

ECO-INNOVATION AS A BASIS FOR SUSTAINABLE DEVELOPMENT

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Abstract. *The purpose* of the article is to substantiate the necessity of introducing ecological innovations into the activities of enterprises, to study the problems and prospects associated with the introduction of ecological innovations, and to make recommendations on increasing the ecologicalization of the activities of enterprises. *Methodology.* The work uses general and special scientific methods and techniques of cognition: methods of theoretical generalization, analysis, synthesis and grouping, logical-historical method, deduction and induction. It is pointed out that one of the means to ensure the balanced development of society is the introduction of ecological innovations in enterprises. This will contribute to the growth of economic well-being of business entities, ensure the competitiveness of their products, give an opportunity to enter the world market of goods and services, increase the level of environmental safety of the territory and the health of people living there. The results of the work show that the direct implementation of ecological innovations will ensure environmental responsibility of business, increase the efficiency of enterprises, increase consumer loyalty to products and, as a final result, high indicators of competitiveness of manufacturers while preserving the environment. *Practical implications.* Eco-innovations provide a gradual impact on sustainable development. Achieving the principles of sustainable development, refusing to achieve high rates of economic growth at the expense of future generations, stopping the processes of depletion of natural resources are possible only through the implementation of effective innovative policies based on greening. *Value/originality.* Environmental innovations should be aimed at solving tasks related to reducing the consumption of resources, controlling harmful effects on the environment, increasing the production of ecological products, reducing the costs of eliminating destructive effects of production activities. Such innovations will lead to a significant reduction in the negative impact of the economic activities of enterprises on the environment and will increase the efficiency of the use of resources, energy and materials. In addition, the ability to ensure the implementation of the waste management process will increase, which will contribute to the sustainable development of the enterprise in the long term.

Key words: ecological innovations, environment, greening, ecological development strategy, environment, sustainable development, competitiveness.

JEL Classification: Q50, E60, F60

1. Introduction

In connection with the necessity of transition to the "green" economy, a special role is assigned to ecological innovations. Ecological innovations are the final product of ecological and innovative activities for creation, implementation and use in production of an innovation aimed at increasing the level of ecology, which is realized in the form of ecological goods, technologies for their

production, methods of management and sale of goods at all stages of production, which contribute to development and improvement of socio-economic efficiency of functioning of business entities, ensure minimization of the impact on the environment. Eco-innovative activity within the economic system (different levels: local, regional, national) also depends on the implementation of framework agreements (rules and norms) by

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subjects (universities, research centers, structures of innovative activity, industrial enterprises and other organizations). The intensity and quality of interaction of these subjects determines the performance of such a system.

In today's reality, economy and ecology are increasingly overlapping. The tension between nature and society is rapidly intensifying, bringing society closer to the reality of the threat of global ecological disaster.

For a long time, society believed that the development of the world economy would always be stable and uninterrupted, and that natural resources would be unlimited. As for environmental problems, they were considered to be only technical problems that could be solved by the same technical means. However, mankind's powerful development of scientific and technological progress, without considering the possible consequences, became the basis of today's environmental problems.

The ecological imperative of social development in the current conditions becomes an endogenous factor in the functioning of the system of economic relations. In order to prevent an ecological crisis, there is a growing need for a transition from an artificial type of development to a sustainable one, which includes the use of the latest technologies designed to meet people's needs without harming the environment and, at the same time, is connected with the application of innovative activities and the use of human potential. In the conditions of the growing burden on the ecological system, the threat of the global economic crisis, ecological innovations are of the utmost importance for the sustainable development of both individual industrial enterprises and the country as a whole.

2. Theoretical content of the concept of ecological innovations and their main types

The concept of "eco-innovation" first appeared in world literature in 1996 in the book "Driving Eco-Innovation: A Breakthrough Discipline for Innovation and Sustainability" by Claude Fassler and Peter James in the following formulation: "eco-innovations are products and processes that contribute to sustainable development". In his article, Peter James defines eco-innovations as "new products and processes that are designed to satisfy the business interests of companies and at the same time must significantly

reduce the impact on the environment". (Kosyakova, Kapmar, 2017)

Among the many approaches to defining the concept of ecological innovation, it is worth highlighting the most traditional:

- any innovation aimed at meeting the ever-increasing needs of citizens and leading to a significant reduction or minimization of the destructive impact on the environment;
- progressive technical and technological changes in production, which promote the transition to modern ecological technologies.

Taking into account the above, it can be argued that environmental innovations are changes in the field of development of competitive advantages, which are achieved by improving the efficiency of use of natural resources, minimizing the harmful impact on the environment, creating and promoting the use of ecological products.

Eco-innovations, like others, can be technical (for example, equipment that works on natural substances), technological (for example, technologies that minimize harmful emissions into the atmosphere), product (for example, reusable goods produced on such resources that have a short period of decay in the environment), organizational (introduction of quality standards that correspond to sustainable development), regulatory or marketing to increase the so-called "green competitiveness" of the enterprise. (Boyarynova, Bychkovska, 2020) More broadly, such innovations include: development, creation and introduction of economical technological processes, closed production cycles, cascade technologies of resource use (technological eco-innovations); development and application of resource-saving and multifunctional equipment (technical eco-innovations); development and production of environmentally friendly products (product eco-innovations).

Eco-innovators are divided into the following four categories: ecological technologies; organizational innovations for the environment; innovative goods and services that provide environmental benefits; innovations of green systems or alternative systems of production and consumption (Table 1).

One of the most important factors of environmental and economic development is the interaction of innovation and investment, which should become the basis of sustainable growth,

Table 1

Categories of environmental innovations according to the purpose of their implementation

| Categories | Characteristics of environmental innovations included in the category |
|--|--|
| Environmental technologies | <ul style="list-style-type: none"> – Pollution control technologies, including wastewater treatment technologies; – technologies for cleaning atmospheric air from pollutants; – cleaner technological processes: new production processes that pollute less and/or use resources more efficiently; – waste management equipment and technologies; – environmental monitoring and control and measuring devices; – green energy technologies; – water supply; – noise and vibration control. |
| Organizational innovation for the environment | <ul style="list-style-type: none"> – Environmental pollution prevention schemes; – environmental management and audit systems: formal environmental management systems, including measurement, reporting and accountability for material, energy, water and waste use (e.g., EMAS and ISO 14001); – network management: cooperation between enterprises for the purpose of rational use of raw materials and materials, reduction or avoidance of environmental damage of materials during the entire life cycle of the product. |
| Product and service innovation offering environmental benefits | <ul style="list-style-type: none"> – New or ecologically improved goods (products, services), including eco-houses and construction; – green financial products (for example, ecological lease or "green" mortgage); – environmental services: management of solid and hazardous waste, wastewater, environmental consulting, testing and engineering, other testing and analysis services; – services aimed at reducing environmental pollution and optimal distribution of resources. |
| Green system innovations | <ul style="list-style-type: none"> – Alternative systems of production and consumption that are more ecologically safe than existing systems: biological agriculture and an energy system based on renewable energy sources, etc. |

Source: (Kotsko, 2019)

eventually leading to the emergence of new economic opportunities.

The introduction of innovative technologies and technological rearmament of outdated environmental protection equipment requires significant financial investments. A systemic barrier for Ukrainian enterprises in the implementation of environmental protection measures is the lack of investment resources. (Andreychenko, 2017) Frequently, business owners perceive eco-innovations as economically unprofitable large financial investments. In addition, the vast majority of enterprises are focused on short-term investments and achieving quick profits, and the costs associated with the implementation of eco-innovations are quite significant.

A final analysis of the evolution of the concepts of ecological innovations and ecologically safe production from the point of view of approaches to greening of production and the achieved ecological consequences was proposed by the Organization for Economic Cooperation and Development. This evolution takes place in the direction from processes and technological solutions (dominance of recycling and waste

disposal) to the principles of cleaner production, product life cycle management, implementation of integrated production and environmental management systems, creation of ecological industrial parks (Figure 1).

Environmental management is based on the control of waste and release of harmful substances, assessment of the impact of pollution on the environment in accordance with international standards developed by the International Organization for Standardization (ISO). The system of standards for the green economy includes ISO 14001 on environmental management systems, ISO 19011 on environmental management system auditing, ISO 14031 on environmental performance evaluation, ISO 14020 on environmental labeling and declarations, ISO 14064 on greenhouse gas assessment and verification. (Vitkin, 2016; Tomashuk, 2022)

As a result of ecological innovations, new business models are emerging in practice – eco-industrial parks (EIP), which use the synergy of economic and environmental protection activities of manufacturers of industrial products, which under normal conditions are not related to each other.

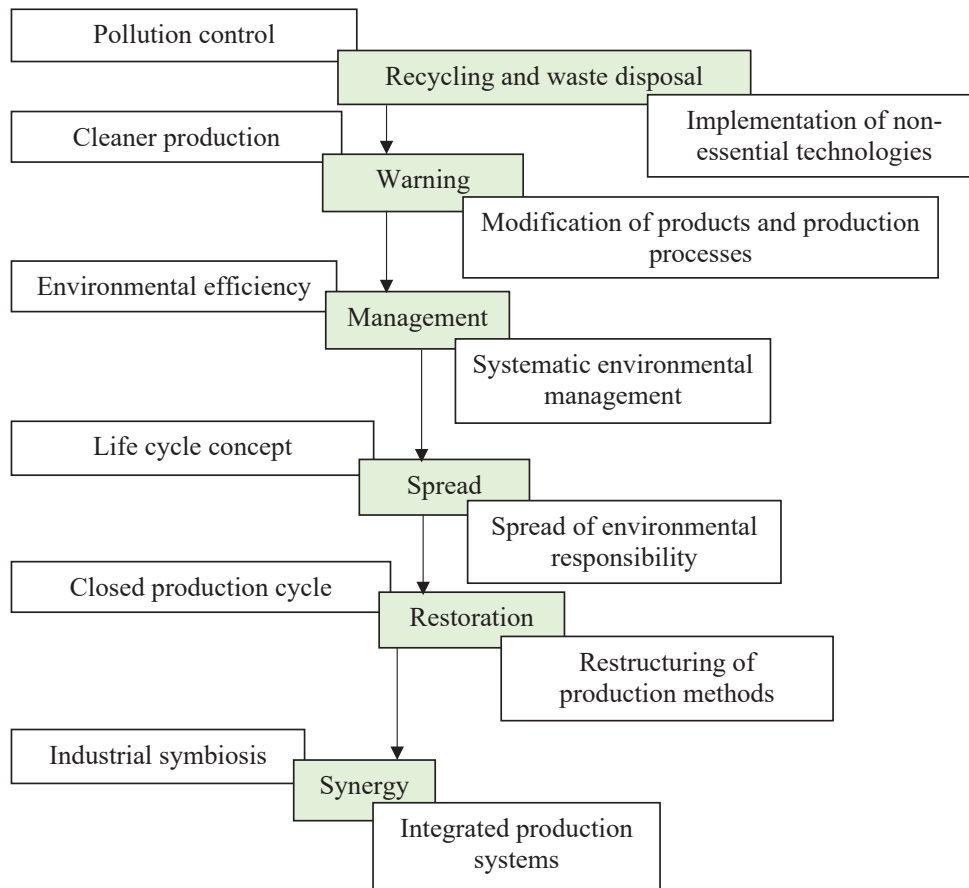


Figure 1. Evolution of concepts and practice of ecological innovations

Source: designed based on research

As a result of this synergy, companies benefit from the efficient use of all available resources and the entire production cycle, which allows them to significantly reduce costs and thus achieve one of the main goals of the company.

3. The essence of enterprise development and its connection with greening

In today's rapidly changing socio-political and economic conditions, all companies are faced with the task of not only surviving, but also constantly developing and increasing their potential.

Development as a process is subject to the action of economic laws: general (the law of supply and demand, the law of synergy, the law of self-preservation) and partial (the laws of production management, the law of competitiveness of managers) of content, which reflect the cause-and-effect relationships of socio-economic phenomena.

One component of development is economic development, which scientists define as qualitative and structural changes in national economies as a result of economic growth. The economic development of an enterprise describes the dynamics of the processes of its development and can be classified according to a separate type of development, namely a growing type of development (the feature of this type is to ensure economic growth by increasing the number (volume), measured by certain indicators, of the results of the enterprise's activity for a certain period of time); a shrinking type of development (this type is characterized by negative dynamics of the key indicators of economic growth); a stable type of development (characterized by the equality of the indicators of the enterprise's activity when comparing the current and previous stages; in the case when the market is observed with unchanged prices for goods and services, this type is able to ensure simple reproduction).

However, one of the most important vectors for the implementation of the sustainable development program is the greening of production, the implementation of which will allow solving environmental problems at the level of enterprises and regions.

Scientists distinguish three models of environmentalization of business activity – passive, active and traditional. Taking into account the above models, as well as the factors of formation of the potential of environmentalization of innovative activities of enterprises, it is possible to distinguish five models of environmental policy based on the level of development of the organizational culture of the enterprise and its capabilities (Figure 2).

Greening takes into account the priority of issues of harmful impact on the environment when making decisions on creation of new or modernization of outdated industries for the purpose of business development. The term "greening" itself is a rather broad concept and means a reduction of the integral eco-destructive impact of the processes of production and consumption of products per unit of the total social product. (Kaletnik, Lutkovska, 2022)

Each of the proposed models of greening provides a separate system of directions and tools that can be included in the activities of the enterprise if there is an environmental management subsystem. (Kotsko, 2019)

It should be noted that there is no universal mechanism of greening that would be suitable for all companies. Currently, greening is at the beginning of its development – it is a long, complex, gradual and rather expensive process.

It largely depends on people's ecological awareness, psychological mood and ecological qualifications, which in turn requires the formation of a new ecologically oriented world view from childhood.

In modern realities, it is impossible to achieve completely waste-free technologies. Thus, it is possible to speak only of "nature-preserving" technologies, which scientists divide into five types (Figure 3).

In this context, the integral indicator of the ecological level, which can be calculated both for some individual types of man-made pollution, and as a generalizing integral indicator according to the formula, will be characterized:

$$I_i = (FW_{a_1} + DP_{a_2} + HE_{a_3} + HW_{a_4}) * IP,$$

where I_i – integral indicator;

FW – volume of fresh water consumption for production needs (million cubic meters);

DP – volume of discharge of polluted effluents (million cubic meters);

HE – the amount of harmful emissions into the atmosphere (million tons);

HW – volume of hazardous solid waste (million tons);

IP – volume of sold (produced) industrial products (million hryvnias);

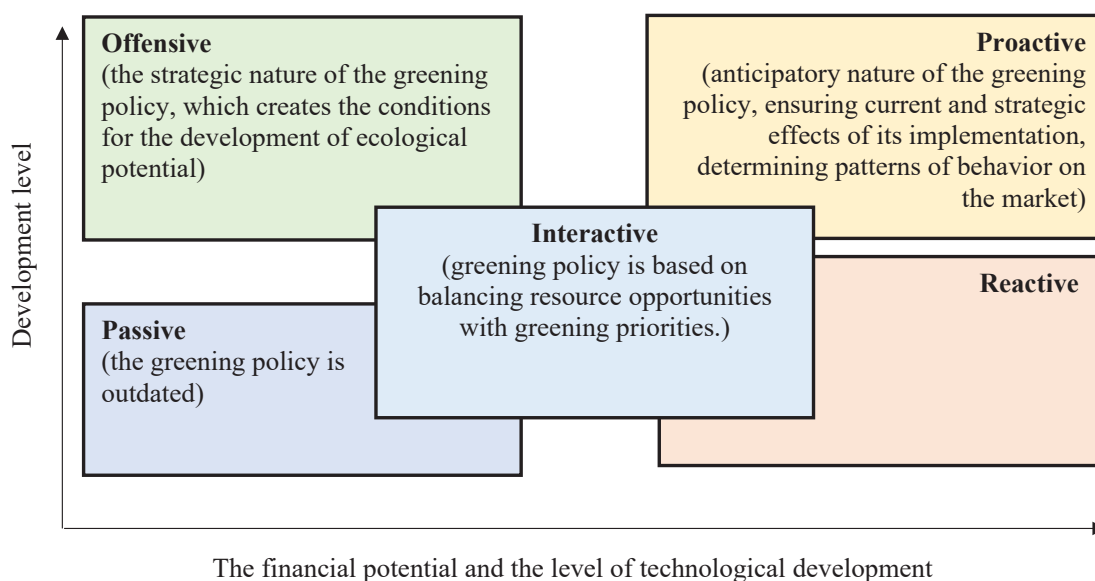


Figure 2. Models of environmentalization of business activity

Source: (Kotsko, 2019)

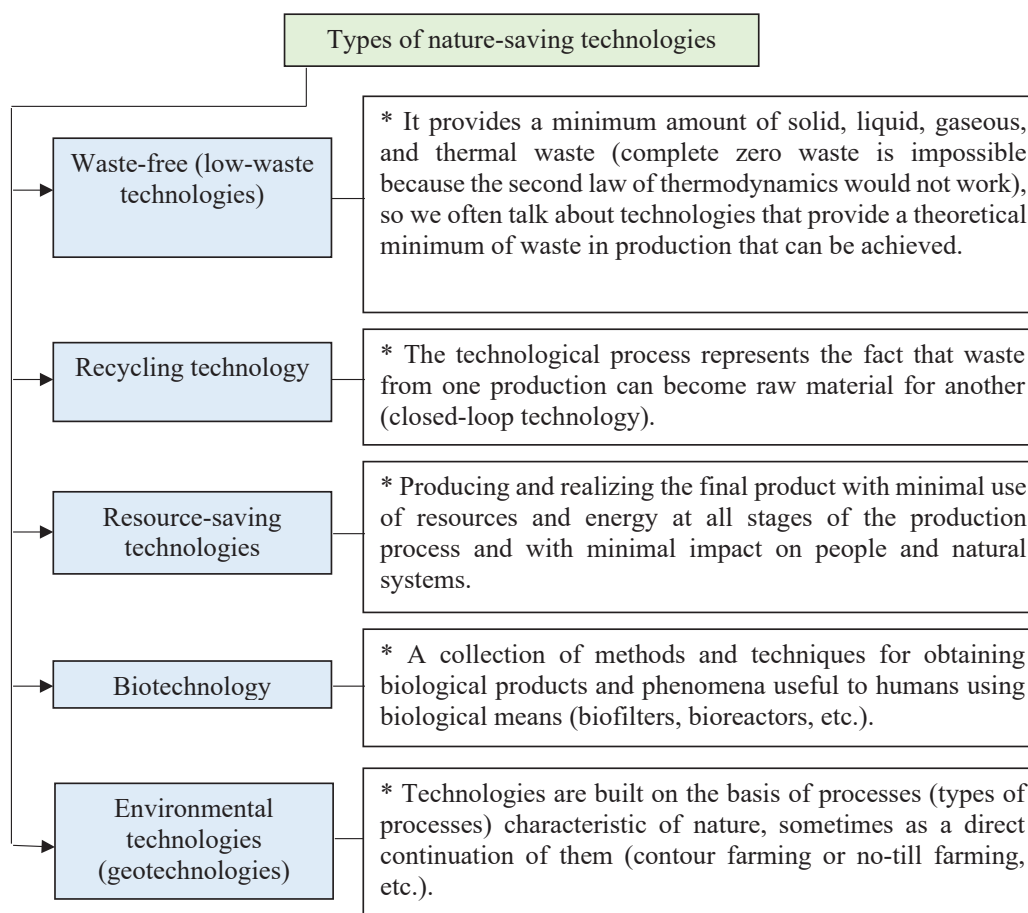


Figure 3. Types of nature-saving technologies

Source: designed based on research

a_1, a_2, a_3, a_4 – weighting coefficients (the degree of importance of the i th type of impact in relation to other types of eco-destruction). The coefficients are determined by an expert and can take any value from 0 or higher, for example: 0.5; 1; 1.5; 4; 7 and others.

In today's world, the solution to the global crisis related to the protection of the environment and the rational use of natural resources cannot be achieved only by implementing methods of processing, reusing and disposing of waste – new ways are needed, based on fundamentally innovative, non-traditional scientific developments.

4. Formation and regulation of environmental responsibility of enterprises: domestic and foreign practice

Unfortunately, environmental responsibility in modern domestic companies remains primarily a way to achieve economic goals. Investments in the environment and environmental innovation

activities do not provide quick sources of profit capitalization and therefore are usually considered by management as lost market opportunities. It is also worth noting that Ukrainian enterprises do not yet perceive the greening of their activities as a dominant factor in the competitive struggle.

Practice shows that a well thought-out system of environmental responsibility is an important tool for preventing violations of normative environmental requirements and, as a result, for fulfilling the environmental obligations of enterprises. The concept of corporate environmental responsibility, environmental impact assessment and environmental audit should be distinguished by a number of features: the composition of the subject and object, the purpose of implementation, the nature of publicity and obligations, forms of public participation (Table 2). It should also be noted that companies that carry out environmental audits and environmental impact assessments

Table 2

Demarcation of concepts in the field of environmental responsibility

| Signs | Eco-responsibility of industrial enterprises | Environmental impact assessment | Environmental audit |
|----------------------------|--|--|--|
| Subjects | Businesses, community, state and local government, stakeholders. | Business entities, state authorities, local self-government bodies, the public. | Executive authorities, local self-government bodies, owners of environmental audit facilities, public representatives, environmental auditors. |
| Objects | Management system, systems environmental quality control in the sphere of influence of the enterprise, production processes. | Planned economic activity, including construction, reconstruction, technical re-equipment, re-purposing, liquidation of objects. | Industrial enterprises, their associations, separate production sites, raw materials, discharges, waste, environmental management systems. |
| Goal | Greening of industrial activity, establishment of ecological and economic balance through social dialogue. | Ensuring ecological safety, environmental protection, rational use of nature, in the process of making decisions about conducting business activities. | Ensure compliance with environmental protection legislation in the course of economic and other activities. |
| Reporting | Social reports with disclosure environmental information. | Environmental impact assessment report, conclusion from environmental impact assessment. | Environmental audit conclusion. |
| News | Partly voluntary. | Mandatory. | Voluntary/mandatory. |
| Public access | Yes | Yes | Yes – when conducting an external environmental audit |
| The role of local hromadas | Participation in the formation of the development strategy of the industrial enterprise, control, construction of social dialogue. | Public discussion, making comments and suggestions, contesting the conclusion of the environmental impact assessment. | Initiation of external audit. |

Source: (The Law of Ukraine "On Environmental Impact Assessment"; Law of Ukraine "On Protection of the Natural Environment"; Law of Ukraine "On Strategic Environmental Assessment")

are not automatically considered to be environmentally responsible, given the mandatory nature of these procedures.

In this connection, the question arises about the introduction and observance of a clear strategy for the implementation of entrepreneurial activities of enterprises. In general, the strategy of ecological development contains a philosophy of behavior and directions for development of business associations, corporations and individual enterprises of their activities taking into account environmental priorities.

In Table 3 indicators of the volume of capital investments in environmental protection in Ukraine by types of environmental protection measures are presented. In general, there are a number of specific types of ecological development strategies in the world. Each of these strategies reflects the usual conditions of formation, object-subject composition, strategic advantages, etc.

The majority of post-Soviet enterprises adhere to the strategy of protective ecological development,

which is characterized by compliance with mandatory standards of the enterprise's relationship with the environment. Scientific literature and international practice of environmentally friendly business distinguish 4 classification categories of such tools – administrative, social motivation, economic and organizational.

In fact, economic instruments, in turn, can be classified according to the methods of influencing the issuer. It is appropriate to distinguish such categories as market, financial, collateral, fiscal and those belonging to the system of obligations.

Environmental impact assessment plays an important role in the North American model of environmental liability. Yes, in the USA it is the National Environmental Policy Act (NEPA), the Environmental Quality Improvement Act of 1970, Section 309 of the Clean Air Act, as amended (42 US Code 7609) and Executive Order 11514 (March 5, 1970, as amended). (Beloborodova, 2014)

Table 3

**Capital investments in Ukraine for environmental protection
by type of environmental protection measure¹ (in actual prices; thousand UAH)**

| Year | Total | Including | | | | |
|----------------------------------|------------|----------------------------|-----------------------|------------------|---|--------------------------------|
| | | Air and climate protection | Wastewater Management | Waste Management | Protection and remediation of soil, groundwater and surface water | Other environmental activities |
| 2006 | 2194188,5 | 762538,6 | 777924,5 | 339529,6 | 247695,4 | 66500,4 |
| 2007 | 3080687,6 | 1379250,6 | 809677,1 | 388386,6 | 393036,8 | 110336,5 |
| 2008 | 3731400,4 | 1476343,3 | 927352,9 | 422918,6 | 787303,8 | 117481,8 |
| 2009 | 3040732,7 | 1273789,4 | 882525,4 | 400016,9 | 401425,6 | 82975,4 |
| 2010 | 2761472,1 | 1139946,7 | 734663,4 | 475584,3 | 319922,0 | 91355,7 |
| 2011 | 6451034,6 | 2535632,6 | 721325,5 | 1183880,2 | 639123,1 | 1371073,2 |
| 2012 | 6589336,5 | 2462675,3 | 846955,4 | 730544,4 | 540516,8 | 2008644,6 |
| 2013 | 6038783,0 | 2411935,1 | 834114,8 | 713856,3 | 324980,1 | 1753896,7 |
| 2014 | 7959853,9 | 1915129,7 | 1122149,3 | 783965,4 | 359925,6 | 3778683,9 |
| 2015 | 7675597,0 | 1422946,6 | 848881,2 | 737498,9 | 388259,2 | 4278011,1 |
| 2016 | 13390477,3 | 2502805,8 | 1160029,1 | 2208676,6 | 419988,9 | 7098976,9 |
| 2017 | 11025535,2 | 2608027,4 | 1276530,2 | 2470969,5 | 1284502,0 | 3385506,1 |
| 2018 | 10074279,3 | 3505920,6 | 1692640,7 | 1182045,8 | 1444291,6 | 2249380,6 |
| 2019 | 16255671,8 | 4276767,6 | 1753869,1 | 5754260,9 | 1721924,9 | 2748849,3 |
| 2020 | 13239649,8 | 5595319,4 | 1578201,4 | 2899793,4 | 2554224,5 | 612111,1 |
| Deviation (+/-) 2020/2006 | | | | | | |
| | 11045461,3 | 4832780,8 | 800276,9 | 2560263,8 | 2306529,1 | 545610,7 |

¹ Data for 2014-2020 exclude the temporarily occupied territory of the Autonomous Republic of Crimea, the city of Sevastopol, and part of the temporarily occupied territories in the Donetsk and Luhansk regions.

Source: (Official website of the State Statistics Service of Ukraine)

In general, environmental assessment in the United States began to be used as part of a rational decision-making process in the 1960s. At that time, it was considered a technical assessment for decision making.

If talking about Canada, in this country environmental liability is regulated based on the Canadian Environmental Assessment Act (CEAA), which is the legal basis for the federal practice of environmental assessment in most regions of Canada; "Directive on the Environmental Assessment of Policy, Plan and Program Proposals". (Vitkin, 2016) Strategic environmental assessment is defined as a systematic and comprehensive process for evaluating the environmental impacts of proposed policies, plans, programs, and other strategic initiatives. In the North American model, financial support mechanisms such as environmental insurance are also increasingly used.

In the European Union, the problems of environmental responsibility of companies and corporations are increasingly coming to the fore in the context of the implementation of

Directive 2004/35/EU "On environmental responsibility for the prevention and elimination of the consequences of damage to the environment", the adaptation of which was completed by all EU Member States in July 2010 (Directive of the Council of the European Union № 2004/35/CE on environmental liability, aimed at preventing environmental damage and eliminating its consequences).

In the European Union, environmental responsibility is part of the development strategies of states, which is determined by the existence of a number of national environmental strategies. In promoting environmental responsibility, the governments of European countries are primarily trying to ensure that government institutions themselves set the right example.

Great Britain and Japan are a good example of a combination of features of the North American and Western European models. As for the Japanese model, it has a significantly expressed internal character, directed at employees and collective decision-making in environmental

management, which in turn is part of general corporate management. (Beloborodova, 2014) A large share of state ownership harmoniously determines a high level of regulation by state authorities.

As far as the British model is concerned, the basic point of environmental responsibility here is the pronounced activity of companies and corporations themselves in creating projects, which in general fully corresponds to the principle of voluntariness. It is worth noting that the position of Minister for Corporate Social Responsibility was created for the first time in Great Britain. This fact indicates a high level of attention to environmental responsibility in the country.

The post-Soviet model is used in Eastern European countries and traditionally focuses on the fact of causing damage. That is, in case of damage to the environment (including atmospheric air), the enterprise must pay financial compensation to the state, even if restoration of this component of the environment is impossible.

Today the legislation of Ukraine on environmental protection includes the following basic laws, documents and codes Constitution of Ukraine, relevant branch codes (Code of Land, Air, Forest, Water, Subsoil), about 40 laws, including: "On Environmental Protection", "On Environmental Expertise", "On Ecological Audit", "On Nature Reserve Fund of the Country", "On Atmospheric Air Protection", "On Animal Life", "On Energy Saving", "On Use of Nuclear Energy and Radiation Safety", "On Management of Radioactive Waste", "On Use of Nuclear Energy and Radiation Safety", "On Radioactive Waste Management", "On Legal Regime of the Territory Radioactively Contaminated as a Result of the Chernobyl Accident", "On Status and Social Protection of the Citizens Affected by the Chernobyl Accident" and others. (Economic Code of Ukraine)

Regarding legal liability for environmental violations, Ukraine uses 4 types of legal liability: disciplinary, administrative, criminal and property. To date, the issue of adoption of the Environmental Code of Ukraine (ECU) remains unresolved. The vast majority of scientists are inclined to accept the ECU, but some areas of regulation remain controversial and need to undergo in-depth scientific discussions.

An important vector of development of environmental responsibility of enterprises in Ukraine is their reorientation towards international standards of environmental restoration. Modern Ukrainian realities require stricter state regulation in the field of environmental responsibility of enterprises, as the level of business motivation in the country is currently low. The legislation does not provide for the granting of benefits and preferences to the so-called "green" production. (Andreychenko, 2017) It is worth noting that the share of enterprises, which believe that business should participate in the solution of environmental problems of society, is significantly higher among state-owned enterprises than among private enterprises.

It is also important to solve the problem of substantiating the conceptual basis of economic methods and tools of environmental regulation, stimulating and improving their efficiency. Solving these problems will significantly contribute to increasing the level of environmental responsibility of domestic enterprises. (Mazur, Kovalchuk, 2019)

At the present stage of social development, the problems of global ecological and economic interrelations and international ecological cooperation in environmental protection are among the most important. The solution of these problems should lead mankind to find rational ways to prevent and minimize the consequences of the global environmental crisis.

5. Analysis of the state of innovative development and the needs of greening

With the development of humanity and scientific and technological progress, the destructive impact on the environment is increasing, more and more global environmental problems are appearing, and therefore the attention to ecological innovations is growing both in domestic and international circles. The direct implementation of ecological innovations can ensure the environmental responsibility of business, increase the efficiency of enterprises, increase consumer loyalty to products and, as a result, high indicators of competitiveness of producers while preserving the environment.

The introduction of measures for sustainable development into the basis of management of economic entities requires the formation of new

methods of carrying out production activities, assessing their impact on the environment. In order to assess the effectiveness of the introduction of environmental innovations at the international level, a number of indicators have been developed and implemented.

One of these indicators is the Environmental Performance Index (EPI) – a comprehensive indicator of the assessment of the environmental policy of the state and its individual subjects. The index is calculated on the basis of 24 performance indicators in ten categories of health, environment and ecosystem viability. (Beloborodova, 2018) These indicators make it possible to assess the level of achievement of environmental policy goals by countries. In Table 4, information on the position of Ukraine in the international rankings reflecting innovative development for the period 2015–2021 is presented.

Related to ecology is the Global Cleantech Innovation Index, which was launched in 2012. The index is calculated for 40 countries of the world as a weighted sum of assessments of two groups of indicators: available resources and conditions for innovation (inputs to innovation) and achieved practical results of innovation

implementation (outputs of innovation). The final index represents the ratio of the cost of innovation development and the achieved effect. (Markevich, 2019) Table 5 shows the dynamics of changes in the indices of the European Innovation Scoreboard for Ukraine for the period 2015–2021.

China, Switzerland, Sweden, the United States, the Netherlands, the United Kingdom, Finland, Denmark, Singapore, and Germany are among the top ten countries in the Global Index of Environmentally Clean Innovations. The Republic of Korea is also approaching the top ten. As for Ukraine, according to the results of innovative activity, it took the 45th place and also entered the group of economies that successfully demonstrated themselves in the sphere of innovation in 2020. Among the ten countries with below-average income level with the best result in its category, Ukraine took the second place (Innovation rating 2020 and the COVID crisis, 2020). According to the index of efficiency of transition to sustainable development (SDP) in 2021. Ukraine took the 64th place in the world (Table 6).

The key to the implementation of any innovation in the company is the positive dynamics

Table 4

Ukraine's place in international rankings reflecting innovative development in the period 2015–2021

| Indicator | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | Deviation (+/-) 2021/2015 |
|--|------|------|------|------|------|------|------|---------------------------|
| Global Innovation Index | 64 | 56 | 50 | 43 | 47 | 45 | 49 | -15 |
| Innovation Input | 84 | 76 | 77 | 75 | 82 | 71 | 76 | -8 |
| Institutions | 98 | 101 | 101 | 107 | 96 | 93 | 91 | -7 |
| Human capital & research | 36 | 40 | 41 | 43 | 51 | 39 | 44 | 8 |
| Infrastructure | 112 | 99 | 90 | 89 | 97 | 94 | 94 | -18 |
| Market sophistication | 89 | 75 | 81 | 89 | 90 | 99 | 88 | -1 |
| Business sophistication | 78 | 73 | 51 | 46 | 47 | 54 | 53 | -25 |
| Innovation Output | 64 | 40 | 40 | 35 | 36 | 37 | 37 | -27 |
| Knowledge & technology outputs | 34 | 33 | 32 | 27 | 28 | 25 | 33 | -1 |
| Creative outputs | 75 | 58 | 49 | 45 | 42 | 44 | 48 | -27 |
| Index of innovative development for Bloomberg | 33 | 41 | 42 | 46 | 53 | 56 | 58 | 25 |
| Productivity | 48 | 50 | 50 | 50 | 60 | 57 | 55 | 7 |
| Patent activity | 25 | 28 | 27 | 27 | 35 | 36 | 36 | 11 |
| Efficiency of higher education | 5 | 5 | 4 | 21 | 28 | 48 | 57 | 52 |
| Value-added production | 40 | 46 | 47 | 48 | 58 | 57 | 57 | 17 |
| Intensity of research and development | 39 | 45 | 44 | 47 | 54 | 57 | 59 | 20 |
| Concentration of researchers | 39 | 41 | 44 | 46 | 48 | 49 | 52 | 13 |
| High technology penetration | 31 | 36 | 34 | 32 | 35 | 35 | 39 | 9 |
| Innovation Index of the European Innovation Scoreboard | 35 | 35 | 35 | 36 | 33 | 33 | 34 | -1 |

Source: (European Innovation Scoreboard 2021)

Table 5

Dynamics of changes in the indices of the European Innovation Scoreboard for Ukraine in the period 2015–2021

| № | The main blocks of EIS | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | Deviation +/- 2021/2015 |
|----|---------------------------------------|------|------|-------|-------|-------|------|------|-------------------------|
| 1 | HR | 67 | 66,1 | 131,6 | 100,8 | 53,4 | 46,4 | 31,8 | -35,2 |
| 2 | Attractive research systems | 8 | 14,9 | 22,3 | 15 | 17,3 | 15,1 | 17,3 | 9,3 |
| 3 | Innovative Environment/Digitalization | - | - | 5,5 | 6 | 169,6 | 97,5 | 72 | 72 |
| 4 | Funding and Innovation Support | 23 | 19 | 16,7 | 7,6 | 11,3 | 9,8 | 17,7 | -5,3 |
| 5 | Innovation costs | 46 | 46,8 | 44,8 | 52,9 | 45,1 | 34,8 | 41 | -5 |
| 6 | Innovators | 0 | 15,7 | 16,0 | 15,6 | 20,2 | 22,6 | - | - |
| 7 | Ties | 24 | 4,6 | 9,6 | 3 | 37,6 | 36,5 | 10,1 | -13,9 |
| 8 | Intellectual Property | 29 | 23,6 | 13,4 | 13,1 | 20,9 | 22,4 | 9,8 | -19,2 |
| 9 | Impact on Employment | - | 77,9 | 77,9 | 77,4 | 86,9 | 80,5 | 78,2 | 78,2 |
| 10 | Impact on exports | 44 | 33,1 | 32,8 | 34,7 | 53,1 | 35,3 | 37,5 | -6,5 |

Source: (European Innovation Scoreboard 2021)

Table 6

Ranking and scores of non-EU European countries and Central Asia on the Sustainable Development Transition Performance Index (SDP) in 2021

| Place for SDP | | Name of country | The value of SDP in points according to the directions of transition: | | | | |
|---------------|--------------|-----------------|---|----------|--------|------------|------------|
| In the region | In the world | | General | Economic | Social | Ecological | Management |
| 1 | 1 | Switzerland | 78,4 | 79,8 | 82,9 | 71,7 | 83,0 |
| 2 | 5 | United Kingdom | 73,3 | 58,2 | 77,1 | 78,0 | 75,7 |
| 3 | 8 | Norway | 71,3 | 67,3 | 85,8 | 54,2 | 86,8 |
| 4 | 31 | Iceland | 61,2 | 67,2 | 89,7 | 28,7 | 79,1 |
| 7 | 44 | Armenia | 54,2 | 33,1 | 66,2 | 55,6 | 59,6 |
| 8 | 49 | Georgia | 53,2 | 29,8 | 61,8 | 56,0 | 61,1 |
| 9 | 53 | Turkey | 51,9 | 47,1 | 53,5 | 55,6 | 49,3 |
| 10 | 56 | Moldova | 50,6 | 41,4 | 65,8 | 46,8 | 51,3 |
| 13 | 61 | Serbia | 49,4 | 37,5 | 63,4 | 42,8 | 57,1 |
| 14 | 64 | Ukraine | 48,5 | 40,3 | 70,5 | 42,7 | 45,7 |

Source: (Transitions Performance Index 2021)

of its financial indicators, which ensures the company's ability to financially support the implementation of innovative projects and be prepared for certain risks associated with this process.

6. Problems and prospects of implementation of ecological innovations in the enterprise

Among the modern global problems of humanity, one of the main and most important is the problem of ecology and environmental protection. The extensive development of the economy as a result of ignoring its impact on the environment led to an environmental crisis, which in the course of the 20th century moved from the local to the global level.

The imperfection of the methods of modern economic development, the depletion of resources and the interdependence of all ecological and economic processes became the main reason for searching for ways of balanced development of society. The main goal of such development should be to satisfy the needs of present generations without endangering the ability of future generations to satisfy their needs. One of the most important methods of ensuring the balanced development of humanity is ecological innovation, which promotes the environmentalization of all spheres of social life. (Andreychenko, 2017)

The new model of economic growth should be based on an innovative type of development, which, in turn, implies the redefinition of concepts such as scientific and technological

progress and scientific and technological development. This implies the emergence of new priorities, in particular the intellectualization of production activities, the use of advanced information technologies and environmental friendliness. This model also requires the formation of a new financial and credit policy at the macro level, the effective stimulation of innovations, especially ecological ones, the development of knowledge-intensive industries and the minimization of nature-using industries; at the micro level it is possible to talk about a change in the type of entrepreneurial activity, the active involvement of small and medium-sized private enterprises in the production of socially useful products. (Yastremska, Yastremska, 2020)

At present, ecological innovation is still an underdeveloped field in the economic space, despite the rapidly growing global problem of environmental sustainability of industry and increasing environmental sustainability of enterprises. Therefore, the implementation of environmental innovation requires the system and complexity of the relevant environmental innovation processes. However, it is worth noting that the interest of enterprises in ecological innovation is increasing against the backdrop of growing global environmental problems. First of all, such innovations can increase the competitiveness of enterprises and ensure the social and environmental responsibility of business. (Tomashuk, Tomashuk, 2021) Thanks to the principles of sustainable development, new approaches to the functioning of the industrial sector of the economy are formed, while improving technologies and their technological support, as well as developing a conscious strategic vision of the top management in the field of sustainable development.

Today it can be clearly stated that the number of low-waste and resource-saving technologies in enterprises, although not significant, has started to grow since 2016. Awareness of the processes of the necessity of changes under the influence of resource depletion, increased control over harmful effects on the environment, and modernization of technical and technological support of enterprises acquire significant indicators of activation.

However, it is worth noting that in the presence of such a positive trend in the growth of modern

ecologically oriented technological processes at enterprises, their percentage value among all implemented technologies is not significant. Thus, in 2016 it was no more than 21%, and in 2019 – 37% (official website of the State Statistics Service of Ukraine). With its gradual development, environmental innovations are transformed into business approaches, which, in turn, ensure sustainable development of enterprises and increase the efficiency of operations and competitiveness. In this regard, the main factors that encourage companies to implement environmental innovations in their operations are as follows:

- focus on the causal nature of action, which means addressing the causes, rather than the consequences, of adverse environmental and human health impacts of business activities;
 - delimitation of liability, which includes determination of the degree and direction of liability of the subjects of ecologically destructive activities;
 - formation of a motivational toolkit, which must correspond to the existing socio-economic conditions;
 - efficiency maximization, i.e., achieving environmental goals with minimum costs and obtaining the maximum return on investment.
- Figure 4 shows the indicators of innovation costs in Ukraine by types of economic activity in 2020.

The goal of any business has traditionally been to increase profitability while increasing sales and reducing production costs.

However, the implementation of eco-innovations in the specified context is not always a priority for manufacturers, as it implies an increase in costs for modernization of production processes, replacement of outdated technologies, renewal of the material and technical base for the same production volumes. This causes the problem of lack of interest of the product manufacturers in the introduction of sustainable development into technological processes, which requires research and actualizes the need to raise issues of eco-oriented innovative activity. Table 7 shows the performance indicators of Ukrainian enterprises in the period 2010–2021.

Eco-innovations have a gradual impact on sustainable development. Even if there are no significant changes, the indicators of environmental sustainability of enterprises continue to grow,

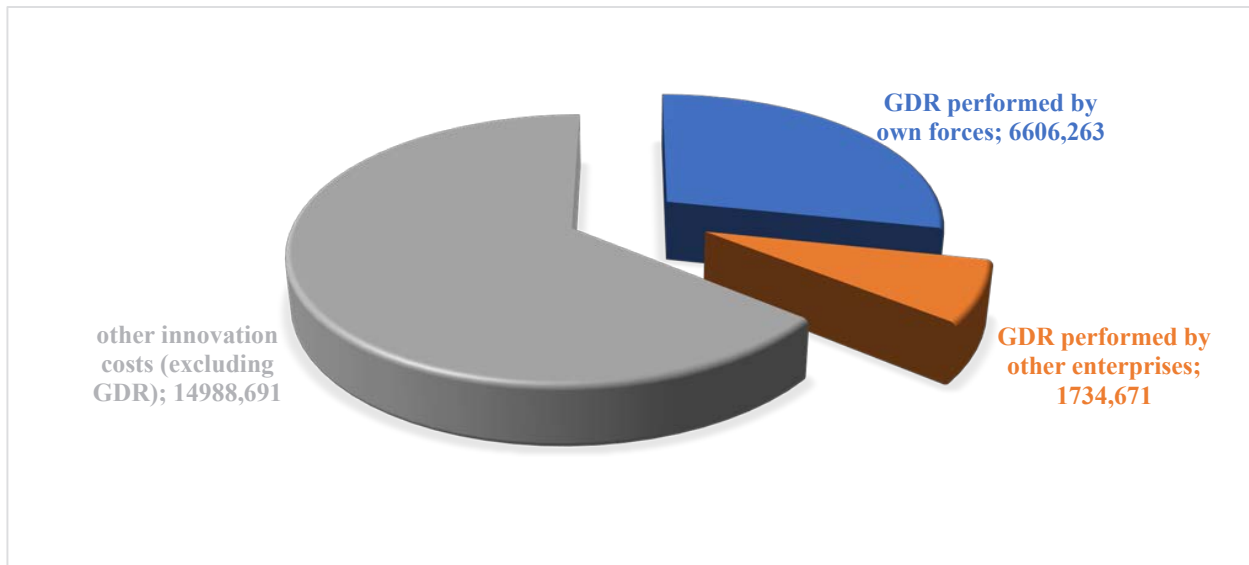


Figure 4. Costs for innovation in Ukraine by types of economic activity^{1,2}, mln. UAH in 2020

¹ The data exclude the temporarily occupied territory of the Autonomous Republic of Crimea, the city of Sevastopol and part of the temporarily occupied territories of the Donetsk and Luhansk regions.

² Data are for legal entities with an average of 10 or more employees.

Source: (Official website of the State Statistics Service of Ukraine)

which collectively forms a comprehensive focus on establishing the principles of sustainable development at the scale of the real sector of the country's economy. (Tomashuk, 2022)

However, despite the proven effectiveness of eco-innovation development and implementation, researchers identify a number of inherent limiting factors:

- the inertia of human thought and behavior;
- resistance to change on the part of those who benefit from the status quo;
- incomplete knowledge of the global ecosystem, its synergistic nature;
- self-centered and limited short-term interests of stakeholders. Table 8 shows examples of the main industries that are currently most active in using environmental innovations.

Therefore, in order to activate the processes of greening at the enterprises of the agricultural sector, as well as at other enterprises, it is necessary to create and ensure a number of economic conditions (Honcharuk, Tomashuk, 2022):

- creation of a reliable insurance market for reliable insurance of business activities in case of losses resulting from the development and implementation of environmental innovations;
- development of the market of alternative energy sources, subsidizing enterprises for the transition to their use;

- creation of clusters of ecologically oriented production, which would include producers of ecological raw materials, final products, energy-saving, resource-saving, ecologically safe technologies;

- increase the attractiveness of investing resources in the greening of businesses and corporations;
- creation of dedicated funds in companies for the development and implementation of eco-innovations;
- formation of a program of sustainable development of ecological innovations and support of enterprises in its implementation.

These proposals for the activation of greening processes can ensure the sustainable development of the enterprise, solve the problems of stimulating the introduction of eco-innovations, create affordable conditions for obtaining investment resources for greening, and increase the economic interest of enterprises for their direct introduction into production. (Honcharuk, Kovalchuk, Tsitsyura, Lutkovska, 2020)

Ecological orientation contributes to the development of the company and the achievement of its economic efficiency, because the expected positive effect on the environment is the main reason for the development and implementation of ecological innovations. The main advantages of introducing environmental innovations are as follows:

Table 7

Performance indicators of Ukrainian enterprises, grouped by special aggregations provided for by Regulation (EC) № 251/2009 of 11.03.2009 on structural statistics of enterprises in 2010–2021¹

| Year | Number of active companies, units | Number of employees, thousands of people | Of which, number of employees in thousands | The volume of sold products (goods, services) according to the institutional approach, million UAH | Volume of produced products (goods, services) according to the institutional approach, million UAH | Value added at factor cost, million UAH |
|---------------------------|-----------------------------------|--|--|--|--|---|
| 2010 | 378810 | 7958,3 | 7836,4 | 3366228,3 | ... | ... |
| 2011 | 375695 | 7793,1 | 7712,4 | 3991239,4 | ... | ... |
| 2012 | 364935 | 7679,7 | 7577,6 | 4203169,6 | 2593346,7 | 1015503,5 |
| 2013 | 393327 | 7406,5 | 7285,6 | 4050215,0 | 2468790,2 | 977145,0 |
| 2014 | 341001 | 6298,5 | 6193,0 | 4170659,9 | 2723971,2 | 1234090,1 |
| 2015 | 343440 | 5889,7 | 5778,1 | 5159067,1 | 3215287,9 | 1329264,5 |
| 2016 | 306369 | 5801,1 | 5713,9 | 6237535,2 | 3884617,6 | 1702670,5 |
| 2017 | 338256 | 5812,9 | 5714,6 | 7707935,2 | 4872748,1 | 2099504,8 |
| 2018 | 355877 | 5959,5 | 5870,6 | 9206049,5 | 5626457,3 | 2310580,6 |
| 2019 | 380597 | 6407,5 | 6241,9 | 9639730,6 | 6301412,2 | 2744295,8 |
| 2020 | 373822 | 6366,1 | 6288,4 | 10049870,8 | 6508169,6 | 2883240,0 |
| 2021 | 370834 | 6391,7 | 6289,7 | 13616793,2 | ... | ... |
| Deviation (+/-) 2021/2010 | | | | | | |
| | -7976 | -1566,6 | -1546,7 | 10250564,9 | - | - |

¹ The data are given without taking into account the results of the activities of banks, budget institutions for 2014–2021 without the temporarily occupied territory of the Autonomous Republic of Crimea, the city of Sevastopol and a part of the temporarily occupied territories in the Donetsk and Luhansk regions.

Source: (Official website of the State Statistics Service of Ukraine)

Table 8

Key industries using eco-innovations

| Branch | Examples of ecological innovations |
|---|---|
| Management of natural resources and emissions | – Innovations to reduce the consumption of raw natural resources. |
| Energy | – The use of new resource-saving technologies that lead to greater economic efficiency; – Alternative sources of energy supply, which are distinguished by their efficiency, minimum level of service and optimal price. |
| Industry | – Transformation of one product into another. |
| Urban planning | – Ecological urban planning, technologies that minimize emissions of harmful substances on a city scale. |
| Green construction | – Approaches to design, construction and operation buildings containing a certain number of solutions, measures, materials and equipment aimed at energy and resource efficiency. |
| Alternative transport and logistics | – Vehicles running on ecological and cheap fuel, for example on electricity. |

Source: (Markevich, 2019)

- calculation and forecasting of the activities of organizations in the field of eco-innovation, consumer behavior and the development of zero-waste production;
- identification of factors that negatively affect the creation and implementation of environmental innovations, necessary for the development of effective tax and trade policies;
- raise awareness of environmental innovations among interested parties and encourage companies

- to green their activities, based on an analysis of the benefits to companies, sectors and the economy;
- providing information to society on the link between economic growth and environmental degradation;
- create a need for ecological products and an ecological way of life.

There are various motivating factors for the introduction of eco-innovations in enterprises. The most important of these factors is the solution

of the problem of reconciling the goals of effective economic activity of enterprises with clear regulation of the impact of such activity on the environment.

7. Findings

The instability and changeability of modern economic conditions, the difficulty of the content and structure of industrial relations of production with the environment, the strengthening of harmful eco-destructive tendencies in the development of social transformations at the present stage are a characteristic feature of the modern period of economic development of Ukraine.

In this context, solving the problem of ensuring the effectiveness of management of ecological and economic development should require a comprehensive solution of an equally important and multifaceted list of many production, organizational, economic and social problems, the most important of which should include the following:

- formation, support and development of the company's natural resource potential that is rational in terms of quantitative, qualitative and structural parameters;
- introduction of technical and technological, organizational, economic, social and other

conditions for ensuring anticipatory growth of efficiency of management of ecological and economic development of the enterprise;

- implementation of modern achievements of scientific and technical progress in production activity, increase of productivity of use of natural resources with the help of automation of production processes;

- development and implementation of a consistent and targeted set of measures to promote the creation, expansion and modernization of a flexible and broad range of knowledge, skills and abilities among employees;

- formation of organizational, economic and social conditions to ensure increased compliance of the motivational complex of labor activity of personnel with the established priorities of ecological and economic development at the enterprise level;

- establishment of a favorable organizational culture of the enterprise in terms of preservation and protection of the environment. Any enterprise with a high level of environmental responsibility should be based on a strategy of balanced environmental management based on modern trends in the field of strategic management and sustainable development (Table 9).

Implementation of the principles of greening in the activities of enterprises with effective state

Table 9

Environmental strategies of enterprise development

| The level of responsibility for the environment | Areas of activity of the enterprise | Type of environmental development strategy |
|---|--|--|
| Unsatisfactory | <ol style="list-style-type: none"> 1. Cleaning up emissions, creating a waste management strategy at the end of the production and technological cycle. 2. Compliance with pollution reduction procedures. 3. Meeting the requirements for publication of external environmental reports. 4. Availability of environmental services. | <ul style="list-style-type: none"> – Defensive strategy. – Normative environmental management. |
| Satisfactory | <ol style="list-style-type: none"> 1. Reduce emissions to legal levels. 2. Internal environmental audits (of various types and orientations). 3. Long-term environmental protection measures, including technological changes. 4. Responsibility of departmental managers for compliance with the environmental parameters of the production system. | <ul style="list-style-type: none"> – Compensation strategy (sufficiency strategy). – Effective environmental management. |
| Sufficient | <ol style="list-style-type: none"> 1. Prevent emissions to the environment. 2. Compliance with environmental standards for products on international markets. 3. Reflect the concept of sustainable development in the company's reporting. 4. External and internal environmental audits of the company. | <ul style="list-style-type: none"> – Proactive strategy (strategy of balanced nature management). – Management of an environmentally responsible organization. |

Source: formed based on research results

stimulation of innovative developments will make it possible to ensure an effective mechanism of rational use of nature and environmental protection.

8. Conclusions

Implementation of environmental innovations in most developed countries is an effective tool for solving both environmental and economic problems, a tool for achieving the principles of sustainable development. Such innovations are capable of solving the problem of reducing the consumption of limited natural resources, ensuring the preservation of the environment, increasing the profitability of business activities

and creating a circle of environmentally conscious consumers.

The promotion of environmental innovations, in particular the introduction of energy-efficient and resource-saving technologies, the development of alternative energy sources and the introduction of environmentally friendly production at the regional level is considered a strategic program for ensuring sustainable development. In the current conditions of global transformation processes, the implementation of ecological innovations becomes a priority direction of economic development, ensuring sustainable development and competitiveness of the national economy both on the domestic and foreign markets.

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