pollutant emissions in 2020 (an increase of only 1 p.p.), however, the scale of development achieved in 2019 (coverage of 6% of enterprises) allows us to place this area of greening in the middle ranking in terms of priority. In addition, technological measures aimed at reducing material consumption (growth from 5 to 9%) can be included in the same group. The least developed area among all those presented should be recognized as the use of digital technologies for the transition to renewable energy sources. In 2019, only 1% of enterprises from the entire sample registered this direction, and in 2020 the number of such enterprises increased by only 2 percentage points to 3%.

The Green Deal is also fraught with very significant challenges for the EU bloc as a whole. On the one hand, the policy of active decarbonization is beneficial for the European Union, since it allows maintaining its international competitiveness in political and economic aspects in the context of global instability and the transition to the fourth technological order. Today, hydrocarbons make up a significant share of the EU energy mix, while the share of renewable energy sources does not exceed 20 percent19. The transition to renewable energy in such conditions will not be possible without a powerful technological and economic transformation. At the same time, it should be noted that the Green Deal implies significant solidarity within the EU and significant investment in the transformation of economies that are most in need of restructuring and cannot afford it. Thus, the states of Eastern Europe will still receive assistance in the implementation of the EU Green Deal. Non-EU countries probably won't have that option. The introduction of a carbon tax could put many Russians in a difficult position. The Boston Consulting Group estimates that if a CO_2 tax is introduced, Russian exporters are likely to lose between $3 billion and $4.8 billion a year if they don't decarbonize their production. This will affect the exporters of rolled metal products, paper and chemical products - it is expected to reduce profits by about half. However, oil and gas and metallurgical companies will have to pay the most in this case, which is associated with large export volumes. According to KPMG's forecast, on average, gas suppliers will incur additional costs of around 1.4-2.3 billion euros per year (Souter, 2019).

2 RESEARCH METHODS

The term "green building" in the generally accepted world practice means such an approach to the design and construction of buildings, structures, as well as the architectural environment, which takes into account the requirements of energy efficiency, resource saving and environmental safety to the maximum. Often people who are not specialists in this field interpret this term literally, and understand the problems of landscaping and gardening, landscape design, etc. by them.

Of course, these are very close and interconnected issues, however, "green building" is a broader concept, it is a new, dynamically developing area of architecture and construction, associated with the

revision of the priorities of modern society in its growth.Currently, in foreign countries and in Russia, the concept of building "green" buildings with zero energy consumption is actively developing. A zero-energy building (ZEB) is a highly energy-efficient building capable of producing energy on site from renewable sources and consuming it in equal amounts throughout the year. If the amount of energy produced is less than the energy consumed, such a building is called a near zero-energy building (nZEB). The choice of an indoor thermal comfort model to establish optimal humidity conditions has a significant impact on the energy consumption of zero-energy buildings in hot climates.

In 2013, the first office building with zero energy consumption was put into operation in Germany (Souter, 2019; Braverman, 2019). The two-storey building is located in Berlin and is designed in such a way that the total annual energy consumption is lower than the receipts from renewable energy sources. The actual total annual consumption of electrical energy is close to the design data. However, monitoring of the building showed a significant discrepancy between the expected and measured values of electricity consumption for individual indicators: for heating and hot water supply (+172%), ventilation (-36%), lighting (-33%), engineering equipment and auxiliary needs (-14 % and -13% respectively) (Korchagina, 2019). To investigate the causes of these deviations, as well as to further improve the energy performance of the building, a numerical model was developed, calibrated in various ways. The average systematic error between observed and simulated energy performance is less than ±2% for all considered energy uses. According to the results of observations and modeling, a good agreement was established, both in terms of the energy needs of the air conditioning system, and in terms of changes in the air temperature in the room during the heating and cooling periods of the year. The identified deviations in the consumption of electrical energy are mainly related to the characteristics of the building under study and the behavior of people. The results obtained allow us to propose measures aimed at further reducing the energy consumption of buildings.

An important element of the heat-insulating shell of a "green" building is the "green" roof (green roof). This is a multilayer enclosing structure, consisting of a reinforced concrete roof slab (with a cement-sand mortar ramp), the main layer of a waterproofing carpet, thermal insulation from extruded polystyrene foam boards, a separating layer of geotextiles, a drainage and filtering layer, a soil layer, a plant layer. Depending on the type of vegetation layer, roof gardening can be divided into intensive and extensive. In intensive landscaping based on the use of tall plants with a developed root system (roof garden), a massive soil layer up to 1 m thick may be required; such a roof requires, as a rule, constant care by gardeners. Extensively green roofs, on the other hand, do not require systematic maintenance, and a minimum layer of soil or compost is required to accommodate plants. Compared to "intensive" roofs, "extensive" roofs have a simpler design solution (Gakaev, 2020).

The construction industry has great potential to protect the environment and improve the comfort and well-being of people. The concept of sustainable development meets the three main challenges of our time - improving the quality of human life, saving the planet and generating profits. As a response to these challenges, one of the tools is a special approach - life cycle analysis. According to the concept of sustainable development, at each stage of the existence of a building: design - construction - renovation, the comfort and well-being of people should be improved, the consumption of natural resources, including electricity, should be minimized, damage to the environment should be reduced, and economic efficiency should be increased.

The nature of the project. Buildings and their construction are the activities that worldwide account for the largest share of the use of natural resources and the emission of pollutants into the atmosphere. It is known that in developed countries, the construction and operation of buildings are responsible for 25-40% of the use of the total amount of energy consumed, up to 30% of the use of raw materials, up to 40% of global greenhouse gas emissions and up to 40% of solid waste production. The demand for green buildings is on the rise, and this is especially evident in the growing number of eco-labeled materials in building construction around the world. The number of certified square meters under green building programs has increased markedly over the past 10 years. Standards, policies and regulations are developed using a building life cycle analysis, from the extraction of raw materials to the demolition of a building and its recycling of its components. The construction industry as a whole is restructuring towards increasingly sustainable building methods.

3 RESULTS AND DISCUSSIONS

At the moment, Russia is facing not only such traditional challenges as the need to diversify the economy and reduce dependence on the commodity

sector, but also the downturn in global business activity due to the COVID-19 pandemic and the accompanying fall in demand and prices for fossil fuels, which may become long term. Also, some of the world's major economies, including neighboring countries, are beginning a large-scale transformation of their economic systems in response to the global climate and environmental crises. In the absence of a timely and appropriate response to these events, Russia risks increasing its economic and technological gap with the world's leading economies (Vladimirov, 2019). How Russia will emerge from the COVID-19 crisis will largely determine the trajectory of its economic development in the coming years or even decades. Since the start of the pandemic, dozens of civil society organizations, corporations, and even ministers from the world's leading countries have presented their vision of a way out of the COVID-19 crisis. The vast majority of these statements contain a call to stimulate the economy through the development of green sectors. The European Union remained committed to the European Green Deal announced before the pandemic and continued to develop it, and also decided to support green sectors as part of its anti-crisis policy. China, Japan and South Korea have pledged to set official targets for carbon neutrality by mid-century soon. Elected in November 2020, US President Joe Biden plans to push for a 100% clean energy transition and zero net emissions in the US by 2050.It is known that the effect of "heat islands" in an urbanized environment is due to higher temperatures of the outer surfaces of buildings, in particular roofs. The installation of "green" roofs contributes to the equalization of the temperature on the outer surface and a significant reduction in energy consumption. The authors of the article (Molchanova, 2019) Y.-Y. Huang, C.-T. Chen, Y.-C. Tsai assessed the effect of hydroponic coatings of "green" roofs on the amplitude of temperature fluctuations and heat flow. (Hydroponics is a method of growing plants in artificial media without soil.) Factors such as the thickness of the water layer, types of plants and nutrient medium were studied. The experiments were carried out in Taichung, the third largest city in Taiwan, in a subtropical climate. The results showed that to ensure efficient operation of the hydroponic cover, it is sufficient to have a layer of water about 10 cm thick. The combination of vegetation and hydroponic cover leads to a decrease in temperature on the roof surface by 3–5 K, while the amplitude of the heat flux fluctuation decreases by 16% compared to roof without vegetation. The type of plants does not affect the amplitude of temperature fluctuations and heat flow. It is shown that the application of a solid hydroponic cover is more difficult in terms of installation and maintenance of the roof system. "Green" roofs are an effective way to increase the green area in the urban environment and improve the microclimate of buildings. The article (Egorova, 2020) (authors Y. He, H. Yu, N. Dong et al.) studied the thermal and energy characteristics of an extensively green roof in an unconditioned and air-conditioned building in Shanghai, a coastal city with hot and humid summers. The experiment was carried out on two full-scale models of the building premises. One room had a green roof covering, the other a standard covering. The results show that when exposed to solar radiation, the green roof has the greatest cooling effect. Soil moisture content has a significant impact on the energy balance of a building. In recent years, "green" building coatings have become increasingly popular due to the clear environmental benefits. The authors of the article (Meckling, 2020) X. Tang and M. Qu, based on experimental studies and numerical simulation, assessed the energy characteristics of "green" roofs in cold climates. The test bench was located on the rooftop of Schleman Hall on the campus of Purdue University in West Lafayette, Indiana. The stand was equipped with a recording device and sensors for measuring soil temperature, moisture content, etc. The experiment consisted in determining the thermal characteristics of a "green" roof in a cold climate and assessing the effect of phase transitions of moisture in the nutrient medium of the coating on thermal characteristics. This article provides new insights into the process of moisture phase transition in green roofs and its impact on the thermal performance of the structure (Molchanova, 2019; Egorova, 2020).

Green roof structures are widely used for energy saving purposes in many countries with different climatic conditions. The scope of their application in heated and cooled buildings is highly dependent on the design features and the outdoor climate. In particular, an increase in the thermal storage capacity of "green" roofs compared to traditional roofs is shown. The authors P. La Roche, U. Berardi in the article (Korchagina, 2019) explore the energy saving potential of "green" roofs with "variable insulation strategy". Four examples of insulated traditional roofs, non-insulated green roofs, insulated green roofs, and variable insulation green roofs were studied over the course of several years in hot, dry climates with mild winters. The results of the study showed that the use of "variable thermal insulation" is more effective. The color of the coating has a great influence on the thermal regime of roofs. Recently,

"white" (whites) and "green" roofs began to replace the usual "black" roofs (black roofs) in order to mitigate their negative impact on the urban environment. It is shown that in comparison with "black" "white" and "green" roofs provide a significant economic effect. The choice of coating color is based on the preferences of the customer (Mauritzen, 2016). To address global warming, light-colored roofs should be used, which are three times more efficient than green roofs. If local environmental factors are at the forefront, "green" roofs should be used to provide a "natural" urban landscape. Recommendations are given for the gradual reduction of the area of roofs with a dark coating in a warm climate.

4 CONCLUSIONS

In 2020, Russia faced critical economic challenges that jeopardize its further development while maintaining a modern economic model: the limitation of economic activity due to the coronavirus pandemic and the resulting drop in global demand for fossil fuels; a sharp drop in prices for energy resources on world markets, followed by a recovery to lower levels than at the beginning of 2020. According to the forecasts of the International Energy Agency (IEA), the demand for energy in 2020 will decrease by 5%. At the same time, oil consumption will decrease by 8%, coal - by 7%, natural gas - by 3%, and electricity consumption from renewable energy sources will increase by 1%. The main reasons for the positive trends in renewable energy during the general downturn are the low operating costs of RES and the priority access of RES-based power plants to the grid. According to World Bank estimates, oil prices fell by 30% in the first three quarters of 2020. In 2019, a barrel of oil cost an average of $61 (Meckling, 2020; Hibbard, 2019). At the end of 2020, it is expected that its average cost will be $41, and in 2021 - $44. Gas prices recovered after the spring decline, especially in Europe. At the end of October, they were only 5% below the pre-pandemic level. Coal prices remain low - 25% lower than before the introduction of the self-isolation regime. According to World Bank expectations, gas prices will recover in 2021, while coal prices will remain at current levels. Despite attempts to diversify the Russian economy over the past decade, the fuel and energy complex still plays a crucial role in Russia's development. The World Bank estimates that the fossil fuel sector generated about 14% of Russia's GDP in 2018, and fuel provided 52% of the country's total merchandise exports. The share of oil and gas revenues in the federal budget for 2018 was 46%, for 2019 - 39%. For comparison, in 2006 this figure was 47%. The coronavirus pandemic has had a sharply negative impact on the Russian energy sector. In April-May 2020, Russian oil and gas revenues decreased by 43% compared to the same period in 2019; in the period from January to May, the decrease was 30.1%. In the second quarter of 2020, the federal budget had a deficit of 823 billion rubles, for the first time since 2017 (Monasterolo, 2018). The corporate "green" standard was launched in May 2010 after a year of active discussions among industry participants in the preparation process for the Games. This event marks the first attempt at an integrated approach to understanding the sustainability of the construction industry in Russia. All green building advocates and the most influential non-profit environmental organizations such as WWF, Greenpeace, FSC and RuGBC eagerly awaited the release of the standard and also participated in its development. The corporate standard has become innovative due to the fact that it is the first such standard in Russia, and also due to the fact that it covers not only free-standing buildings, but also infrastructure facilities such as roads and railways. The preparation of the standard was carried out with the participation of representatives of environmental and architectural organizations. The working groups developed criteria, analyzed their relevance, and also described the procedure for passing the assessment. The standard, which is currently voluntary, has all the prerequisites to become mandatory. For successful implementation and development, the standard needs to be tested and constantly improved. International environmental standards such as BREEAM have been tested and refined over more than 20 years. Such results in Russia can only be achieved through extensive investment and a long period of time allotted for the process of “running in” the standard.

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