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ECOLOGICAL AND ECONOMIC ASPECTS OF THE TRANSFORMATION OF CONSTRUCTION ENTERPRISES ON THE BASIS OF BIOSPHERE COMPATIBILITY

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Abstract. The *purpose* of the article is the question of creating an indicative base to determine the level of biosphere compatibility of construction market participants. Biosphere compatibility is considered as a characteristic of the processes of production, management and organization from the point of view of preservation of natural resources and ensuring sustainable development in the construction industry. The relevance of creating adaptive mechanisms of construction enterprises for the implementation of transformational changes at the micro, meso- and macrolevels has been determined. *Methodology.* Typical sustainability indicators were grouped and analyzed using a three-year (2018, 2019, 2020) dataset of 15 construction companies, although these indicators are universal regardless of the industry in which they apply. On the basis of these indicators, the meaningful parameters of the state of the construction enterprise system that can be obtained as a result of transformations based on biosphere compatibility have been established. The *result* is a model for obtaining indicators, which helps to predict and evaluate the effectiveness of sustainable transformation of the enterprise. Factors influencing the formation of the concept of urban environment production, resource use policy, energy efficiency of production and operation of the final construction products during the life cycle, the main factors influencing the formation of the environmental and economic mechanism of development of construction enterprises on the principles of biosphere compatibility are considered. *Practical implications.* Formation of the concept, the strategy of development of the construction industry, fully taking into account global, national, regional conditions and restraining (limiting) regressive influences, especially important in circumstances where the current circumstances of the industry sometimes contradict the principles of sustainable development. The reasons determining the transition to biosphere-compatible construction are based on generally accepted concepts of conscious consumption of resources and modified models of urban society economy that take into account the social component. Comprehensive assessment of design solutions for the construction of biosphere-mixing facilities, based on a system of not only economic factors, but also environmental and social, which corresponds to the principles of sustainable development. *Value/originality.* Targeted biosphere-compatible transformation of construction market participants, based on the biosphere-compatibility assessment system in this article, should become a leading tool for the development of modern cities, as it takes into account not only technological, but also social, economic and environmental aspects.

Key words: sustainable development, biosphere-compatible change management, greening the economy, biosphere compatibility of production, assessment of biosphere compatibility.

JEL Classification: Q01, P18, O14, O22, L15, Q55

1. Introduction

The priority development of Ukrainian cities, their dominance in the social and domestic infrastructure of the population, is the cause of the deformation of the moral and ethical components of human consciousness as an element of the biosphere, which is a unique self-regulating system. The deterioration of urban ecology, population density and, as a consequence, the decreasing demands on the living conditions of urban society cause a number of problems that lead to a demographic crisis, extinction and biological and genetic degradation of the people. According to Stephen R. Mann's chaos theory, small actions will be sufficient for the extinction of humanity, as the

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"butterfly effect" leads to a loss of balance on the scale of global processes. Usually these imbalance processes return to equilibrium because the stabilizing forces of nature are great, but it is unknown whether humans will exist at the moment of stabilization. After all, the range of human existence is very narrow. The balance between the spheres of the human and the natural must be maintained not so much from the position of the impossibility of existence from each other – human egocentric thinking, but from the position of V. Vernadsky's noosphere reality – the possibility of existence and development of nature without humanity. Therefore, the dominance of anthropogenic factors in any sphere of human activity can no longer be considered an absolute axiom.

Given the ecological and biological threats of today's world, humanity's future depends on obligatory collective responsibility for the actions and consequences of our technological civilization, affecting nature as a necessary condition, in terms of transforming or substantially changing development goals from economic to combined, socio-ecological ones. In this context, the greening of the economy through changes in the construction industry and the optimization of social and environmental factors is a relevant opportunity to achieve synergy.

2. Transition to biosphere-compatible change management

Any modern major city is a system of complex, inextricably linked natural and anthropogenic components, where the advantages of one lead to the dominant impact on the architecture of the city (Tsygychko, 2012). The anthropogenic component has the most irreversible effects. But even in this case, there is always the opposite effect of natural components. For example, air pollution in large cities, in turn, negatively affects the condition of the materials of building envelopes, and the construction of multistory buildings with a small building area affects the natural level and direction of groundwater, which leads to wetting of foundations, corrosion of structures, subsidence or removal of buildings and loss of bearing capacity of individual structures and buildings as a whole (Tsygychko, 2009). Greening the economy also has a marketing side, it causes people to have "greener" needs (Ottman, Reilly, 2006). Therefore, the introduction of biosphere-compatible construction as a modern concept of urban planning that meets the goals of sustainable development, aimed at meeting a set of socio-environmental, economic and economic needs of the population, is quite relevant. Small changes in the initial conditions of decision-making lead to a huge impact on aspects of strategic development (Mann, 1992). What is biosphere-compatible construction? In the author's interpretation, it is a special type of complex social, environmental and economic (complex and open) system, which is centrally subordinated to the regulatory and permissive framework of acts in design, construction and operation, has a clearly defined regional aspect, socio-economic anomalies and depends on natural resources (Shpakova, 2020). Modern design and construction of any local objects or large urban complexes, as well as the reconstruction of buildings and territories, can no longer be carried out without taking into account environmental standards.

Studies by many international environmental organizations have shown that the desire to improve environmental efficiency can lead to negative social and/or economic consequences. Therefore, it is almost never possible to make progress in the three dimensions in the same period of time. Hence the conclusion that not every new production technology, beneficial in terms of productivity and capital, is suitable for the environment. The key to resolving a certain contradiction between economic growth and ecology, as foreign experience shows, is mutual understanding and coordination between government and business.

Therefore, the ecological and economic assessment of production should be based simultaneously on the principles of sustainable development, i.e. on structural-criteria indicators. On the basis of E. Warhurst's research for the Warwick Business School (Warhurst, 2002), the indicators (hereinafter indices) of sustainable development can be represented as conditionally divided into environmental, social and economic components, which are also the limiting parameters of the "ecology" – "economy" – "society" system. This ranking of parameters is justified from the point of view of universalization of the assessment of biocompatibility of production through the use of data from the statistical and accounting database, formed in enterprises in accordance with the requirements of business.

The grouping of sustainable development indices by type can be represented as follows:
– a group of universal indices that describe all three components: Descriptive (I), Production (II), Economic (VIII);
– a group of transitional indices describing two components – environmental and economic: Production (V), Accounting (Reporting) (VII), Quality (IX);
– a group of unique indices that describe only one environmental component: Effective (III), Regulatory (IV), Regulatory (VI), Environmental (X) (Shpakova, 2019; Warhurst, 2002).

The principles of biosphere-compatible construction, based on the principles of sustainable development, have polymorphic belonging to the group, provoked by the overlapping areas of the system "ecology" – "economy" – "society" (Figure 1). "Aggregating" the indicators of the three components in the measurement of sustainable development may require analysis to determine the importance (significance) in the hierarchy of biosphere building compatibility assessment.

It is necessary to normalize the data, focusing on the principles of biosphere compatibility of any production. Therefore, it is advisable to compare the components of sustainable development by type and the components of biosphere compatibility.

The principles of biocompatible production, implemented on the basis of the concept of sustainable development, are comprehensive in nature. Their analysis and evaluation should be based on a system-integrated approach, that is, the definition of multifactor indicators (indicators) reflecting the relationship of economic, social and environmental components in terms of the usefulness of biocompatible construction technologies at the state level. This requires regrouping and specifying sustainable development indicators in accordance with the principles of biosphere compatibility.

3. Assessment of design solutions in the socio-ecological-economic system

The main difficulty at the microeconomic level, where eco-economic problems are localized and spatially contingent, is the need to make a difficult choice between "economic upliftment" and biosphere-compatible technological progress. This means that production must be evaluated according to an environmental standard in terms of emissions and/or use of primary natural resources. Thus, the choice made by enterprises in connection with the greening of production and products will depend not only on a number of purely economic factors (economic calculation), but also on mandatory legal regulation and environmental expertise, and especially in the case of industrial innovation – on the knowledge and environmental awareness of consumers and the economic benefits they receive, also accounted for by a significant number of factors, indicators, etc. It should also be borne in mind that it is impossible to take into account the effects of all factors, as this could lead to a loss of control over the system. Therefore, an important task is to determine a limited set of major factors that allows a focused assessment of the criterion of "biocompatibility" of production under study in this case.

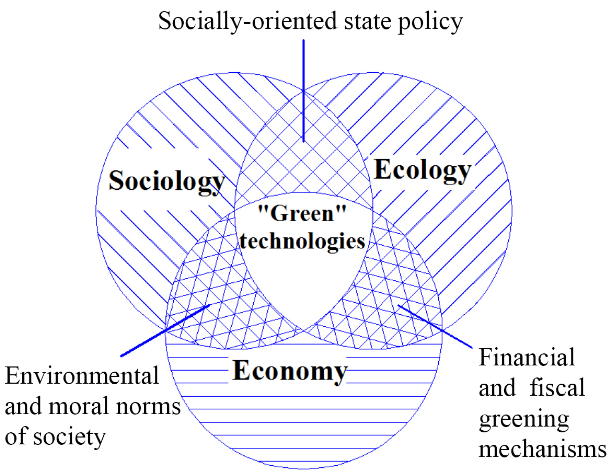


Figure 1. Schematic diagram of polymorphism of parameters of the system "geology" – "economy" – "society"

As a result, the groups of indicators for assessing biosphere-compatible production by direction are as follows:

1. socio-ecological direction – index of compliance with current conditions (standards) of labor protection at the enterprise (1.1), coefficient of pollutant emissions (greenhouse gases, waste water, solid toxic waste, etc.) according to the results of environmental expertise (1.2), occupational illness rate (1.3);
2. eco-economic direction, the growth rate of production costs (2.1), the closed cycle resource ratio or processing ratio (2.2), the product energy consumption rate (2.3), the product specific resource consumption rate (2.4), the index of compliance with certification requirements (2.5), index of compliance with environmental requirements of local, regional, national regulations (2.6), payment for the use of natural resources (2.7), fixed asset renewal rate (2.8), production growth rate (2.9), natural resource turnover rate (2.10), use of primary resources, associated resources in production (packaging), rejected products (2.11), costs to overcome environmental pollution consequences in case of emergency (2.12);
3. socio-economic direction – labor productivity (3.1), productivity factor (3.2), labor costs (3.3), environmental efficiency coefficient (3.4), job creation coefficient (3.5), production social prestige coefficient (relative to living wage) (3.6), production social prestige coefficient (3.7), cost coefficient for training and retraining personnel for greening production (3.8).

The general system of biosphere compatibility indicators is presented in Figure 2.

These indicators have a different mathematical nature: one part of them – absolute values, and the other – the coefficients, partially integrated, which are relative characteristics of production. In addition, there are a number of indicators that are actually protective, automatically eliminating the need for further data analysis to determine the biosphere compatibility indicator due to non-compliance with regulatory and additional (voluntary) restrictive requirements. These nuances must be taken into account in the mathematical evaluation apparatus of the complex index.

The effectiveness of design decisions depends on targeting one, two, or all three areas of biosphere compatibility. The visualization of this model is presented in Figure 3.

The quantitative assessment (positive or negative) of the environmental component of the decision on such a model is plotted, for example, on the X-axis. In turn, the assessment of the economic and social components – on the axes Y and Z, respectively.

The elements of assessment of the effectiveness of project solutions in the socio-ecological-economic system are presented in Figure 4. From Figure 4(a) shows that point A, i.e., the quantitative assessment of the project solution is in the area of the desired positive decision, which is the most attractive in the development of the project. The corresponding evaluations, labeled points B, C, and D, are less acceptable because they have two negative or minimal quantitative evaluations of the three areas, and are in the areas of critical but acceptable solutions. Figure 4(c) denotes the area of unsatisfactory solutions, where none of the project requirements are positively evaluated.

In Ukraine, the main indicator of environmental assessment is environmental expertise, which is carried out by state environmental protection authorities. "Environmental expertise in Ukraine is a type of scientific and practical activity of specially authorized state bodies, environmental expert formations and associations based on interdisciplinary environmental research, analysis and assessment of pre-project, design and other materials or objects, the implementation and operation of which may negatively affect or will affect the environment and human health" (Smovzhenko, 2015). Modern world standards for the standardization of environmental parameters of the architectural and construction industry relate mainly to the environmental, energy and economic efficiency of so-called "Green Buildings". On their basis, in parallel with European national norms (directives) relating to the standardization of environmental quality, corporate and voluntary environmental quality rating certificates of production have been developed and exist. The most famous of these are the English BREEAM and the American LEED. The mechanisms of these systems are based on

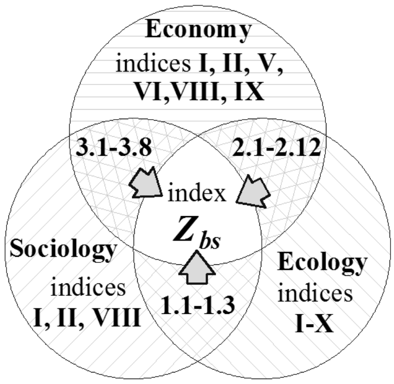


Figure 2. The system of indices and indicators that characterize the assessment of biocompatibility of production

the monitoring of environmental indicators, namely monitoring the state of the biosphere, assessment and prediction of its condition, identification of factors and sources of influence, determination of the degree of anthropogenic impact on the environment.

But the data obtained as a result of environmental observations should be evaluated at the macro level of sustainable development of urban society as a whole, taking into account the greening component of the urban environment, the industrial anthropogenic component. In turn, the assessment of the industrial anthropogenic component should take into account the symbiosis of regulatory design factors, construction conditions and economic reserves of the period of operation of buildings and structures in terms of social responsibility and future commercial potential of the object for customers, developers, owners (Smovzhenko, 2015).

Under these conditions, the implementation of the concept of biocompatible construction for urban society is divided into the following stages.

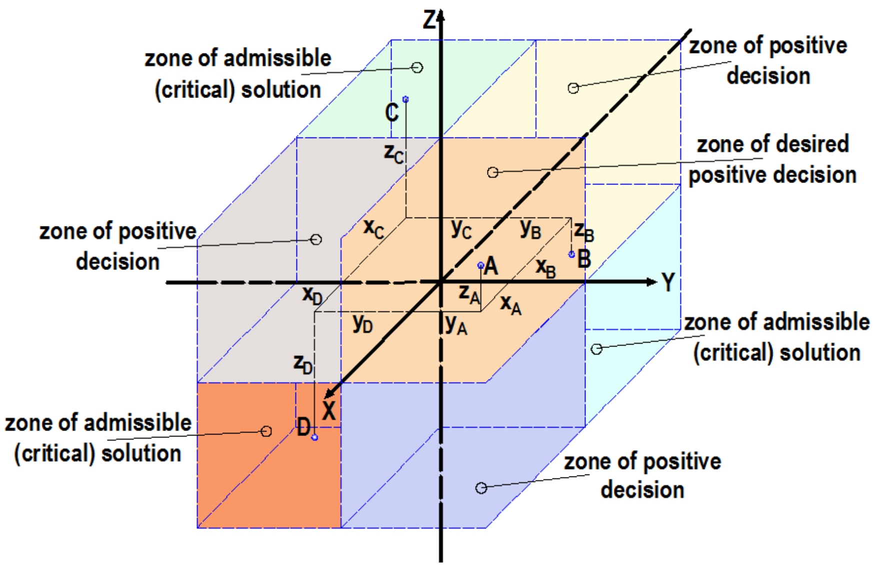
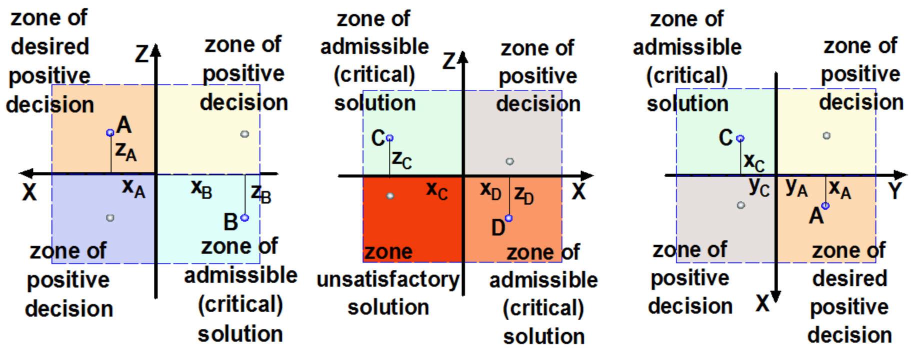


Figure 3. The space of modeling the effectiveness of design solutions in the social and eco-economic system



(a) (b) (c)

Figure 4. Elements of the assessment of the effectiveness of project decisions in the social and eco-economic system: (a) projection on the social-ecological plane of decision-making with a positive economic assessment; (b) projection on the eco-economic plane of decision-making with a positive social assessment; (c) projection on the social-ecological plane of decision-making with a negative economic assessment

The first stage is the creation of a targeted strategy for the biocompatible construction of a modern city, taking into account the infrastructure and the city-forming factor (industrial, resort, tourist, etc.).

The second stage is the creation of a symbiotic system of mutual development of the city and man "sine qua non", critically taking into account the mutual influence of natural and anthropogenic components.

The third stage is the creation of a unified system of diagnostics, assessment and monitoring of the system of biosphere-based existence, which aims to study the anthropogenic criteria (city population) and the natural potential of territories.

The fourth stage is the establishment of regulatory boundaries for the implementation of biocompatible construction, relating to requirements for the design, construction, operation, reconstruction and/or disposal of facilities throughout the life cycle, in accordance with national, international environmental standards and socio-humanitarian paradigms.

The fifth stage is the creation of a national system of ecological certification of construction products, aimed at a comprehensive assessment of the environmental, social and economic parameters of projects, existing buildings and structures (Shpakova, 2020).

This formalized approach seeks to follow a clear logic of consistent implementation of biocompatible construction at the request of urban society, a clear architectonics of the interrelations in the system "ecology" – "economy" – "society" is created, and the step-by-step implementation of the strategy allows to solve local problems. These local problems include the legislative framework at the macrolevel, taking into account the specifics of the construction site in the design at the microlevel, followed by integration into a single industry-wide program of state reform. The structural and logical scheme of the strategy does not provide for the removal of any of the stages, as this would lead to an imbalance of the system and the loss of time for the development of the industry in terms of sustainable development.

Each of the proposed steps should have its own practical results. The first stage should clearly form the orientation of the city within the industrial complex of the state as a budget-forming unit, which will avoid contradictions between the social and environmental constraints and design standards of facilities and urban infrastructure, i.e. will take into account the priority for the city design solutions for the construction and modernization of areas, which will correspond to the practical results of the second stage of the strategy. The result of the third stage is the development of a national system for monitoring the biosphere-oriented existence of society, its adaptation to international standards of environmental quality and integrated use within a unified coordinate system for real-time assessment of the state of the industry. This approach will allow a rapid response to changes in the system that lead to progressive or regressive developmental effects. At the fifth stage, based on the monitoring of biocompatibility within the construction industry, a rating scale of national manufacturers should be formed, supported by the state apparatus with image and fiscal incentives (national quality certificates, tax benefits and environmental fines, etc.). The basis for the application of state regulation mechanisms should be the legislative framework – the practical result of the fourth stage.

3. Conclusions

To determine development priorities, evaluation criteria and recommendations for the implementation of mechanisms to regulate the relationship between man and nature at the macro level, carrying mainly socio-ecological burden, and business and government at the meso- and macrolevel, where the nature of relations is more clearly seen in the eco-economic plane, it is necessary to define with the tools used to determine a comprehensive index of biosphere compatibility. On the basis of studies of indicators of sustainable development, statistical data of the construction industry, developments of domestic and world scientists proposed a method for calculating indicators of assessment of biosphere compatibility of production, which is based on an analytical set of diffuse indicators that take into account entropic data of construction companies and evaluate the development of the system (project) in accordance with the declared regional, national or international environmental standards for the integral indicator of biosphere compatibility.

The general formula for the indicator of biocompatibility of production can be represented as:

$$Z_{bs} = \sum_{i=1}^{n} \frac{\{K_{bs}\}}{\{I_{bs}\}} (Z_i \cdot m_i), \quad (1)$$

where Z_i – indicator of biosphere compatibility of the *i*-th component of the overall assessment;

$m_i = \{m(K_i); m(I_i)\}$ – weights of the relevant factors affecting biosphere compatibility depending on the branch, determined by various methods (preference method, ranking method, pairwise comparison method, etc.);

$\{K_{bs}\}$ the system of coefficients of social and ecological, eco-economic and socio-economic components of assessment of biosphere production compatibility;

$\{I_{bs}\}$ a system of indicators of the socio-ecological and ecological-economic components of the assessment of the biosphere's compatibility with production.

It should be noted that the system of indicators defined in the binary system (1 or 0) is a fuse to exclude from the calculation of incorrect data or those that do not meet the specified standards.

Global attention to the ecological existence of urban society only began in the twentieth century. In 1993, the 18th World Congress of Architects in Chicago adopted the Declaration of Interdependence for a Sustainable Future, which recognized environmental sustainability and consideration of environmental requirements as a priority in design and construction, and in 2002 the European Organization of the Construction Industry decided to introduce a set of environmental protection measures in the construction process. However, the Ukrainian state and the construction industry in particular must promptly engage in the concept of implementing biosphere-compatible construction in the context of our country's policy to achieve sustainable development goals. In this connection, the development of a system of standards for the balanced development of biosphere-compatible construction requires profound changes in the economic, social, environmental, and ethical spheres, as well as their harmonization with the laws of biosphere development and the principles of humanism.

It should be noted, however, that biosphere-compatible construction should not be adapted to maximize the economic downturn based on the linear model of production inherited from the country's post-industrial revolutions. The linear model assumes that the cost of raw materials (resources) increases in direct ratio to the volume of production, which contradicts the task of conserving them. The circular economy model is optimal under conditions of sustainable development. Therefore, a simultaneous transformation of relations in the national economy as a whole is necessary.

References:

Mann, S. R. (1992). Chaos Theory and Strategic Thought. *Parameters*, vol. XXII, pp. 54–68.

Tsygychko, S. P. (2012). *Ekologhija v arkhitekturi i mistobuduvanni* [Ecology in architecture and urban planning]. Kharkiv: KNAMG. (in Ukrainian)

Tsygychko, S. P. (2009). Arkhitekturna ekologhija jak zasib zabezpechennja stalogho rozvytku suchasnykh mist [Architectural ecology as a means of ensuring sustainable development of modern cities]. *Kommunalnoe hozyaystvo gorodov* [Municipal economy of cities], vol. 90, pp. 21–25.

Shpakova, H. V. (2019). *Ekologho-ekonomichnyj mekhanizm rozvytku biosferosumisnogho budivnyctva v Ukrajini: teorija, metodologhija, praktyka* [Ecological and economic mechanism of biosphere-compatible construction development in Ukraine: theory, methodology, practice]. Kyiv: ArtEk Publishing House. (in Ukrainian)

Shpakova, H. V. (2020). *Teoretyko-metodologhichni zasady formuvannja ekologho-ekonomichnogho mekhanizmu rozvytku biosferosumisnogho budivnyctva v Ukrajini* [Theoretical and methodological principles of ecological and economic mechanism formation for biosphere-compatible construction development in Ukraine] (Doctor of sciences thesis), Kyiv: Kyiv National University of Construction and Architecture.

Warhurst, A. (2002). Sustainability indicators & sustainability performance management. *Mining and Energy Research Network*, vol. 43.

Smovzhenko, T. S., & Skrynnyk, Z. E. (2015). *Ukrajinsjka ljudyna v jevropejsjkomu sviti: vymiry identychnosti* [Ukrainian man in the European world: dimensions of identity]. Kyiv: UBS NBU. (in Ukrainian)

Ottman, J. A., & Reilly, W. R. (2006). *Green Marketing: Opportunity for Innovation.* Booksurge Ltd. P. 288.