Assessment of the Mutual Influence of Energy Intensity of the Economy and Pollutant Emissions

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Abstract. This article analyzes the relations between the energy intensity of the economy and the amount of pollutant emissions in the atmosphere. The authors reviewed the main global trends in the field of emissions of pollutants and energy intensity of the economy. The authors also determined the specifics of the Russian economy regarding the structure of energy consumption and the main directions of energy intensity reduction. The study analyzed key indicators of the energy intensity of the economy, the structure and dynamics of consumption of traditional fossil fuels and renewable energy sources. The problems of the growth of pollutant emissions in Russia were considered also. The authors analyzed the dynamics of the emission of pollutants by the main sources of pollution: industrial sectors and automobile transport. The article also analyzed the structure of the growth of pollutant emissions in industries (mining, manufacturing, production and distribution of electricity, gas and water), as well as in road transport. An important aspect in the field of improving the environmental efficiency of production and reducing emissions of pollutants in the atmosphere is the cost of protecting the environment. The main trends in changing the level of environmental protection costs in industrial sectors were identified. Based on the analysis, the authors made conclusions about the nature of the growth of pollutant emissions in industry and road transport based on the analysis.

1. Introduction
Improving the quality of life by increasing the energy efficiency of the economy, reducing emissions of pollutants is a key component in the formation of a long-term policy for the sustainable development of the economy. The main sources of pollutants are industrial production and automobile transport. There are various ways to solve the problem of emissions. In European countries, the problem of pollutant emissions is solved by decarbonizing the economy and increasing the consumption of renewable energy sources [1]. Nevertheless, in Russia, due to the specific structure of the economy and the resource base, the main direction to reduce emissions of pollutants is to increase the economic and environmental efficiency of using traditional energy sources. The object of study is industry and road transport as the main sources of pollutants. The subject of the study is the emission of pollutants in the atmosphere. The main objective of the study is to analyze long-term trends in the field of emission of pollutants in industries and automobile transport.
2. Literature review
In most countries with developed economies, an increase in energy efficiency in the use of energy resources and a decrease in the energy intensity of GDP has occurred over the past 30–40 years [2, 3]. Currently, the energy intensity of developed European countries is the lowest among other regions of the world. Traditionally, the countries of Northern Europe are leaders in pursuing policies to increase the energy efficiency of the economy and reduce emissions of pollutants in the atmosphere [4, 5].

The change in the energy intensity level of the Russian economy has a similar dynamics with the countries of Eastern Europe. However, it is worth noting a higher level of energy intensity of the Russian economy and a significantly higher level of emissions. The main source of pollutant emissions in Russia is road transport, which accounts for more than 45% of the total emissions, about 45% of emissions are in the industrial sectors, and other sectors account for 10% (Fig. 1). Moreover, in recent years there has been an increase in the absolute volume of emissions of pollutants in the atmosphere. It can be explained not only by an increase in industrial production, but also by a decrease in environmental efficiency in industries [6].

![Figure 1. Pollutant emissions from stationary sources and Automobile transport in Russia, thousand tons.](image)

3. Methods
The study used econometric methods of analysis, including regression analysis, time series analysis and coefficient analysis, allowing identifying stable trends in the structure and dynamics of key indicators.

The research algorithm includes four blocks:
- Analysis of the structure of energy consumption and energy intensity of GDP of Russia;
- Study of long-term trends in the field of air emissions from industries;
- Study of long-term trends in the field of emissions of pollutants in the air from automobile transport;
- Comparison of the dynamics of environmental protection costs and specific indicators of pollutant emissions in industry (Fig. 2).
4. Result and discussion

4.1. Industry

The Russian economy has a relatively stable energy balance structure with a high share of traditional fossil fuels. However, in the period 1995-2018, the share of fossil energy carriers in the structure of energy consumption decreased from 90.4% to 87.5% [7, 8]. The low volume of alternative energy relative to the European level is explained by relatively high hydrocarbon reserves and low cost-of-production [9, 10]. Thus, unlike the countries of Europe, which are making the transition to a low-carbon economy, in Russia the development of the economy is focused on the use of traditional fossil fuels [11, 12].

In this regard, the greatest contribution to the reduction of pollutant emissions in the atmosphere in the coming decades should be made by the high potential for energy conservation and a decrease in the energy intensity of the Russian economy. At present, the energy intensity of the Russian economy is 2.3 times higher than the world average and 3.2 times higher than in Europe. At the same time, for the period 2017-2018, energy intensity increased by 3.4% and amounted to 11 kg of oil equivalent per 1000 rubles of GDP (in 2011 prices) (Fig. 3).

![Energy intensity of GDP of Russia](image)

**Figure 3.** Energy intensity of GDP of Russia (in 2011 prices).

The growth in the energy intensity of the economy and the growth in the consumption of fossil energy carriers over the past few years have been practically not compensated by the growth of environmental efficiency, primarily in industry. As a result, emissions of pollutants into the atmosphere from stationary sources increased from 17.3 million tons in 2015 to 17.5 million tons in 2017. [13, 14].
The greatest potential for reducing emissions of pollutants into the atmosphere is the production and distribution of energy, gas and water, as well as the production of building materials. Relative to 2005, the volume of pollutant emissions calculated per ruble of value added in the production and distribution of energy, gas and water decreased by more than 30%, but stagnation has been observed in the last five years, and in 2017, we can see a growth of this indicator. A similar trend is also observed in other industries (Fig. 4).

Figure 4. The volume of emissions of pollutants emanating from stationary sources per ruble of benefit by type of economic activity (in 2011 prices), tons per million rubles.

An important aspect in the field of improving the environmental performance of production and reducing emissions of pollutants into the atmosphere is the cost of environmental protection [15]. In the period 2005-2017, the real volume of costs decreased by 26%, and their share in the volume of value added decreased from 1.15% to 0.53% (Table 1).

Table 1. Current environmental costs by type of economic activity, million rubles (in 2011 prices).

| Type of economic activity                  | 2005   | 2010   | 2015   | 2016   | 2017   |
|------------------------------------------|--------|--------|--------|--------|--------|
| Mining                                   | 65 143 | 45 487 | 39 060 | 37 040 | 34 538 |
| Manufacturing                            | 142 051| 106 878| 95 989 | 94 845 | 92 137 |
| Production and distribution of electricity, gas and water | 70 117 | 50 662 | 45 555 | 46 747 | 47 025 |
| Other                                    | 20 436 | 21 225 | 38 119 | 43 178 | 47 039 |
| Total                                    | 297 747| 224 252| 218 723| 221 810| 220 00 |

4.2. Automobile transport

The increase in the absolute number of vehicles, the improvement of the environmental characteristics of traditional engines, the introduction of hybrid technologies and electric motors with zero carbon dioxide emissions affect the volume of pollutants emitted by automobile transport [16].

Automobile transport in Russia makes the largest contribution to the growth of emissions of pollutants into the atmosphere [17]. However, the increase in emissions is extensive and is associated with an increase in the number of cars, while the environmental characteristics of new cars are constantly improving. Thus, as studies by Eder L., Filimonova I., Nemov V. et al. showed a decrease in the growth rate of the number of cars in Russia and an increase in the environmental efficiency of road transport will lead to a reduction in the absolute volume of emissions of pollutants in transport from 2024 to 2026 [18].
5. Conclusion
In recent years, despite global trends toward a decrease in specific indicators of pollutant emissions, an increase in emissions has been observed in Russia. The greatest contribution to the growth of pollutant emissions made by automobile transport. However, this growth is extensive and is explained by the high growth rate of the number of cars in Russia. At the same time, due to the regular tightening of environmental requirements for cars in the largest economies in the world, high rates of reduction of pollutant emissions in new cars remain. In the industries of the Russian economy, the growth of pollutant emissions occurs not only due to the growth of industrial production, but also due to a decrease in environmental efficiency. Also important to note a significant reduction in the absolute values of current expenditures for environmental protection in the volume of gross value added in industry over the past 13 years, 1.7-2.7 times (in constant prices).

Thus, the following main trends in the development of energy efficiency of the Russian economy and the dynamics of pollutant emissions can be formulated:
- Stabilization and growth of energy intensity of GDP in recent years;
- Increased emissions of pollutants in industry and in automobile transport;
- Reduction of the absolute values of environmental protection costs and their share in the volume of GVA in industry;
- Energy efficiency continues to increase in automobile transport, but the rapid increase in road transport leads to an increase in the emission of pollutants into the atmosphere;
- After 2025, a decrease in emissions of pollutants in motor vehicles is expected due to increased energy efficiency and an increase in the share of hybrid power plants operating on methane and liquefied petroleum gas.

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**Acknowledgments**
The authors are grateful for financial support to the Russian Science Foundation No. 17-78-20218.