Aspects of sustainable industrial growth in the face of uncertainty

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Abstract. Sustainable development, as a paradigm of a global scale, is the basis of global development, uniting the efforts of people to improve living conditions and solve environmental problems. Reality shows how vulnerable ecosystems with well-established industrial, logistical, and infrastructural ties have turned out to be, which fail in the face of man-made, geopolitical cataclysms. But, if people can preventively assess the impact of these factors, then environmental problems can carry a destructive effect, which many times exceeds the estimates of leading experts. It turns out that industrial corporations act as the driving force of sustainable development. They are at the center of "ecosystem" relations, while representing a source of potential threats of a technological nature, which is why the activities of industrial companies directly determine the ecological situation of entire regions. In the course of the study, it turned out that increased requirements for the design of complex economic facilities demonstrate in practice the possibility of reducing tension in the regions of their presence. With the support of companies, new production facilities for deep processing of raw materials are being created, the production of high-tech products appears, which is typical for both developed and developing regions. It turned out that industrial activity determines the effectiveness of the development of environmental innovations, and the strategy of low-carbon energy goes through a set of decisions on sustainable development under conditions of uncertainty. It is emphasized that the challenges of the external environment, caused by a combination of factors dependent and independent of the activities of industrial companies, increase the degree of responsibility of decisions made in companies that represent an innovative technological "core".

1 Introduction

The steady industrial growth of the economy of the 21st century has moved into a phase when forward movement is seen only in encouraging and stimulating the attraction of "green" investments from the state, expanding the use of resource-saving technologies and practices,

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reducing the volume of hazardous waste and their effective management with the use of renewable energy and water resources, in conservation, as well as the implementation of measures to increase energy efficiency, sustainable use, restoration and reproduction of natural resources. Such events are laid down in the legislative acts of the leading countries of the world. These measures can give impetus to the opening of new business units that will strive to achieve sustainable development goals. European statistics show a positive trend in the registration of new business entities compared to 2015. In particular, before the pandemic at the end of 2019, the increase in the number of registered enterprises amounted to 9.9%, and in the first quarter of 2022 reached a value of 33.3%, taking into account the sharp rise in energy prices, inflationary growth in the economy as a whole (Eurostat. Statistical Office of the European Union 2022a). The main parameters of sustainable development at the level of industrial companies are of a question. Perhaps this is ensuring financial stability to achieve growth of industrial companies, which, of course, will solve the problem of employment, reduce the level of social tension in society. On the other hand, these may be long-term investment projects on environmental safety. Often, they do not bring a quick return on the invested funds, but without solving environmental problems, it is impossible to imagine our civilization as it can be after achieving the Sustainable Development Goals. In this case, we faced an urgent need for a multi-vector policy of managerial decision-making, which is designed to combine both process engineering and environmental demands of industrial companies, and will contribute to reducing scientific and technological risks. In this regard, the relevance of research on the links of integrated economic structures in the context of the quality of life and the disclosure of the ecological potential of ecosystems is increasing. As a promising goal, it is possible to designate the technological integration of industrial enterprises based on the parameters of the digital ecosystem with minimal emissions of waste from the main production and a developed financial support system for "green" technologies.

2 Review of the literature

Scientists and researchers from the perspective of sustainable development of industrial companies consider the problems of ensuring process engineering and environmental components. This is largely due to the deterioration of the overall environmental situation, sharp spikes in fuel prices, and problems in supply chain disruptions. At the same time, the tools of interaction between structural divisions of large companies and research centers specializing in solving environmental problems and developing bylaws in these matters could significantly simplify the transition of the global industrial complex to the implementation of the "Net-Zero" decarbonization policy. It assumes reduction to the "zero" level of emissions of pollutants, in particular CO2 by 2050 (Bag et al. 2020). With the leadership of the information and communication technologies sector, the relevance of information security in terms of protecting digital data of strategic industries has increased. (Bisht et al. 2021; Đorđević et al. 2021). Scientists agree that there is a close relationship between environmental, social and corporate factors and financial and company´s economic performance indicators (Kim and Li 2021). In this aspect, security is approaching the limits of control over financial stability and solvency. From our point of view, these parameters can be supplemented with technological integration as a process combining business processes and production-technological parameters of the development of industrial companies in the conditions of energy transition (Kuznetsov et al. 2019), (Nekrasova et al. 2014). The organization of step-by-step work on the path of ecological improvement of production is directly determined by the innovation policy of the company's management to solve the problems of the fourth industrial revolution. Scientists propose options for strengthening innovation activity, which lie in the field of environmental innovation, the formation of new competencies in the field of innovation while considering options for the development of industrial complexes with the inclusion of small innovative companies in the

current chain (Li et al. 2021; Podshivalova et al. 2021). We can agree with the opinion that the transformation in the field of environmental management is determined by the factors of intellectualization of production systems concerning regions and the territorial location of related business entities. Scientists propose development trajectories of the main elements of 3D modeling of a "smart" company at the level of global research in the following areas: "smart" personnel, "smart" environment, "smart" innovations and solutions (Chursin et al. 2021). Digital production al-lows the use of unified models for tracking emissions into the atmosphere to reduce the "carbon footprint". The energy transition should be based on a risk-based approach to quality management in the implementation of innovative projects. It will allow achieving high efficiency and ensure the strategic development of the company (Ilyina and Sanovich 2021).

Along with financial and economic risks, there are also scientific and technological ones, since technologies will determine the speed of transition to a "green" production. "Green" technologies form the basis of production processes and logistics, which makes it possible to produce and sell products with the least harm to the environment. Research in the field of formation and development of innovative organizational culture are the fundamental values of a modern organization (Bayhan and Korkmaz 2021).

The works of scientists describe the experience of transformation of the human re-source management system. There is revealed an influence of corporate reputation and social identity on innovative labor productivity through the participation of the organization (Frare and Beuren 2021; Iqbal et al. 2020). We can agree with these conclusions, be-cause ecological culture is an important indicator of the readiness of society and individual companies to decarbonize by switching to energy-saving circular-type technologies (Jovičić 2022).

Specialists offer methodological approaches to the organization of scientific research in the field of safe and "clean" production, as well as real steps for their practical implementation. The most important factors for guaranteeing economic security are the security of global financial markets in the digital economy in terms of the dominance of new cyber risks, as well as public administration tools. (Karanina et al. 2021; Bunnell et al. 2021). In our opinion, it is worth considering preferential "green" credit lines as a measure of sup-port and encouragement of "clean" production. It becomes especially relevant at the cur-rent level of investment in R&D in the oil and gas sector. Today global oil companies find themselves in difficult conditions, as their breakthrough technologies should provide an effect in the low-hydrocarbon energy of the future, including the formation and development of the oil and gas industry 4.0 and marketing strategic management of industrial companies (Matkovskaya and Vechkinzova 2020), (Chkalova et al. 2020). Solving the problems of financing R&D will minimize scientific and technological risks in manufacturing companies, accelerate the process of obtaining the necessary knowledge for innovation and activate the transition to innovative technologies (Carvache-Franco et al. 2020). An important direction in the implementation of the energy transition is a combination of commercial and state interests. Therefore, the participation and role of the state in measures to promote "clean" technologies is one of the priorities for the managerial decision-making process (Goyal et al. 2021; Penate-Valentin et al. 2021). The deepening of the technological chain is subject to special control, since all stages rep-resent a set of economic and environmental indicators of the "purity" of production and high-tech products (Bondarenko et al. 2020), (Krasyuk et al. 2020).

3 Methodology

The theoretical and methodological prerequisites of this study are based on the identification of the essence and content of the categories "environmental safety", "environ-mental management", "carbon-neutral and carbon-free energy", scientific and institutional prerequisites for risk management of technological integration, as well as the assessment of

factors determining specific features in the context of global challenges. When assessing current trends, emphasis is placed on the energy sector. For this purpose, industry indicators estimated in the global economy are used. The sources of statistical and operational information used were data from the Statistical Office of the European Union (Eurostat), the International Energy Agency, as well as corporate websites of energy companies.

Methods of statistical analysis (dynamic series, structural analysis), the method of graphical illustration of data, and selective observation are used to study the trends in the development of the oil industry. As a database, there were used open sources of domestic and foreign companies in the field of mastering technological innovations to ensure "zero" emissions into the environment.

4 Results

The ecological and economic system of industrial enterprises is dynamic and depends on a system of external and internal factors that can influence the activities of economic entities in the direction of active environmental management. Significant internal factors that depend on the enterprise include the following:

- Level of depth of technological processes;
- Structure of manufactured products and the share of high-tech products in the total volume of effective demand;
- Magnitude and structure of the costs of solving environmental problems, their dynamics in comparison with income;
- Composition and structure of "green" financial resources;
- Qualification of personnel involved in the field of environmental management at the company level;
- Accounting policy of the company;
- Degree of independence of an economic entity when adopting environmental improvement programs.

External factors are:

- Dynamics and fluctuations of effective demand for products with the eco logo;
- Phase of the economic cycle, which is especially important now, as a negative manifestation of successive waves of the spread of coronavirus infection;
- Tax and monetary policy concerning "dirty" types of production organization;
- Customs legislation, in particular, the development and introduction of "carbon units";
- General geopolitical stability;
- System of cultural-ecological values in society and others

The composition and structure of "green" financial resources, the volume of costs and incomes of enterprises remain important internal factors. The optimality of these indicators is determined by the implementation of the main functions of environmental management: management of production assets, greening of the technological process, attraction of preferential sources of financing within the framework of "green" projects.

In the asset management of an industrial company there should be paid special attention to monitoring the state of the technological process, in which several related industrial facilities participate since each of them must regularly confirm compliance with high environmental standards. The statistics of environmental innovations of Russian companies indicate insufficient activity in this direction (Figure 1).

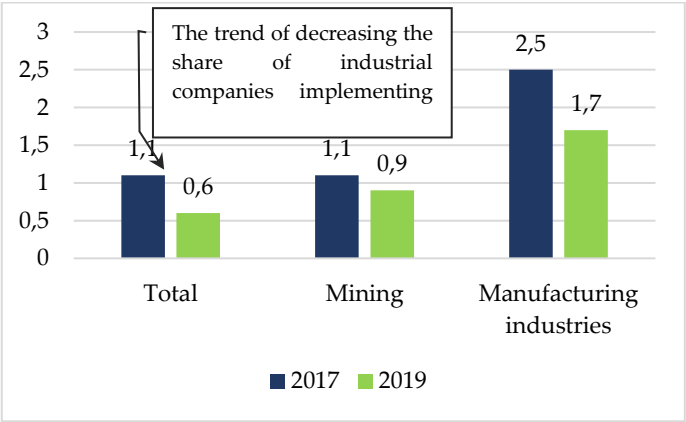

Fig. 1. The share of Russian organizations that carried out environmental innovations in 2017, 2019, as a percentage of the total number of surveyed organizations. Source: (Federal State Statistics Service of the Russian Federation 2022).

The situation in the field of organizing technological processes according to im-proved environmental standards also requires strengthening of the environmental measures (Figure 2).

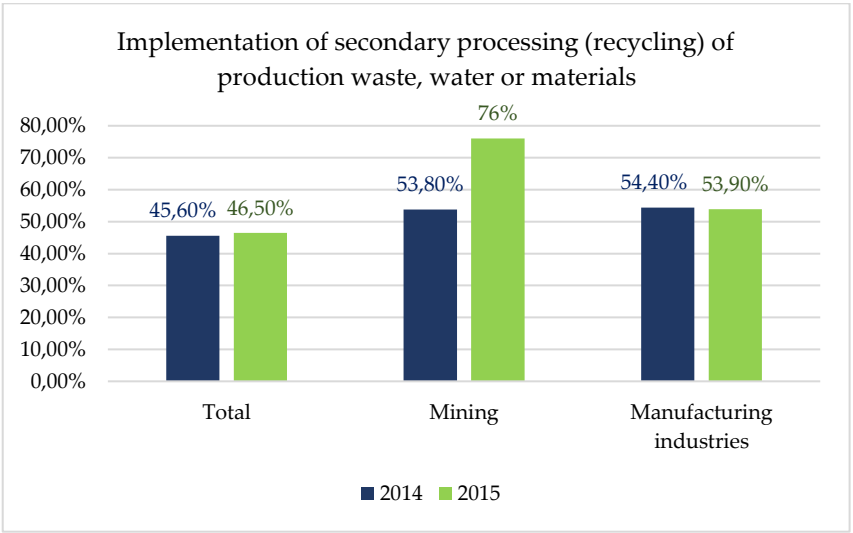

Fig. 2. Share of organizations implementing innovations that improve environmental safety in the process of production of goods (works, services) in 2014-2015, as a percentage of the total number of surveyed organizations. Source: (Federal State Statistics Service of the Russian Federation 2022).

Statistics of European countries prove the urgency of aggravating the environmental situation. Because most of the industrial facilities in this region are concentrated in large agglomerations, after the partial removal of restrictive measures, there is an increase in industrial emissions into the atmosphere (Figure 3).

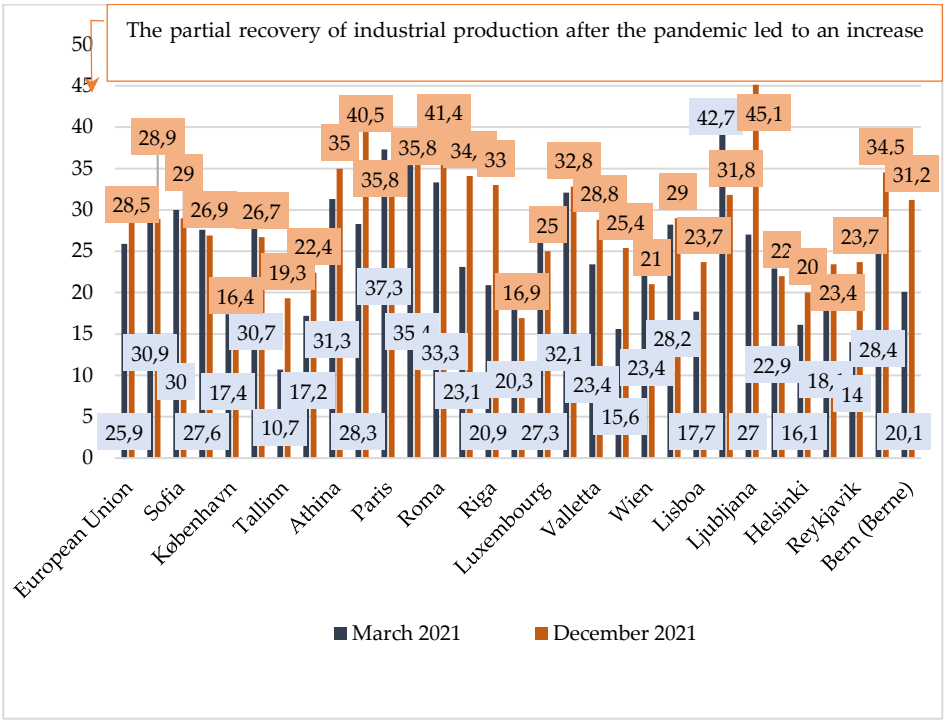

Fig. 3. Emissions of greenhouse gases and air pollutants. Nitrogen dioxide concentrations in European capitals in March and December 2021, in micrograms per cubic meter. Authors using the source: (Eurostat. Statistical Office of the European Union 2022b).

The environmental sector of the world economy includes a set of environmental benefits (goods, services, intellectual property objects) that can be applied in one of three directions:

– measurement and reduction of pollution;
– contributing to the reduction of emissions by increasing resource efficiency and return on the raw materials and materials used;
– providing the opportunity to use natural resources on the terms of a circular economy.

Gross value added (GVA) in the ecological economy of the EU countries tends to increase. In particular, in 2018, the volume of GVA reached 306799 million euros, or 2.27% of the gross domestic product (GDP) of European countries (Eurostat Statistical Office of the European Union 2022b). Companies in the following sectors have the largest share in the structure of the GVA: electricity, gas, steam and air conditioning; water supply; sewerage, waste management and restoration work (Figure 4).

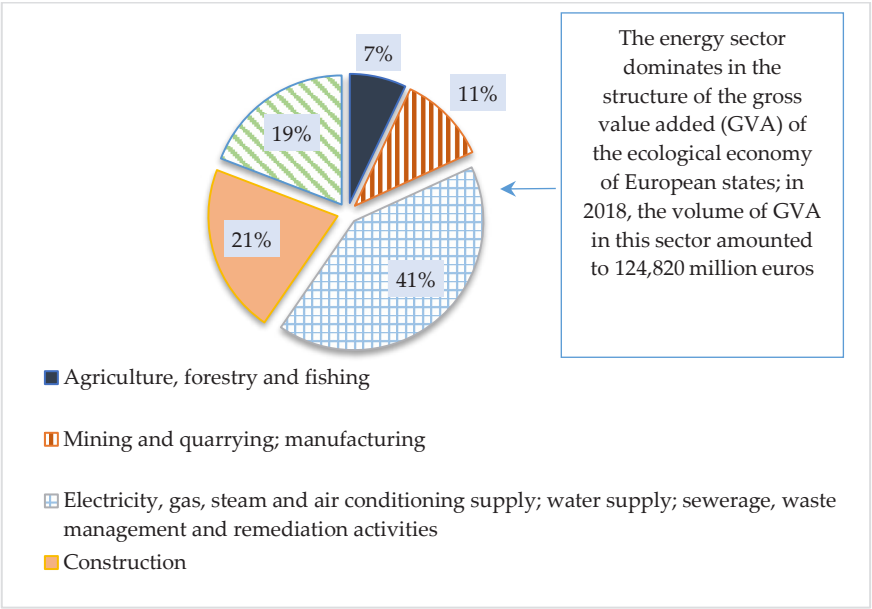

Fig. 4. Gross value added (GVA) structure in the ecological economy of EU countries in 2018, as a percentage of total GVA. Source: (Eurostat. Statistical Office of the European Union 2022b).

Focusing on ensuring environmental and economic security, it is important to emphasize that it is the companies of the energy complex that are at the epicenter of the "green" reform, since they often include industrial complexes integrated into the general technological chain, therefore they can be assessed by the "carbon footprint" at all stages of the production cycle. In companies of this complex, the desire to reduce environmental risks becomes part of the management strategy.

In particular, the American diversified holding company General Electric Company and the Cricket Valley Energy Center (CVEC) have started implementing a roadmap for environmentally friendly hydrogen technologies (H2 Roadmap) as part of the CVEC Combined Cycle Power Plant Carbon Reduction Project (Dover Plains, New York) (Figure 5).

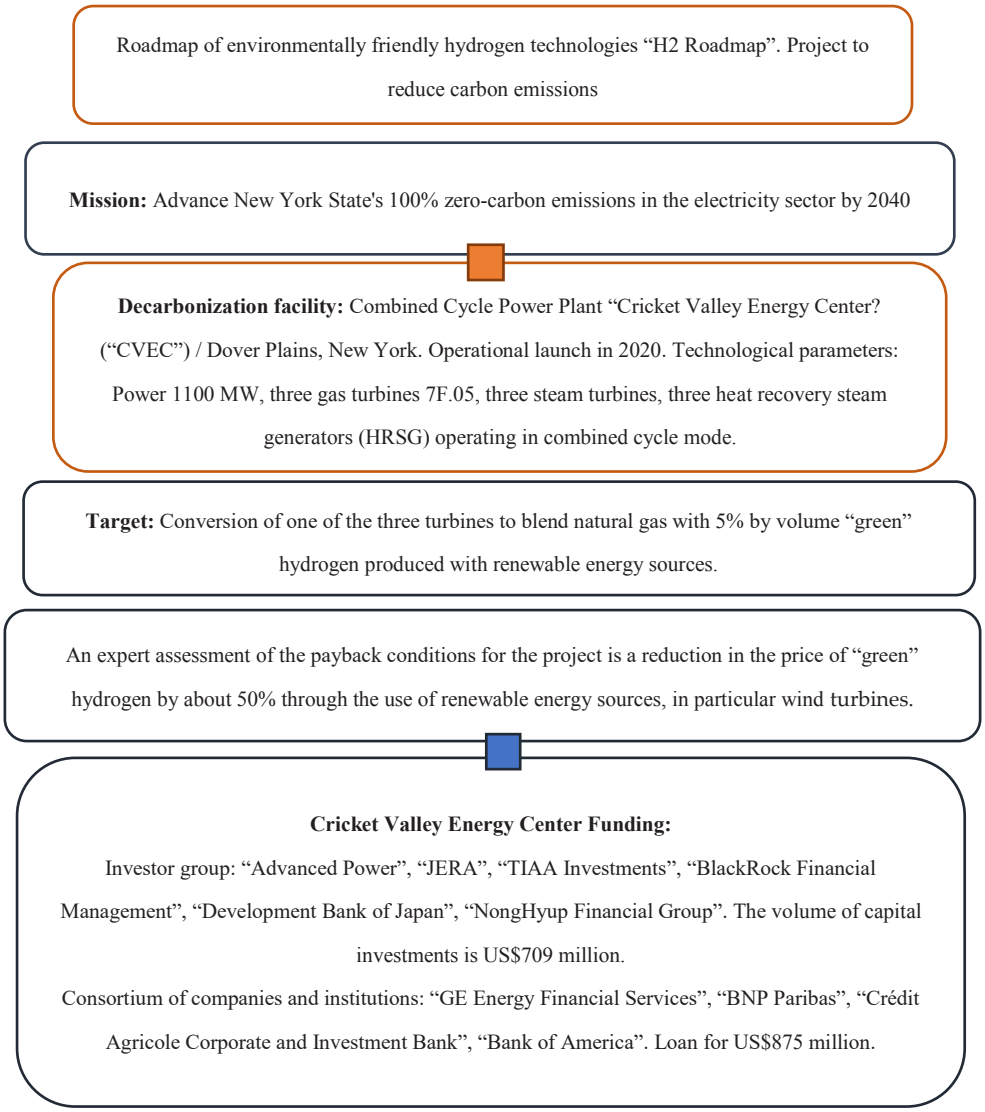

Fig. 5. Implementation of the environmental strategy of the General Electric Company as part of the H2 Roadmap. Authors using the source: (Palmer 2021).

The transformation of the global energy infrastructure should lead to an increase in the share of electric vehicles in annual sales from 3% to more than 50% by 2030, an increase in investments in environmentally friendly electricity from 380 billion US dollars to 1.6 trillion US dollars (Birol, 2021).

Leading energy companies recognize global environmental values and strive to find tangible and intangible sources for the implementation of the energy transition (Table 1).

Table 1. The main parameters of the implementation of «green» projects (Source: En+ Group 2021; RUSAL 2022; Total Energies 2021; KazMunayGaz 2022).

Project targets	Mechanisms of investment activity within the framework of projects	Investments, US dollars
En+ Group, International Company Public Joint Stock Company United Company RUSAL		
«En+ Group». Reduction of direct emissions, including fuel combustion at facilities (gas boilers, fleets, air conditioning); reduction of indirect emissions (from the distribution of energy purchased based on direct contracts). Introducing the "green" aluminum ALLOW to the market. Electricity from renewable sources is used for the production of more than 90% of aluminum, and a minimum "carbon footprint" is recorded at all stages of the technological process.	Issue of «International Renewable Energy Certificate» («I-REC»), opening of voluntary "coal-native loans". Operational reporting of emissions produced along the product supply chain within the framework of voluntary carbon reporting «Carbon Disclosure Project» («CDP»)	The "New Energy" program for the modernization of the Angara-Yenisei Cascade hydroelectric power plant in order to increase the level of safety, reliability and quality of energy supply to consumers in the regions of Siberia
Total S.A., Microsoft Corporation		
Digital transformation projects based on artificial intelligence to accelerate the transition to a "zero" economy, in particular, the development of liquefied natural gas (LNG) production and carbon removal technologies based on Microsoft's Power Platform cloud platforms; automation of business processes, cost reduction and simplification of data access for civilian developers.	Total. By 2025, the supply of low-carbon energy to 8 million consumers; the production of 35 GW of renewable electricity in 2025 and 100 GW in 2030. Capital investments of 1.5 - 2 billion US dollars per year. Microsoft. Commitment to use 100% renewable energy sources by 2025.	Transformation of Total's corporate strategy, change of the company's name to Total Energy use in 2021. Formation of a portfolio of renewable energy/ electricity sources, which should account for up to 40% of Total sales in 2050
JSC "National Company "KazMunayGas"		
Implementation of an innovative project management system. Creation of a high-precision "Digital Master Plan of the refinery" obtained by laser scanning of real production facilities and 3D modeling to reduce the cost of repairs and design, increase the level of industrial safety and trouble-free operation of installations	Environmental protection costs in 2019 amounted to over 50 million US dollars; they include the payment of taxes for regulatory emissions, environmental protection costs, insurance, compensation in the field of environmental protection and "green" investments	Implementation of an analytical geoinformation system for gas pipeline facilities for rapid response in emergency situations

The study of ties between the participants of economic relations; positive growth rates of investments in the development of intellectual base and technological solutions concerning material production; the global effect of reducing the overall level of environmental pollution can be considered as promising areas of joint scientific research in the field of "green" energy.

5 Discussion

Ensuring ecological security in the conditions of the formation of low-carbon and carbon-free energy is possible if certain steps are followed. These steps are proposed as options for industrial development.

Approach – development of mechanisms to ensure the stability of the asset management system, including their assessment. In this context, it is necessary to make decisions based on ESG risk reduction factors to quantify the vulnerability of enterprises to crises (Hubel and Scholz 2019; Nazarova and Osmanov 2021).

Approach – development of systems for assessing ESG goals and their impact on the return on investment of all participants in integration processes by distributing and unifying the time spent on the integration of assets. It is necessary to take into account the types of M&A transactions, in particular, the level of identity of the goals of companies of different industry affiliation at the same stages of merger (Chipurenko and Lisitskaya. 2021; Feng 2021).

Approach – optimization of production and supply chains through logical-informational and economic-mathematical modeling of processes. In this direction, it is advisable to create a prototype of an intellectual enterprise. It should be focused on continuous monitoring of production and sales of basic products, analysis of capital changes over the shoulder of a financial lever, assessment of the dynamics of human capital, as well as the development and implementation of product and process innovations (Portna et al. 2021; Shinkevich and Barsegyan 2021).

Approach – diversification of financial products and risk models taking into account the features of a closed-cycle economy. It involves modeling the factors of digital production, taking into account financial risks and a pricing system adapted to the specifics of the circular economy (Sintsova and Voskresenskaya 2020; Tashenova et al. 2019). In the implementation of this approach, it is important to develop ESG risk management system in banking management, which takes into account the variation of credit risk by industrial sectors, tightening of corporate lending programs, assessment of the level of ESG borrowers in the framework of long-term lending programs (Bidder et al. 2020; Smirnov 2021).

Practice shows that the development and promotion of these approaches in the manufacturing industry sectors is associated with the design of "green" transport infrastructure and the creation of functional zones, aesthetic improvement of logistics hubs, and transport interchanges as elements of environmental service (Melo et al. 2020). In the conditions of natural disasters and epidemics, the ecological security of industrial companies acts as a stabilizer in the system of human capital management and the institution of stakeholders. The formation of entrepreneurial skills among employees and the population, maintaining a high social level in the regions where industrial companies are present can be regarded as a guarantee of geopolitical stability and sustainable development of the industrial ecosystem (Guiso et al. 2021).

It is important to emphasize that, when conducting further research, it is necessary to take into account the technological complexity of the equipment and software products used, as well as the safety of the use of digital technologies, taking into account potential threats, the increase in the number of unauthorized impacts and the risk of man-made accidents.

6 Conclusions

The state of uncertainty, which has the nature of internal and external imbalances in the market of new technologies, is capable of disrupting old and forming new integration ties that will reduce industrial, scientific and technological risks. It turned out that the

environmental component is becoming the predominant force for sustainable development over typical risks. Programs of comprehensive ecological "improvement" help to activate one of the main modern functions of industrial companies, which is to maintain a "clean" production process. The integration aspects of sustainable functioning have firmly entered the field of investment and financial decision-making based on the principle of classifying objects as "low-carbon" and "carbon-free".

If companies choose the path of long-term prosperity, then, of course, they will set and solve the tasks of supporting internal environmental culture among employees and external environmental culture in the regions where industrial units are located. Thus, there is a continuous stimulation of people to generate and promote "ecological" business ideas. Research has shown that on the way to the introduction of "green" technologies, industrial companies unite with financial institutions, scientific and technological centers and get results in the form of creative investment projects for the gentrification of industrial territories, urban and rural agglomerations.

Engineering and ecology are becoming "symbiotic" phenomena that, in conditions of uncertainty and unpredictability of external factors, are able to provide the most valuable thing – the quality of people's lives.

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Abstract

Sustainable development, as a paradigm of a global scale, is the basis of global development, uniting the efforts of people to improve living conditions and solve environmental problems. Reality shows how vulnerable ecosystems with well-established industrial, logistical, and infrastructural ties have turned out to be, which fail in the face of man-made, geopolitical cataclysms. But, if people can preventively assess the impact of these factors, then environmental problems can carry a destructive effect, which many times exceeds the estimates of leading experts. It turns out that industrial corporations act as the driving force of sustainable development. They are at the center of "ecosystem" relations, while representing a source of potential threats of a technological nature, which is why the activities of industrial companies directly determine the ecological situation of entire regions. In the course of the study, it turned out that increased requirements for the design of complex economic facilities demonstrate in practice the possibility of reducing tension in the regions of their presence. With the support of companies, new production facilities for deep processing of raw materials are being created, the production of high-tech products appears, which is typical for both developed and developing regions. It turned out that industrial activity determines the effectiveness of the development of environmental innovations, and the strategy of low-carbon energy goes through a set of decisions on sustainable development under conditions of uncertainty. It is emphasized that the challenges of the external environment, caused by a combination of factors dependent and independent of the activities of industrial companies, increase the degree of responsibility of decisions made in companies that represent an innovative technological "core".

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