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ECONOMIC SECURITY OF METALLURGICAL ENTERPRISES IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT: CHALLENGES AND OPPORTUNITIES

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The article examines the current challenges to the economic security of Ukrainian metallurgical enterprises and ways to increase their sustainability in the context of sustainable development. Metallurgy is a strategically important industry that has a significant impact on the national economy through exports, employment and integration with related sectors. However, the current global and regional conditions, including military actions, economic instability, and dependence on raw material supplies, force metallurgical enterprises to look for ways to adapt and develop. The article discusses various aspects of economic security that are of particular importance for ensuring production stability and long-term competitiveness. In the context of sustainable development, the authors analyze the opportunities for enterprises, including such measures as the introduction of energy-efficient technologies, optimization of resource use, and modernization of equipment. Waste management and closed-loop production are highlighted as key measures that contribute to economic security. These practices optimize the use of raw materials, reduce resource costs and help minimize environmental impact, which increases compliance with international sustainability standards. Particular attention is paid to social responsibility, including employee support and safe working conditions, which are important for building a sustainable team and increasing productivity. The article also discusses ways to reduce dependence on external factors, in particular by diversifying sources of raw materials, developing local resources, and attracting alternative energy sources. It is shown that these measures reduce the vulnerability of enterprises to fluctuations in global markets, make them more independent and increase their overall resilience to crisis situations. The integration of such approaches into the overall strategy of the enterprise ensures economic security, which is critical in the current environment of uncertainty and instability. The impact of environmental standards compliance on enterprise reputation and its ability to attract investments is analyzed separately. Meeting international environmental requirements allows maintaining a positive image and attracting partners and investors who prefer environmentally responsible companies. This is particularly relevant for Ukrainian enterprises seeking to integrate into the global economy. The proposed recommendations for ensuring economic security encompass a comprehensive approach that includes financial, environmental, and social aspects of sustainable development. The research results emphasize the importance of a systematic approach to economic security management, which includes implementing cutting-edge technologies, innovations in production processes, raising social standards, and environmental responsibility. The paper substantiates the importance of sustainable development for the economic security of metallurgical enterprises and provides practical recommendations for overcoming the challenges facing the industry.

Keywords: economic security, sustainable development, metallurgy, innovation, energy efficiency, environmental standards, financial stability, social responsibility, military risks

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Relevance of the topic

The metallurgical industry is one of the key sectors in Ukraine's industry, providing a significant contribution to the country's economy through the production of raw materials and finished products for many sectors. However, in current conditions, this industry faces numerous challenges, including market instability, dependence on external raw material suppliers, and energy and environmental constraints. Additionally, current military events significantly affect the stability of metallurgical enterprises, creating additional risks to their economic security.

The issue of ensuring the economic security of metallurgical enterprises becomes particularly important, as their stability is key to infrastructure development and export growth, while also helping to reduce the country's dependence on metal products imports. In the context of sustainable development, achieving a balance between enterprises economic interests and environmental standards requirements is a crucial task, as compliance with these standards positively affects enterprises reputation and competitiveness in the international market.

Therefore, studying the relationship between economic security and sustainable development of metallurgical enterprises is extremely relevant, especially in the context of current global and local challenges. Research in this direction will allow assessment of the level of risks threatening economic security and development of effective strategies to overcome them, thus ensuring stable functioning of the industry in the long term.

Literature review

The literature review focuses on the main approaches to ensuring economic security of industrial enterprises under current challenges. Sokolenko S. highlights the role of innovative approaches and clustering in enhancing competitiveness, which is crucial for ensuring enterprise sustainability. Pozhuieva T.O. draws attention to environmental factors and the necessity of implementing energy-efficient technologies. Prokhorova V.V. emphasizes the importance of social responsibility and social security for workers in an industry that depends on labor resource stability. These studies demonstrate that the integration of economic, environmental, and social aspects is critically important for the sustainable development of metallurgical enterprises, particularly during crisis situations such as war or pandemic.

The purpose of the article

The purpose of the article is to analyze the challenges and opportunities for ensuring economic security of Ukraine's metallurgical enterprises in the context of sustainable development. The objective is

to determine optimal approaches to managing risks such as dependence on external suppliers, environmental constraints, and social obligations, as well as to develop recommendations for strengthening industry resilience.

Main part

Economic security and sustainable development are interrelated concepts that are of particular importance for steelmaking companies in today's global and local challenges. Economic security ensures the stability of the enterprise, while sustainable development facilitates adaptation to new environmental and social standards, which allows to maintain and increase competitiveness in the market.

For metallurgical companies, which are energy-intensive and dependent on large volumes of raw materials, sustainability helps to optimize resource use, reducing production costs and increasing process efficiency. For example, the introduction of carbon dioxide emission reduction technologies not only reduces the environmental footprint but also improves the company's reputation, which can help attract investment and support from international partners.

One of the key aspects of sustainable development is energy efficiency, which is becoming increasingly important for Ukrainian companies due to the volatility of energy prices. Improving energy efficiency allows steelmakers to reduce their dependence on external energy suppliers and improves their economic security by reducing the risks associated with sharp changes in energy costs.

Economic security in the steel industry also depends on innovations and modernization of production processes to adapt to international environmental standards. Investing in sustainable development technologies, such as waste recycling and pollution reduction, reduces the risk of sanctions and fines, thus ensuring the financial stability of the enterprise. Sustainable development contributes to the economic security of Ukrainian steelmaking companies by reducing risks, increasing resilience to market changes, and helping to attract investment. Taken together, these factors ensure not only stable operations but also that companies maintain their competitive position in the global steel market.

Ukraine's steel industry is one of the key components of the national economy, accounting for a significant share of industrial production and exports. However, in recent years, the industry has faced a number of challenges that have a significant impact on its economic security. Russia's full-scale invasion of Ukraine resulted in significant losses in the metallurgical industry. In particular, key enterprises such as Azovstal and Ilyich Iron and Steel Works of

Mariupol were destroyed or occupied. This led to a significant reduction in production capacity and output [1]. At the same time, in 2023, steel and rolled products production remained at the level of 2022, indicating stabilization after a sharp decline. However, pig iron production decreased by 6.1% due to the loss of enterprises in Mariupol. Exports of ferrous metals in 2023 decreased by 22% compared to the previous year, which negatively affected the country's foreign exchange earnings [2; 3]. The blockade of seaports also complicated the export of steel products, forcing companies to look for alternative delivery routes, which increased logistics costs and transportation time. This, in turn, reduced the competitiveness of Ukrainian steel products on international markets [3]. Russian attacks on the energy infrastructure also led to interruptions in electricity supply, forcing companies to halt production or operate at reduced capacity. This negatively affected the stability of production processes and financial performance of companies [4]. Due to the hostilities and economic instability, the demand for steel products in both domestic and foreign

markets decreased. This has led to a decrease in sales and revenues of enterprises, complicating their financial situation [5]. Consequently, companies are forced to invest heavily in employee safety, infrastructure protection, and adaptation to new working conditions under martial law, which increases operating costs and affects production profitability.

In addition to the above, military operations and mobilization have led to an outflow of skilled workers, which makes it difficult to maintain production processes at the proper level and reduces the efficiency of enterprises [4].

All of these factors pose serious threats to the economic security of Ukraine's steelmaking companies, requiring them to adapt, implement new strategies and find ways to stabilize in the face of constant challenges. An important step on this path is the implementation of sustainable development principles, taking into account the impact of the pandemic, military events and other factors.

Fig. 1 shows the principles of sustainable development of metallurgical enterprises.

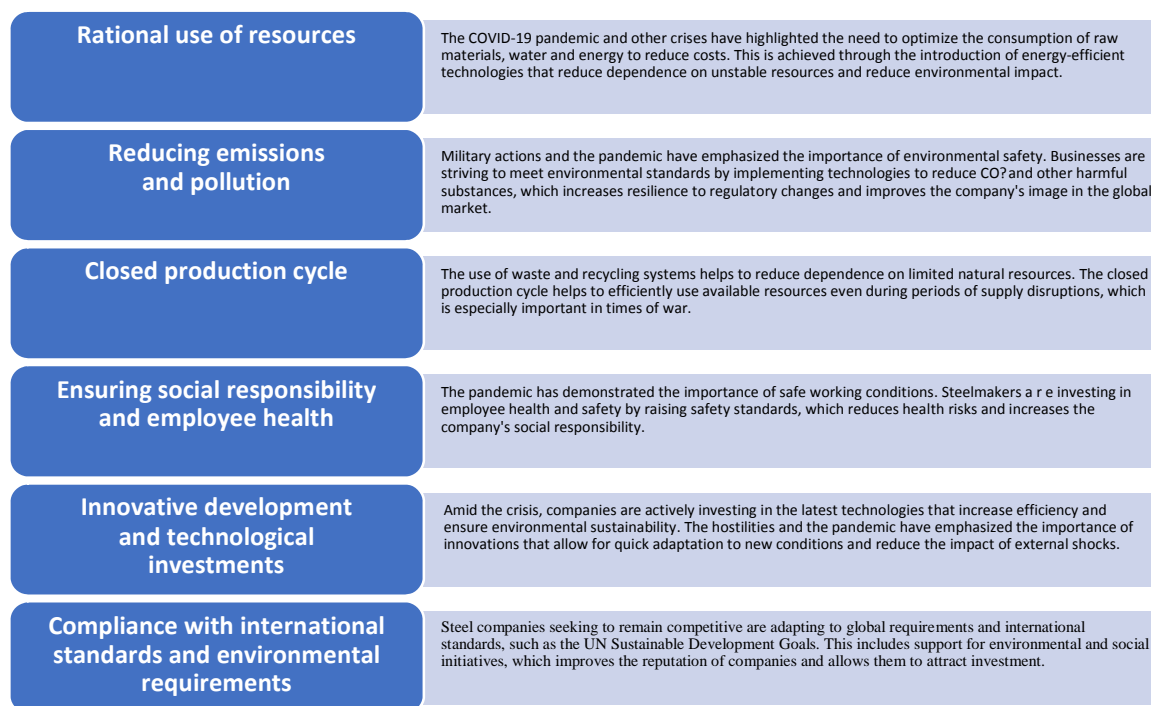


Fig. 1. Principles of sustainable development of metallurgical enterprises

Source: compiled by the authors based on sources [6;7;8].

Sustainable development in the steel industry combines economic, environmental and social aspects to enable businesses to operate sustainably, minimizing their environmental impact and taking into account

current challenges such as the pandemic, military operations and tightening environmental standards. Implementation of these principles helps steelmaking companies not only maintain stability but also adapt

to modern challenges, including pandemics and military operations, while maintaining a competitive position in the global market.

The current challenges create a need for the Ukrainian steel industry to develop new approaches to ensuring economic security, in particular through the integration of sustainable development principles. The main opportunities for improving the economic security of metallurgical companies in this context include a number of points shown in Fig. 2.

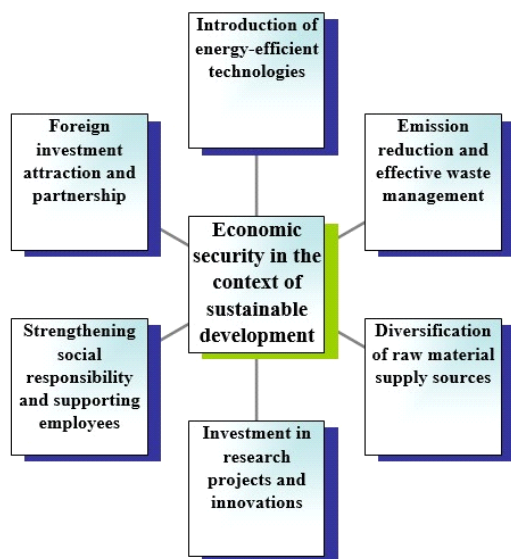


Fig. 2. Ensuring economic security in the context of sustainable development for Ukrainian metallurgical enterprises

Source: compiled by the authors

Modern challenges create a need for Ukraine's steel industry to develop new approaches to ensuring economic security, including through the integration of sustainable development principles. Sustainable development not only strengthens companies but also gives them a competitive edge on the global stage. Metallurgy is one of the most energy-intensive industries, with energy costs accounting for a significant portion of production costs. The use of innovative energy-efficient solutions, such as equipment modernization, switching to renewable energy sources, and recovery systems, can reduce energy costs and dependence on external energy supplies, which ensures cost stability and strengthens the company's economic security while improving compliance with environmental standards. At the same time, the implementation of emission control and CO₂ emission reduction systems increases the environmental responsibility of the enterprise, and compliance with international standards enables steel companies to

maintain their reputation and attract foreign partners. The key to ensuring security for Ukrainian steelmakers is supply diversification, which includes finding alternative suppliers, using local resources or building closed production cycles. In addition, the development and implementation of new technologies is one of the key areas for increasing the competitiveness of steel companies. Investments in research help to create environmentally friendly production methods and improve resource efficiency, which significantly reduces risks and contributes to economic stability. Creating safe working conditions and supporting the professional development of employees, ensuring high labor standards and engaging employees in social initiatives strengthen workforces, reduce staff turnover and increase productivity. It is also worth noting the importance of compliance with international environmental requirements and participation in sustainable development programs, which will make Ukrainian enterprises more attractive to foreign investors and open up opportunities for attracting foreign capital and technology, increasing the economic sustainability of enterprises and their ability to adapt. Thus, using the opportunities outlined in Fig. 2 will allow Ukrainian steelmakers not only to ensure economic security but also to adapt to new challenges, as the introduction of sustainability principles into strategic planning is the key to long-term success and sustainable development of the industry, even in the face of growing global competition and local crises.

This way, we can move on to developing a methodology for ensuring the economic security of metallurgical enterprises in the context of sustainable development, which includes a set of approaches that include risk analysis, strategy development, technology implementation, and continuous monitoring. The main stages of the methodology are described below.

First stage. Identification and analysis of risks.

The first step is to identify the key risks that may affect the economic security of the enterprise. These include:

- financial risks (fluctuations in raw material and energy prices);
- technological risks (outdated equipment);
- environmental risks (compliance with standards, reduction of emissions);
- social risks (personnel stability, social support for employees);
- regulatory risks (changes in government policy).

To assess risks, methods of statistical analysis, factor analysis, SWOT analysis, etc. can be used. At this stage, the probability of occurrence of each risk and its potential impact on the company are determined.

Second stage. Evaluation of the enterprise in terms of sustainable development.

The assessment is based on the key indicators of sustainable development, in particular:

- energy efficiency (energy consumption, implementation of energy-efficient technologies);
- environmental impact (CO₂ emissions volume, waste management);
- social responsibility (working conditions, social support).

This assessment can be conducted using company data, environmental audits, internal audits, and data from open sources. This allows you to assess the current state of the enterprise in terms of sustainable development and identify weaknesses.

Third stage. Developing strategies and planning activities.

Based on the data obtained, strategies are developed that include specific measures to achieve the sustainability goals. The strategies include:

- reducing dependence on energy resources through the introduction of energy-efficient technologies;
- reducing emissions through equipment modernization and transition to cleaner processes;
- optimizing waste management and implementing a closed production cycle;
- strengthening social responsibility by improving working conditions and supporting social initiatives.

For each strategy, a detailed plan is developed, including a list of activities, implementation timelines, responsible persons, and necessary resources.

Fourth stage. Implementation of the latest technologies and innovations.

An important stage of the methodology is the introduction of innovations that meet the principles of sustainable development. Such technologies include:

- heat and energy recovery systems to improve energy efficiency;
- installations to reduce pollutant emissions;
- automated control and monitoring systems for environmental indicators;
- waste processing technologies for the reuse of resources.

At this stage, it is possible to attract international investment or partnerships to access advanced technologies. Implementing innovations helps to increase the economic security of the enterprise by optimizing production processes and reducing environmental impact.

Fifth stage. Performance evaluation and monitoring.

After the implementation of the planned measures, it is necessary to constantly monitor and

evaluate their effectiveness. For this purpose, indicators are used to measure progress in achieving sustainable development goals, such as:

- energy efficiency level;
- emissions and waste treatment;
- social indicators related to employee satisfaction.

Automated monitoring systems and environmental audits can be used to conduct monitoring. Depending on the results of the assessment, the company can adjust its strategies to achieve optimal results in the long term.

Sixth stage. Continuous improvement and adaptation.

The last stage of the methodology is the continuous improvement of processes aimed at increasing economic security and compliance with the principles of sustainable development. Businesses should be prepared to adapt their strategies in the face of changes in the external environment, such as fluctuations in resource prices, changes in regulatory policy, or new environmental requirements.

The proposed methodology allows Ukrainian metallurgical enterprises to take a holistic approach to ensuring economic security by integrating the principles of sustainable development into all aspects of their operations, which not only reduces risks and strengthens competitive positions but also contributes to the long-term sustainability and development of the industry in the face of current economic challenges.

Achieving economic security for steelmaking companies in Ukraine requires a comprehensive approach that includes technological, financial and social aspects. Below are the key recommendations (Table) aimed at ensuring the stable development of enterprises and increasing their competitiveness.

Implementation of the recommendations proposed in the table will help to improve the economic security of Ukrainian metallurgical enterprises, their resilience to external threats and long-term development stability. Integration of sustainable development principles into production and management processes will help achieve a balance between economic goals, environmental responsibility and social stability, ensuring reliable operation of enterprises in the face of current challenges.

Conclusions

The article emphasizes the need for a systematic approach to ensuring the economic security of Ukrainian metallurgical enterprises, especially in the context of current global and regional challenges. Implementation of the principles of sustainable development allows enterprises to reduce the risks associated with economic instability, dependence on

Key recommendations for ensuring economic security against the background of sustainable development

Recommendations.	Details
Introduction of energy-saving technologies and transition to alternative energy sources	<ul style="list-style-type: none"> – modernizing production processes to reduce energy costs and optimize energy consumption; – use of renewable energy sources, such as solar and wind power plants, to reduce dependence on traditional resources and reduce vulnerability to energy crises
Optimizing the supply chain of raw materials and supplies	<ul style="list-style-type: none"> – expanding the supplier base to reduce risks associated with supply disruptions or changes in raw material prices; – preference for local suppliers and the use of recycled materials, which helps reduce logistics costs and dependence on external factors
Investing in research and innovation projects	<ul style="list-style-type: none"> – investing in research and development of new, environmentally friendly and resource-saving technologies; – automation of processes and introduction of artificial intelligence to improve production efficiency and reduce the impact of the human factor on product quality
Ensuring environmental safety and waste management	<ul style="list-style-type: none"> – use of modern technologies to reduce CO₂ and other harmful substances that meet international environmental standards; – establishing an effective waste management system that includes recycling and disposal, which not only reduces the negative impact on the environment but also promotes the use of secondary materials
Supporting social responsibility and caring for staff	<ul style="list-style-type: none"> – ensuring safe working conditions, high health standards and opportunities for employee development; – introducing social support programs, such as insurance and educational programs, to increase employee satisfaction and reduce staff turnover
Expanding cooperation with international environmental initiatives and attracting foreign investment	<ul style="list-style-type: none"> – participation in international environmental and social programs to strengthen the company’s reputation and develop partnerships on the global stage; – attracting foreign capital to implement environmental technologies and innovative solutions
Continuous monitoring and risk assessment	<ul style="list-style-type: none"> – implementation of risk management systems for operational monitoring of changes in the market, in particular in the cost of raw materials and energy resources, which will allow timely response to potential threats; – use of analytical tools to predict risks and develop strategies to minimize them effectively
Effective financial management and cost control	<ul style="list-style-type: none"> – introducing budgeting and cost control systems to help maintain the financial stability of the company and optimize costs; – use of financial instruments to manage currency fluctuations and changes in raw material prices in order to reduce the impact of economic risks on the company

Source: compiled by the author

imported resources and the energy crisis. In particular, the use of energy-efficient technologies not only cuts costs but also reduces dependence on external energy sources, which contributes to the sustainability of production. It is also important to note that compliance with international environmental standards not only increases the environmental responsibility of companies, but also improves their image, which creates additional opportunities for attracting investment and partners who are focused on cooperation with environmentally responsible enterprises.

Businesses that integrate sustainability into their operations reap benefits that go beyond short-term financial gains, as such approaches contribute to long-term stability and competitiveness. The development

of a waste management system and the transition to a closed production cycle allows for efficient use of resources, optimization of raw material costs, and reduction of environmental impact. Another important aspect is the increase in social responsibility, which contributes to the formation of a stable and motivated workforce. This increases overall productivity and strengthens the company’s position in the labor market, which is critical for sustainability in times of crisis.

The approaches and recommendations proposed in this article allow Ukrainian steel companies to adapt to uncertainty, minimize external risks, and at the same time increase efficiency and compliance with modern global standards.

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ЕКОНОМІЧНА БЕЗПЕКА МЕТАЛУРГІЙНИХ ПІДПРИЄМСТВ У КОНТЕКСТІ СТАЛОГО РОЗВИТКУ: ВИКЛИКИ ТА МОЖЛИВОСТІ

Пожуєва Т. О., Бобко Н. А.

У статті досліджуються сучасні виклики економічної безпеки металургійних підприємств України та шляхи підвищення їх стійкості в умовах сталого розвитку. Металургія є стратегічно важливою галуззю, яка значно впливає на національну економіку через експорт, забезпечення зайнятості та інтеграцію з суміжними секторами. Однак, нинішні глобальні та регіональні умови, включаючи воєнні дії, економічну нестабільність, залежність від постачання сировини, змушують металургійні підприємства шукати шляхи адаптації та розвитку. У статті розглянуто різні аспекти економічної безпеки, які набувають особливої ваги для забезпечення стабільності виробництва та конкурентоспроможності у довгостроковій перспективі. Автори у контексті сталого розвитку аналізують можливості для підприємств, включаючи такі заходи, як впровадження енергоефективних технологій, оптимізація використання ресурсів та модернізація обладнання. Серед основних заходів, які сприяють підвищенню економічної безпеки, виділено управління відходами та замкнений цикл виробництва. Ці практики дозволяють оптимізувати використання сировини, знижують витрати на ресурсне забезпечення та сприяють мінімізації екологічного впливу, що підвищує відповідність міжнародним стандартам сталого розвитку. Особлива увага приділена питанням соціальної відповідальності, зокрема підтримці працівників і створенню безпечних умов праці, що є важливими для формування стійкого колективу та підвищення продуктивності. У статті також розглядаються способи зниження залежності від зовнішніх факторів, зокрема шляхом диверсифікації джерел постачання сировини, розвитку місцевих ресурсів та залучення альтернативних джерел енергії. Показано, що ці заходи знижують вразливість підприємств до коливань на світових ринках, роблять їх більш незалежними та підвищують загальну стійкість до кризових ситуацій. Інтеграція таких підходів у загальну стратегію підприємства забезпечує економічну безпеку, що є критичним у поточних умовах невизначеності та нестабільності. Особливо аналізується вплив дотримання екологічних стандартів на репутацію підприємства та його здатність залучати інвестиції. Виконання міжнародних екологічних вимог дозволяє зберігати позитивний імідж і залучати партнерів та інвесторів, які надають перевагу екологічно відповідальним компаніям. Це особливо актуально для українських підприємств, які прагнуть інтегруватися у світову економіку. Запропоновані рекомендації для забезпечення економічної безпеки охоплюють комплексний підхід, що включає фінансові, екологічні та соціальні аспекти сталого розвитку. Результати дослідження підкреслюють важливість системного підходу до управління економічною безпекою, який включає впровадження новітніх технологій, інновацій у виробничих процесах, підвищення соціальних стандартів та екологічної відповідальності. В роботі обґрунтовано важливість сталого розвитку для економічної безпеки металургійних підприємств, а також надає практичні рекомендації для подолання викликів, з якими стикається галузь.

Ключові слова: економічна безпека, сталий розвиток, металургія, інновації, енергоефективність, екологічні стандарти, фінансова стабільність, соціальна відповідальність, воєнні ризики

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The article examines the current challenges to the economic security of Ukrainian metallurgical enterprises and ways to increase their sustainability in the context of sustainable development. Metallurgy is a strategically important industry that has a significant impact on the national economy through exports, employment and integration with related sectors. However, the current global and regional conditions, including military actions, economic instability, and dependence on raw material supplies, force metallurgical enterprises to look for ways to adapt and develop. The article discusses various aspects of economic security that are of particular importance for ensuring production stability and long-term competitiveness. In the context of sustainable development, the authors analyze the opportunities for enterprises, including such measures as the introduction of energy-efficient technologies, optimization of resource use, and modernization of equipment. Waste management and closed-loop production are highlighted as key measures that contribute to economic security. These practices optimize the use of raw materials, reduce resource costs and help minimize environmental impact, which increases compliance with international sustainability standards. Particular attention is paid to social responsibility, including employee support and safe working conditions, which are important for building a sustainable team and increasing productivity. The article also discusses ways to reduce dependence on external factors, in particular by diversifying sources of raw materials, developing local resources, and attracting alternative energy sources. It is shown that these measures reduce the vulnerability of enterprises to fluctuations in global markets, make them more independent and increase their overall resilience to crisis situations. The integration of such approaches into the overall strategy of the enterprise ensures economic security, which is critical in the current environment of uncertainty and instability. The impact of environmental standards compliance on enterprise reputation and its ability to attract investments is analyzed separately. Meeting international environmental requirements allows maintaining a positive image and attracting partners and investors who prefer environmentally responsible companies. This is particularly relevant for Ukrainian enterprises seeking to integrate into the global economy. The proposed recommendations for ensuring economic security encompass a comprehensive approach that includes financial, environmental, and social aspects of sustainable development. The research results emphasize the importance of a systematic approach to economic security management, which includes implementing cutting-edge technologies, innovations in production processes, raising social standards, and environmental responsibility. The paper substantiates the importance of sustainable development for the economic security of metallurgical enterprises and provides practical recommendations for overcoming the challenges facing the industry.

Keywords: economic security, sustainable development, metallurgy, innovation, energy efficiency, environmental standards, financial stability, social responsibility, military risks

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