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SUSTAINABILITY OF COMPLEX RESIDENTIAL DEVELOPMENT BY MINIMIZING LIVING COSTS

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Abstract

This research addresses the challenges of ensuring sustainability in complex residential development through the minimization of living costs. The aim is to identify methods and strategies aimed at reducing overall living expenses to enhance the sustainability of residential complexes. The methodology involves analyzing existing models of construction and operation of residential properties, employing mathematical modeling methods, and statistical analysis to identify effective solutions. One notable result of the research is the development of an integrated approach to planning and managing residential complexes, which allows for the minimization of energy consumption, utilities, and other life support elements. In essence, the study provides a solid foundation for comprehending the intricacies of cost modeling in environmentally-oriented life cycles of residential buildings, contributing to the advancement of sustainable practices in urban development. The study's conclusions underscore the importance of considering factors related to sustainable development in the design and operation of residential complexes, aiming to ensure economic affordability and improve the quality of life for residents.

Keywords: Complex development, competitive selection, development, financing, life cycle cost, residential real estate

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1. Introduction

Ecological and integrated residential construction today is one of the most relevant global trends that have come to the construction industry over the past 20 years and which is an important element of the concept of "sustainability" in the context of turbulent socio-economic development (Schwartz et al., 2022; Scherz et al., 2023; Zhao et al., 2022). In this regard, there is an increasing need to take into account in each construction project issues of greenness and energy efficiency, which ensure the safety, comfort and sustainability of the human environment. Within the framework of this direction, the Decree of the Government of the Russian Federation (2021) was adopted, which identifies two types of projects: green projects, that is, projects (that meet strict sustainability criteria) and adaptation projects (less fulfilled criteria for green projects). In July 2020, the Bank of Russia formulated recommendations for implementing the principles of responsible investment in sustainable development projects (Bank of Russia Information Letter No. IN-06-28/111, 2020). In them, he links responsible investment, in particular, with sustainability factors in the selection and management of investment objects.

The aim of the study is to evaluate and model the cost of ownership of environmentally-oriented life cycles of buildings in terms of total costs as part of complex residential development, taking into account the application of the author's methodological approach based on sustainable development coefficients for local indices of energy efficiency, greenery and infrastructure for competitive selection of projects for financing and evaluation of effects reducing the cost of ownership (Gushchina et al., 2022).

The object of the study was a complex of residential and other real estate as part of an integrated residential development at the stage of developing urban planning solutions designed to prepare projects for competitive selection for financing, taking into account the principle of maximizing the application of green building standards based on the use of a methodology for assessing the cost of building life cycles.

The object of study is characterized by the following information. The microdistrict is the 3rd stage of the construction of the residential area "Novaya Zarya" in the city of Penza. According to the rules of land use and development of the city of Penza, these territories are classified as zones of integrated territorial development. The total area of the microdistrict is 25 hectares and is a territory of medium and low-rise residential buildings with the inclusion of social infrastructure facilities: a school and a kindergarten (Gushchina et al., 2022). The territory of the microdistrict is limited by a street and road network of citywide and district significance, the profile of which includes pedestrian links and bicycle paths; public landscaping is provided along the transport network. Along the perimeter of the building along the citywide street there are built-in and attached objects of cultural, community and social services. The territory of the microdistrict is adjacent to the center of the district, which also includes multifunctional public facilities. This development is solved in a complex manner in accordance with the standards of Green zoom certification (ANO NIIURS, 2018).

2. Materials and Methods

The research methodology is grounded in logical moderation methods, drawing from domestic and international studies. These studies encompass calculation methods analyzing the life cycle costs of

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construction objects. The sources include works by ANO NIIURS (2018), Baronin (2015, 2018), Hromada et al. (2021).

Standards governing the cost structure of construction life cycles and their analysis within contract systems, such as DBFM, LCCA, LCC, PFI, are integral to the methodological framework.

Economic analysis, coupled with logical methods of socio-economic forecasting, is employed to draw conclusions and provide recommendations for future research endeavors. These recommendations focus on minimizing the life cycle costs of capital construction projects within comprehensive residential development initiatives, aligning with criteria and indicators of sustainable development for urban areas.

2.1. Methodology for assessing the cost of the life cycle of a building in the competitive selection of projects for financing and its optimization with the determination of the author's coefficients of "sustainability" in projects of complex residential development

In order to provide methodological assistance for participation in open tenders to determine the cost of life cycles of capital construction objects, a special methodology has been adopted (Methodology for calculating the life cycle of a residential building, taking into account the cost of total costs, 2014). The main principle on which the methodology is based is to reduce the total cost of ownership of a building due to a reasonable increase in initial costs at the design and construction stage, taking into account energy-efficient, environmentally friendly technologies and green building approaches, as a result of which, at the building operation stage, the operating costs of ownership, which are in an average of 75% of the total total costs (Methodology for calculating the life cycle of a residential building, taking into account the cost of total costs, 2014) (Baronin et al., 2023).

Building Life Cycle Cost (BLCC) (Methodology for calculating the life cycle of a residential building, taking into account the cost of total costs, 2014) is the estimated value of the monetary value of the total costs of owning a residential building, including the costs of construction and installation works, subsequent maintenance, operation during their service life, repair, disposal of the resulting operation of the object (elements of the building or the whole building).

In the above guidelines, two correction factors are used - this is the coefficient for taking into account the energy efficiency class and the green factor (Baronin et al., 2023).

The life cycle cost is determined by the formula (Methodology for calculating the life cycle of a residential building, taking into account the cost of total costs, 2014):

$$BLCC = Cunit * Ek * R + Cper * Gk * T * K * R \quad (1)$$

where: BLCC -cost of life cycle costs; Cot - the sum of one-time costs for design, production (construction), commissioning and decommissioning (disposal); Cper - the sum of periodic expenses (costs) during the planned period of operation for resources, maintenance, current and major repairs, consumables, management and wages; Ek is the coefficient for taking into account the energy efficiency class of the building; Gk - coefficient of "greenness"; T - the number of periods for repairs and replacement of equipment during the planned service life (life cycle) for each element of the calculation;

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K - correction factor, taking into account seasonality, and / or deviation from the standards; R - discount factor (Kashezheva et al., 2016).

2.2. Substantiation of the author's coefficient of "infrastructure" in assessing the cost of the life cycle of capital construction projects

As part of the methodology for assessing integrated residential development for the selection of projects for financing, an important component is the indicator of infrastructure availability for objects planned for construction. This aspect is fundamental both for point objects of residential and civil construction, and for the evaluation of integrated development projects.

In this regard, along with the coefficients of "energy efficiency" and "greenness", it seems possible to additionally develop the coefficient of "infrastructure". In most green building standards, within the framework of the concept of sustainable development, the provision and accessibility of social service facilities, the provision of transport and utility services occupies a fundamental position and gives a significant increase to the total number of certification points (Baronin et al., 2023).

As part of the study, it was proposed to form the coefficient of "infrastructure" (Ik) from indices that reflect the availability of infrastructure in the certification of the Green Zoom standard (Table 1).

Table 1. The value of the coefficient of "infrastructure" in the evaluation of projects for integrated and sustainable development

Rating, in points	Number of points scored	Coefficient of "infrastructure"
Not certified	≤39	1,15
class certificate D	40-47	1,00
class certificate C	48-55	0.85
class certificate B	56-64	0.7
class certificate A	65-70	0.55

The "infrastructure" coefficient allows us to assess the convenience, comfort and safety of using residential and public facilities, the availability of functional areas for various purposes as part of complex development, the provision of transport and engineering infrastructure and makes it possible to compare the costs on the part of the developer and the cost of the operating period for end users (Baronin et al., 2023).

2.3. The author's methodological approach based on sustainable development coefficients for local indices of energy efficiency, greenness and infrastructure for the competitive selection of projects for financing

The conducted studies show that it is necessary to optimize the formula for estimating the cost of the life cycle of an object with the assignment of the "greenness" coefficient to the indicator of one-time construction costs, because this indicator primarily affects the change in the cost of designing and building objects. This is due to the use of more expensive green systems in projects of residential buildings and in the improvement of residential and public areas, the use of engineering systems in the project for the use of non-traditional types of energy, etc.

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Thus, the author's version of the methodology for assessing the cost of the life cycle of buildings, taking into account the infrastructure coefficient, will be the following formula:

$$BLCC = Cunit *Ek* Gk* Ik *R + Cper * T*K*R \quad (2)$$

Where: Ik-coefficient of "infrastructure", the remaining components of the formula are taken as in formula (1).

The methodology for assessing the cost of the life cycle of objects of complex residential development within the framework of the experiment, in the analysis below, is calculated in relation to low-rise and high-rise construction, taking into account the urban planning component. Methodically for the base and optimization options, it will look like this:

$$LCC_{CRD} = LCC_{MRB} * N_{MRB} + LCC_{IRB} * N_{IRB} \quad (3)$$

where LCC_{CRD}– life cycle costs of complex residential development;

LCC_{MRB} – life cycle costs of a typical multi-apartment residential building;

N_{MRB}– life cycle costs of a typical multi-apartment residential building;

LCC_{IRB} – life cycle costs of a typical individual residential building;

N_{IRB}– number of houses of individual residential development in the microdistrict.

3. Results and Discussion

3.1. Comparative assessment of the cost of life cycles of complex development objects and recommendations for the competitive selection of projects for financing

The study's findings and discussions are multifaceted, covering various aspects related to the sustainability of complex residential development by minimizing living costs.

One prominent result is the comparative assessment of life cycle costs for complex development objects, serving as a crucial metric for decision-making in project financing. The base project, characterized by specific coefficients representing energy efficiency, green standards, and infrastructure, provides a benchmark for cost analysis. The life cycle cost of the complex residential development under this base project is calculated accordingly.

Furthermore, the optimization project introduces measures aimed at enhancing energy efficiency, incorporating green practices, and maintaining infrastructure standards. This optimization leads to adjustments in the coefficients, influencing the overall life cycle cost. The comparative evaluation offers insights into the potential financial benefits of implementing sustainable and efficient practices in complex residential development.

The discussion delves into the implications of these findings, emphasizing the importance of incorporating sustainability criteria in project selection. Recommendations are provided for competitive project financing, aligning with the broader goals of urban development and sustainable practices.

Overall, the results and discussions contribute valuable insights into the intersection of economic considerations, sustainability goals, and the life cycle dynamics of complex residential development.

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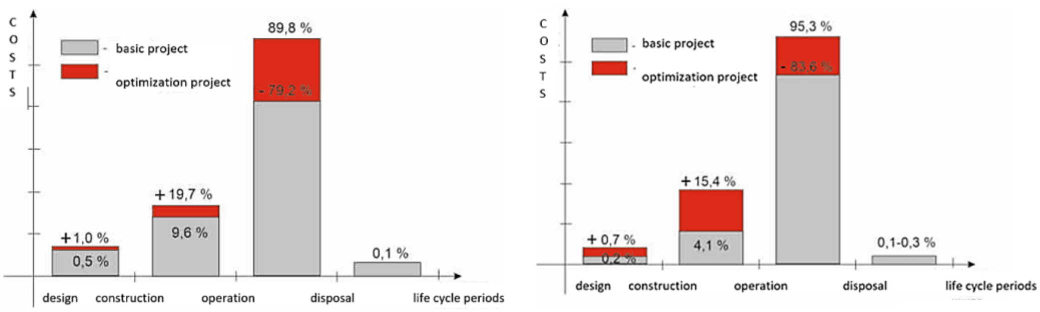
The base project is represented by an average value of the energy efficiency coefficient Ek = 1.15, certification of the base project according to the "green standard" class C = 0.85. The infrastructure factor is represented by the value 0.55. The cost of the life cycle of complex residential development according to the basic version of the project will be:

LCCCRD (b) =4 625 892,7*1.15*0.85* 0.55* 1 + 56 919 056,2*1*1*1 =2 486 995, 5 + 56 919 056,2 = 59 406 051,7 thousand rubles.

The optimization project is also calculated taking into account measures to improve energy efficiency, greenery and infrastructure. As a result of these measures, it is possible to increase the “energy efficiency” coefficient to B+ = 0.85 and the “greenness” coefficient to class B = 0.7. The coefficient of "infrastructure" in the optimization project remains unchanged.

LCCCRD (o) = 6 872 557,7 *0.85*0.7 * 0.55*1 + 30 037 765,7 *1*1*1= 2 249 044,5+30 037 765,7 = 32 286 810,2 thousand rubles.

The results of calculating the life cycle cost of a medium and low-rise residential building for the basic and optimization project in % are shown in Figures 1 and 2.



(a) (b)

Figure 1. (a) Comparative analysis of the life cycle cost of a multi-apartment residential building of an average residential building in % for the basic and optimization project options, (b) Comparative analysis of the LCC of individual number of storeys in % for the basic and optimization versions of the project

Thus, the performed studies allow us to make a final conclusion that it is recommended to choose an optimization option with a minimum life cycle cost of 32,286,810.2 thousand rubles from the compared two project options for financing.

3.2. Evaluation of the effect of reducing the cost of ownership of complex residential development

The cost of the possession effect will be:

$$Eos = LCC_{CRD}\ (b) - LCC_{CRD}\ (o) \quad (4)$$

where Eos – ownership effect;

LCC_{CRD} (b)– the cost of life cycle costs of complex residential development in the base case;

LCC_{CRD} (o)– the cost of life cycle costs of complex residential development in the optimization variant.

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Eos= 59 406 051,7 – 32 286 810,2=27 119 241,5 thousand roubles, based on 50 years (see Figure 2)

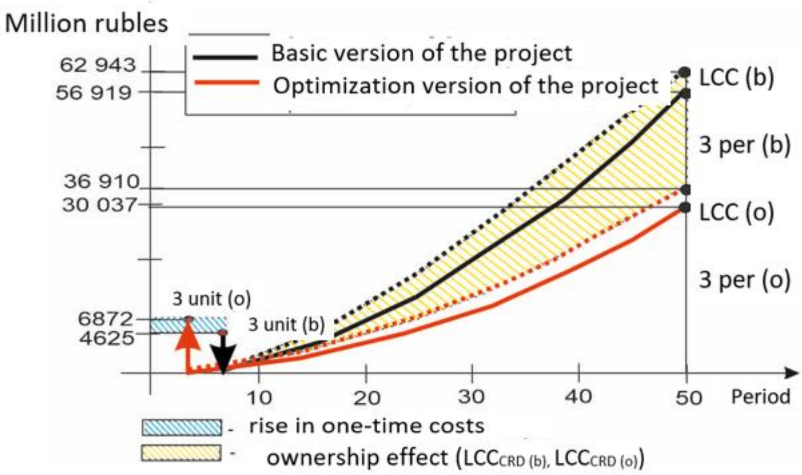

Figure 2. The effect of reducing the cost of ownership of residential facilities of the 3rd stage of construction of the residential area "Novaya Zarya" in the city of Penza based on the adoption of an optimization version of the project with a minimum LCC_{CRD}

4. Conclusion

The study successfully achieved its objective, focusing on modeling the total cost of ownership for environmentally-oriented life cycles within the context of integrated residential development. The research underscores the high relevance of the addressed problem, emphasizing the critical importance of understanding and managing costs in sustainable urban development.

The author's position, articulated within the study, revolves around the methodological modeling of total costs. This involves considering key coefficients related to energy efficiency, green standards, and infrastructure. Such a comprehensive approach emerges as a strategic means to minimize the total cost of ownership within the sustainable development framework for urban areas.

The conclusion highlights the promising avenues for future exploration in this field. These include further scientific and practical advancements, particularly in substantiating and applying the "infrastructure" coefficient for assessing construction project costs in competitive financing. Additionally, there is a call for ongoing scientific developments to refine the methodology for assessing the total cost of ownership, extending its applicability not only to buildings but also to the broader territories encompassed in integrated residential development projects.

In essence, the study provides a solid foundation for comprehending the intricacies of cost modeling in environmentally-oriented life cycles of residential buildings, contributing to the advancement of sustainable practices in urban development.

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References

ANO NIIURS. (2018). *Green zoom city. Practical recommendations for the integrated and sustainable development of territories*. greenzoom.ru/books/6-prakticeskie-rekomendacii-po-kompleksnomu-i-ustojcivomu-razvitiu-territorij/

Baronin, S. A. (2015). Developing affordable and energy efficient housing in Russia based on real estate total cost of ownership management. *Journal of Advanced Research in Law and Economics, 6*(2), 291-298. https://journals.aserspublishing.eu/jarle/article/view/481

Baronin, S. A. (2018). Modeling total cost of ownership of residential real estate in the life cycles of buildings. *International Journal of Civil Engineering and Technology, 9*(10), 1140-1148. https://iaeme.com/MasterAdmin/Journal_uploads/IJCIET/VOLUME_9_ISSUE_10/IJCIET_09_10_113.pdf

Baronin, S. A., Guschina, E. S., & Romanova, A. I. (2023). Integrated green construction as a prerequisite for sustainable urban development. *E3S Web of Conferences, 403*, 02013. https://doi.org/10.1051/e3sconf/202340302013

Decree of the Government of the Russian Federation No. 1587. (2021). *On Approval of Criteria for Sustainable (including Green) Development Projects in the Russian Federation and Requirements for the System for Verification of Sustainable (including Green) Development Projects in the Russian Federation*. https://publication.pravo.gov.ru/Document/View/0001202109240043

Gushchina, E. S., Budanov, I. V., & Baronin, S. A. (2022). Green Building Simulation as a Sustainable Integrated Residential Development. *International scientific and technical journal real estate: economics, management, 3*. https://n-eu.iasv.ru/index.php/neu/issue/download/20/27

Hromada, E., Vitasek, S., Holcman, J., Schneiderova Heralova, R., & Krulicky, T. (2021). Residential Construction with a Focus on Evaluation of the Life Cycle of Buildings. *Buildings, 11*(11), 524. https://doi.org/10.3390/buildings11110524

Kashezheva, A. A., Bizhanov, S. A., & Grebenshchikov, V. S. (2016). Management of energy efficiency in construction based on the total cost of ownership of housing real estate. *Innovative science, 1-1*(13). https://cyberleninka.ru/article/n/upravlenie-energoeffektivnostyu-v-stroitelstve-na-osnove-sovokupnoy-stoimosti-vladeniya-zhilischnoy-nedvizhimostyu

Methodology for calculating the life cycle of a residential building, taking into account the cost of total costs. (2014). *All-Russian non-governmental non-profit organization National Association of Self-Regulatory Organizations Based on Membership of Persons Preparing Project Documents, 2014, 72*. https://sustainabledevelopment.un.org/content/documents/26962VNR_2020_Russia_Report_English.pdf

Scherz, M., Hoxha, E., Maierhofer, D., Kreiner, H., & Passer, A. (2023). Strategies to improve building environmental and economic performance: an exploratory study on 37 residential building scenarios. *The International Journal of Life Cycle Assessment, 28*(7), 828-842. https://doi.org/10.1007/s11367-022-02073-6

Schwartz, Y., Raslan, R., & Mumovic, D. (2022). Refurbish or replace? The Life Cycle Carbon Footprint and Life Cycle Cost of Refurbished and New Residential Archetype Buildings in London. *Energy, 248*, 123585. https://doi.org/10.1016/j.energy.2022.123585

Zhao, C., Liu, M., & Wang, K. (2022). Monetary valuation of the environmental benefits of green building: A case study of China. *Journal of Cleaner Production, 365*, 132704. https://doi.org/10.1016/j.jclepro.2022.132704

Bank of Russia Information Letter No. IN-06-28/111. (2020). On recommendations for implementing the principles of responsible investment. www.garant.ru/products/ipo/prime/doc/74291781/