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## Polyvariance of vector formation of sustainable development of metallurgical enterprises

### Поліваріантність формування вектору стійкого розвитку металургійних підприємств

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#### Abstract

The article establishes that the formation of the vector of sustainable development of metallurgical enterprises should be based on the use of such methodological approaches as systems analysis and program-target approach; on a combination of methods of economic diagnostics (method of expert assessment, method of economic and mathematical modeling, methods of multifactor and trend analysis). The polyvariance of the process of forming a system of indicators, which is the basis for calculating the integrated indicator of the vector of sustainable development, ensures taking into account the state and trends of changes in technical-technological, economic-environmental, and social components of the industrial enterprise. To solve this scientific problem, the stages of polyvariate formation of the vector of sustainable development of metallurgical enterprises are developed, which are based on the established basic principles; actualization of the vector of sustainable development is happening in accordance with the state of technical-technological, economic-

#### Анотація

У статті встановлено, що формування вектору стійкого розвитку металургійних підприємств повинно ґрунтуватись на використанні таких методологічних підходів, як системний аналіз та програмно-цільовий підхід; на комбінації методів економічної діагностики (методу експертного оцінювання, методу економіко-математичного моделювання, методів багатофакторного та трендового аналізу). Поліваріантність процесу формування системи індикаторів, що покладено в основу розрахунку інтегрального показника вектору стійкого розвитку, забезпечує врахування стану та тенденції змін техніко-технологічної, економіко-екологічної та соціальної компонент діяльності промислового підприємства. Для вирішення цього наукового завдання розроблено етапи поліваріантного формування вектору стійкого розвитку металургійних підприємства, які ґрунтуються на встановлених базових принципах; актуалізація вектору стійкого розвитку відбувається у відповідності до стану техніко-технологічної, економіко-екологічної та соціальної складових та

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environmental and social components and takes into account the modes of operation of the metallurgical enterprise, corresponding to the actual level of the integrated indicator.

**Keywords:** polyvariance, the vector of sustainable development, indicators, the integrated indicator, environment-friendly production processes.

## Introduction

Studies of the state of the domestic metallurgical industry clearly show that the negative consequences that occur in the enterprises of the metallurgical industry are the result of an imbalance in the management mechanism of the entire mining and metallurgical complex of Ukraine. The key features of the unbalanced mechanism are systemic technical-technological, economic-environmental, and social destructive phenomena in enterprises that are strategic producers of metal products.

The solution to the scientific problem of developing the vector of sustainable development of metallurgical enterprises is proposed by using the advantages of methodological approaches at the same time, namely a program-targeted approach to developing and adjusting the program of actions to achieve the goal of the enterprise and methodologies of system analysis in terms of using methods of economic diagnostics, in particular methods of expert evaluation, economic and mathematical modeling, multifactor and trend analysis. The analytical basis for providing a polyvariate approach to the formation of the vector of sustainable development of metallurgical enterprises is the calculation of a system of indicators of evaluation and integrated indicators, which are focused on dynamics of change and development of preventive measures in all functional areas of metallurgical enterprise, including technical-technological, economic-environmental, and social components of the enterprise as a complex socio-economic system.

As the results of research, the stages of polyvariate formation of the vector of sustainable development of metallurgical enterprises have been proposed. Under conditions of uncertainty, they provide an opportunity to update indicators of assessment of technical-technological, economic-environmental, and social levels of activity of metallurgical enterprise on the basis of retrospective analysis of achieved results by individual indicators and by establishing cause and effect relationships between the absolute and relative indicators of financial statements.

Based on the results of practical testing of the integrated indicator of sustainable development of the metallurgical enterprise, the basic principles are substantiated, compliance with which is mandatory in the modeling of processes and phenomena and the formation of multiple linear regression models for analysis, planning, and forecasting.

## Theoretical Framework or Literature Review

The Decree of the President of Ukraine No. 722/2019 of 30.09.2019 approved the Sustainable Development Goals of Ukraine until 2030, which, in particular, includes several goals that complement each other, focused on the formation of a vector of sustainable development of enterprises and highlight problems that need to be addressed immediately on the way to sustainable development of the economy, civil society and the state as a whole. Those goals are: promotion the sustainable, inclusive, and sustainable economic growth, full and productive employment, and decent work for all; creating sustainable infrastructure, promoting inclusive and sustainable industrialization and innovation; ensuring the transition to rational models of consumption and production; ensuring openness, security, viability and environmental sustainability of cities and other settlements.

At the beginning of the last century, at the first International Conference for Nature Conservation, held in Bern in November 1913, stressed the urgent need to implement global nature conservation through interrelated activities at the national and international levels (Sarazen, 1913). This thesis later became the basis for the formation of an international approach to environmental security as part of the overall security of the country, in particular at the UN Conference on Environmental problems (Stockholm, 1972), the Second UN Conference on Environmental problems and Development called "Earth Summit" (Rio de

враховує режими функціонування металургійного підприємства, що відповідають фактичному рівню інтегрального показника.

**Ключові слова:** поліваріантність, вектор стійкого розвитку, індикатори, інтегральний показник, екологічність виробництва.

Janeiro, Brazil, 1992) and others. Of particular importance in this area was the UNESCO General Conference on October 16, 2003, which recognized the Charter of the Earth. The Charter has defined the fundamental principles of a just, sustainable, and peaceful global society in the XXI century. It has emphasized the interdependence of the world, the mutual responsibility of all, both to each other and all living and future generations (Landveld, 2012).

Following the UN Conference on Sustainable Development (Rio + 20; Brazil, Rio de Janeiro, June 2012), the final document "The Future We Want" was adopted. It's reaffirming the course set at the World Summit on Balanced Development in 2002 for sustainable development and for ensuring the construction of an economically, socially, and environmentally balanced future for the planet, for present and future generations (Landveld, 2012).

The 70th-anniversary session of the UN General Assembly (September 2015) in New York (USA) hosted the Summit on Sustainable Development, which set a global course for sustainable development and building an economically, socially, and environmentally balanced future for planets, as well as the rule of life and management in every country in the world: "it is economically advantageous to be environment-friendly" (Outcome Documents, 2015).

This historical digression into human awareness of the environmental dangers of its activities illustrates the steps taken by the international community to come to the final conclusion that the main vector of world development in the near and long term should be the combination of environmental and economic goals. In turn, against the background of the merging of resource, environmental and economic threats, it is necessary to ensure efficient, sustainable, and environment-friendly regimes for the functioning of material industries in general and industrial enterprises as major polluters in particular.

The sustainable development of metallurgical enterprises is considered in the context of the relationship of technical and technological (production), economic-environmental and social components. In this context, the polysemy category of "economic-environmental security" formulated by Afonov R.P. (2020) in relation to the metallurgical enterprise, draws attention, namely: it is a dynamic state of resources..., which is characterized by the stability of its economic interests; transparency, and efficiency of results due to the process of continuous improvement of technical and technological potential through the implementation of corporate missions and strategies, which, ultimately, ensures its sustainable development in external and internal threats with mandatory compliance with the principle of environmental conditionality of production. We believe that taking into account the provisions of the Strategy of Environmental Security and Climate Change Adaptation for the period up to 2030 approved by the Cabinet of Ministers of Ukraine, which was designed to ensure compliance with regulations such as the Law of Ukraine "On ratification of the UN Framework Convention on Climate Change"; the Law of Ukraine "On Ratification of the Association Agreement between Ukraine, on the one hand, and the European Union, the European Atomic Energy Community, and their Member States, on the other hand"; the Law of Ukraine "On Ratification of the Paris Agreement" (Resolution of the Cabinet of Ministers of Ukraine no. 218, 2021) (6), etc., it is necessary at the legislative level and in scientific schools to gradually abandon the term economic security, at least when assessing the security of industrial enterprises, replacing it with complex phrases technical-technological and economic-environmental security. After all, now the economic goals and tasks, both at the enterprise level and the state level had to be environment-friendly; moreover, today we are talking about the greening of all spheres of human activity in society.

The process of globalization of the economy requires consideration of sustainable development of metallurgical enterprises in combination with technical-technological, economic-environmental, and social issues. Following this direction is especially important for Ukraine due to the presence of many factors, the impact of which is destructive on the development of the industry and the national economy as a whole, namely:

- export-oriented metallurgical enterprises and their dependence on foreign markets;
- extremely high level of depreciation of the active part of fixed assets (both physical and moral);
- material consumption and energy consumption of production;
- unsatisfactory brand and size range of metal products;
- pollution of the natural environment by emissions into the atmosphere and discharges into water bodies;
- irrational use of basic natural resources and their depletion;

lack of sufficient infrastructure and effective waste management system, which leads to the mass formation of unauthorized landfills and numerous violations of the Law of Ukraine "On Waste" and other regulations; lack of an effective system of state supervision (control) in the field of environmental protection, etc. (Resolution of the Cabinet of Ministers of Ukraine no. 218, 2021).

reduction of the number of the employed population in the industry from 3236.7 thousand people in 2012 to 2358.6 thousand people in 2020 (Voronko-Nevidnycha, et al., 2021; Voronko-Nevidnycha & Sirenko, 2020).

It should be noted that the domestic metallurgical industry is one of the largest polluters of the environment in the country due to the use of mostly obsolete and low-efficiency technologies. As for the methods of steel production, three methods are used in Ukraine: open-hearth; oxygen-converter; production of electric steel. Moreover, if we talk about the open-hearth method, as obsolete and most harmful to the environment, energy-intensive and dangerous compared to others, then, according to the world organization World Steel Association, our country is the undisputed world "leader" in this regard (Voronkova & Metelenko, 2020). The presence of uncertainty in the economic activity of domestic metallurgical enterprises significantly complicates the process of selecting optimal solutions and can lead to unpredictable results. Regarding the peculiarities of enterprise management, their detailed standardization is given, in particular, in Section II of the Commercial Code of Ukraine No. 436-IV of, 2003. However, the Commercial Code of Ukraine does not regulate such defining guidelines for the functioning of the business entity as the mission and strategy of the enterprise, which are mandatory prerequisites for the formation of a vector of sustainable development.

The methodological basis for the polyvariant formation of the vector of sustainable development of metallurgical enterprises is the use of both systematic analysis (in the formalization of complex structures) and a program-targeted approach, which provides the ability to reveal the integrity of the object and its mechanisms; identifying the types of internal and external relations and bringing them into a single theoretical picture; development and adjustment of the program of actions in the interests of achievement of the purpose (formation of a vector of sustainable development) by the decision of triune scientific task in a subsystem of technical and technological, economic-environmental and social components; standardization of the system of legislative, normative-legal and sub-normative acts of regulation of activity of industrial enterprises of the metallurgical branch taking into account interests of the state and business interests of subjects of managing.

The application of economic diagnostics as a system of target analysis in conditions of uncertainty using the methods of expert assessments, economic and mathematical modeling, multifactor and trend analysis using indicators of evaluation and calculation of integrated indicators, focused on developing preventive measures in all functional areas of metallurgical enterprise, in particular in the technical-technological, economic-environmental and social components of the enterprise as a complex social and economic system.

The application of the program-target approach is accompanied by the use of the method of expert evaluation, which is acceptable and objectively necessary in the formation of the vector of sustainable development of the enterprise. System analysis in this case allows not only a new approach to solving many pressing problems of polyvariate formation of the vector of sustainable development of metallurgical enterprises but also to explore specific actions, situations, and goals in combination with established and measured factors of influence; to structure new models of estimation taking into account influence on them of branch and organizational structure, features of production technology, processes of "aging" of manufacture, limited access to resources, etc. Domestic scientists (Zaloznova, 2018; Kindzersky, 2016; Mazur, 2016) assess the current state of the industry as a state of deep deindustrialization; they note that in a quarter of a century of economic transformations Ukraine has dropped out of the top ten industrialized countries and has now become the poorest country in Europe with deindustrialized production and that the current spontaneous, unjustified and unregulated industrial policy of Ukraine has resulted in deindustrialization.

Thus, in general, we can conclude that domestic research on the sustainable functioning of industrial enterprises (Hroznyi, et al., 2019; Tarasova, et al., 2020; Voronkova & Metelenko, 2020) covers certain areas of activity, but does not focus on the most important components, which today play a crucial role in shaping prospects for both domestic and international metal markets. Analytical evaluations are mostly carried out by calculating indicators or integrating them without building a system of actions that takes into

account the integral relationship of the components of technical-technological, economic-environmental, and social systems.

Therefore, there is a need to develop stages of polyvariate formation of the vector of sustainable development of the metallurgical enterprise, which must meet such requirements:

be based on the joint application of systems analysis and program-targeted approach to the identification of factors and conditions for the formation of the vector of sustainable development of metallurgical enterprises;

apply the methodology of economic diagnostics (using the methods of expert assessments, economic and mathematical modeling, multifactor and trend analysis) for developing and adjusting the program of action in the interests of achieving the goals of the enterprise;

to ensure the polyvariate process of forming a system of indicators (including integrated indicators), which takes into account the relationship of such components (areas) of the enterprise as technical and technological, economic, environmental, and social;

take into account the dynamics of changes in all components (areas) of the industrial enterprise and adapt to changing environmental conditions without significant losses for the enterprise as a complex socio-economic system.

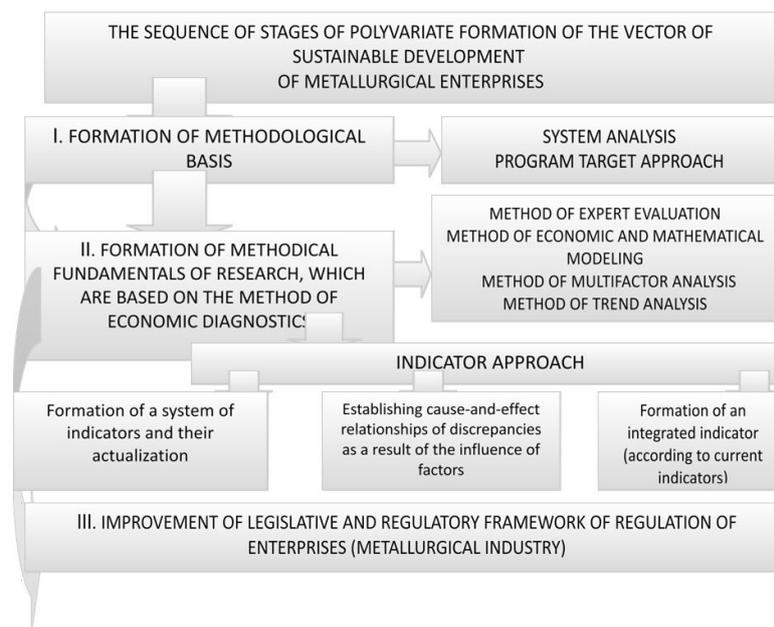
**Methodology**

The sequence of stages of polyvariate formation of the vector of sustainable development of metallurgical enterprises in conditions of uncertainty of the external environment is shown in Figure 1.

The scheme was developed by the authors of the article.

The system of indicators and their updating is formed on the basis of using the calculation method set out in the "Guidelines for identifying signs of insolvency of the enterprise and signs of actions to conceal bankruptcy, fictitious bankruptcy or bankruptcy" (The Order of the Ministry of Economy of Ukraine No. 14, 2006).

The updating of indicators for assessing the technical-technological, economic-environmental and social levels of the metallurgical enterprise is based on a retrospective analysis of the results achieved by individual indicators and by establishing causal links between absolute and relative indicators of financial statements.



**Figure1.** Stages of polyvariate formation of the vector of sustainable development of metallurgical enterprises in conditions of uncertainty.



method of calculating these coefficients and their interpretation is similar to the method of calculating the linear correlation coefficient for the case of a one-factor connection.

With help of the outlined procedure of multifactor regression analysis, the prediction of changes in the simulated process (phenomenon) as a result of changes in one or more factors (indicators and their components) is carried out and the new vector of sustainable development of the metallurgical enterprise is formed, i.e. the process of polyvariant, which is based on the identification of technical and technological, economic-environmental and social levels of the metallurgical enterprise is ensured.

Thus, for building an integrated indicator in order to form one of the options for the vector of sustainable development of the metallurgical enterprise, we have selected such relevant indicators that are included in the list of indicators (The Order of the Ministry of Economy of Ukraine No. 14, 2006) and reflect (directly or indirectly) processes occurring in technical-technological, economic-environmental and social spheres of activities of the industrial enterprise:

$k_1$  – the share of fixed assets in the assets of the enterprise;

$k_2$  – maneuverability of own current assets;

$k_3 k_3$  – coverage ratio;

$k_4 k_4$  – the share of current assets in assets;

$k_5$  – the financial autonomy ratio;

$k_6$  – long-term investment structure ratio;

$k_7$  – fixed-asset turnover;

$k_8$  – equity turnover;

$k_9$  – Beaver's ratio;

$k_{10} - k_{10}$  – return on equity.

Based on the calculations of the actual level of current indicators of economic activity of the metallurgical enterprise in accordance with the Methodology (The Order of the Ministry of Economy of Ukraine No. 14, 2006), as well as the formation of multiple linear regression functions, the calculation of the integrated indicator of sustainable development vector of the metallurgical enterprise is carried out. The algorithm for determining the integrated indicator is based on the calculation of indicators  $k_1 - k_{10}$ , the density of the relationship between which and the significant impact on the performance indicator has been proven experimentally. Each indicator characterizes a particular aspect of the economic activity of the metallurgical enterprise and reflects the (direct or indirect) impact on the level of the integrated indicator. Standardization of selected indicators is carried out by dividing the actual indicators by the standard value, and the integrated indicator is determined as follows:

$$I_{fs} = \sum_{i=1}^n \frac{k_i^{fact}}{k_i^{st}} * \omega_i \tag{4}$$

where  $k_i^{fact}$  – the actual value of the current indicator from the list of selected indicators;

$k_i^{st}$  – the standard value of the current indicator (recommended experimentally, in accordance with modern conditions of operation of the metallurgical enterprise);

$k_i^{st} \omega_i$  – weight (significance) of the current indicator.

The aggregation of features into one integral assessment is based on the so-called "additive value theory" according to which the value of the whole is equal to the sum of the values of its components (Grabovetsky, 2009). The integrated indicator varies within the limits of change of modes of functioning of the metallurgical enterprise are shown in Table 1.

**Table 1.**

*Modes of functioning of the metallurgical enterprise in accordance with the actual level of the integrated indicator of the vector of sustainable development*

<b>The level of the integrated indicator</b>	<b>The limits of the indicator</b>	<b>The mode of functioning of the enterprise</b>
<b>Unsatisfactory (critical, low)</b>	0,00 – 0,30	Systemic signs of crisis phenomena in the technical-technological, economic-environmental and social spheres for a long period. Unprofitable activities for a long time. Lack of own financial sources to ensure current activities.
<b>Satisfactory (allowable)</b>	0,30 – 0,50	Periodic crises in the technical-technological, economic-environmental and social spheres (loss of qualified personnel, loss of markets, pollution of the environment, lack of resources to upgrade equipment and technologies, etc.)
<b>Satisfactory (sufficient)</b>	0,50 – 0,70	Sustainable functioning in the technical-technological, economic-environmental and social spheres throughout the year. Positive changes in volume economic indicators (volumes of activity in-kind). Sufficient level of competitiveness of products and an enterprise in the market. Profitable activities at all levels of profit. Periodical processes of investing in fixed assets, technology, personnel.
<b>Normal</b>	0,70 – 0,90	Sustainable functioning in the technical-technological, economic-environmental and social spheres for three years. Stable positive dynamics of increasing the volume of economic activity. Increasing the level of competitiveness of products and enterprises as a whole in the market of goods and services. Periodical implementation of investment and innovation projects at the expense of own sources of financing.
<b>Optimal</b>	0,90 – 1,00	Sustainable functioning in the technical-technological, economic-environmental and social spheres for five years. Stable positive dynamics of annual growth of economic activity. High level of competitiveness of products and enterprises in general in the market of goods and services. Investment activity of the enterprise and their financing from their sources (net profit). Investing in staff development. Update of technologies in the direction of the realization of the principle of the greening of production.

Source: own research

Thus, we have developed stages of polyvariate formation of the vector of sustainable development of metallurgical enterprises, which, among other things, include the construction of multiple linear regression functions, which allows for organically combination qualitative and quantitative factors, the relationship between which has been proven experimentally; take into account the modes of functioning of the metallurgical enterprise, which are differentiated according to the currently achieved level of the integrated indicator, that was calculated based on current assessment indicators.

## **Result and Discussion**

The practical approbation of the developed integrated indicator was carried out at the metallurgical enterprise of the Zaporizhzhia region PJSC MK "Zaporizhstal". It was established that in 2018 and 2019 the level of the integrated indicator is characterized as "normal"; in 2019 and 2020 - as "satisfactory", i.e., during 2020 - 2021 the vector of sustainable development of the metallurgical enterprise has a negative trend are shown in Table 2.

**Table 2**
*The integrated indicator of the vector of sustainable development of the metallurgical enterprise*

Name of the enterprise / research period	01.01.2018	01.01.2019	01.01.2020	01.01.2021
<b>PJSC MK "Zaporizhstal"</b>	0,86	0,89	0,59	0,52

Source: own research

Polyvariance of the proposed approach to the formation of the vector of sustainable development of metallurgical enterprises is the diversity of logical selection, combining relevant indicators and forming on their basis multiple linear regression models for analysis, planning, and forecasting. In general, modeling is a scientifically based method that evaluates almost all the characteristics of complex systems used for the development and implementation of management decisions (Petrenko, 2010). For solving each of the problems, as scientists say, «you need to build your own mathematical model of the process or phenomenon, which would take into account their» (Stepanyshyn & Tysovsky, 2012). The proposed stages of the polyvariate formation of the vector of sustainable development of metallurgical enterprises, which is updated taking into account the state of technical-technological, economic-environmental, and social components, have provided an opportunity to formulate basic principles that are mandatory for the sustainable development of metallurgical enterprises:

- the principle of scientific validity (combination on the basis of scientific research the ecological and economic interests of society, which provide real guarantees of human rights to safety, health, and favorable living environment; determination of optimal costs to ensure natural and anthropogenic and ecological safety and environmental protection from various sources);
- the principle of economic responsibility (consists in obligatory compensation by nature users of damages caused to the environment, human health, and property of individuals and legal entities as a result of man-made and environmental offenses);
- the principle of complexity (systematic, comprehensive coverage of the situation), which contributes to the multi-purpose use of resources, the development of low- and zero-waste production, processing of raw materials;
- the principle of economic calculation (requires a link between the greening of production and its economic efficiency and profitability), which is fundamental in the

formation of the management system of the production sphere in general, as it meets the interests of economic entities and society as a whole;

- the principle of payment for the use of natural resources (aimed at solving important social, economic, and environmental problems of increasing interest in efficient nature management, the formation of additional financial sources for the reproduction of limited environmental resources);
- the principle of the greening of production, which provides for a gradual transition to environment-friendly technologies in order to reduce the level of man-made load on the environment.

We also insist that the sustainable functioning and development of industrial enterprises in Ukraine should take place in accordance with the approved state program on the cooperation of public authorities and self-government with owners of metallurgical enterprises with the mandatory involvement of recognized domestic scientific experts in this field. It is necessary to develop a comprehensive "road map" for the development and modernization of each individual metallurgical enterprise due to the importance of their impact on the prospects of Sustainable Development of Ukraine. In our opinion, the program should provide for large-scale modernization and renewal of metallurgical production, reduction of harmful effects on the environment, real regulatory measures (financial and credit, price, tax regulation, etc.) that would stimulate enterprises to both production and to social responsibility.

### Conclusions

It is established that the peculiarity of research on the sustainability functioning of industrial enterprises is the lack of focus on the most important areas - technical-technological, economic-environmental and social, which further hinders the process of building an orderly system of actions aimed at forming an adequate vector of their sustainable development. The development of the vector of sustainable development is based on the joint application of

systems analysis and a program-targeted approach to the identification of factors and conditions of formation; applies the method of economic diagnostics to develop and adjust the program of action in the interests of achieving the goal of the enterprise; provides a polyvariate process of forming a system of indicators and takes into account the dynamics of changes in all components (areas) of the industrial enterprise, adapting to changing environmental conditions.

The sequence of stages of polyvariate formation of the vector of sustainable development of metallurgical enterprises allows measuring the impact of qualitative and quantitative factors on the effective indicators of assessing the level of sustainable development of the enterprise in accordance with the modes of the function of the metallurgical enterprise, differentiation of which corresponds to the actual level of the integrated indicator, calculated based on current evaluation indicators.

The principles that are mandatory for sustainable development of metallurgical enterprises, in particular for PJSC MK "Zaporizhstal" and the need to develop a comprehensive "road map" for the development and modernization of each metallurgical enterprise due to the importance of their impact on the perspective of sustainable development of Ukraine as a whole have been practically proved and substantiated.

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