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MANAGEMENT OF ENVIRONMENTALLY ORIENTED INNOVATIVE DEVELOPMENT OF ENTERPRISES UNDER CONDITIONS OF DIGITAL TRANSFORMATION OF THE ECONOMY

Abstract. *The article examines the theoretical and methodological foundations for managing environmentally oriented innovative development of enterprises under the conditions of the economy's digital transformation. It is evident that intensifying environmental challenges, growing requirements for sustainable development, the need to implement ESG principles, and the spread of digital technologies necessitate a rethinking of traditional approaches to enterprise innovation management. Environmentally oriented innovative development is considered as a comprehensive process of implementing technological, organizational, managerial, and digital innovations aimed at reducing the negative impact of enterprises on the environment, ensuring the rational use of resources, increasing energy efficiency, and forming long-term competitive advantages.*

The article reveals the role of environmental innovations in production modernization, waste minimization, energy intensity reduction, improvement of environmental safety, and strengthening the enterprise's business reputation. Attention is paid to digital technologies as important tools for accelerating innovation. It is emphasized that the use of the Internet of Things, artificial intelligence, big data analytics, cloud technologies, digital twins, and automated environmental monitoring systems enables improved control over resource consumption, emissions, waste generation, and production efficiency. This creates an information basis for making more substantiated managerial decisions and increases enterprises' adaptability to transformational changes.

The importance of integrating ESG principles into the enterprise management system is determined. Such integration allows enterprises to combine economic efficiency, environmental responsibility, and social orientation, which is an important prerequisite for sustainable and balanced development. The article identifies the main problems of implementing environmental innovations, including high investment costs, insufficient technological readiness, limited access to green financing, a shortage of qualified personnel, low digital maturity, and weak integration of environmental priorities into strategic management.

A comprehensive mechanism for managing environmentally oriented innovation development is proposed. This mechanism combines analytical, organizational, financial-economic, technological, digital, personnel, and control blocks. Its implementation will allow enterprises to move from fragmented environmental measures to a systemic model of sustainable innovative development, reduce

environmental risks, increase resource efficiency, strengthen investment attractiveness, and ensure long-term competitiveness in the digital economy.

Keywords: *management, innovative development, environmental innovations, enterprises, agricultural sector, industrial enterprises, digital transformation, sustainable development, ESG principles, mechanism of innovative development, innovation index, environmental modernization, economic transformation.*

Problem statement and its connection with important scientific and practical tasks. The current development of enterprises takes place amid increasing environmental challenges, the digital transformation of the economy, growing requirements for sustainable development, and the need to integrate ESG principles into the management system. Traditional approaches to innovation no longer ensure sufficient competitiveness, as enterprises must not only modernize technologies and business processes but also focus on environmental safety, resource efficiency, reducing negative environmental impact, and adapting to new digital conditions of economic activity.

The issue of developing an effective mechanism to manage environmentally oriented innovation in enterprises is becoming increasingly relevant. Such a mechanism should combine tools from digitalization, environmental innovation, strategic management, and the assessment of innovation activity. The insufficient integration of environmental priorities into the management system for innovative development limits enterprises' opportunities to modernize production, increase investment attractiveness, ensure sustainability, and build long-term competitive advantages.

In this regard, there is a need for scientific substantiation of approaches to managing innovative development of enterprises based on environmentalization, digital transformation, and ESG-oriented management. This will ensure their adaptability, resilience, and effectiveness amid economic transformation.

Analysis of recent publications on the problem. The issue of managing the innovative development of enterprises is actively studied in modern economic science, as innovation is considered a fundamental prerequisite for enhancing the competitiveness, adaptability, and sustainability of business entities amid the challenges of globalization. N. Stoyanets emphasizes the need to develop effective approaches to managing the innovative development of enterprises, considering transformations in the external environment, increasing competition, and the need to adapt management mechanisms to new economic conditions [1]. The issues of the innovative development of the agricultural sector are also revealed in I.'s studies. Rasevych and O. Demydenko, who define innovations as a key factor in the

development of agricultural production at the regional level [5]. In this context, the study by N. Stoyanets, Z. Hu, L. Niu, and J. Chen is also important, as it proposes an approach to managing sustainable development in the agricultural sector based on the entropy-weight TOPSIS model [6].

Considerable attention in scientific works is paid to digitalization as a factor in enterprise transformation and the formation of their competitive advantages. O. Gudz, S. Fediunin, and V. Shcherbyna consider digitalization as a tool for strengthening the competitive positions of companies, which makes it possible to increase the efficiency of business processes, improve the quality of managerial decisions, and enhance the adaptability of enterprises to changes in the market environment [3]. O. Aleinikova, O. Datsii, I. Kalina, and other researchers substantiate the role of digital technologies as both a cause and a tool of dynamic transformation of territory marketing, which indicates the wider application of digitalization not only in production but also in communication and management areas [4]. At the same time, G. Karcheva, D. Ogorodnya, and V. Openko analyze the impact of the digital economy on the development of national and international economic systems, emphasizing its capacity to transform traditional economic models [8].

A separate body of scientific research focuses on technological platforms, blockchain technologies, and digital tools that can increase transparency, efficiency, and innovation of business processes. O. Lapko and O. Solosich reveal the essence of blockchain technology, areas of its application, and its impact on business, emphasizing its importance for ensuring trust, data security, and transparency of operations [9]. T. Lozova, H. Oliinyk, and O. Oliinyk study the digitalization of the technical inventory of real estate objects, which demonstrates an example of the applied use of digital technologies in accounting and information management [10]. P. Putsenteilo and O. Humeniuk consider the digital economy as a modern vector of reconstruction of the traditional economy, which is important for understanding the general prerequisites of digital transformation of enterprises [11]. N. Demchyshak and V. Bilenka focus on the development of technological platforms as an instrument for implementing the innovative potential of Ukraine [12].

The issues of ESG-oriented management and sustainable development are becoming especially relevant in the context of environmentally oriented innovative development. A. Kaminskyi, D. Baiura, and M. Nehrey study ESG investing under conditions of turbulence, particularly through the prism of risk-return correspondence, which allows ESG principles to be considered as an important tool for forming the investment attractiveness of enterprises [2]. In studies on the stability of agricultural enterprises, the need to assess their long-term viability and ability to function under uncertainty is emphasized [16]. Research on the economic security of enterprises is also related to this issue, as environmental innovations and ESG approaches help

reduce risks, increase resilience, and establish a safe model of enterprise development [15; 17].

Scientific literature also examines issues in investment planning, financial constraints, and macroeconomic conditions that directly influence enterprises' ability to implement innovations. P. Mykytyuk and Yu. Mykytyuk substantiates approaches to managing the effectiveness of investment planning using economic and mathematical modeling, which is important for assessing the effectiveness of innovation projects [7]. S. Claessens and A. Kose analyze the macroeconomic implications of financial imperfections, which may limit enterprises' access to investment resources and restrain their innovation activity [14]. In this context, the formation of the financial and economic block of the innovation development management mechanism is especially important, as it should consider both the enterprise's internal capabilities and external investment conditions [7; 14].

Some studies reveal the role of digital technologies in the development of industries and economic sectors. H. Haponenko and V. Vasylenko analyze the prospects for using blockchain technology in the tourism industry, which demonstrates the cross-sectoral nature of digital innovations and their potential to increase transparency and management efficiency [13]. O. Akimov, M. Karpa, O. Parkhomenko-Kutsevil, and other authors study the formation of professional qualities of e-commerce managers, which is important in the context of developing digital competencies of personnel and managers [18]. This indicates that digital transformation requires not only technological renewal but also training specialists to work effectively with digital tools [13; 18].

Highlighting previously unresolved parts of the overall problem. The generalization of scientific approaches indicates that researchers have sufficiently addressed issues related to innovation development, digitalization, ESG investing, sustainability, economic security, and investment planning. At the same time, a comprehensive approach to managing environmentally oriented innovative development of enterprises remains insufficiently developed. Such an approach should combine environmental innovations, digital transformation, ESG principles, investment support, and strategic management mechanisms. This determines the need for further research on this issue and the formation of an integrated mechanism for managing environmentally oriented innovative development of enterprises.

The aim of the article is to substantiate theoretical and methodological approaches to managing the environmentally oriented innovative development of enterprises under conditions of digital transformation, considering ESG principles, sustainable development priorities, and the need to develop an effective mechanism to enhance their adaptability, competitiveness, and innovation activity.

Presentation of the main research material. Environmentally oriented innovative development should be considered a comprehensive process for implementing technological, organizational, managerial, and digital innovations to reduce an enterprise's negative environmental impact, ensure the rational use of resources, and increase its competitiveness. Such development is not limited to the modernization of production processes or the introduction of environmentally safe technologies; it also entails a systemic transformation of the enterprise's entire operating model in accordance with the principles of sustainable development, environmental responsibility, and resource efficiency.

Under current conditions, the environmental component of innovative development is gaining strategic importance, as enterprises are forced to adapt to stricter environmental requirements, rising resource costs, the need to reduce production energy intensity, and the growing demand for transparency in economic activity [1-2]. Environmental innovations serve not only as a tool for minimizing harmful environmental impact but also as an important factor in forming long-term competitive advantages. Their implementation enables enterprises to optimize costs, improve product quality, strengthen their business reputation, and expand opportunities to enter markets where environmental standards are a key condition for cooperation.

Digital technologies play a key role in advancing environmentally oriented innovation by enabling the monitoring of environmental indicators, the automation of production processes, the analysis of resource consumption, and more informed managerial decision-making. The use of digital tools enables enterprises to identify environmental risks in a timely manner, control emission levels, assess the efficiency of material and energy resource use, and build an information base for strategic planning of innovation activities.

Thus, environmentally oriented innovation in enterprise development is an important prerequisite for their adaptation to transformational changes in the economy. Its essence lies in combining innovation, environmental responsibility, digitalization, and strategic management, which ensures not only a reduction in environmental pressure but also an increase in the long-term resilience, efficiency, and competitiveness of enterprises.

Environmental innovations ensure the modernization of production, the rational use of resources, the reduction of energy intensity, waste minimization, improvement of environmental safety, and the formation of a positive business reputation of an enterprise [3]. In the context of sustainable development, they act as an important tool for transforming traditional business models into more resource-efficient, environmentally responsible, and innovation-oriented systems.

The implementation of environmental innovations enables enterprises to reduce the negative environmental impact of production activities by introducing cleaner

technologies, energy-efficient equipment, recycling systems, waste-free or low-waste production processes, and modern environmental monitoring tools. As a result, enterprises can not only comply with environmental standards and regulatory requirements but also increase the efficiency of their economic activity.

An important advantage of environmental innovations is their ability to combine ecological and economic effects. On the one hand, they help reduce emissions, waste, and excessive resource consumption. On the other hand, they help optimize production costs, improve product quality, increase investment attractiveness, and strengthen the enterprise's competitive position in the market [4].

In addition, environmental innovations have a significant reputational effect. Enterprises that actively implement environmentally responsible solutions are perceived by consumers, investors, partners, and society as more reliable, transparent, and socially responsible [5-6]. This contributes to the formation of long-term trust, strengthens the company’s image, and creates additional opportunities for cooperation within the framework of ESG-oriented business development.

Thus, environmental innovations should be considered not only as a means of solving environmental problems but also as a strategic factor in ensuring the sustainable and competitive development of enterprises amid economic transformation and digitalization.

Digital transformation plays a significant role in accelerating the innovative development of enterprises, as digital technologies create new opportunities for improving production, managerial, environmental, and analytical processes. In the context of environmentally oriented innovative development, digital tools enable the automation of production operations, the monitoring of environmental indicators, the analysis of large volumes of data, the reduction of resource losses, and the improvement of managerial decision-making quality.

The use of digital technologies allows enterprises to move from fragmented environmental measures to a systematic model of innovation management. Technologies such as the Internet of Things, artificial intelligence, big data analytics, cloud platforms, digital twins, and automated monitoring systems provide enterprises with timely information on resource consumption, emissions, production efficiency, and environmental risks. This strengthens enterprises' ability to respond quickly to changes in their internal and external environments and to implement more effective environmental innovations.

The key directions of using digital technologies in the process of environmentally oriented innovative development are presented in Table 1.

As shown in Table 1, digital technologies perform not only a technical function but also a strategic management function. They provide an information basis for substantiating innovative decisions, assessing the environmental consequences of

production activity, and identifying priority areas for modernization. As a result, digital transformation is an important factor in increasing enterprises' adaptability, resource efficiency, environmental responsibility, and competitiveness.

Thus, digital transformation should be considered as an integral component of environmentally oriented innovative development. Its implementation enables enterprises to integrate technological modernization with environmental priorities, improve management quality, ensure transparency of environmental indicators, and strengthen their position in the context of sustainable development and ESG-oriented business practices.

The integration of ESG principles into the enterprise management system enables companies to combine economic efficiency, environmental responsibility, and social orientation, an important prerequisite for sustainable development. In modern conditions, ESG-oriented management is becoming not only a response to external regulatory and market requirements but also a strategic tool for increasing competitiveness, investment attractiveness, and long-term business resilience.

Table 1

The role of digital technologies in ensuring environmentally oriented innovative development of enterprises [7-9]

Digital technology	Role in enterprise development	Expected effect
Internet of Things	Monitoring of equipment, energy consumption, emissions, and resource use	Reduction of resource losses and improvement of environmental control
Artificial intelligence	Forecasting, optimization of production processes, and risk assessment	Improvement of managerial decisions and prevention of environmental risks
Big data analytics	Analysis of production, environmental, and market data	Identification of trends and justification of innovation priorities
Cloud technologies	Integration and storage of enterprise data	Better coordination of business processes and flexible management
Digital twins	Modeling production processes and environmental impacts	Testing innovations before implementation and reducing modernization risks
Automated environmental monitoring systems	Control of emissions, waste, water use, and compliance with standards	Increased environmental transparency and ESG-oriented management

ESG principles influence managerial decision-making in three key dimensions: environmental, social, and governance. The environmental component focuses on reducing negative environmental impacts, improving resource efficiency, minimizing

emissions and waste, and implementing environmental innovations [10]. The social component encompasses personnel development, occupational safety, social responsibility, stakeholder partnerships, and trust-building within the enterprise. The governance component provides transparency, accountability, risk management, ethical business conduct, and effective strategic control.

The main areas of ESG influence on enterprise management are presented in Fig. 1.

As shown in Fig. 1, ESG principles create a comprehensive basis for transforming enterprise management. Their implementation contributes to the formation of a balanced management model in which economic results are achieved without ignoring environmental and social consequences. Therefore, ESG-oriented management should be considered as an important component of environmentally oriented innovative development, as it ensures the coordination of innovation activity with the priorities of sustainability, responsibility, and strategic development.

The relevance of environmentally oriented innovative development is confirmed by current international statistics. According to the International Energy Agency, global investment in clean energy is expected to reach about USD 2.2 trillion in 2025, while investment in fossil fuels is estimated at USD 1.1 trillion. This means that clean energy investment is already twice as high as investment in oil, gas, and coal. Such dynamics indicate a global shift of capital flows towards low-carbon technologies, energy efficiency, renewable energy, grids, storage systems, and electrification.

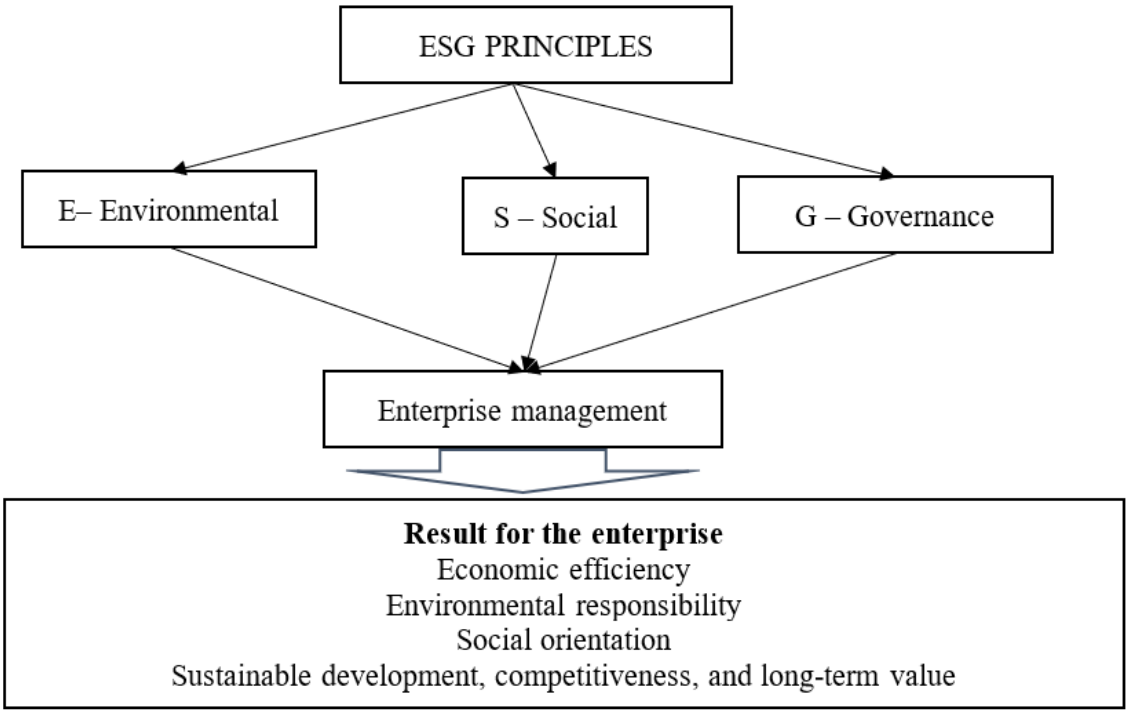

Fig. 1. The impact of ESG principles on enterprise management

At the same time, the expansion of renewable energy capacity underscores the growing role of ecological innovations in transforming production and energy systems. According to IRENA, in 2024 the world added 585 GW of renewable energy capacity, the largest annual increase ever recorded. Renewables accounted for 92.5% of global power capacity additions, with solar alone providing 452 GW of new capacity.

However, despite the rapid development of clean technologies, global greenhouse gas emissions remain high. According to UNEP, global GHG emissions reached a record level of 57.1 $GtCO_2e$ in 2023, which was 1.3% higher than in 2022. This confirms that the current pace of ecological modernization remains insufficient to ensure the necessary reduction in environmental pressure.

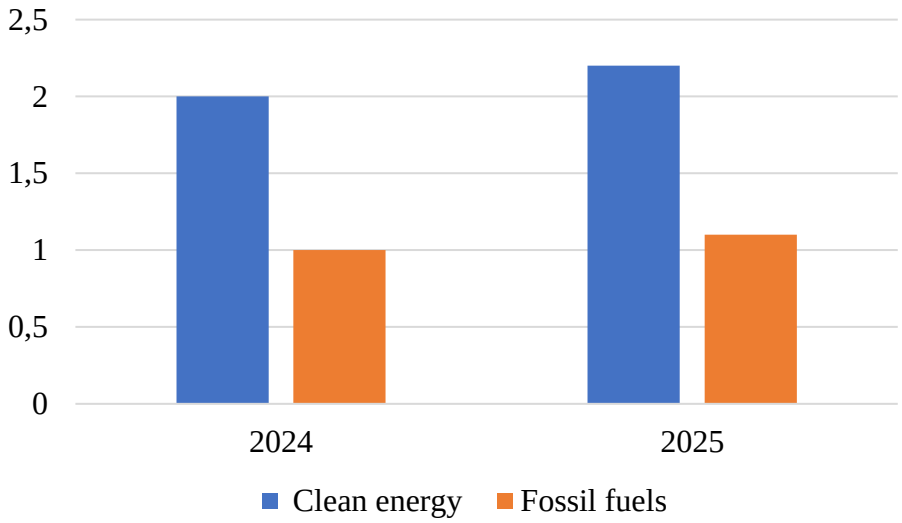

Fig. 2. Global energy investment by direction

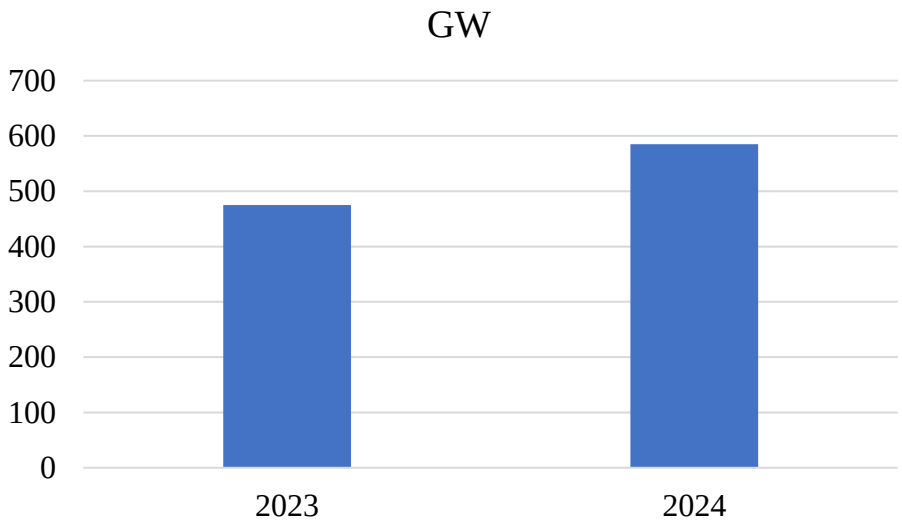

Fig. 3. Global renewable capacity additions

The presented statistical data show that enterprises operate in an environment where ecological innovations are becoming not only a tool of environmental protection but also a strategic factor of competitiveness. The growth of clean energy investment and renewable capacity creates new opportunities for enterprises to modernize production, reduce energy intensity, introduce resource-efficient technologies, and strengthen ESG-oriented management. At the same time, the continued increase in global emissions proves the need for more active implementation of environmental innovations at the enterprise level [11].

Thus, statistical trends confirm the necessity of integrating ecological, technological, digital, and managerial instruments into a single model of innovative development. For enterprises, this means transitioning from isolated environmental measures to a systemic approach that integrates investment in clean technologies, digital monitoring, ESG principles, and strategic innovation management.

Despite the strategic importance of environmental innovations, their implementation in enterprises is accompanied by several organizational, financial, technological, and managerial challenges. These problems slow enterprises' transition toward environmentally oriented, innovative development and reduce the effectiveness of sustainable transformation.

One of the main barriers is the high cost of implementing environmental innovations. The introduction of energy-efficient equipment, waste treatment systems, renewable energy technologies, digital monitoring tools, and cleaner production processes requires significant investment resources. For many enterprises, especially small and medium-sized businesses, such costs pose a serious constraint, as the payback period for environmental projects may be long and their economic impact is not always immediate.

Another important problem is the insufficient level of technological readiness of enterprises. Many companies continue to use outdated production facilities, which complicates the implementation of modern ecological technologies. In such conditions, environmental innovations require not only the purchase of new equipment but also the modernization of technological processes, retraining of personnel, and restructuring of the enterprise management system [12-14].

The lack of qualified personnel also limits the implementation of environmental innovations. Effective ecological modernization requires specialists with knowledge of environmental management, digital technologies, innovation management, ESG reporting, and resource efficiency. However, many enterprises face a shortage of such competencies, which negatively affects the quality of planning, implementation, and monitoring of environmental innovation projects.

A significant barrier is also the weak integration of environmental priorities into the strategic management system. In many cases, environmental measures are

implemented piecemeal and perceived as a response to regulatory requirements rather than as a source of competitive advantage. As a result, enterprises do not fully exploit the potential of environmental innovations to reduce costs, improve reputation, increase investment attractiveness, and enter new markets.

In addition, the implementation of environmental innovations is complicated by insufficient financial and institutional support. Limited access to green financing, ineffective incentive mechanisms, regulatory instability, and insufficient innovation infrastructure development reduce enterprises' motivation to invest in ecological modernization. This is especially relevant for enterprises operating amid economic uncertainty and limited investment capacity [15].

Thus, the main problems in implementing environmental innovations include high innovation project costs, technological backwardness, a shortage of qualified personnel, weak strategic integration of environmental priorities, insufficient digital maturity, and limited access to financial support. Overcoming these barriers requires developing a comprehensive management framework that integrates ecological, economic, digital, organizational, and institutional instruments.

Overcoming the challenges associated with implementing environmental innovations requires establishing a comprehensive mechanism for managing environmentally oriented innovation. This mechanism should ensure coordination among ecological, technological, digital, financial, organizational, and managerial instruments to increase the efficiency, adaptability, and sustainability of enterprise development.

Its formation should be based on the principles of systemacity, adaptability, resource efficiency, innovation orientation, environmental responsibility, and strategic coherence. Environmental innovations should not be implemented as isolated technical measures, but should become an integral part of the enterprise development strategy. In this context, ecological modernization is closely linked to digital transformation, ESG-oriented management, investment planning, and the development of long-term competitive advantages.

The structure of such a mechanism may include several interrelated blocks. The analytical block provides diagnostics of the enterprise's current state, an assessment of environmental risks, and analyses of resource consumption, innovation potential, and digital maturity. The organizational block aims to define responsible units, coordinate innovation processes, and establish an internal environmental management system. The financial and economic block involves substantiation of investment needs, assessment of costs and expected effects, and attraction of green financing. The technological block includes the introduction of clean technologies, energy-efficient equipment, recycling systems, and digital monitoring tools [16-18].

Importance belongs to the digital block, which ensures the collection, processing, and analysis of data on production efficiency, emissions, waste, energy consumption, and resource use. The personnel block focuses on developing competencies in environmental management, innovation management, digital technologies, and ESG reporting. The control block provides monitoring of the results of environmental innovations, assessment of their effectiveness, and adjustment of managerial decisions.

As a result, the proposed mechanism enables the transition from fragmented environmental measures to a systematic model of environmentally oriented innovative development. Its implementation enables enterprises to reduce environmental risks, increase resource efficiency, improve the quality of managerial decisions, enhance investment attractiveness, and ensure sustainable competitive development amid digital transformation.

Conclusions. Thus, environmentally oriented innovative development should be considered as one of the key directions of enterprise transformation in modern economic conditions. Its importance lies in the need to combine economic growth with environmental responsibility, the rational use of resources, technological modernization, and compliance with the principles of sustainable development. Environmental innovations reduce the negative impact of production activities on the environment, increase resource efficiency, improve the quality of products and processes, and strengthen the competitive position of enterprises.

The development of digital technologies significantly expands the possibilities for implementing environmental innovation. Digital tools enable enterprises to monitor environmental indicators, analyze large volumes of data, control emissions and resource consumption, and make more effective managerial decisions. At the same time, the integration of ESG principles into enterprise management creates the basis for balancing economic, environmental, and social goals.

However, implementing environmental innovations requires overcoming several barriers, including high investment costs, insufficient technological readiness, limited access to green financing, a shortage of qualified personnel, and weak integration of environmental priorities into strategic management. Therefore, enterprises need a comprehensive management mechanism that combines analytical, organizational, financial, technological, digital, personnel, and control components.

Prospects for further research. The practical implementation of such a mechanism will contribute to the transition from separate environmental measures to a systemic model of environmentally oriented innovative development. This will enable enterprises to enhance sustainability, reduce environmental risks, strengthen investment attractiveness, and ensure long-term competitiveness amid digital transformation and economic change.

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УПРАВЛІННЯ ЕКОЛОГІЧНО ОРІЄНТОВАНИМ ІННОВАЦІЙНИМ РОЗВИТКОМ ПІДПРИЄМСТВ В УМОВАХ ЦИФРОВОЇ ТРАНСФОРМАЦІЇ ЕКОНОМІКИ

Анотація. *У статті досліджено теоретико-методичні засади управління екологічно орієнтованим інноваційним розвитком підприємств в умовах цифрової трансформації економіки. Обґрунтовано, що посилення екологічних викликів, зростання вимог до сталого розвитку, необхідність упровадження ESG-принципів та активізація цифровізаційних процесів зумовлюють потребу в переосмисленні традиційних підходів до управління інноваційною діяльністю підприємств. Визначено, що екологічно орієнтований інноваційний розвиток доцільно розглядати як комплексний процес упровадження технологічних, організаційних, управлінських і цифрових інновацій, спрямованих на зменшення негативного впливу підприємства на довкілля, раціональне використання ресурсів, підвищення енергоефективності та формування довгострокових конкурентних переваг.*

У роботі розкрито роль екологічних інновацій у модернізації виробництва, мінімізації відходів, зниженні енергоємності, підвищенні екологічної безпеки та зміцненні ділової репутації підприємства. Доведено значення цифрових технологій як інструменту прискорення інноваційного розвитку, оскільки вони забезпечують автоматизацію виробничих процесів, моніторинг екологічних

показників, аналіз великих обсягів даних і підвищення якості управлінських рішень. Акцентовано увагу на тому, що інтеграція ESG-принципів у систему управління підприємствами дає змогу поєднати економічну ефективність, екологічну відповідальність і соціальну орієнтацію.

Визначено основні проблеми впровадження екологічних інновацій, серед яких високі інвестиційні витрати, недостатня технологічна готовність, обмежений доступ до зеленого фінансування, нестача кваліфікованих кадрів і слабка інтеграція екологічних пріоритетів у стратегічне управління. Запропоновано формування комплексного механізму управління екологічно орієнтованим інноваційним розвитком, що поєднує аналітичний, організаційний, фінансово-економічний, технологічний, цифровий, кадровий і контрольний блоки. Практична значущість дослідження полягає у можливості використання запропонованого підходу для підвищення ресурсоефективності, інвестиційної привабливості, екологічної стійкості та конкурентоспроможності підприємств.

Ключові слова: *управління, інноваційний розвиток, екологічні інновації, підприємства, аграрний сектор, промислові підприємства, цифрова трансформація, сталий розвиток, ESG-принципи, механізм інноваційного розвитку, інноваційний індекс, екологічна модернізація, трансформація економіки.*

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