

Innovation to ensure sustainable development in the coal industry

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Abstract. The rapid growth of mineral extraction and its use in the fuel and energy complex, particularly in the coal industry, has led to a significant global environmental impact. This has resulted in increased harm to both the environment in production and use regions, as well as to the global population. Furthermore, significant negative social effects are observed, including harm to human health and well-being. In response to these negative consequences, many countries have introduced stricter environmental protection measures to ensure long-term preservation of life and health.

1 Introduction

Responses to these challenges and stakeholder demands are driving the transformation of existing business models. Therefore, organizations gradually began to integrate the concept of sustainable development into their development strategies and began to realize the benefits that lead to increased competitiveness. Innovations that would contribute to the implementation of the concept of sustainable development at the enterprise began to be called “sustainable” [1-3]. In this context, sustainable innovation refers to the motivated efforts of organizations to advance the interests of stakeholders based on a balance of economic, social and environmental benefits. Sustainability innovation thus influences firms' competitiveness and improves sustainability. Modern research in the field of the concept of sustainable development and innovation covers an increasing number of problems. This is due to the growing uncertainty of development and the complication of the socio-economic environment. Therefore, sustainable innovation is not perceived only as an improvement in technical characteristics, but also as a change in the philosophy of the organization.

2 Materials and methods

The study used statistical methods to analyze the situation in the coal industry, namely, an analysis of the dynamics of changes in coal production and polluting emissions during its mining was carried out. The main factors that influence the occurrence of accidents were considered. Innovative activity is analyzed, including the direction of environmental innovation.

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3 Results and discussion

Historically, the formation of sustainable innovations from traditional ones is an objective process. Continuous changes in the world economic system in the course of innovative development, an increasing need for resources and emerging negative social and environmental effects have led to the need for a gradual change in the essential characteristics of traditional innovations. They began to transform and include components of various types of innovations, among which economic, social and environmental ones stood out. Each of them brought its own characteristics to the essence of sustainable innovation [4,5].

As domestic and foreign experience shows, the gradual awareness of the importance of solving social and environmental problems has led to the emergence of a new type of innovation, sustainable innovation.

For example, European countries have adopted the “European Green Deal”, which involves gradual decarbonization. This document implies a reduction in net greenhouse gas emissions to zero by 2050; the development of the continent's economy should be independent of the use of resources and ensured by the development of human capital, while simultaneously achieving social justice. First of all, countries wanted to abandon coal mining and its use for energy generation. However, as practice has shown, the energy crisis has made its own adjustments and many countries have restored the use of this raw material. This has led to an increase in the per capita share of emissions from coal use. It should also be noted that the total consumption of coal in the world is growing every year. Many developing countries are increasing its production. In this regard, it is worth noting that it is not possible to completely abandon the use of coal in the short term. Therefore, it is necessary to introduce technologies that in the future would significantly reduce the negative effect on the environment. It manifests itself in closed production methods in the release of hydrocarbons (methane) into the atmosphere and wastewater pollution. It is necessary to introduce modern methods and technologies for wastewater treatment [6-8]. The main stationary sources of methane emissions into the atmosphere are mine ventilation shafts. With the open method, harm to the atmosphere occurs due to the formation of large amounts of dust.

Thus, it is necessary to develop new technologies to reduce environmental damage. Which would include improvements in reducing the amount of solid waste, emissions of hydrocarbons into the atmosphere (their use for generating electricity) and the use of new methods for reclamation of disturbed lands. Foreign experience shows that it is possible to use methane from coal mines and open-pit mines to produce thermal and electrical energy. However, it should be noted that this is achieved at a methane concentration of over 25%. The leaders in the application of this technology in the coal industry are manufacturers in Australia, Canada, China and the USA. The use of ventilation emissions with methane concentrations of less than 1% is at the testing stage. Currently, the country is paying increased attention to solving the problems of reducing pollutant emissions in the fuel and energy complex and the coal mining industry. The government has approved the country's low-carbon development strategy until 2050. The main goals of the strategy are sustainable economic growth with simultaneous decarbonization in the process of mining and processing of minerals in the country.

At the moment, many coal mining companies in the Russian Federation use equipment to purify industrial emissions, which significantly reduces them, but they are not innovative in nature. In this regard, it is necessary to develop radically new and improving technologies that, in the long term, will significantly reduce the amount of emissions and increase the amount of reused production waste.

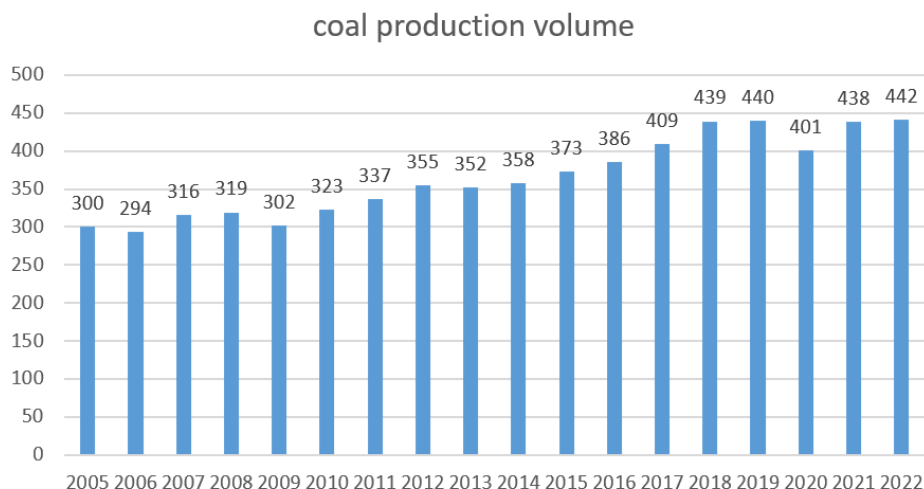


Fig. 1. Coal production volume in the Russian Federation.

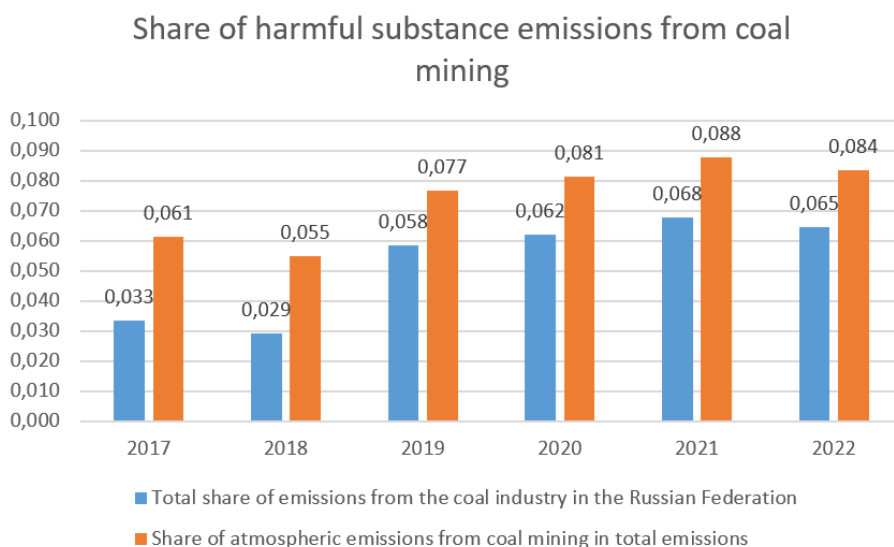


Fig. 2. Share of harmful substances released into the atmosphere from coal mining.

Statistics on emissions of harmful substances into the atmosphere from coal mining show that despite the fact that coal production has remained almost unchanged over the past five years, with the exception of 2020, emissions are increasing. It should also be noted that the share of emissions from coal mining is increasing in comparison with the total volumes of emissions from stationary and mobile sources. The share almost doubled during the study period. This indicates the low effectiveness of technologies and prevention measures. And it may be due to the lack of desire of companies to introduce innovations that are aimed at sustainable development. So, for example, according to Rostekhnadzor in the coal industry, the number of fixed production assets exploited after the expiration of their useful life over the past five years is:

- Lifting installations – 82%;

- Fan units – 65%;
- Mine electric locomotives -80%;
- Mechanized cleaning complexes – 12%;
- Excavators – 9%;
- Bulldozers – 11%;
- Dump trucks -7%.

It should be noted that the wear and tear of fixed assets is high, which largely contributes to the emissions of pollutants into the atmosphere. The operation of mechanized treatment complexes after their useful life has a high percentage. This has a significant impact on the volume of pollutant emissions into the atmosphere and the number of accidents, including fatalities, at coal mining facilities. Therefore, in our opinion, it is necessary to further analyze the accident rate [9-11]. Since it reflects the social responsibility of business owners. And this is of great importance for the sustainable development of enterprises.

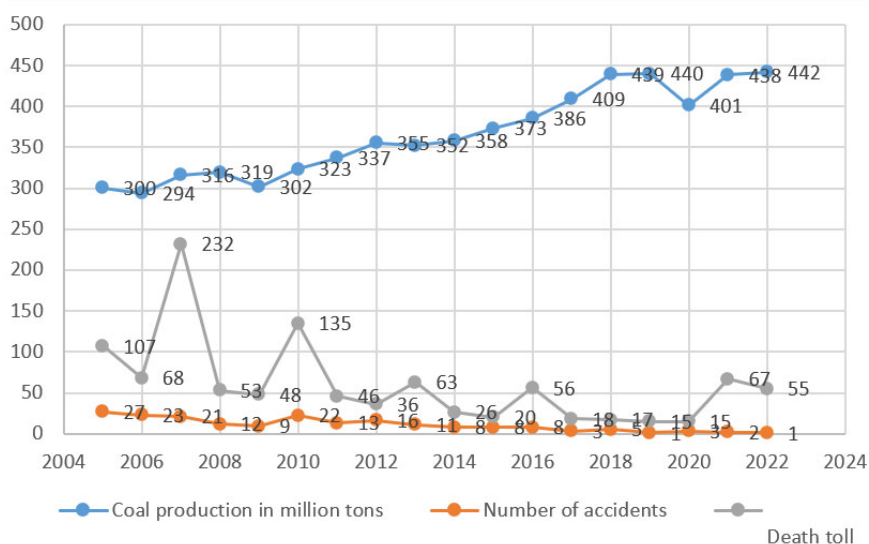


Fig. 3. Coal production volume. Number of accidents at coal mining sites. Number of deaths in accidents (compiled according to data from the Federal Service for Environmental, Technological and Nuclear Supervision).

These diagrams show that the specific indicator of fatal injuries (comparing the number of deaths with the total volume of coal production by year) has multidirectional dynamics. There is no gradual decline year on year. And in recent years it has increased several times. It is necessary to answer that, despite the decrease in the number of accidents, the number of fatally injured per 1 accident has increased. For example, in 2021, two accidents occurred and a total of 67 people died, and in 2022, 55 people already died in one accident. This indicates a decrease in the quality of the industrial safety system and can be caused by both high wear and tear of fixed assets and organizational errors caused by the human factor. The tables below show the main violations that led to fatal accidents in coal mines and open-pit coal mines.

Table 1. Violations during the operation of coal mines (compiled according to data from the Federal Service for Environmental, Technological and Nuclear Supervision).

Analysis of identified violations during the operation of coal mines	
Violation of design, technological and operational documentation	19%
Violation during operation of technical devices	19%
Violation of the passport for securing mine workings	17%
Violations during the operation of electrical equipment	14%
Violation of fire and emergency safety	14%
Violation of labor protection and production control	10%
Violation of dust explosion protection	5%
Other reasons	2%

It is worth noting that violations across groups of factors are evenly distributed in the analysis of accidents in coal mines. Most often, violations of design, technological and operational documentation occur during further operation. This may be due to low control on the part of enterprises over these processes [12,13]. To achieve this, we propose to introduce process innovations that would improve these processes and reduce the number of violations that lead to accidents.

Table 2. Violations during the operation of coal mines (compiled according to data from the Federal Service for Environmental, Technological and Nuclear Supervision).

Analysis of identified violations during the operation of coal mines	
Violation of production control	43%
Violation of design, technological and operational documentation	40%
Violation during operation of technical devices	10%
Violations during the operation of electrical equipment	3%
Violation of dust explosion protection	2%
Other reasons	2%

When operating coal mines, the most common causes are related to violations of production control. In this regard, it is necessary to audit production control programs and propose organizational innovations that would significantly reduce violations in this area.

In this regard, we propose to analyze the innovative activity of a coal industry enterprise. According to the Federal State Statistics Service, enterprises that mine and enrich coal have a very low level of innovation activity (Figure 4). The low level of innovative activity (along with the operation of equipment after the expiration of its useful life, a large number of fatal accidents, a low level of rationalization proposals, high emissions of harmful substances into the atmosphere and water sources) shows the ineffectiveness of the management system.

Thus, during the period under study, the level of innovation activity did not exceed 5.9%, which indicates that only every 19 companies introduce process or product innovations. This is a very low indicator, which has a significant impact on both operational financial performance and the organization of environmental protection. Additionally, we analyzed the number of organizations that implemented innovations aimed at improving the environment. From 2017 to 2019, only one company introduced environmental innovations aimed at increasing environmental safety as a result of consumer use of innovative products. The company did not develop or implement environmental innovations that would be aimed at improving the environmental safety of production. Although, as we know from Figure 2, the main contribution to environmental pollution occurs at the production stage. In 2021, two companies across the country introduced environmental innovations that were aimed at reducing emissions into the air, water sources and recycling waste.

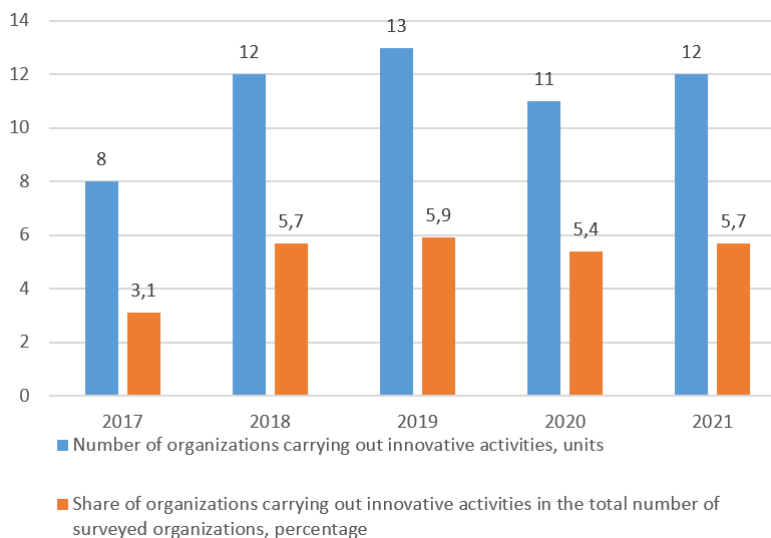


Fig. 4. The number of enterprises that carried out innovations.

At the same time, the main tools for achievement should not be extensive factors and short-term development planning with the abandonment of hydrocarbons, but the development, implementation and replication of innovative technologies in the field of energy and resource conservation and cyclical processing of waste that is generated in the process of coal mining and processing. Thus, it can be argued that innovation in the long term should become the driver for the implementation of the strategy. However, traditional innovations cannot fully achieve planned goals and comprehensively solve accumulated problems. Continuous improvement of technological and organizational processes is important, but a radical rethinking of approaches to the development and implementation of innovation is necessary [14]. Environmental, social, process and product innovations individually can replace some of the negative consequences of economic activity in the coal industry. However, in our opinion, it is advisable to introduce complex innovations, the implementation of which would allow simultaneously obtaining a socio-ecological and economic effect and creating value for all interested actors.

4 Conclusion

Thus, it can be argued that in order to change the situation in the industry, improve environmental, economic and social indicators and achieve the 2050 strategy (to achieve carbon neutrality), it is necessary to radically change the approach to the development and implementation of innovations. In our view, sustainable innovation will simultaneously solve existing problems for all stakeholders.

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