The environmental component of construction projects in the aspect of sustainable development

Diana Dzhidzhelava[0000-0002-0725-5714] and Anastasiya Fedina[0000-0002-6279-3283]

Industrial University, Tyumen, 625000, Russia
E-mail: diana-dzhidzhelava@yandex.ru

Abstract. The authors of the article pay special attention to the environmental component in substantiating the significance of construction projects and focuses on the synthesis of such aspects as: social, economic and environmental in formulating the concept of «sustainable development». A comprehensive assessment of these aspects and their quantitative expression can serve as a basis for establishing causal relationships that determine the ecological situation in a particular territory, and can also be used to develop measures for environmental protection, and as a result, for the harmonious implementation of the construction project in the formation of a comfortable urban environment. The article summarizes the results of the analysis of causal relationships, revealing the direction of eliminating the negative impact of factors on the environment and developing environmental measures for inclusion in the design documentation of the construction project. In the south of the Tyumen region, the determining direction for improving project documentation should be the VIII section of the Technical Project, which, in turn, requires the implementation of strict control over the implementation of declared environmental measures in terms of reducing emissions of pollutants into the atmosphere.

Keywords: ecology, construction project, sustainable development, construction, environment, urban studies.

1 Introduction
Under the conditions of modern urbanization, one of the main sources of environmental pollution includes project developers and title holders of buildings and structures. Such entities not only consume energy resources, but also produce a tremendous amount of carbon dioxide emissions and solid waste [1–8]. In order to ensure sustainable development of urban and rural areas of the regions, by maintaining citizens high standard of living, an inalienable requirement will be to maintain stabilization of the state of natural systems and environmental quality [9–12]. It is important for each commercial project to comply with environmental requirements in relation to the regulatory framework of the area in which the designed enterprise will operate [13–15], which in turn is reflected in the design documentation structure of any construction project for industrial and non-industrial purposes in Section VIII «List of Protection Measures environment». The measures take into account the impact on all elements of the ecological system, such as: soil (mainly an assessment of the negative impact on its structure), water (the impact of the used resources of the enterprises on the chemical composition of open and underground water bodies and sources), and air (pollutant emissions into the atmosphere). Such measures implemented to achieve environmental efficiency goals can be carried out in the following areas: efficient use of energy resources; increasing labor efficiency at the construction site; reduction of the negative impact of various types of emissions on the environment [16–20]. On a larger scale, such measures can be considered with the example of a
The basic principles of the development of «smart cities» are presented in the article by A. I. Romanova, D. S. Romanov, O.V. Maksimchuk, A.V. Voronin: «...The transformation of industrial cities into «smart» cities is a worldwide trend, as well as a realistic prospect for Russian cities. At the same time, the reorientation in the strategy for the development of cities, megacities and their agglomerations suggests a radical restructuring of the management system for the development of municipalities, including a change in priorities, standards, criteria, goals and objectives, performance indicators and efficiency. It requires a different assessment of the resource potential of the territory, new ways of achieving the set goals» [21].

2 Materials and methods
The most widely used in practice at the pre-investment stage are such research methods as: theoretical (search, analysis and synthesis of existing publications of young scientists in the selected section of urban studies); mathematical methods make it possible to form an evidence base on the means of using econometric and economic-statistical models in the analysis and assessment of the significance of construction projects at the appropriate stage of its implementation; empirical methods make it possible to clarify and verify the objectivity of theoretical conclusions obtained in the process of testing econometric and economic-statistical models, normative calculations on means of interviewing the public and experimental developments in terms of launching environmental events at a single construction site and so on.

We consider the sequence of testing the listed research methods. An interesting assessment algorithm, which the authors of this publication will take as a basis in substantiating the content of a technical project section, is presented and justified in an article by L.A. Filimonova, N.K. Skvortsova: «... The theoretical and methodological basis of this study was the fundamental and applied scientific works of Russian and foreign authors in the field of ecology, technospheric security, economic theory, statistics and economics. To justify the results of the research we used methods of economic and mathematical modeling, elements of resource and system approaches, statistical methods. Summarizing the results of the research carried out on theoretical and practical material on available printed and electronic resources, the authors of the article agree on the expediency of carrying out appropriate surveys in a comprehensive assessment of the region's investment attractiveness ...» [22].

To determine the most preferable environmental measures for a particular territory, it is necessary to assess the current environmental situation in this territory through the analysis of key indicators of environmental impact by urban and rural buildings.

At the first stage, it is necessary to form an initial database to determine the causal relationship between the indicators (table 1).

| ASSESSMENT OF THE ENVIRONMENTAL SITUATION OF THE TERRITORY |
|-----------------------------------------------------------|
| Ecological negative from buildings | Production |
| Air and water pollutant emissions | Gross regional product |
| Mining | |
| Investments in fixed assets aimed at protecting the environment and rational use of natural resources | Environmentally Friendly Activities |
| | Environmental protection measures for business entities |

The initial database is formed in the form of a table, where all the selected indicators are listed. The observation period should be 10 years or more.
At the second stage, when the initial database is formed, a correlation analysis is carried out, which is a part of the mathematical group of methods. As a result of passing this stage, we obtain a matrix of linear correlation coefficients. At this stage, it will be necessary to filter the results. Those indicators are subject to selection - factors whose linear correlation coefficient is in the following ranges: 0.35 ≤ k ≤ 0.75 and -0.75 ≤ k ≤ -0.35, where k is the linear correlation coefficient. Indicators whose correlation coefficients belong to these intervals demonstrate a moderate strength of communication between each other (in the range from noticeable to strong). This study uses the Cheddock scale. According to the result of filtering, indicators whose coefficients fell into a given range form a table for the next stage.

The third stage is the normalization of the source data after filtering. This requires bringing data with different dimensions to normalized (dimensionless) values, which minimizes the subjective effect of inflationary processes present in cost indicators, such as gross domestic (regional) product, investment in fixed assets, size of subventions, etc. The following optimization model is used for this stage:

\[
\begin{align*}
    b_i &= \max \left\{ a_i + \frac{\min a_i}{\max a_i}, i \in N \right\} \\
    &= \max \left\{ a_i + \frac{\min a_i}{\max a_i}, i \in N \right\} \\
\end{align*}
\]

where \( a_{ij} \) - quantitative value of the i-th indicator of the j-th block;
\( b_{ij} \) - normalized value of the i-th indicator of the j-th block;
\( \min a_i, \max a_i \) - minimum and maximum quantitative value of the i-th indicator of the j-th block.

The fourth stage will be concluding. At this stage, to obtain an integrated assessment of the territory ecological situation, it is necessary to use the following compromise scheme:

\[
F = \sum_{j=1}^{m} b_j \rightarrow \max
\]

where \( j=1,m \) - investigated blocks of the environmental situation;
\( i=1,n \) - indicators included in the evaluation system;
\( t=1,T \) - number of observation periods.

As a result, the analyst comes to a certain integral coefficient, which is an indicator of the state of the studied area ecological situation, which can subsequently be used to justify the environmental protection measures applied in construction projects. Also, this coefficient can be used to compare the environmental situation of several territories, constituent entities of the Russian Federation for the investor or project developer to make an investment decision to launch a construction project.

3 Results
The method mentioned above was tested on the example of the south of the Tyumen region. The result of calculating the integral development coefficient of the south of the Tyumen region based on indicators of the environmental component is shown in figure 1.
The follow-up period was 14 years (2004–2018). After filtering, carried out at the second stage of the study, to assess the environmental situation in the south of the Tyumen region, the following indicators were selected: emissions of pollutants into the atmosphere, emanating from stationary sources; emissions of sulfur, nitrogen dioxide; number of wastewater treatment plants put into operation; the number of facilities having emissions of pollutants into the atmosphere; investments in fixed assets aimed at protecting the environment (including new construction, the construction of wastewater treatment plants); discharge of polluted wastewater into surface water bodies; the amount of oil and gas produced; gross regional product by type of economic activity «manufacturing».

In accordance with the fact that the subsequently selected definitions of cause-effect relationships at the second stage are indicators mainly related to emissions of pollutants into the atmosphere and wastewater, it is logical to assume that environmental protection measures should be aimed specifically at reducing the negative consequences of these emissions.

In general, according to the results obtained, it can be said that during the study period, the environmental situation in the south of the Tyumen region improved significantly. Although, if you compare the period from 2010 to 2018, the situation is noticeably worse. This recession is significantly affected by the increased number of facilities that have pollutant emissions into the atmosphere (993 facilities in 2010, and 1,186 facilities in 2018). If we consider industry, then it is the main environmental pollutant in the region (especially the enterprises of the fuel and energy complex). The buildings and structures of the fuel and energy complex include: oil and gas wells, pipelines, power lines, roads and technological facilities and production facilities serving. Due to the low quality of construction work and building materials used (in most cases pipes), the lack of necessary technologies, large-scale pollution of the area occurs (all environmental elements are involved: soil, air, water).

The proposed method can be used to compare different territorial units. In accordance with this, it will be relevant to use this method to compare the three components of the Tyumen region, including the Khanty-Mansiysk Autonomous Area and the Yamalo-Nenets Autonomous Area. The results are presented in figure 2.
Figure 2. The integral coefficient for assessing the environmental situation in the south of the Tyumen region, Khanty-Mansi Autonomous Area and Yamalo-Nenets Autonomous area.

According to the fig. 2, it is clear that until 2011 environmental situation in the considered territorial units was approximately at the same level. However, since 2011, the environmental situation in the Khanty-Mansi Autonomous Area has become higher than the Yamal-Nenets Autonomous Area and the south of the Tyumen Region. The reason can be considered the economy development specifics of each of the entities under study. In the structure of industrial production of the Khanty-Mansi Autonomous Area and the Yamalo-Nenets Autonomous Area mining prevails, and in the structure of the industry of the south of the Tyumen region, manufacturing is dominant. The economy of the south of the Tyumen region today is more diversified and independent of raw materials than neighboring autonomous regions. The oil and gas production sector is to a greater extent the basic sector of the Khanty-Mansi Autonomous Area and the Yamalo-Nenets Autonomous Area. However, the indicator of oil production in the region decreases every year, gas production (natural and associated) is also reduced, but the amount of oil supplied to the primary processing is increasing.

We consider several possible options for the use of alternative energy sources and their application in the construction project sections development, and determine their advantages and disadvantages.

Solar energy. The conversion of solar energy into electrical energy occurs using photovoltaic plates. With a solar panel area of approximately 0.2 m², the module power is approximately 10 watts. The voltage at maximum load is about 25 V. The short circuit current is about 500 microamp. The weight of such a module is about 2 kg. Typical solar cell efficiency is from 14 to 18 %. The service life of the plate is at least 25 years. The amount of energy that can be obtained from solar panels varies and depends on their location and solar activity at different times of the year.

Advantages: the most efficient renewable energy sources, high environmental friendliness of the technology, long service life, independence from the main energy suppliers.

Disadvantages: low efficiency, high cost, relatively low power, relatively low energy output per unit area, long payback period.

Wind energy. Models of wind generators come in different designs and vary in power. According to the geometry of the main rotor axis rotation they are divided into: vertical and horizontal type. The simplest is a generator with low power up to 300 watts. It produces energy with a wind force of 10-12 m/s. For vertical wind generators, the efficiency is 20-30 %, for horizontal 25-35 %. On average, the duration of energy production is designed for 15 - 25 years of service. According to forecasts, by 2040, wind energy will be able to generate up to 34 % of global electricity.
Advantages: ease of maintenance, thanks to ground placement; the ability to install at low altitude.

Disadvantages: high price, noise, wind speed for the full promotion of the generator should be at least 4 m/s, an area of at least 100 meters to each side of the mast is required, high operating costs.

The placement of such autonomous energy sources can occur in the following ways:

1. Placement on the surface: in this case renewable energy sources are located on the roof of the house being built or during reconstruction of the existing one. This type of placement is suitable for solar panels.
2. Integration into the building structure: with this type of placement, the energy source will form a single structure with the architectural and structural elements of the building.
3. Accommodation in the form of a separate volume.

The effectiveness of alternative energy sources directly depends on the region in which they are planned to be installed. Along with the environmental friendliness of these facilities, they are characterized by instability of the energy potential. Therefore, most often, they are used in combined power systems in combination with each other and with traditional energy sources.

4 Discussions

Summing up all mentioned above, it can be argued that the environmental component, acting as an integral element of sustainable development, is a mandatory requirement that must be observed when creating construction projects. Improving environmental safety can be based on the following principles: the use of environmentally friendly building materials and technologies; construction of buildings and structures using energy-saving technologies, reducing energy consumption and eliminating heat loss during their operation; waste reduction during construction; ecological reconstruction of the urban environment; restoration and maintenance of biodiversity in construction and urban areas; implementation of environmental monitoring systems for construction (CALS – technologies and others) at all stages of the life cycle of a construction project; minimization of negative impacts (pollution, excess noise, vibration, etc.) on natural ecological systems; restoration of disturbed construction sites.

The key parameters for the examination of construction projects for the analyzed territory in the framework of public hearings and the assessment of significance should be a section of the following environmental measures: reducing the discharge of contaminated wastewater into the centralized system, introducing recycling water supply systems, and abandoning traditional energy sources to provide the construction object (coal, gas etc.) with the transition to alternative / renewable, which in turn will require a review of the design elements of the project in terms of installation of related equipment for reduction of air pollutant emissions; rational use of natural resources, secondary raw materials; regeneration – processing of production and municipal waste; reclamation of industrial territories. With a formal approach to the formation of Section VIII of the design documentation for construction projects, it should be sent for revision with the strengthening of the listed measures that the listed indicators reveal.

The use of renewable energy sources (RES) in buildings allows you to produce energy directly at the facility, abandoning the cost of external engineering systems that significantly pollute the environment. The maintenance of buildings and the provision of the production process accounts for ≈30 % of all energy resources purchased by the enterprise. As a rule, a number of specific energy-saving measures taken by enterprises can increase their profitability and improve the competitiveness of products by reducing their cost. In industry, there are a lot of simple, advanced and high-tech ways to save energy through electricity, heating, water and gas.

References

1. Mutani, G., Todeschi, V.: Energy resilience, vulnerability and risk in urban spaces. J. Sustain. Dev. Energy, Water Environ. Syst. (2018). https://doi.org/10.13044/J.SDEWES.D6.0211.
2. Anna, M., Ksenya, V.: Innovacionnye faktory i usloviya ustoichivoego razvitiya sel'skih territorij [Innovative factors and conditions of sustainable development of rural territories]. Balt. Reg. (2012).
3. Kutsenko, E.: Pilot innovative territorial clusters in russia: A sustainable development model. Foresight Russ. (2015). https://doi.org/10.17323/1995-459X.2015.1.32.55.

4. Petrisor, A.-I., Meita, V., Petre, R.: Resilience: Ecological and Socio-Spatial Models Evolve While Understanding the Equilibrium. Urban. Archit. Constr. (2016).

5. Sözer, H., Kükkrer, E.: Evaluation of Sustainable Design Strategies Based on Defined Indexes at a District Level. Dev. Energy, Water Environ. Syst. (2018). https://doi.org/10.13044/j.sdewes.d6.0208.

6. Andrić, J.M., Wang, J., Mahamadu, A.M., Zhong, R.: Understanding environmental incidents on construction sites in Australia: The causal factors, environmental impact and their relations. J. Civ. Eng. Manag. (2019). https://doi.org/10.3846/jcem.2019.10435.

7. Kauko, T.: How to pick relevant sustainability criteria for the built environment: A bottom-up approach. Urban. Archit. Constr. (2019).

8. Sarhan, S., Elnokaly, A., Pasquire, C., Pretlove, S.: Lean construction and sustainability through IGLC community: A critical systematic review of 25 years of experience. In: IGLC 2018 - Proceedings of the 26th Annual Conference of the International Group for Lean Construction: Evolving Lean Construction Towards Mature Production Management Across Cultures and Frontiers (2018). https://doi.org/10.24928/2018/0274.

9. Marcinkowski, A.: The spatial limits of environmental benefit of industrial symbiosis - Life cycle assessment study. J. Sustain. Dev. Energy, Water Environ. Syst. (2019). https://doi.org/10.13044/j.sdewes.d7.0270.

10. Ferova, I.S., Lobkova, E. V., Tanenkova, E.N., Kozlova, S.A.: Tools for Assessing Sustainable Development of Territories Taking into Account Cluster Effects. J. Sib. Fed. Univ. Humanit. Soc. Sci. (2019). https://doi.org/10.17516/1997-1370-0412.

11. Yin, J., Guo, J., Ji, T., Cui, J., Xiao, L., Dong, Z.: An extended todim method for project manager’s competency evaluation. J. Civ. Eng. Manag. (2019). https://doi.org/10.3846/jcem.2019.10521.

12. Ozcan, O., Ersoz, F.: Project and cost-based evaluation of solar energy performance in three different geographical regions of Turkey: Investment analysis application. Eng. Sci. Technol. an Int. J. (2019). https://doi.org/10.1016/j.jestch.2019.04.001.

13. Rosa, L. V., França, J.E.M., Haddad, A.N., Carvalho, P.V.R.: A resilience engineering approach for sustainable safety in green construction. J. Sustain. Dev. Energy, Water Environ. Syst. (2017). https://doi.org/10.13044/j.sdewes.d5.0174.

14. Maqbool, R., Rashid, Y., Sultana, S., Sudong, Y.: Identifying the critical success factors and their relevant aspects for renewable energy projects; An empirical perspective. J. Civ. Eng. Manag. (2018). https://doi.org/10.3846/jcem.2018.1691.

15. Carvalho, P., Spataru, C., Bleischwitz, R.: Integration of water and energy planning to promote sustainability. J. Sustain. Dev. Energy, Water Environ. Syst. (2019). https://doi.org/10.13044/j.sdewes.d4.0246.

16. Apenko, S.N., Fomina, Y.A.: Analysis of the Maturity of Sustainable Project Management in Russian Enterprises in the Transition to the Digital Economy. J. Sib. Fed. Univ. Humanit. Soc. Sci. (2019). https://doi.org/10.17516/1997-1370-0407.

17. Goldobina, L.A., Demenkov, P.A., Trushko, O. V.: Ensuring the safety of construction works during the erection of buildings and structures. J. Min. Inst. (2019). https://doi.org/10.31897/PMI.2019.5.583.

18. Cobzaru, A.: ELECTROPOLLUTION IN OUR URBAN ENVIRONMENT. Urban. Archit. Constr. (2015).

19. Hanaoka, T., Masui, T.: Co-benefit reductions of short-lived climate pollutants and air pollutants by 2050 while achieving the 2 degree target in Asia. J. Sustain. Dev. Energy, Water Environ. Syst. (2018). https://doi.org/10.13044/j.sdewes.d6.0218.

20. Silvestre, J.D., Silva, A., De Brito, J.: Uncertainty modelling of service life and environmental performance to reduce risk in building design decisions. J. Civ. Eng. Manag. (2015). https://doi.org/10.3846/13923730.2014.890649.

21. Romanova, A.I., Romanov, D.S., Maksimchuk, O.V., Voronin, A.V.: Basic principles of innovation
management in the urban economy of Smart-city. Int. J. Eng. Technol. (2018). https://doi.org/10.14419/ijet.v7i4.38.24593.

22. Filimonova, L.A., Skvortsova, N.K.: On Issue of Algorithm Forming for Assessing Investment Attractiveness of Region Through Its Technospheric Security. In: IOP Conference Series: Materials Science and Engineering (2017). https://doi.org/10.1088/1757-899X/262/1/012196.