



Research Article

Received: November 10, 2021

Accepted: December 30, 2021

Published: December 30, 2021

ISSN 2658-5553

Economic, environmental, and social benefits of green building

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Keywords:

Green building; Cost savings; Global warming; Energy efficiency; Environmental friendliness

Abstract:

The object of research is the problem of the introduction of green construction. The main economic, social and ecological advantages of green construction are given. Brief explanations and justification of the need for the construction of green buildings are given. **Method.** The basis for the development of a calculation formula for determining the comparative economic efficiency of green construction is based on the method of comparing the total reduced costs, taking into account the factor of their different times and areas of application. At the same time, costs are taken into account in the field of creation and supply of environmentally friendly building materials and structures, in the field of construction of energy-efficient construction facilities and in the field of operation of buildings and structures. **Results.** The conducted research allows us to conclude that the additional costs for the construction of a green building pay off during the first years of operation of the building, bringing considerable profit in the future. And for eco-resistant buildings, plus to the specified economic effect, it is necessary to add a significant improvement in the physiological and social aspects of living in such buildings.

1 Introduction

The society pays special attention to issues of social responsibility and sustainable development. Systems for assessing buildings for their compliance with environmental standards have appeared in different countries. The main purpose of these standards is to provide a formal procedure for assessing the compliance of a building with certain environmental requirements [1,2].

Following green standards implies compliance with a number of aspects: the use of environmentally friendly materials and economical plumbing equipment; the availability of centralized ventilation, air conditioning and climate control systems, dust removal and humidification. The energy saving program is implemented through the use of light sensors and energy-saving lamps, alternative energy technologies, and the maximum use of natural lighting. All this allows you to reduce the cost of water, heat and electricity by 40% compared to conventional buildings [3,4]. Mandatory conditions for environmental friendliness are also landscaping and landscaping of the territory, including landscaping of the roof, separate collection and disposal of waste, maximizing the capacity of parking lots and thoughtful transport accessibility of the building.

Given the availability of natural resources in Russia and their relative cheap-ness, the issue of rational use of energy by the Russian consumer is not as acute as, for example, in European countries, which constrains the spread of energy-efficient construction in Russia. However, over time, the situation will change due to the further increase in energy prices, as well as with the tightening of environmental legislation.

Dergunova A.V., Erofeev V.T.

Economic, environmental, and social benefits of green building;
2021; *AlfaBuild*; 20 Article No 2005. doi: 10.57728/ALF.20.5



At the moment, for most market participants, green construction implies significant initial investments in technology, as well as the use of expensive building materials. In addition, the well-known specific risks of the construction business in Russia, such as the volatility of the ruble, limited access to credit resources, high cost of financing, etc., force investors to choose projects with shorter payback periods instead of projects with significant cash flows in the long term. The average payback period for environmental construction projects in Russia is in the range of 8 to 15 years, which implies additional risks of their implementation, taking into account the existing uncertainty and volatility of business in Russia [5,6].

Nevertheless more and more attention is being paid to green construction, the advantages of which are obvious [7-9]. There are many reasons for the introduction of green construction. A number of them are discussed in this article, brief explanations of the advantages are given.

1. Economic benefits of green construction

Reducing infrastructure costs

Substantial savings on initial costs can often be achieved with green building due to differences in how infrastructure is created. For example, innovative storm-water filtration systems can reduce or eliminate the need for storm sewers and ponds to collect storm water; narrower streets to slow down traffic can reduce the area of paved territory; and grouping buildings on the site can reduce the area of paved territory and the length of sewer and utility networks [3]. For some projects, the savings on infrastructure are so significant that they can offset some of the other higher costs of green construction.

Reduction of material consumption and savings on the disposal of construction waste

Designing smaller, more compact residential buildings and other buildings can save a significant amount of materials [10-11]. Disposal of construction waste was once an almost insignificant component of construction costs, but in many regions it has become significant. Since the amount of construction waste is generally proportional to the size of the building, smaller buildings also produce less construction waste. Reducing construction waste by optimizing the size of the building, and separation and recycling of waste can significantly reduce these costs.

Savings by reducing the size and power of the equipment

By improving the energy characteristics of building enclosing structures, it is often possible to reduce the size of equipment, including heating systems. When using air conditioning equipment, the cost is largely proportional to the cooling capacity, so reducing energy consumption for cooling directly leads to savings. With a significant reduction in loads, completely new approaches to heating and cooling become available. In some cases, by improving the energy characteristics of a building, it is possible to completely abandon heating or cooling equipment, thus compensating for most or all of the costs of improving the building during operation.

Lower energy costs

Reducing energy consumption is often the single most obvious economic advantage of green buildings [12-14]. Minimizing energy consumption is a priority in almost all green buildings - from private houses to multi-storey buildings. Green buildings typically consume less than half the energy than their conventional counterparts, and some green buildings consume less than a quarter of the energy. Most of the savings are achieved through improved thermal protection of the building and more energy-efficient equipment, but in the case of residential projects, simply creating small buildings can save a huge amount of energy. In addition to reducing energy consumption, many areas of green design reduce energy demand, which has a huge impact on energy costs in industrial buildings. If the cost of electricity continues to grow at the same pace, energy savings will become an even greater driving force for green construction.

Lower water costs

Many resource experts are more concerned about freshwater supplies than energy supplies in the coming decades. Due to a combination of water saving strategies, many green buildings consume almost a quarter less water than conventional buildings [15]. In addition to saving water, some green buildings collect water from their roofs or use wastewater collection and treatment systems for use in landscape irrigation. Very high water costs or high connection fees may be the motivation for implementing such solutions to reduce water consumption in construction.

Greater durability and fewer repairs

A very important, but often overlooked feature of green buildings is durability [16]. Well-designed and properly constructed green buildings will not experience problems with humidity in the premises, because the principles of "healthy construction" as a science were laid down in design and construction.



Durable buildings are cheaper to operate, since the repair and replacement of failed building structures occur much less frequently. Although durable building materials, structures and equipment may cost more, however, the costs for them during their service life are often lower than for conventional products, because they last longer and require fewer repairs.

Reduced cleaning and maintenance costs

Some areas of green construction, materials and products require less maintenance costs or reduce the need for cleaning. For example, the design of the siding with rain protection reduces the need for repainting of the wooden covering. Grilles on the driveways and carpeting ensure the cleanliness of the building, trapping dirt before it gets inside the room, and thus reduces cleaning costs.

Reduction of waste generation inside the building

Many green buildings are specially designed in such a way as to minimize waste generation. Many types of buildings may include waste recycling facilities. For example, hotels and inns can install soap and shampoo dispensers to minimize the amount of disposable soap and shampoo bottles.

Increased property value

When using any income-generating (rented) real estate, reducing operating costs can increase the value of real estate. This is because lower operating costs increase net operating income.

Faster rental

Green buildings, whether office space or residential real estate, are often rented out faster than conventional buildings, and often at a higher price. The reasons for this lie in the mass media, which distribute marketing materials advertising low operating costs or increased comfort, as well as reviews of residents and other users about such buildings.

Faster sales of buildings

Green buildings often sell faster than their conventional counterparts. Faster sales mean lower running costs and lower interest on loans, which increases the final profit.

Simpler recruitment of employees

The selection of high-quality employees can be a problem for any employer, be it a private company, a government institution, a hospital or a school. The quality of the room in which potential employees will work, including indicators such as daylight, street views and indoor air quality, can have a significant impact on the employment decision.

Reducing the risk of liability

Lawsuits over mold in buildings and the "sick building" syndrome are becoming more common. Green buildings designed using the most modern achievements in the field of construction science, in particular humidity control, pose a much lower risk of lawsuits related to these problems.

Many property owners will be surprised if they find out that mold-related problems are increasingly excluded from insurance coverage, and, of course, there is a possibility that mortgage holders and commercial real estate lenders will begin to require some kind of quality control certification regarding durability.

Positive public image

A positive public image that can be realized through a commitment to healthy, environmentally responsible buildings can be extremely beneficial.

New business opportunities

Specialization in eco-friendly design and construction of green buildings has proved profitable for many investors. As rumors spread about the economic efficiency of these buildings, many experts in eco-friendly construction have gained new opportunities. While these benefits are difficult to measure, they can be substantial.

2. Social benefits of green building

Improving health

Thanks to the materials used, increased humidity control, measures to prevent air pollution by ventilation of premises, green buildings are more "healthy". People spend 85-95% of their time indoors, so the quality of the indoor environment is extremely important. Indeed, in many sectors of the economy, ensuring a healthy life-style and optimal temperature and humidity conditions in the workplace is likely to be the single most important driving force behind the transition to eco-friendly construction [17] - [19].

Increased comfort

Measures that reduce drafts, minimize the temperature difference from floor to ceiling, noise reduction and control increase comfort in buildings. In commercial and institutional buildings, the manageability of individual workspaces (a feature of many green buildings) takes into account the fact that different people have different needs when it comes to temperature, ventilation and light levels.



People often get psychological satisfaction simply from the realization that they are in control of their work environment [20-22].

Improving the productivity of employees

The economic benefits of increased productivity are enormous. For example, an increase in labor productivity by only 1% compensates for the total energy costs in a conventional building. Studies have shown an increase in labor productivity in green buildings, ranging from 0.4% to 18%. As more and more companies begin to realize the value of increasing productivity, this is likely to become an increasingly important driving force behind green building [20-22].

Faster recovery from the disease

It has been shown that the view of the street and the connection with nature contribute to a faster recovery in hospitals, while improved ventilation systems can significantly reduce the spread of viral and bacterial infections transmitted by air-borne droplets, which is a growing problem in many hospitals. Such features of green construction are increasingly being considered as methods of reducing health care costs.

Reduced demand for utilities

Many green buildings have lower water needs and produce less wastewater than conventional buildings, which reduces the demand for utilities [23]. In areas where droughts are frequent or where water utilities are already operating at full capacity, this advantage of green building can be significant. Even when the capacity of communications is not a problem, the use of energy and chemicals in wastewater treatment plants is proportional to the volume of treatment, so reducing the volume of wastewater is environmentally attractive.

Reduction of soil erosion and storm runoff

Some of the most localized impacts of buildings on the environment are soil erosion that occurs during construction, and an increase in storm water runoff resulting from the creation of an impenetrable surface when asphaltting roads and access roads. Proper site planning, landscaping and other features of green construction can significantly reduce both of these problems [24].

Reducing the use of cars, traffic jams

Eco-friendly construction should go beyond the individual building and take into account how well this building is integrated into the infrastructure of the community and regional highways. The first priority should be to reduce dependence on cars. Clustering buildings, combining residential and commercial real estate, connecting buildings with walkways, building tram and bus routes within walking distance, as well as providing amenities and incentives to encourage commuting in ways other than private cars - all this can help reduce car use and traffic jams. Reducing traffic congestion in the area improves the quality of life, increases labor productivity (as people spend less time in traffic jams) and reduces air pollution.

Support for local agriculture

A key feature of green development is the preservation of open space - both for the benefit of the ecosystem and for the protection of agricultural land. Often houses are located on steeper terrain, so that the flatter land most suitable for agriculture can remain in productive use.

3. Environmental benefits of green construction

Reducing the effects of global warming

Due to the fact that "green" buildings consume less energy and emit less carbon dioxide during their operation, they have less impact on global warming, which is certainly one of the greatest environmental threats we face today. It is important to recognize that the effects of climate change are global. What we do in one state affects the global climate, and, conversely, everything we do to reduce greenhouse gas emissions leads to global benefits [25-27].

Minimized destruction of the ozone layer

Green buildings minimize the use and release of ozone-depleting substances. It should be noted that in the case of refrigerants, it is often necessary to consider the trade-off between the destruction of the ozone layer and the potential for global warming. With the reconstruction of existing buildings, measures can be taken to capture and destroy ozone-depleting refrigerants and foaming agents.

Reducing toxic emissions

The production of some building materials, including some types of plastic, leads to the release of toxic air pollutants. The same materials can also release toxins when they are disposed of in landfill or incinerated after the end of their use. Commitment to eco-friendly building materials is a commitment to consider these issues. Natural building materials often pose the least environmental risk.

Reduction of energy consumption and other impacts during transportation of materials



The greater the distance it is necessary to deliver construction materials and products (and the greater the distance it is necessary to deliver raw materials in the production of these finished goods), the greater the energy consumption and environmental impact. With eco-friendly construction, it is often necessary to choose more local materials [28].

Reducing urban heat islands

Heat island is a zone of elevated temperatures over cities and industrial areas, formed as a result of increased emission of thermal energy, resulting in the formation of thermal waste. As a rule, it is observed in large cities, where the air temperature throughout the year is several degrees higher than in the surrounding areas. Urban heat island is an area in the inner part of a large city characterized by elevated air temperatures compared to the periphery. The center of the urban heat island is usually shifted away from the city center in the direction where the prevailing winds are directed. In green construction, reflective and green roofs are used, which lead to a decrease in the effect of an urban heat island.

The purpose of the study is to substantiate the advantages of green construction. The objectives of the study are to calculate the effectiveness of the introduction of green construction.

2 Materials and Methods

The assessment of the economic efficiency of green construction has its own characteristics [29], [30]. It is obvious that all the additional innovative structures and equipment used in green construction significantly increase one-time costs, i.e. the costs of designing and erecting a building. However, when assessing the economic efficiency of construction, it is a big mistake to focus only on the cost of the construction itself and not take into account the savings of future operating costs for the maintenance of the building. Therefore, it is most appropriate to use such an indicator as the above costs to determine the economic efficiency of buildings. The above costs are the construction costs of the building plus the costs of its operation for a certain period of time (usually this is the payback period for construction costs) [31].

The basis for the development of a calculation formula for determining the comparative economic efficiency of green construction is based on the method of comparing the total reduced costs, taking into account the factor of their different times and areas of application. At the same time, costs are taken into account in the field of creation and supply of environmentally friendly building materials and structures (sphere I - supplier), in the field of construction of energy-efficient construction facilities (sphere II - contractor) and in the field of operation of buildings and structures (sphere III - customer) [31].

Based on the provisions of the standard methodology for determining the economic efficiency of capital investments, in each of the areas under consideration, the reduced costs are determined, representing the sum of the cost and capital investments reduced to the same dimension in accordance with the efficiency standard:

for sphere I, the above costs are determined by the formula

$$ZI = C_m + E_n \cdot K_m \quad (1)$$

where C_m is the cost of environmentally friendly building materials and structures; K_m is capital investments in the organization of their production; E_n is the standard of efficiency of capital investments; for sphere II, the above costs are determined by the formula

$$ZII = C_t + E_n \cdot F \quad (2)$$

where C_t is the cost of environmentally friendly building structures; F is capital investments in fixed assets of construction organizations;

for sphere III, the above costs are determined by the formula

$$ZIII = C_c + E_n \cdot K_e \quad (3)$$

where C_c is the cost of production of the enterprise in terms of depreciation of buildings and structures; K_e is capital investments in the repair base and protective equipment used during operation.

In addition, area III should take into account the costs incurred during the operation of buildings and structures.



3 Results and Discussion

Let's consider the efficiency of green buildings on the example of calculating the introduction of new more environmentally friendly building materials.

In the calculations of economic efficiency, when determining the cost of construction and installation work, direct costs and overhead costs are taken into account. Overhead costs are determined depending on the change in the basic salary of workers and labor costs (15% of the basic salary and 0.6 rubles per 1 person / day).

As a basic option, coatings based on a cement binder are selected. The coefficient of accounting for the change in service life is calculated by the formula.

The service life of plaster wall coverings in buildings is 4-5 years. The proposed estimated durability of coatings based on biocidal materials in green buildings under similar conditions is at least 15 years.

The calculation of the cost of materials, wages, labor costs and operating costs of machines per 1 m² of cement-sand plaster mortar coating according to the basic and proposed options is given in Table 1-3.

Table 1. Calculation of the cost of materials per 1 m² of plaster coating

Material	Unit of measurement	Amount of material	Price	The amount
Basic version				
Portland Cement	kg	2.7	0.54	1.46
Quartz sand	m ³	0.011	351.00	3.86
Water	kg	1.30	0.24	0.31
Cost of all materials				5.63
Proposed version (green building)				
Portland Cement	kg	2.7	0.54	1.46
Quartz sand	m ³	0.011	351.00	3.86
Water	kg	1.20	0.244	0.29
Biocidal additive	kg	0.06	2.80	0.17
Cost of all materials				5.78

Table 2. Calculation of wages, labor costs and operating costs of machines per 1 m² of cement-sand coating according to the basic and proposed version

Justification	Title of works	Salary, rub.	Norm of time, person-h	Operating costs of machines, rub.
Territorial unit prices, base price as of January 1 twothousand	Plastering of walls with cement mortar	6.41	0.75	0.96

Table 3. Initial data for calculating the cost of 1 m² of cement-sand coating

Indicator	Basic version, rub.	The proposed version (green construction), rub.
Materials	5.63	5.78
Basic wages of workers	6.41	6.41
Operation of machines and mechanisms	0.96	0.96
Overhead costs depending on:		
basic salary	0.32	0.32
labor costs	0.45	0.45
Total cost price	13.77	13.92
Specific capital investments in production funds	8.07	6.20



Labor costs, person-h	0.75	0.75
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The expected economic effect of the introduction of eco-friendly materials in green construction is calculated according to formula 1:

$$Z_{\text{basic version}} = 13.77 + 0.15 \cdot 8.07 = 14.98 \text{ rub.};$$

$$Z_{\text{proposed version}} = 13.92 + 0.15 \cdot 6.2 = 14.85 \text{ rub.};$$

$$\Delta Z = 14.98 \cdot 2.014 - 14.85 = 15.32 \text{ rub. на } 1 \text{ m}^2.$$

Thus, the economic effect of the implementation of the development amounted to 15.32 rubles per 1 m² when using eco-friendly materials in green buildings in construction.

And for eco-resistant buildings, plus to the specified economic effect, it is necessary to add a significant improvement in the physiological and social aspects of living in such buildings [32,33].

4 Conclusions

The idea of "green" construction has many benefits for the environment, the welfare of society and the health of each individual. Its widespread implementation can solve a number of global problems, such as climate change and lack of resources. The operation of eco-friendly buildings is also more profitable from an economic point of view: this makes it possible to significantly reduce the costs of water supply, heat and electricity. For example, the economic effect calculated during the research was 15.32 rubles per 1 m² when using eco-friendly materials in green buildings in construction.

Real estate developers are also showing interest in this concept - the cost of eco-friendly buildings is constantly growing in the real estate market. At the level of the whole state, ecological construction is also a priority: it stimulates the development of new technologies and, together with an increase in economic indicators, increases the indicators of the quality of life of the population.

"Green" projects support the national economy, create new jobs and improve the investment image of the state.

All "green" technologies, not only construction, take root well where positive changes have already taken place in the public consciousness. Therefore, one of the main tasks of modern "green" construction can be called the creation of conditions that will push citizens to a more environmentally friendly behavior.

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