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# ENVIRONMENTAL ACTIVITIES OF RAILWAY TRANSPORT ENTERPRISES: RISKS AND OPPORTUNITIES IN THE CONTEXT OF DIGITALIZATION

***Ovchynnikova V., Doctor of Economics Sciences, Professor,***
***Obruch H., Doctor of Economics Sciences, Associate Professor,***
***Toropova V. I., PhD (Economics) (USURT)***

*The environmental activity of railway transport enterprises was studied and it was found that the level of the latter is extremely low and is actually ensured by the implementation of traditional measures focused on increasing energy efficiency and minimizing operating costs. It was noted that the reduction of costs of railway transport enterprises is ensured mainly by saving energy resources. It was found that in other aspects of the environmental responsibility of railway enterprises, neither the implemented measures nor the pace and scale of implementation meet the requirements of the transport and logistics sector entities and global innovation trends in this area. Given the urgent need to implement progressive changes in the environmental policy of Ukrainian railway transport enterprises, the use of alternative power sources and generally increasing their level of independence in resource management, it is proposed to focus attention on the digital potential of implementing the listed measures. The potential of digitalization is investigated as a basis for the formation of an innovative environmental policy of railway transport enterprises, risks and threats are highlighted, and promising areas of application of digital solutions for achieving significant environmental effects are revealed. It is emphasized that the use of modern digital technologies allows to significantly reduce, and in some cases completely eliminate, emissions of harmful substances, as well as minimize the negative impact on the environment during emergencies. It is emphasized that innovative digital solutions form the basis for the development of symbiotic interaction models that ensure waste-free production and a significant increase in the energy efficiency of business processes. It is substantiated that digital technologies and innovative digital tools can provide the necessary conditions for the formation and spread of environmentally conscious behavior.*

***Keywords: railway transport enterprises, environmental activities, greening, digitalization, digital innovations.***

# ЕКОЛОГІЧНА ДІЯЛЬНІСТЬ ПІДПРИЄМСТВ ЗАЛІЗНИЧНОГО ТРАНСПОРТУ: РИЗИКИ ТА МОЖЛИВОСТІ В УМОВАХ ЦИФРОВІЗАЦІЇ

***Овчиннікова В. О., д.е.н., професор,***
***Обруч Г. В., д.е.н., доцент,***
***Торопова В. І., доктор філософії з економіки (УкрДУЗТ)***

*Досліджено екологічну діяльність підприємств залізничного транспорту і виявлено, що рівень останньої є вкрай низьким і фактично забезпечується реалізацією традиційних заходів, зосереджених на підвищенні енергоефективності та мінімізації операційних витрат. Відзначено, що зниження витрат підприємств залізничного транспорту забезпечується в основному шляхом економії енергоресурсів. Виявлено, що в інших аспектах екологічної відповідальності підприємств залізничної галузі ані реалізовані заходи, ані темпи й масштаби впровадження не відповідають вимогам суб'єктів транспортно-логістичного сектору та світовим інноваційним тенденціям у цій сфері. Зважаючи на гостру потребу реалізації прогресивних змін в екологічній політиці українських підприємств залізничного транспорту, застосування альтернативних джерел живлення і загалом підвищенні рівня їх самостійності в управлінні ресурсами запропоновано зосередити увагу на цифровому потенціалі реалізації перелічених заходів. Досліджено потенціал цифровізації в аспекті як основи формування новаційної екологічної політики підприємств залізничного транспорту, виділено ризики та загрози і розкрито перспективні напрями застосування цифрових рішень для досягнення значних екологічних ефектів. Підкреслено, що застосування сучасних цифрових технологій дозволяє суттєво зменшити, а в деяких випадках і повністю усунути викиди шкідливих речовин, а також мінімізувати негативний вплив на довкілля під час надзвичайних ситуацій. Акцентовано увагу, що інноваційні цифрові рішення формують основу для розвитку симбіотичних моделей взаємодії, які забезпечують безвідходне виробництво та значне підвищення енергоефективності бізнес-процесів. Обґрунтовано, що цифрові технології та інноваційні цифрові інструменти можуть забезпечити необхідні умови для формування та поширення екологічно свідомої поведінки.*

***Ключові слова: підприємства залізничного транспорту, екологічна діяльність, екологізація, цифровізація, цифрові інновації.***

**Introduction.** All over the world, the activity of railway transport enterprises is considered one of the most environmentally friendly among enterprises in the transport sector, because compared to competitors, the impact on the environment during their operation is not so significant.

Understanding the importance of environmental protection, many countries around the world have initiated the implementation of programs aimed at reducing the harmful impact of business activities, including the transport complex, on the environment. The European Union has developed and is implementing a number of program documents to achieve a climate-neutral Europe by 2050. Seeing the serious threat of climate change to the sustainable growth of the European Union, the latter adopted for implementation the European Green Deal, the communiqué "European Green Deal", the EU Hydrogen Strategy and the EU Strategy for Adaptation to Climate Change, which are designed to ensure the halt of climate change, the preservation of biodiversity, increased energy efficiency, the growth of green agriculture and smart mobility, zero emissions into the atmosphere,

etc. [1].

Railway transport enterprises of Ukraine, contrary to global trends, have a significant environmental impact on the environment. The accounting reports of railway transport enterprises show that they are responsible for more than 16 thousand units of stationary emission sources, of which only 65% - are equipped with purification systems. In addition, the use of rolling stock that has long since reached the end of its service life in the transportation process is accompanied by significant emissions of carbon monoxide, nitrogen oxide, soot, nitrogen dioxide, solid products of incomplete combustion, etc.

The use of land for the construction and operation of railway tracks and structures leads to a violation of the stability of natural landscapes, which ultimately causes erosion and landslides. In addition, there are systematic emissions of oil products and bulk cargo onto railway tracks, which leads to contamination of the roadbed with extremely environmentally hazardous waste.

Given the urgent need to introduce progressive innovations in the field of energy efficiency, attract renewable energy sources, and increase the resource autonomy of Ukrainian railway transport enterprises in order to support their competitiveness in the dynamic market of transport and logistics services, it is advisable to analyze in more detail the features of the development of environmental activities of enterprises in the industry.

**Analysis of research and publications.** A significant number of scientists are concerned with environmental issues and the search for directions and tools to increase the environmental responsibility of railway transport enterprises. Among them: Bosak P. V., Dykan V. L., Korin M. V., Rybina O. I., Tokmakova I. V. and other [2-6]. At the same time, progressive changes in the environmental policy of a number of countries and companies themselves require a review of the environmental activities of Ukrainian railway transport enterprises, including studying the potential of digitalization for implementing environmental transformations.

**The purpose of the article** is to identify directions and progressive tools for the development of environmental activities of Ukrainian railway transport enterprises in the context of digitalization.

**Presenting main material.** In order to achieve zero greenhouse gas emissions, a quarter of which is currently carried out by the transport complex, within the framework of the European Green Deal in the field of transport, in parallel with the initiative to increase the level of use of alternative fuels in the transport complex, a course has been taken to increase the density of high-speed railways, stimulate the development of multimodal transportation and the transition to rolling stock with zero greenhouse gas emissions, introduce digital road traffic management systems and generally integrated ecosystems for managing the operation of the transport complex.

To transform the European Union into a climate-neutral economy by 2050, it is envisaged to stimulate the development of multimodal transport, increase ecological mobility, “greening freight transport” and digitalization of mobility. Accordingly, the European transport and logistics system is currently experiencing a period of systemic transformations: comprehensive systemic digitalization and greening of the transport complex is taking place. The European Green Deal has identified the following key flagships for ensuring the transition of the transport complex to sustainable development and mobility [1]:

- introduction of environmentally friendly vehicles and alternative fuels. Based on the fact that a quarter of carbon dioxide emissions in the EU (70%) are accounted for by transport, provided that road transport is significantly reduced, Europe has chosen a course to reduce dependence on fossil fuels and switch to electric transport. The European Green Deal has defined the following framework limits and indicators for

reducing fuel dependence: by 2030 – 30 million zero-emission cars, 80 thousand trucks and 1 million public electric vehicle charging stations; by 2030 – 2 times increase in rail transport; by 2050 – 2 times increase in rail freight transport;

- stimulating the development of multimodal transport and mobility as a service by developing public transport and cycling infrastructure, as well as expanding cross-border transport routes for seamless connectivity. Shared mobility is being developed through the introduction of digital technologies and intelligent traffic management systems, which allow for 24-hour transport and logistics service for customers;

- development of public transport, including the development of local high-speed rail connections. By 2030, passenger traffic on high-speed European railways is expected to increase by more than 2 times and the introduction of integrated micromobility [7].

Guided by the goals of the European Green Deal in the field of transport, a number of European countries are already implementing innovative projects aimed at greening transport and infrastructure. According to a study by Helios, a manufacturer of fast charging technologies, the Netherlands, Sweden, Belgium, Luxembourg and Denmark are among the top 5 environmentally developed countries implementing green projects in the field of transport to achieve the status of a "carbon-neutral" country. The leader of the rating is the Netherlands, which has the most developed infrastructure of charging devices for electric vehicles with over 90,000 places and almost 100% of the country's car fleet is made up of zero-emission vehicles [8].

In turn, the results of a study of the level of emissions of harmful substances by railway transport enterprises indicate that, despite their status as environmentally friendly transport, their activities cause enormous harm to the environment. The total volume of waste generated of various degrees of danger during 2018-2020 increased (the increase was 7,439 thousand tons), which generally does not correspond to the European course on the greening of the transport complex [9-10].

The growth in the total amount of waste generated at railway transport enterprises was the result of the internal policy of decommissioning rolling stock (more than 17 thousand units of rolling stock were decommissioned), which led to the accumulation of excess ferrous scrap, which accounts for the largest share of waste (in 2020 - 63%). Although waste of hazard class 2 occupies a small share in the structure of waste of railway transport enterprises (in 2018 it accounted for 0.9%, in 2019 - 0.98%, in 2020 - 0.6%), their generation has a more detrimental impact on the environment.

The most threatening type is waste of hazard class 1, the share of which is negligible (in 2018 it accounted for 0.1% of the total volume of waste generated, in 2019 – 0.14%, in 2020 – 0.1%), however, their generation poses a huge risk to the health of citizens and the country's ecosystem.

About 3.3 million tons of ore, 15 thousand tons of salts and 36 thousand tons of mineral fertilizers enter the environment each year during the transportation of goods by railcars, and due to the violation of the tightness of valves and drain devices on tank cars, significant volumes of petroleum products spill out. At the same time, during the operation of rolling stock (at the stages of gaining speed and stopping), lubricants are released, which settle on the railway tracks and the bed and, under the influence of sunlight, evaporate extremely harmful substances into the air. The bed is also polluted with solid household waste and wastewater during the operation of passenger rolling stock, which are simply dumped onto the superstructure of the track during movement.

A huge load on the ecosystem occurs during emergencies that occur in the work of railway transport enterprises. The dynamics of transport incidents at railway transport

enterprises during 2018-2021 (Fig. 1) indicates an increase in their number during the analyzed period and indicates a deterioration in the situation with the state of safety and ecology at the enterprises of the industry. Due to collisions or derailments of rolling stock, the destruction of wagons, tanks, grain trucks and locomotives occurs, and accordingly, their contents enter the environment.

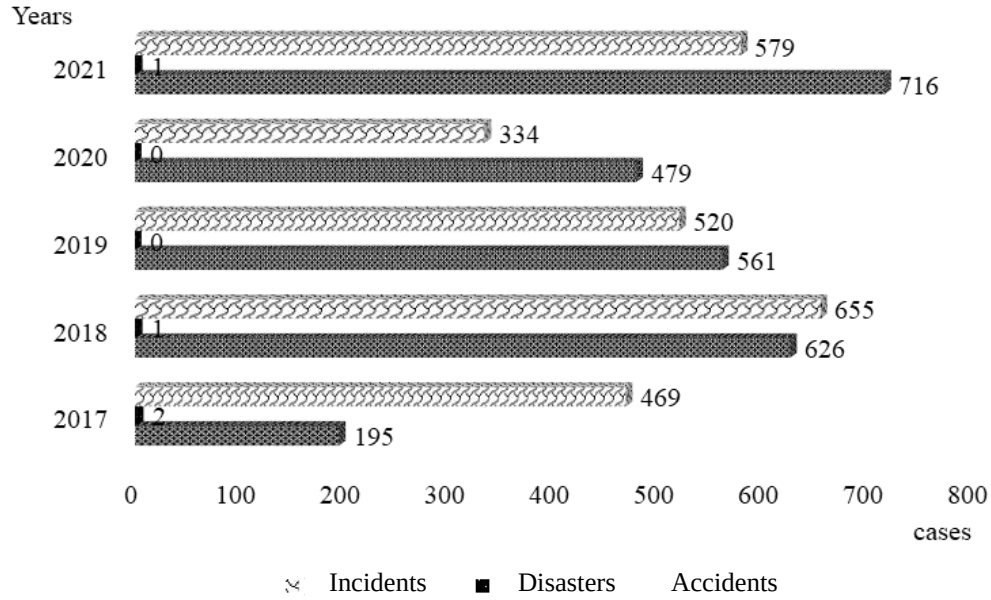


*Fig. 1. Dynamics of transport events at railway transport enterprises during 2018-2021* [2, 11, 12]

In addition to the ecological burden on the environment, accidents at industry enterprises cause significant financial losses. In 2019 alone, railway transport enterprises suffered material damage of UAH 2 million 898 thousand as a result of various accidents (Fig. 2) [11].

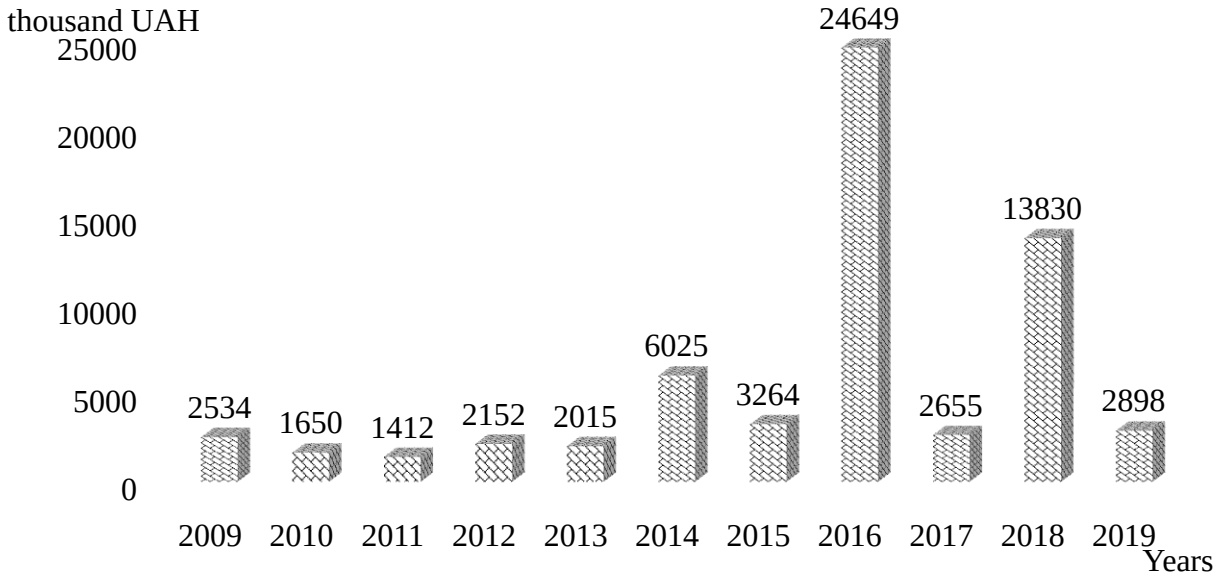


*Fig. 2. Dynamics of material losses of railway transport enterprises as a result of emergency situations in the period 2009-2019* [11]

In addition to land pollution, the activities of railway enterprises also harm the country's water resources by using surface and groundwater, discharging industrial, household and rainwater into water bodies. The enterprises of the industry have 737 wells under their control, of which 535 are in operation, and 485 are equipped with control and accounting facilities. These wells are the main source of meeting the industry's water needs [10].

Unfortunately, the technological process of railway transport enterprises is designed in such a way that a significant portion of water used to meet domestic and sanitary and hygienic needs and after a certain stage of purification is returned to the reservoir, although its composition does not always comply with environmental standards. In the period 2018-2020, both the volumes of water used and the volumes of return water discharge into reservoirs by railway transport enterprises decreased: if in 2018 10309.53 thousand cubic meters of water were used and 6974.4 thousand $m^3$ of return water was discharged into reservoirs, then in 2020 – 8531.05 thousand $m^3$ and 6133.577 thousand $m^3$, respectively.

Despite the fact that wastewater is treated at wastewater pre-treatment facilities, of which there are 117 on the balance sheet of railway enterprises, quite often due to outdated technologies the quality of treated water is low. Discharge of not fully treated wastewater into water bodies leads to deterioration of its physico-chemical properties and destruction of flora and fauna. Unfortunately, currently only 30% of water used by railway enterprises is subject to repeated and recycled water supply, the rest after treatment is returned to water bodies.

This situation indicates a deterioration in the level of environmental responsibility of railway enterprises and indicates a decrease in the efficiency of the existing system for regenerating used water resources.

Due to the use of outdated rolling stock and heating equipment by railway transport enterprises, the emission of exhaust gases that are extremely hazardous to human health, such as carbon monoxide, hydrocarbons, nitrogen and sulfur oxides, and soot, which not only irritate or clog the respiratory system, but also cause serious lung diseases [6].

In the structure of pollutants emitted as a result of the operation of fixed assets of railway transport enterprises, the largest share, both in 2020 and in previous years, was occupied by carbon dioxide, which accounted for more than 90% of all emissions into the atmosphere. In second place in terms of emissions are substances in the form of suspended solid particles, the share of which, excluding carbon dioxide emissions, is 34% (Table 1). If we compare in dynamics, then in general there is a positive trend, which is expressed in a decrease in the level of emissions of harmful substances into the air, however, this is largely due to macroeconomic processes associated with a decrease in the transport activity of business entities.

In addition, the work of railway transport enterprises requires the use of subsoil, in particular gravel and sand, which are used to form railway tracks and maintain traction rolling stock. The transportation process itself is accompanied by a certain amount of noise during the movement of rolling stock and, accordingly, this has an acoustic impact on the environment, and the movement of electric trains and other means causes a certain level of electromagnetic radiation, which also negatively affects the environment.

Thus, it can be noted that the activities of domestic railway transport enterprises have a significant negative impact on the ecosystem of Ukraine, causing pollution of water bodies, soils and atmospheric air and increasing environmental threats to the country's population. Although railway enterprises annually implement certain projects to modernize cleaning systems, renew rolling stock, re-equip boiler rooms and other facilities with a high level of danger, the level and pace of implementation

of environmental technologies do not meet either the needs of enterprises in the industry or the global goals of sustainable development and environmental responsibility. Among the main measures taken by railway enterprises in recent years and aimed at increasing the level of environmental safety and reducing the impact on the ecosystem, it is worth highlighting the following: - introduction of new models of passenger cars and diesel trains equipped with a closed system for collecting household waste;

- carrying out anti-landslip measures on railway tracks and reconstruction of the railway section Korosten-Podilskyi – PostPivdennyi;

- carrying out major repairs and modernization of outdated diesel locomotives;

- carrying out repair work at treatment plants, modernizing sewer culverts and building a single sewer network;

- implementation of preventive measures on oil traps, renovation of heating systems, implementation of ecological and thermal adjustment of boilers and modernization of dust and gas cleaning units, etc.

*Table 1*

*Volumes of emissions of major substances from stationary sources of railway transport enterprises into the atmosphere in 2019-2020 [9-10]*

| Types of pollutants | Years | | Absolute growth, thousand tons | Growth rate, % |
|---|---|---|---|---|
| | 2019 | 2020 | | |
| Substances in the form of suspended solid particles | 0,87 | 0,854 | -0,016 | 98,16092 |
| Carbon monoxide | 1,117 | 0,967 | -0,15 | 86,57117 |
| Non-methane volatile organic compounds | 0,435 | 0,374 | -0,061 | 85,97701 |
| Sulfur dioxide and other compounds | 0,452 | 0,391 | -0,061 | 86,50442 |
| Nitrogen compounds | 0,317 | 0,252 | -0,065 | 79,49527 |
| Metals | 0,036 | 0,03 | -0,006 | 83,33333 |
| Others | 0,049 | 0,025 | -0,024 | 51,02041 |
| Carbon dioxide | 168,62 | 148,25 | -20,37 | 87,91958 |

So, summing up, it is worth noting that the level of environmental activity at railway transport enterprises is extremely low and is annually limited to traditional measures aimed mostly at increasing the energy efficiency of the transport process. It is clear that saving energy resources is one of the key areas through which enterprises in the industry have the opportunity to optimize costs. In other areas of environmental responsibility, neither the set of implemented measures nor the pace and scope of implementation meet the needs of enterprises in the industry and global innovation trends in the field of environmental responsibility. Today, railway transport enterprises urgently need to implement progressive innovations in the field of energy efficiency, attract renewable energy sources and increase resource autonomy in order to maintain their own competitiveness in the dynamic market of transport and logistics services in Europe.

Significant opportunities for supporting sustainable environmental growth of railway

transport enterprises are created by digital technologies, the potential of which allows not only to achieve a reduction in the level of resource consumption, but also to significantly reduce the risks of emergency situations, thereby minimizing the impact of activities on the ecosystem. Among the key digitalization technologies, the potential of which allows to reduce energy consumption and rationalize the level of resource use by railway enterprises, it is worth highlighting the following:

- artificial intelligence allows for information monitoring, identification and prediction of changes in the ecosystem, and automation of the decision-making process in real time;
- remote sensing technologies or unmanned aerial vehicles are used to plan and monitor the state of land resources, control changes in water or climate, and protect natural resources;
- Internet of Things technologies are used to collect and analyze data from stationary and mobile observation points;
- Big data technologies are used to accumulate, store, process, and analyze information contained in information systems and data banks regarding the state of natural resource potential;
- the digital twin allows you to create databases of natural resource potential objects.

It is undeniable that digitalization processes and their technologies have a dual impact on the ecosystem: on the one hand, by reducing the level of resource consumption and environmental impact, and on the other hand, by increasing the technogenic load due to the accumulation of metal waste from the use of digital technologies and increasing energy consumption (Fig. 3).

Large-scale implementation of digital solutions in all spheres of public life can lead to:

1) an increase in the risk of social and personal degradation, cyborgization of man;
2) an increase in the scale of cybercrime;
3) a reduction in the level of employment due to a decrease in the number of jobs as a result of the displacement of man by technology;
4) an increase in digital inequality, an increase in public resistance to change;
5) a lack of guarantees of the accuracy of information;
6) a blurring of the boundaries of responsibility;
7) the formation of a huge amount of non-recyclable waste.

At the same time, digital solutions allow achieving tangible environmental effects in such areas of influence of railway transport enterprises as:

environment – the use of innovative digital solutions makes it possible to significantly reduce and even eliminate emissions of harmful substances into the air, water and land resources, and reduce the level of damage to the environment in the event of emergencies;

resource conservation – the implementation of innovative projects related to the digital transformation of enterprises in the industry will significantly reduce the level of consumption of fuel and energy resources, introduce mechanisms for using renewable energy sources, and increase the efficiency of existing energy and heat supply models;

production – digital solutions are capable of implementing models of symbiotic relationships that will allow for waste-free production and, accordingly, qualitatively improve the energy efficiency of business processes;

ecological culture – digitalization tools and technologies can create conditions for the promotion of environmentally responsible behavior.

**Conclusions.** The environmental activities of railway transport enterprises were studied and it was found that the level of the latter is extremely low and is annually limited to traditional measures aimed mostly at increasing the energy efficiency of the transport process. It was noted that saving energy resources is one of the key areas through which enterprises in the industry have the opportunity to optimize costs.

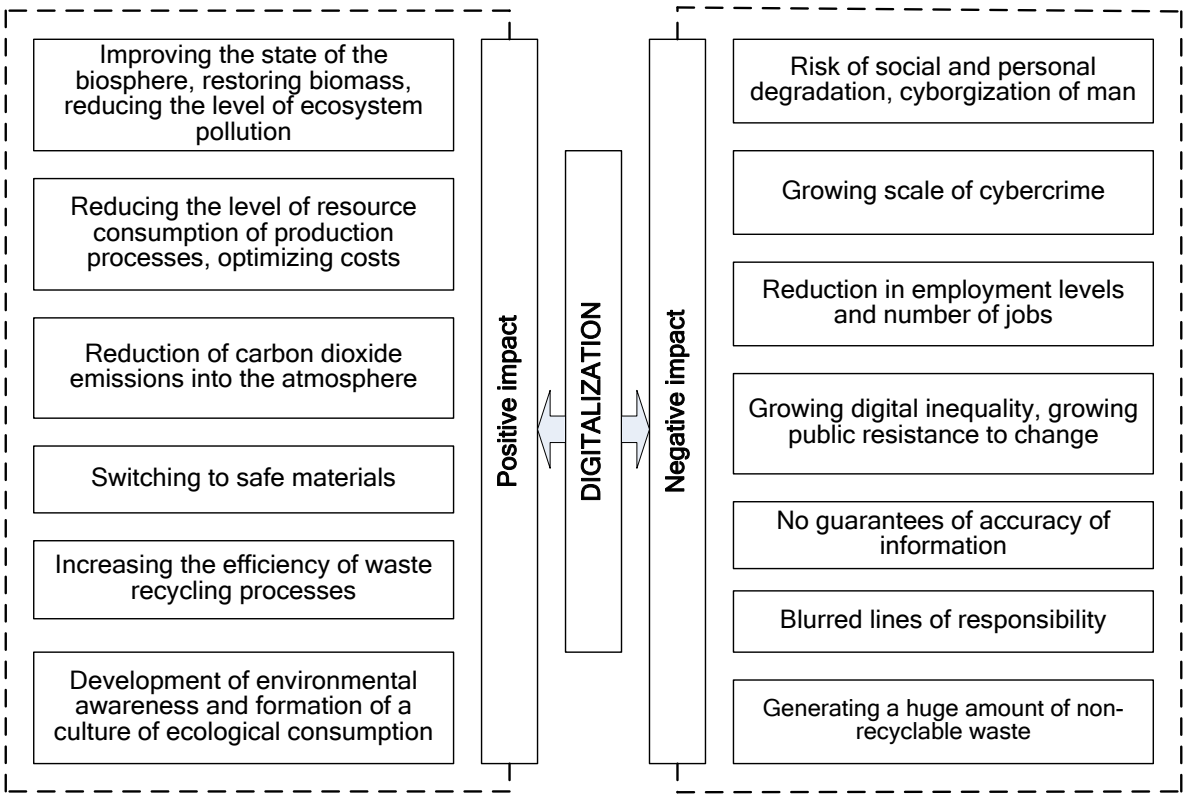


*Fig. 3. The content of the innovative ecosystem*

In other areas of environmental responsibility, neither the set of implemented measures nor the pace and scope of implementation meet the needs of enterprises in the industry and global innovation trends in the field of environmental responsibility. It was proven that today railway transport enterprises urgently need to implement progressive innovations in the field of energy efficiency, attract renewable energy sources and increase resource autonomy in order to maintain their own competitiveness in the dynamic market of transport and logistics services in Europe. The potential of digitalization was studied in terms of the basis for forming an innovative environmental policy of railway transport enterprises, risks and threats were identified and promising areas of application of digital solutions to achieve significant environmental effects were revealed.

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