Formation of system of indicators for evaluation of environmental activities

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Abstract. Sustainable environmental and economic development of the national economy is feasible provided that the economic and environmental performance of enterprises is equal. The article is devoted to the formation of a system of indicators for assessing the activities of industrial enterprises, taking into account environmental factors. Since all the economic and financial results depend on the level of technology and management, the assessment of the organizational and technical level of the enterprise, taking into account environmental aspects, reflects the complex ecological and economic characteristics. The authors propose the mechanism for assessing the environmental activities of enterprises producing construction materials, based on the economic and mathematical model. In view of the fact that the domestic market of building materials is only at the stage of awareness of the need for environmental products in the system of evaluation indicators presented, an attempt was made to take into account some requirements of international standards of "green" construction.

1. Introduction
Priority direction in the Strategy of scientific and technological development of the Russian Federation until 2035 is the ecological sustainable development of the national economy at all levels of the economic system. Organization of environmental activities at enterprises is the first step towards sustainable ecological and economic development of the national economy.

It can be said about the sustainable development of the human community if the ecological balance of the biosphere is ensured, where the economy develops in such a way that the needs of the living people are met and, at the same time, the resources of the lives of future generations are not jeopardized. [1]

Evaluation of the results of environmental activities (EA) at the enterprise is a necessary procedure to determine how effective this area of activity in the enterprise is and to suggest possible directions for its improvement.

2. Literature Review
The economic and environmental aspects of the operation of an industrial enterprise are often analyzed separately from each other. With such a one-sided approach, the strategy of sustainable environmental and economic development of the organization is not feasible. Management should be based on indicators that reflect not only economic, but also environmental activities. [2]

The need to include environmental factors in the overall system of assessing the functioning of the enterprise was stated by many researchers [3-6]: Belo-usov A.I., Knysh Yu.A., Nuzhina I.P., Petrova...
E.E. They investigate factors, interrelations and methods of evaluation of EA. The main directions and stages of the formation of a system of ecological and economic indicators were studied. A number of authors [7-11] propose sectoral environmental indicators that reflect a specialized focus in the fields of fisheries, agriculture, rail transport and metallurgy.

However, these decisions can not be applied to the manufacturing enterprises, in particular to the construction industry enterprises. Also, in the proposed methods, in our view, the correlation of the EA indicators with the production and financial aspects is not sufficiently reflected, the EA is more viewed as an isolated sphere of functioning. In addition, not all the indicators have a clear quantitative representation. The original methodology for assessing the efficiency of resource use, taking into account environmental factors, is presented in [12]. In [13] the author describes in detail the model for assessing the competitiveness of an industrial enterprise, taking into account the factor of eco-risk. But for a comprehensive evaluation of the EA it is needed an analysis of the technical and managerial potential of the enterprise.

In connection with this, the purpose of this work is the formation of such a system of indicators for the evaluation of EA, which reflects the relationship between the environmental and production activities of organizations for the production of building materials and orientates the business entity for sustainable development.

3. Theoretical model

Therefore, since the technical progress is the main condition for the development of production and all the indicators of economic and financial activities depend on the level of technology and management, the analysis and evaluation of the organizational and technical level of the enterprise provides a comprehensive description and determines the ways of improving the organizational and technical level. The environmental aspects of the industrial enterprise's activity are such components of the organizational and technical level of production (OTLP), which determine the degree of influence on the environment, the amount of responsibility for the enterprise and the corresponding obligations.

The existing indicators for the evaluation of OTLP can be subdivided into 4 groups [14-16]: technical and economic equipment of production, technical and economic state of equipment, level of organization and management, and resource efficiency and complement indicators that take into account priority environmental factors.

For enterprises in the construction industry, an important environmental protection factor and a competitive advantage is the environmental friendliness of the building materials produced, since the level of their environmental impact depends on the level of the negative impact of construction projects on the environment, primarily on human health. The existing international certification systems for "green building" are based on the use of environmentally friendly building materials and are effective tools for managing the quality of the environment. However, the Russian materials market is only at the initial stage of awareness of the need for environmental friendliness of building materials. [17] The system of indicators for the assessment of OTLP attempts to take into account some of the requirements for the most effective international standards for green building, such as LEED (USA), BREEAM (Great Britain), DGNB (Germany), and national standards STO NOSTROY 2.35.4-2011 "Green building". The buildings are residential and public. Rating system for assessing the sustainability of the habitat", STO NOSTROY 2.35.68-2012" Green building. "Residential and public buildings. Accounting for regional features in the rating system for assessing the sustainability of the habitat».

4. Results of approbation

The proposed system of indicators for the assessment of OTLP taking into account environmental factors (Table 1) practically does not contain financial, commercial and reputation indicators.
Table 1. The system of indicators for assessing the organizational and technical level of production, taking into account environmental aspects.

| Indicator                                                        | Calculation                                                                 | Direction of indicator and justification of the norm                                                                 |
|-----------------------------------------------------------------|-----------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|
| Level of mechanization of the main process,%                    | The ratio of mechanized labor in the main process (person-hour) to the total amount of labor, including mechanized and non-mechanized | max The level of mechanization depends on industry specific features. Therefore, the optimum value will be considered the maximum in similar organizations or the maximum reached level of the analyzed enterprise for the analyzed period |
| The level of mechanization of environmental process,%            | The ratio of mechanized labor costs in the environmental process (man-hour) to the total volume of labor of this process, including mechanized and non-mechanized | max The higher the level of mechanization of the nature protection process, the higher the productivity and quality of the EA |
| Stock-equipping of an active part of the fixed assets of the main process, thousand rubles / person. | The ratio of the cost of the active part of the fixed assets of the main process to the average number of workers in the main production | max The maximum index of capital-expenditure for the analyzed period. |
| Stock-equipping of nature protection process, thousand rubles / person. | The ratio of the cost of the active part of the main means of the environmental process to the average number of workers in the environmental process | max The maximum indicator of the assets-saving nature of the environmental process over the last 5 years |
| The technological capacity of products, t / thousand rubles.    | The cumulative amount of pollutants in relation to the volume of output      | min The lower the level of pollutant, accounting for 1 thousand rubles. the more ecological the production. The minimum value is taken for the analyzed period |
| Waste utilization rate                                          | Share of waste used in production to total volume of waste                   | max Production is considered clean (waste-free) if the utilization rate of waste is in the range of 90-100%; 50-90% - low-waste; <50% is open. As the target initial indicator we will take - 50% [18] |
| The radius of the extraction of raw materials                   | The limitation of the radius of the extraction sites helps to reduce the negative impact of transportation for production | min The production radius should not exceed 800 km |
| Coefficient of water use                                        | The ratio of the amount of water used to the quantity taken from the source | max The coefficient should approach 100%, i.e. there must be a desire for as much use of wastewater without descent into the body of water |
| The indicator of the conformity of product quality              | Share of products certified to the total volume of products produced        | max As a target initial indicator, we establish - 100% |
| The indicator of conformity of ecological compatibility of production | Share of products ecologically certified and marked to the total volume of products produced | max The share of products is ecologically certified in the total volume of products produced. As the target initial indicator - 10% |
| Indicator                                                                 | Description                                                                                                                                                                                                 | Min | Description                                                                                                                                                                                                 |
|--------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Emission compliance indicator                                            | The quantity (mass) of pollutant emissions in relation to the established maximum permissible amount of emissions                                                                                      | min | The indicator should not exceed 1 when it aspires to the minimum possible value                                                                                                                             |
| The discharge compliance indicator                                       | Number (mass) of pollutant discharges in relation to the established maximum allowable number of discharges                                                                                               | min | The indicator should not exceed 1 when it aspires to the minimum possible value                                                                                                                             |
| The indicator of compliance of the sanitary protection zone             | Correspondence of the area of the sanitary protection zone (SPZ), degree of gardening, types of planting to regulatory requirements                                                                          | max | All SPZ elements must comply with regulatory requirements. The maximum possible value is 100%                                                                                                               |
| Equipment with monitoring and measuring equipment for environmental control | The actual number of units of instrumentation and equipment to the planned (necessary) quantity                                                                                                               | max | The process of environmental monitoring should be 100 % equipped                                                                                                                                             |
| Technical and economic state of equipment                                |                                                                                                                                                                                                            |     |                                                                                                                                                                                                            |
| Wear factor of equipment in the main process                             | Amount of depreciation for the restoration of fixed assets of the main process to their original cost                                                                                                    | min | 0 ≤ wear factor <0.5 - for the recently active 0.5 ≤ Wear factor ≤ 0.65 - indicates a continuous update policy 0.65 < wear factor ≤ 1 means the discreteness of the reproduction of fixed assets [19] |
| Wear factor of environmental protection equipment                         | The amount of depreciation charges for the restoration of environmental assets to their original cost                                                                                                          | min | Let us assume, by analogy with the previous indicator                                                                                                                                                       |
| Coefficient of use of production capacity                                | The ratio of actually produced products to the project                                                                                                                                                        | max | Ideal is the indicator close to 100%                                                                                                                                                                         |
| Factor of change of work of the equipment of the basic process           | Actually worked out number of machine shifts in relation to the total number of installed equipment                                                                                                          | max | For the most expensive equipment, the shift coefficient should reach 2.5-2.7                                                                                                                               |
| Integral utilization factor of equipment                                 | The use of equipment in terms of productivity and time (the utilization factor for productivity multiplied by the time utilization ratio)                                                            | max | The use of equipment in terms of time and performance should strive for 1                                                                                                                                   |
| Level of organization and management                                     |                                                                                                                                                                                                            |     |                                                                                                                                                                                                            |
| Staff turnover rate                                                      | The ratio of those who resigned at their own volition and dismissed for violation of labor discipline to the average number of employees                                                                    | min | At industrial enterprises, the generally accepted value of the staff turnover rate is 13-15%                                                                                                                |
| Coefficient of working conditions                                        | The degree to which the real working conditions at workplaces correspond to the regulatory (design) conditions (temperature, dust, noise, illumination and air exchange)                                      | max | It reflects the correspondence of the production area, noise, illuminance, temperature, air exchange to normative values.                                                                                  |
| Growth of market share                                                  | Ratio of the market share of the reporting period to the market share of the base period                                                                                                                    | max | It reflects the growth rates of market share. The indicator must be at least 1                                                                                                                             |
Growth of market share of green products

The ratio of the market share of green products of the reporting period to the market share of the base period

max

Let us assume, by analogy with the previous indicator

The indicator of environmental reporting

The ratio of the number of reporting documents that take into account environmental aspects to the total value of reporting documents for a particular process

max

The more reporting documents reflect the environmental aspects of activities, the more effective the EA. As the target initial indicator we will take - 50% [20]

Coefficient of contractors and suppliers requested for environmental aspects of their activities

The ratio of the number of suppliers requested by the environmental aspect of their activities to the total number of contractors and suppliers

The ideal situation seems to be if all contractors are involved in creating an environmental utility product. The indicator should aim at 100%.

max

The actual profitability of production should be no less than planned. As a standard, we will take the maximum value for the last 5 years

Indicator of management efficiency

The ratio of the actual profitability of production to the planned

min

As a normative value, we accept the minimum value of the capital productivity for the last 5 years

Material consumption of products, rubles / rub.

The ratio of the cost of raw materials to the total output of products

min

As a normative value, we accept the minimum value of the material consumption for the last 5 years

Energy intensity of products, rubles / rub.

The ratio of electricity costs to the volume of output

min

As a normative value, we accept the minimum value of the energy intensity of products for the last 5 years

Capital productivity, rubles / rub.

The ratio of the value of output to the average annual value of fixed assets

max

As a normative value, we take the maximum value of capital productivity for the last 5 years

Labor productivity, rubles / person.

The ratio of the value of output to the average number of personnel

max

As a normative value, we take the maximum value for the last 5 years

Expenses for 1 rub. of the output, rubles / rub.

The ratio of the cost of production to the total value of output

min

As a normative we accept the minimum value for the last 5 years

Efficiency of resource use

First, reputational indicators, as well as some commercial indicators (for example, an increase in the cost of intangible assets due to effective EA) are difficult to quantify quantitatively.

Secondly, each industrial production should be safe regardless of the market situation (the level and correlation of supply and demand, market activity, price level, etc.). It is the material and technical base that provides the necessary degree of production safety. And commercial efficiency is determined, in turn, by the efficiency of goods and services, which is carried out outside the industrial zone. However, the commercial factor is nevertheless represented in the third group "level of organization and management" and is expressed by the growth rates of the market share of products.

Third, technological development of production is not only technical modernization and rearmament, but also the development of new materials, packaging, processes, and so on. Thus, there is a change in the impact on the environment, which predetermines the improvement and the corresponding equipment of monitoring. The indicator "equipment of control and measuring equipment for environmental monitoring" reflects, on the one hand, the production and technological level, on the other hand, the environmental aspect.
In order to obtain the indicator characterizing the result of the production and economic activities of the enterprise taking into account environmental factors, it is necessary to form an integrated indicator.

The mathematical formulation of the integral indicator requires the introduction of the following notation:

- \( j = 1, m \) – the directions of the evaluation of the OTLP (technical and economic equipment, technical and economic state of the equipment, the level of organization and management, the efficiency of the use of resources);
- \( i = 1, n \) - i-th private indicator (n - number of indicators of the j-th direction);
- \( b_i \) – particular indicator of the OTLP assessment system;
- \( a_{ij} \) – standardized value of the private indicator of the j-th direction;
- \( Q_{genj} \) – generalized assessment of the j-th direction;
- \( Q_{int} \) – Integral indicator of the assessment of OTLP, taking into account environmental aspects.

Since the calculated partial indicators are multidirectional, they possess the properties of heterogeneity and different scales, it is necessary to standardize them using the following formula:

\[
a_{ij} = \left( \frac{b_i}{b_{opt}} \right)^k,
\]

where \( b_i \) – the actual value of the private indicator; \( b_{opt} \) – the optimal value of the i-th indicator (max or min, depending on the orientation of each indicator).

Thus, the generalized indicator for each group is determined:

\[
Q_{obj} = \frac{1}{n_j} \sum_{i=1}^{n} a_i \cdot d_i,
\]

where \( a_j \) – i-th standardized indicator of the group; \( d_i \) – significance of the indicator in the group; \( n_j \) – number of indicators of the j-th group.

The integral indicator of the organizational and technical level of production (\( Q_{int} \)) is determined by the formula:

\[
Q_{int} = \sum_{j=1}^{4} Q_{obj} \cdot \lambda_j,
\]

where \( \lambda_j \) – the importance of the j-th group.

A common method of determining the significance is the method of paired comparisons.

The integral indicator is in the range from 0 to 1. For interpretation of the obtained values of the indicators, generalized by groups and integral index, verbal-numerical scales can be used. The Harrington Scale (Table 2) is the most commonly used verbal-numerical scale.

| Numeric value | A meaningful description of gradations | Description, in relation to the evaluation of OTLP |
|---------------|---------------------------------------|--------------------------------------------------|
| 0.0-0.2       | Very Low                              | Very low level of OTLP                            |
| 0.2-0.37      | Low                                   | Low level of TOT                                 |
| 0.37-0.64     | Average                               | The average level of OTLP                         |
| 0.64-0.8      | High                                  | High level of OTLP                               |
| 0.8-1.0       | Very High                             | Very high level of OTLP                           |
5. Conclusion
In accordance with modern requirements and actual tendencies in the field of nature management and environmental protection at the mega-, meso- and micro-levels of the economy, the issue of organizing effective environmental activities at domestic enterprises is acute, with the aim of orienting the industry towards sustainable environmental and economic development. The effectiveness of environmental protection can be established using the procedure for assessing its results.

A characteristic feature of the construction industry is the high resource intensity: in the production of products, considerable quantities of raw materials and energy are consumed. Also at the present stage, one of the most important requirements for the quality of construction materials is the requirement for their safety and environmental friendliness. The authors presented one of the possible ways of assessing the activity of construction industry enterprises, which takes into account not only the organizational and technical characteristics, but also the most significant environmental aspects of the industry.

Organizational and effective management of EA can become a valuable lever to improve financial, economic, social and image indicators of construction industry enterprises.

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