

Environmentalization of Production as a Direction of Ensuring the Sustainability of Production Activities of Enterprises and Increasing Their Economic Security



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ABSTRACT

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Within the article, the essence of the concept and theoretical aspects of greening production as a separate area of ensuring the sustainability of production activities of the enterprise is considered. The basic principles of ensuring the environmentalization of production have been studied, among the key ones are the principles of systematization, complexity, responsibility, scientific validity, economic balance, as well as the principle of permanent improvement. The authors also consider the main tools for production greening (utilization, recycling, biochemical, bioenergy technologies and technologies of environmental adaptation), as well as a study of the main stages of production greening. The dynamics of some indicators that characterize the trends in the prevalence of production greening among entrepreneurs in terms of the number of enterprises that implement relevant measures and those, which measures, are innovative and significant. The methodical approach of estimation of production greening with use of the methods of standardization, complex indicators and comparison is offered. A list of recommended measures for production greening by enterprises has been formed. The list of recommendatory measures of the enterprises production greening is formed, which include: development of ways to ensure the processing and reuse of industrial waste; conducting a study of the production system for the possible generation of returnable waste; introduction of measures to reduce the material consumption of products; reduction of energy consumption of equipment's separate elements; development and implementation of technological processes that eliminate or minimize emissions and emissions of harmful substances into the environment, etc.

1. INTRODUCTION

One of the key trends of the last decade is the comprehensive adoption of the concept of sustainable development by economic entities and government agencies at all levels of economic organization. The reasons for this approach as the dominant one was the permanent growth and critical exacerbation of a set of contradictions that arose in both the social and natural environment of economic entities, due to the unappeasable acceptance of the economic criterion as the basis and source of further economic systems. The consequence of such processes was the addition of the then dominant paradigm of socio-economic development, such two system-forming components as social and environmental, which allowed on the one hand to partially overcome the gap between public and commercial interests at the institutional level. On the other hand, to lay the foundations for balanced development on a long-term basis, taking into account the challenges and interests of future generations, in particular in matters of natural and man-made and unequal nature, and to ensure economic security of actors at various levels. The peculiarity of this concept is the interdependence, interpenetration and balance of these components; although

for some time, the issue of environmental components was not perceived with the appropriate level of importance and responsibility, due to the fact that its impact on development is not one-time mostly in long-term, often irreversible, consequences.

The environmental component has a special place, because on the one hand, has a direct impact on social development in the context of public health, quality and level of labor potential of the population, and on the other hand, finds its special expression in the effectiveness of economic relations, in particular its material base development, which is production. It is important to note that the sustainability of production activities in the context of its environmental component is not aimed at limiting any negative effects of production systems on the environment, but redirecting such effects in the opposite direction as a source of additional economic benefits and obtaining a positive economic effect.

That is why the study of production greening is an extremely important issue to ensure, on the one hand, the sustainability of production systems, and on the other hand, a potential direction for maintaining and developing national industrial potential and improving economic security.

2. LITERATURE REVIEW

The study of theoretical and applied aspects of the implementation of the basic principles of the concept of sustainable development, including production greening, has found its wide representation in numerous works of researchers in various fields of scientific and social activities [1-24].

The purpose of the research of Ovchinnikova et al. [13] is to analyze the system of criteria that allow to assess the level of environmental safety of the enterprise. Scientists claim that environmental problems, problems of production ecology, consumption of natural resources lead to an increase in production growth. The authors single out the main indicators that determine the level of nature management, including indicators of resource intensity, the degree of restoration of natural resources, indicators of conservation of primary natural resources. Scientists have developed ways to improve the processes of production greening, which, in their opinion, can improve the environmental situation in the regions of the country and establish the relationship between a man, nature and the industrial sphere.

Marinchenko [11] proved that the production of biological agents for protection and control, as well as stimulating the development of crops is one of the ways to increase the efficiency and profitability of production, reduce the burden on the environment. Scientists say that this will help increase the competitiveness of producers, which lies in the concept of a green economy, as well as for sustainable agricultural development. Scientists have studied domestic biotechnological developments in crop production, which increase production efficiency and reduce the burden on the environment.

Hai et al. [7] have developed an integrated closed ecosystem to reduce pollution and prevent pollution on rice paper farms. The authors present two modes of operation aimed at complete treatment of wastewater and exhaust gases in accordance with the requirements of the Vietnamese national standards. The authors argue that the application of this system contributes to the "greening" of the rice production chain in the Mekong Delta, Vietnam, and is an example of a local closed-loop economy.

Ionescu et al. [8] is aimed at analyzing the trends of increasing costs for waste disposal at the municipal landfill and the viability of investments for the integration of the compost platform. In the research, the authors calculated the economic effects of greening and capitalization of sludge waste on the basis of the optimal option. As a result of the study,

the authors proved that efficient waste management turns an environmental problem into an economic and environmental advantage for businesses.

According to the study Momodu et al. [12], the authors propose to study the PU industry for non-toxic reagents that could be obtained locally, compared to overcoming the problems of sustainable development (greening the economy) in Nigeria. The authors believe that attracting local resources for the production of PU is economically feasible. The results of the study proved that non-isocyanine polyurethane is relatively beneficial for human health and the environment.

In the article of Sidorova [17], scientists have studied modern trends in waste management and analysis of their impact on the development of the circular economy and environmental protection. The authors propose a methodological approach to assessing the use of waste based on their impact on resource processing and greening of industrial production. The study proved that the use and recycling of waste is an important area, because it requires less cost and eliminates harmful effects on the environment.

Voronkova et al. [22] propose organizational and economic transformations in the direction of greening of agro-industrial production. Within the article, the process of using the resource potential, involving producers in the production of environmentally friendly products and the development of organic agriculture is considered. Scientists have developed and substantiated the mechanisms for solving a set of problems.

The main emphasis of the Berchin et al. [4] is on the development of the green economy as the main dominant of achieving sustainable development. In the article, the authors argue that investing in greening the energy sector helps reduce greenhouse gas emissions while helping to develop a more sustainable economy. Researchers have analyzed how public policy can help green the ethanol sector in Brazil. The study analyzes how Brazilian bioenergy policy has helped improve the efficiency of sugar cane production and improve air quality in cities.

Zhu et al. [9] are studying the use of hazardous waste as a source material for production, which creates environmental benefits by avoiding the impact on recycling, mitigating the impact of production and conserving primary resources. It has been proven that China encourages reuse through the "Integrated Resource Management (CUR)" policy. According to the study, researchers argue that the evaluation of CUR results provides a solid foundation for the circular economy and offers additional opportunities to improve incentives under the CUR to increase environmental benefits.

Table 1. The main context of publications on the research topic

Source	The main concept of the study
Ref. [13]	The analysis of the system of criteria is carried out, which allows to assess the level of enterprise ecological safety
Ref. [11]	Increasing the efficiency of production and reducing the burden on the environment through the introduction of biotechnological developments in crop production
Ref. [7]	An integrated closed ecosystem has been developed to reduce pollution and prevent pollution on the example of rice paper farms
Ref. [8]	The economic effect of greening and capitalization of sludge waste at the municipal landfill and compost platform is proposed and calculated
Ref. [12],	It is proposed an approach to the study of the PU industry for non-toxic reagents, which could be obtained locally on the example of Nigeria
Ref. [17]	Current trends in waste management are substantiated and their impact on the development of the circular economy and environmental protection are analyzed.
Ref. [22]	Organizational and economic transformations in the direction of greening of agro-industrial production were proposed
Ref. [4]	The directions of the green economy introduction as the main dominant of sustainable development achievement aimed at reduction of greenhouse gas emissions on the example of Brazil are substantiated
Ref. [9]	The example of China is studying the use of hazardous waste as a source material for production, which creates environmental benefits by avoiding the impact on recycling, mitigating the impact of production and conservation of primary resources

Table 1 presents the results of the analysis of literature sources in a more grouped form.

However, despite the existence of a wide range of various theoretical and applied developments, as well as generally increased research activity in this area, in-depth consideration requires the incorporation of environmental approach in the organization of production activities as an important element of sustainable development and economic security.

3. METHODOLOGY

The methodology of this study is based on the fundamental principles of the theory of sustainable development, economic security of enterprises, resource management, as well as related theories. General scientific methods of scientific knowledge and special research methods were used. The methodology is based on the principles of system and resource approaches.

General scientific and specific methods of scientific knowledge were used, including: dialectical - to outline the relationships and contradictions of greening research and development of methodological foundations for the effectiveness of greening policy as determinants of its sustainability and economic security; analysis and synthesis - to identify trends and dynamics of indicators of the implementation of technologies of production greening at the enterprises of Ukraine, grouping of the indicators of assessment of production greening; abstraction and monograph - to substantiate the principles and tools of production greening, development of stages of greening of production and areas of the greening-oriented policy of organization of production activities to increase the sustainability and economic security of the enterprise; statistical and analytical modeling - to substantiate the methodological approach to assessing production greening as a direction of ensuring the sustainability of production activities of enterprises and improving their economic security; generalizations and formalizations - to develop directions that will accelerate the existing processes of greening of industrial enterprises by ensuring the sustainability of their production systems and economic security.

Among the special research methods used the method of decomposition, including the method of decomposition, to analyze existing approaches to the study of greening production as the determinants of ensuring the sustainability of production activities of enterprises and increase their economic security and other methods that allow a more thorough approach to achieving the goal. The methodology is based on the principles of system and resource approaches.

4. PRESENTING MAIN MATERIAL

Production greening is an important element of process management of the organization, because it takes place at all stages of its implementation within the relevant functional components; a special role is played by the production component, as it serves as a key source of environmental impact and benefits in case of proper management ensuring the economic security of enterprises.

Production greening is a process characterized by a set of measures for monitoring, control and regulation of technical and technological parameters of the production system in order to achieve goals while reducing negative impacts on the

environment and obtaining additional positive economic and / or social effects of capacious determinant of economic security.

The main principles on which the process of successful greening of production is based, regardless of the direction or scope of the enterprise are as follows (Figure 1).

First, the system is characterized by a consistent approach to production greening at the enterprise, which involves, on the one hand, avoiding selective choice of directions, which is often limited by financial needs of such activities, and on the other hand, taking into account existing intersystem links, namely in matters of ensuring their coordination to maintain the rhythm and uniformity of production;

Second, the complexity implies that the changes implemented by the enterprise on production greening activities must be fully consistent in the functional and temporal dimension of their implementation, taking into account existing production links, nature and extent of potential side effects from the implementation of appropriate actions enterprises, and the impact of their production on the environment;

Third, the responsibility lies in the conscious use of a natural resource by the enterprise, understanding the range of possible consequences of abuse and its careless use for natural ecosystems, enterprise personnel, local community, etc.;

Fourth, scientific validity involves the application of a scientific approach in the process of research, planning and direct implementation of the measures to green production in accordance with the latest developments and practical developments in this field;

Fifth, economic balance implies that the implementation of the process of greening is based on a combination of environmental and economic efficiency criteria, synergistic interaction of which may ultimately give the highest level of production return;

Sixth, the permanence of the improvement process is to consider the issue of greening not as a target state of the production system, but as a process of continuous improvement of its production parameters in order to minimize negative environmental impacts while achieving maximum economic results.

These principles of production greening of the enterprise are realized themselves through the use of appropriate tools, which in accordance with the extent and nature of the impact on the degree of environmental friendliness of production are divided into resource-saving, low-waste and waste-free technologies.

At the same time, in terms of content, the tools used to green production can be divided into recycling, biochemical, bioenergy and environmental technologies. Next, we propose to consider each tool in more detail.

Utilizing technologies - technologies of adaptation of production systems to the production of reverse type waste, i.e. those that can potentially be converted into certain raw materials or materials that, unlike waste, have a certain level of usefulness depending on which can be used or sold by the enterprise.

Recycling technologies - a technological process in which waste from one production becomes a raw material for another (closed loop technology).

Biochemical technologies - this type of technology allows to obtain positive environmental effects by changing the molecular structure or composition of waste in order to obtain raw materials whose physical and chemical properties can be further applied in production.

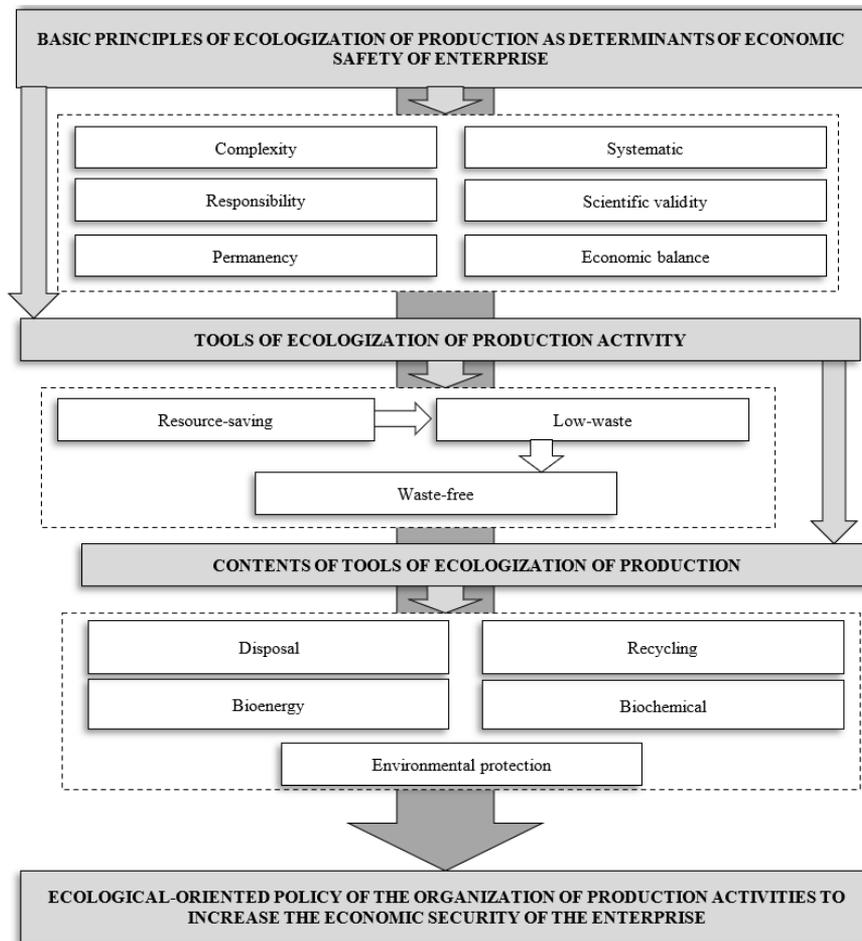


Figure 1. Principles and tools of greening of production activities (Source: built and substantiated by the authors)

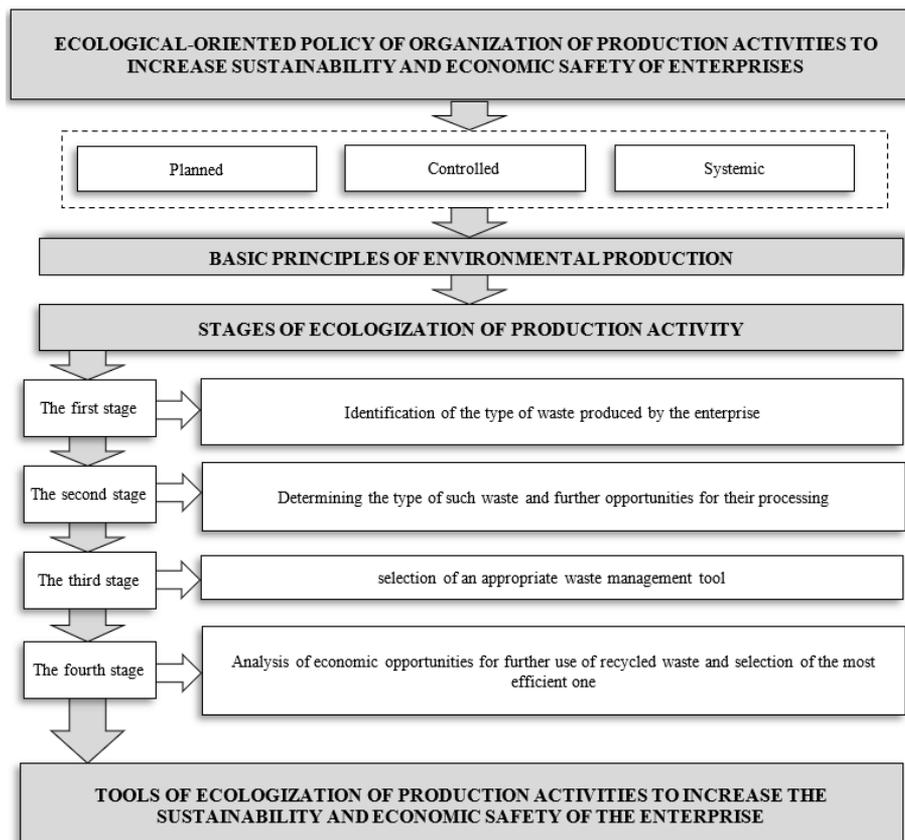


Figure 2. Environmentally-oriented policy of organization of production activities to increase the sustainability and economic security of the enterprise (Source: compiled by the authors)

An example of such technologies is extrusion processing of waste, which has proved particularly effective in the field of animal husbandry, which can be used to obtain a product from meat waste, which is a protein feed additive with the following characteristics: protein - 14-20% (depending on the type of recyclable waste and vegetable filler); high biological value that promotes digestibility (about 90%); digestible energy of feed to restore energy expenditure contains - 290-310 kcal per 100 g of nutrients; long shelf life - no more than 12 months.

Bioenergy technologies - technologies aimed at the processing of industrial waste in order to further use the results of such processing in order to meet the energy needs of production.

One of the successful examples of the application of bioenergy technologies is the production of biogas, which is carried out by technological processing of certain raw materials, which can serve as wood, as well as certain types of plant and animal waste. Biogas, which consists of 63-65% methane and 32-34% carbon dioxide, has a high calorific value - 23 MJ / kg, can be an additional source of energy. The biological processes of biogas production are not environmentally harmful in their nature, and the resulting gaseous fuel is environmentally friendly.

Technologies of ecological adaptation - based on the use of a wide range of scientific tools for in-depth analysis of the whole set of natural and climatic conditions in which the company operates in order to maximize adaptation and actual integration of production activities into the local ecosystem.

It should be noted that the implementation of environmentally-oriented policy on the organization of production activities cannot be chaotic, selective and situational, because in its content and preset principles greening of production is a planned, controlled and systematic process implemented consistently at certain stages (Figure 2).

The main stages of production greening to increase the sustainability and economic security of the enterprise are as follows:

First, identification of the type of waste produced by the enterprise. This stage involves a thorough analysis of the production system of the enterprise in terms of potentially negative environmental impacts on the environment, as well as identification of the type of such impacts. The most

common impact of the enterprise on the environment is the production of certain wastes, which may be exclusively of industrial or domestic origin;

Second, determining the type of such waste and further opportunities for their processing. This stage determines the potential characteristics of industrial waste and determines the list of possible areas of their use (energy resources, recycling, etc.);

Third, on the basis of a certain type and type of waste, selection of an appropriate waste management tool, which involves determining the further direction of waste use, which may be disposal, disposal, reutilization, processing, disposal, commercialization to the party unchanged;

Fourth, analysis of economic opportunities for further use of recycled waste and selection of the most efficient one. This stage involves the analysis of potential alternatives to waste management according to the economic criteria in order to determine the most appropriate of them. Such alternatives may be the use of recycled waste in production or as an energy resource for their commercial sale of waste or waste disposal.

Trends in recent years show that production greening has become widespread among enterprises in leading countries, in particular as a separate component of corporate social responsibility systems. Moreover, the high level of environmental friendliness of production is the key to successful foreign economic activity of the enterprise, as an access to the most attractive markets is often limited by a large number of non-tariff barriers, which are high requirements for product quality and a number. Gradually, Ukrainian enterprises are also joining the relevant systems of quality standards, but the dynamics of such changes is extremely slow (Figure 3).

The presented illustration shows the low number of measures taken by enterprises to green production, and the number of significant improvements is also low, although there is a positive trend in the growth of this indicator.

To assess production greening as a direction of ensuring the sustainability of production activities of enterprises and increase their economic security, it is proposed to assess four groups of indicators, namely in accordance with the social and organizational and economic components of production greening; greening of labor and means of production (Table 2).

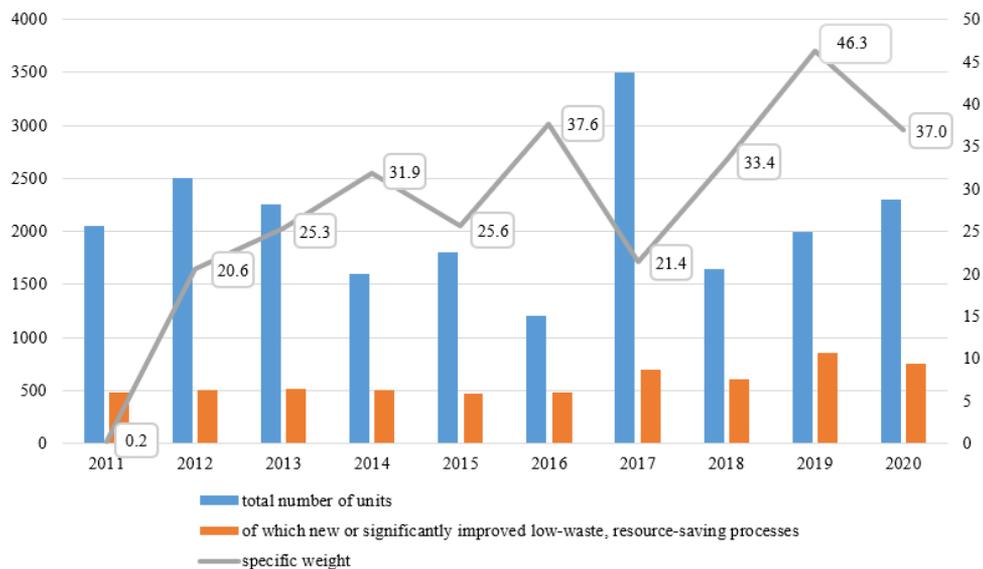


Figure 3. Dynamics of indicators of the introduction of technologies of production greening at the enterprises of Ukraine
Source: built by the authors

Table 2. Groups of the indicators for assessing production greening as a direction of ensuring the sustainability of production activities of enterprises and improving their economic security

No.	Indicators of production greening as a direction of ensuring the sustainability of production activities of enterprises and improving their economic security
The social component of production greening	
x ₁	The share of the amount of resource and environmental payments of the enterprise that fully reimburse the cost of natural resources used in the production process and losses from discharges (emissions) of pollutants
x ₂	The share of investment resources to finance environmental projects and programs in the total investment of the enterprise
x ₃	The share of the achieved targets in the total amount of indicators on environmental policy
Organizational and economic component of production greening	
x ₄	The quality of distribution of powers and responsibilities in decision-making on environmental issues
x ₅	The quality of environmental reports (if any) is assessed on a ten-point scale
x ₆	The share of costs (revenues) for the production of goods produced using environmentally friendly technologies
x ₇	The share of implemented eco-innovations in the total amount of innovations
Greening of labor	
x ₈	The share of qualified specialists in the environmental profile in the average number of employees at the enterprise
x ₉	Proportion of employees of the enterprise who increase environmental literacy without interruption from production through retraining and advanced training (for the last five years)
x ₁₀	Proportion of incentive payments paid to employees for achieving high rates of environmentally responsible behavior in the total amount of incentive payments
x ₁₁	Proportion of employees in the enterprise who work in hazardous conditions (if any)
Greening of production means	
x ₁₂	The share of environmentally friendly equipment in the total amount of capital resources
x ₁₃	The share of investment in environmentally friendly fixed assets in total investment
x ₁₄	The share of environmentally friendly raw materials in the total production stocks
x ₁₅	The share of reusable and standard packaging in the total packaging
x ₁₆	Share of recycled waste

Source: generated by the authors

In order to assess production greening as a way to ensure the sustainability of production activities of enterprises and increase their economic security, it is necessary to standardize indicators to allow further research with a single scale of measures and numerical order. The procedure of standardization of the indicators does not have a significant impact on the results of further assessment of production greening. Standardization is carried out using the method of linear scaling. For each group of indicators, the integrated index of the group of greening of production (I_{ij}^n) is determined as Eq. (1).

$$I_{ij}^n = \frac{X_{ij}}{X_{\max+1j}} \quad (1)$$

where, I_{ij}^n - integral index of the n-th group of production greening;

X_{ij} - standardized values of the j-th indicator (Table 1) for the i-th period;

$X_{\max+1j}$ - the maximum value of the j-th indicator of the group of greening of production.

After determining the integrated indices of the groups of production greening, it is proposed to determine the deviation of the calculated value of integrated indices from the maximum possible by Eq. (2):

$$E_{ij} = 1 - I_{ij}^n \quad (2)$$

where, E_{ij} - deviation of the value from the maximum possible value.

To determine the scale of deviation and compare them, it is proposed to use the Euclidean distance (Dl_i) and perform calculations according to Eq. (3):

$$Dl_i = \sqrt{\sum_{j=1}^m (I_{ij}^n)^2} \quad (3)$$

Determining the Euclidean distance in the assessment of production greening, it is possible to level the negative values of indicators and obtain a qualitative assessment of production greening based on the interpretation of quantitative measures.

Since in our case all indices of production greening have the same value, the complex index is defined as the average of all groups of indices. Therefore, on the basis of integrated indices of groups is determined by the integrated index of production greening of the enterprise (C_i) as a whole by Eq. (4):

$$C_i = \frac{\sum_{i=1}^m IE_i}{n} \quad (4)$$

where, n - the number of groups of indicators of production greening, namely: social and organizational and economic components of production greening, greening of labor and means of production.

The use of the proposed methodological approach to assessing production greening makes it possible to obtain a comprehensive description of production greening at the enterprise through the use of tools of multidimensional statistics, which allow to assess the impact of individual factors on production greening as a whole. The proposed methodological approach to assessing production greening to increase the sustainability and economic security of the enterprise makes it possible to assess the groups of indicators of production greening and greening in general by determining integrated indices and deviations of existing values by determining the Euclidean distance from the possible standard.

Assessing production greening as a direction of ensuring the sustainability of production activities of enterprises and improving their economic security makes it possible to determine the effectiveness of production greening and

propose areas of the environmentally friendly policy of organization of production activities to improve economic security.

Based on the study, we can propose the following list of areas that will accelerate the existing processes of greening of industrial enterprises by ensuring the sustainability of their production systems and economic security:

- development of possible ways to ensure the processing and reuse of industrial waste;
- study of the production system for the possible generation of returnable waste;
- reduction of material consumption of products;
- ensuring a high frequency of technical and technological renewal of production;
- achieving a continuous process of the intensification of production;
- increasing the level of unit capacity of equipment, modernization of their quality characteristics;
- reduction of energy consumption of individual elements of equipment both in the direction of reducing the consumption needs of energy-intensive resources and reducing the level of waste generated during this process;
- analysis of technological processes of waste generation and further research of possible business entities interested in their acquisition;
- maximum reduction of technological stages of production, which serve as an additional source of waste and loss of raw materials;
- monitoring of the market of technical innovations and analysis of opportunities for their implementation at the enterprise;
- development and implementation of technological processes and schemes that eliminate or minimize waste and emissions of harmful substances into the environment;
- creation of water cycle cycles and drainless systems for economy and protection against pollution of fresh water with harmful substances as one of the most scarce resources.

5. CONCLUSIONS

In summary, it can be argued that the introduction of production greening at enterprises is an important element in ensuring the sustainability of their production activities and improving economic security and is of great positive importance for the national economy as a whole.

The scientific novelty of the study is the substantiation of theoretical and methodological principles for production greening as a direction of sustainability of production activities and increase their economic security, which involves, first, highlighting the basic principles and tools of production greening as a determinant of economic security, second, assessment of production greening using standardization methods, complex indicators and comparisons; third, the introduction of environmentally-oriented policies for the organization of production activities to increase the sustainability and economic security of the enterprise.

As a result of the study, the main theoretical provisions for ensuring the green development of enterprise production to increase the sustainability and economic security of the enterprise were considered. The basic principles of organization of the processes of production greening are defined, namely systematization, complexity, responsibility, scientific substantiation, economic balance and permanence of

improvement processes. The main types of the tools for production greening, such as recycling and recycling technologies, biochemical and bioenergy technologies, as well as environmental adaptation technologies have been identified. The study formed four main stages of production greening, considered the dynamics of this phenomenon among the business sector and provided a list of recommendations for accelerating the development of such processes that will improve the sustainability and economic security of enterprises.

Four main stages of greening production introduction in the research process were formed, which consist of: identification of produced type of waste by the enterprise; determining the type of such waste and further opportunities for their processing; selection of an appropriate waste management tool, which involves determining the further direction of waste use; analysis of economic opportunities for further use of recycled waste and selection of the most efficient one.

The dynamics of this phenomenon development among the business sector is considered and a corresponding list of recommendations for accelerating the development of such processes that will help increase the sustainability and enterprises economic security.

Further research requires the development of directions to improve energy efficiency of production within the framework of ensuring the green development of enterprise production to ensure the sustainability and economic security of enterprises.

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