
Issues of Industrial Production Environmental Safety in Modern Economy

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Abstract

The modern world is characterized by the problem high urgency of production ecological safety and reducing the anthropogenic influence on the natural environment. Aggravation of the environmental situation and increasing ecological requirements to the entities of the economy has led to the strengthening of environmental functions. The economic mechanism of environmental sustainability is expressed through the greening of production. Environmental safety is based on the concept of sustainable development. Actual and perspective trend in this case is the achievement of competitive superiority, increase of business efficiency at the expense of achievement of productions' ecological stability, growth of investments in innovative development of the industry and formation of the new companies. The goal of the article is to study the peculiarities of the process of industries' greening and the assessment of the expenditures' level for environmental purposes, depending on the degree of market orientation and financial sustainability of petrochemical plants. The leading method for the study of this problem is the method of system economic analysis, which allows identifying the essence, patterns, and trends in the processes of production greening. An economic approach to the concept of sustainable development using the Hicks-Lindahl theory of total income is considered. Five principal factors of process of greening of industrial production are allocated. The conceptual model of monitoring of indicators' system allowing to diagnose technical parameters' change of production's greening and to estimate economic effect in the cost – effect dimension is offered. The materials of the study are of scientific and practical value in the design of environmental management system, the development of financial policy of environmental investment, the formation of environmental legislation, and ecological certification of production.

Keywords: sustainable development concept, production waste, waste recycling, environmental management system, production greening, environmental investment, environmental monitoring, environmental safety

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INTRODUCTION

Economic and social development in the second half of the twentieth century is more oriented on rapid economic growth without taking into account the consequences of man-made impact on the environment. The model of extensive growth of scales in use of natural resources in industrial production is formed. The world community is faced the growing needs of the economy and the inability of the biosphere to meet these needs. In the last twenty years, the anthropogenic influence on the natural environment has increased significantly and the problem of environmental safety has become highly relevant one. Researchers have attempted to identify economic trends and environmental consequences for particular areas and globally. The emergence of the concept of

sustainable development becomes a logical continuation of scientific research.

In developed countries, the strengthening of environmental problems has led in the 80s of the last century to a significant change in public policy in the field of environmental protection, the creation of a number of European social greens' movements. As a result of the measures taken there was an increase more than 7 times in the expenditures on environmental protection measures. Developed countries on average spend up to 1.8% of gross national product on environmental purposes, while the amount of damage caused to the biosphere is estimated at 6% or more in relation to the gross product. If an economic entity does not compensate for environmental damage, it is

recognized as unprofitable at the state level, even if it generates profit.

As the need for sustainable development was realized, it was understood that environmental problems could not be solved within a region or state. In this regard, strict international standards have been introduced stipulating the content of harmful substances in the products produced that can be released during its operation. As a result, large chemical and petrochemical companies are trying to comply with the principles of sustainable development in the regions where they operate within the framework of environmental ethics. At the same time, many activities of the petrochemical industry use obsolete technologies that do not meet the requirements of sustainable development. Therefore, the modernization of equipment, technologies and production processes in order to minimize the environmental consequences of production is of key importance for the sustainable development of the economy.

Increased anthropogenic pressure and increasing environmental requirements to the entities of the economy have led to some changes in industrial production in terms of environmental functions. At the same time, there is a negative phenomenon of de-concentration of production wastes by diluting them in large volumes of the environment – in air and water bodies, which, although in terms of parameters, reduces the maximum permissible concentration of harmful substances, but has nothing to do with the development of environmental industries and the principles of sustainable development's concept. In addition, this pseudo-environmental phenomenon has recently been supplemented by the trend of exporting environmentally hazardous industries to underdeveloped countries.

The main directions of research in the field of the concept of sustainable development and production's greening are defined by the studies of such scientists as Burkinsky and Galushkina (2011), Ignatieva and Mochalova (2008), Kovalev (2014), Serditova (2013), Mikhailov and Mikhailova (2007). Theoretical and practical aspects of the development of environmental stress assessment's methodology and of ecosystems' monitoring with varying degrees of completeness were considered in the works of domestic scientists Zhemchugov and Zhemchugov (2017), Kandilov et al. (2010), Malysheva (2016), Shinkevich et al. (2016).

However, despite the presence of a vast theoretical and methodological array of data and practical solutions,

there is a lack of research aimed at the development of effective environmental policy as a basis for ensuring the competitiveness of production at the micro and meso levels. The main functional tasks for assessing the possibilities of industry's territorial greening and improving the efficiency of industrial zones are not defined. The aspect studied has not been considered in previous studies.

The above mentioned problems determine the relevance of this direction.

The purpose of the scientific article is to study the features of the process of production's greening and assessing the level of expenditures for environmental purposes, depending on the degree of market orientation and financial stability of petrochemical industries.

MATERIALS AND METHODS

The Study Methods

Achieving environmental sustainability is possible through the production greening. Perspective and politically competent directions in production greening are modernization of purification technologies and high purification of industrial emissions and effluents. The next level of production greening development involves waste's capture and their utilization as secondary raw materials (Veretekhin 2017). In developed countries, the industry associated with waste processing is one of the leading industries with a high level of income and social orientation. Thus, there is an ecological conversion of production, where the capitalization of income is carried out not to the detriment of the environment, but, on the contrary, by reducing the anthropogenic stress.

In our view, five fundamental areas (factors) in the greening process of industrial production can be allocated (ECO) (Malysheva 2016):

- 1) restructuring of the economy by minimizing the number of high-waste industries and environmentally hazardous products (CISP – Changing Industry Structure of Production);
- 2) cooperation of various productions for the purpose of waste recycling, their maximum use as secondary raw materials; creation of high-closed production systems (*CMWR-Cooperation Manufacture of Waste Recycling*);
- 3) technological re-equipment of production, introduction of low-waste technologies in

production, controlling of economic and technical parameters of greening (TRP – Technological Re-Equipment of Production);

- 4) development and starting of innovative products' production with a long life cycle, allowing the return of goods to production after their moral and physical obsolescence (RNTP – Release of New Types of Products);
- 5) Increasing the level of cleaning industrial waste from pollutants, the introduction of highly efficient technologies for waste collection and subsequent disposal (IPWT – Improvement of Production Waste Treatment).

Each of these areas can only solve a local problem in the organization, and therefore the greening process requires an integrated approach as a whole. Thus, the level of industrial production greening can be considered as a function of the proposed factors described in the direction of minimizing the anthropogenic impact on the environment:

$$ECO = f(X_1(CISP), X_2(CMWR), X_3(TRP), X_4(RNTP), X_5(IPWT)) \quad (1)$$

The purpose of the proposed method is to provide analysts and managers of various levels with effective toolkit for modeling and implementing the process of industrial production's greening. The proposed technique will complement the existing methods for assessing the effectiveness of environmental management, which together will provide the necessary mechanism for a comprehensive analysis of industrial ecosystems.

The Object and Information Base of the Research

The object of the research is the processing enterprises of oil products' production, chemical production, and production of rubber and plastic products of the Republic of Tatarstan, which have different levels of technological development, environmental management, financial stability and ability to innovative processes.

The study of methodical approaches to assessing the economic efficiency of environmental protection expenditures, the potential of ecological management in the regional innovation system is based on official regulations and documents of socio-economic development of the Russian Federation and the Republic of Tatarstan. Within the framework of statistical reporting data on the volume and dynamics of

products' production, expenditures on environmental safety, industrial waste are formed.

The Stages of the Research

The study includes the following steps:

- Study of the basic principles of the of industrial production's greening process from the perspective of sustainable development concept;
- Study of the features of production greening process in some countries of the European Union and CIS countries;
- Study of the relationship between the level of expenditures of industrial production on environmental protection measures and the degree of environmental stress of the territories;
- Assessment of the level of expenditures for environmental purposes, depending on the degree of market orientation and financial stability of petrochemical industries.

RESULTS AND DISCUSSIONS

Study of the Basic Principles of the Industrial Production Greening Process from the Perspective of the Concept of Sustainable Development

The concept of sustainable development is based on two interrelated principles: maintaining the level of satisfaction of society's needs and further industrialization of the economy; maintaining the level of natural capital and ensuring environmental safety. These principles point to the recognition of the interchangeability of technogenic and natural capital, which leads to the weakening of the factor of limited natural resources and the actualization of the role of technological innovations. In turn, the requirement of the concept is the preservation of natural capital. From an economic point of view, the concept of sustainable development is considered within the framework of the Hicks-Lindahl theory of maximum total income flow (Ignatiev 2008). This concept includes the rational use of resources and the introduction of high-tech equipment, production of environmentally friendly products, minimization and recycling of waste.

The assessing of the level and efficiency of the production's greening processes provides for the development of indicators' system to diagnose changes in the technical parameters of production and to assess the economic effect in the dimension *cost – effect*. Monitoring and analysis of level and dynamics of

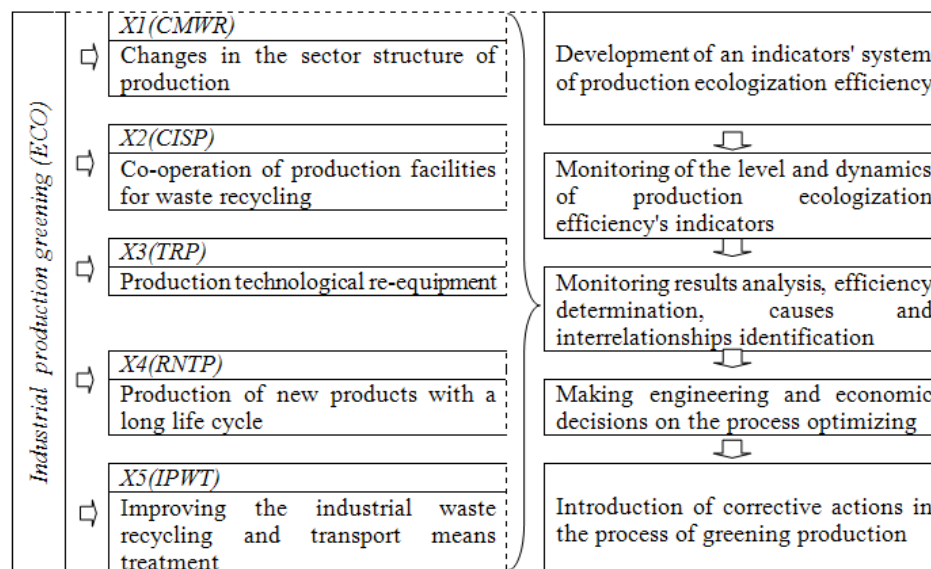


Fig. 1. A conceptual model of industrial production greening (organizational dimension)

indicators allows determining the degree of appropriateness of organizational and technical solutions for the organization of ecological production systems to produce corrective actions (Adzhienko, 2017). The proposed algorithm of industrial production's greening can be represented as a conceptual model (Fig. 1).

The use of production greening directions proposed in the model depends on the nature of production processes and activities of organizations. Thus, for oil and natural gas production enterprises, characterized by high volumes of product transportation, the greening of the process is connected, to a greater extent, with the introduction of fundamentally new capital-intensive technologies. Deep processing of raw materials and recycling of waste is an effective form of greening for processing petrochemical industries (Bukrinsky 2011).

Study of the Features of the Production Greening Process in Some Countries of the European Union and CIS Countries

Undoubtedly, the implementation of production greening process within the concept of sustainable development requires large-scale investment in the development of new technologies and innovative modernization of the economy. The effectiveness of the production's technical re-equipment process depends largely on the consistency and effectiveness of the financial mechanism. Today, investing in environmental protection is an important element of many stimulus packages. For example, China (22,300 million euros), Japan (12,300 million euros), Korea (9,300 billion euros), France (5, 7 billion euros),

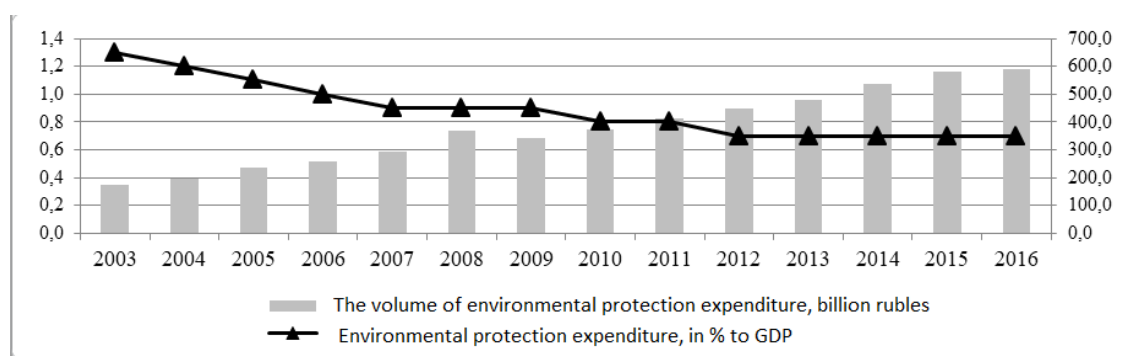
Denmark (0, 7 billion euros), Belgium (0.12 billion euros) have the largest volume of investments in environmentally-oriented measures to restore the economy (Kovalev 2014). Member countries of the Organization for economic cooperation and development have sought to promote environmental investment and sustainable environmental management, as well as to exchange information on environmental investment flows, policies and best practices.

Implementation of the sustainable development goals in different countries is proceeding at an uneven pace. In some States it is progressing, in others the achievement of all sustainability goals seems problematic. **Table 1** shows the specific air emissions of the most common pollutants for individual countries of the European Union and the CIS. Chemicals such as sulfur dioxide, nitrogen oxide and carbon monoxide are often wastes from petrochemical industries and other industries where chemical reactions and combustion products occur, as well as the overall result of industrialization and motorization of the economy and society. According to the results of emissions of pollutants per capita, countries were ranked according to the level of environmental stress, where the lowest value of the rank corresponds to the best environmental situation.

Correlation analysis of the variables-the level of environmental stress (X1) and the volume of environmental expenditures to GDP (x2) – showed a weak positive dependence (correlation coefficient 0.35) between the growth of environmental expenditures and

Table 1. Environmental and economic characteristics of individual countries' development in the European Union and CIS countries

Country	The most common pollutants' emissions into the atmosphere per capita, kg			Rank by the level of environmental stress (1 – the best, 19–the worst)	Environmental protection costs, % of GDP
	Sulphur dioxide	Nitrogen oxide	Oxide		
Netherlands	3,0	17,0	36,7	3	2,0
Ireland	10,0	24,9	53,8	11	1,3
Austria	2,7	24,8	87,5	15	1,2
Greece	40,2	32,2	96,7	5	1,1
Denmark	3,6	28,7	112,8	18	1,1
Great Britain	8,4	23,1	40,1	19	1,1
Finland	13,0	31,9	97,1	17	1,0
Portugal	10,6	25,2	58,5	12	0,9
Italy	4,9	18,0	65,1	9	0,8
France	6,5	21,2	92,8	16	0,8
Russia	30,0	13,0	40,0	7	0,7
Germany	6,0	16,8	48,9	6	0,7
Belgium	9,2	22,3	65,3	13	0,6
Spain	12,0	28,5	53,8	14	0,6
Belarus	5,0	6,0	8,0	2	0,3
Ukraine	29,0	8,0	23,0	4	0,3
Sweden	3,3	17,0	66,7	8	0,3
Moldova	0,4	0,4	1,0	1	0,2
Kazakhstan	47,0	14,0	27,0	10	0,1


Fig. 2. Dynamics of environmental protection expenditures in the Russian Federation

environmental improvement. This is due to the fact that at the present stage of the economy greening, a very small proportion of industrial companies have made the transition to the so-called *green* production. And the amount of expenditures made on environmental protection measures does not yet produce the desired effect due to the presence of a certain time lag in the *cost – effect* system. Today, the volume of industrial waste, first of all, has a close relationship with the level of development of industrial production and the economy of the state as a whole. With the implementation of the industrial production's greening process, the dependence of the environment state on the invested environmental investments will increase.

Study of the Relationship Between the Level of Industrial Production Expenditure on Environmental Protection Measures and the Degree of Areas' Environmental Stress

Investments in the environment increase the market value of the enterprise, its investment attractiveness and

competitiveness. Positive trends in the field of environmental protection began to develop in the Russian industry. Some companies started to invest in nature protection; long-term economic programs appeared (Kandilov and Malysheva 2015). According to Russian Statistics for the period from 2003 to 2016, the Russian enterprises' expenditures for environmental purposes in current prices increased 3.4 times. However, the inflation rate for the same period, according to our estimation, made by the method of chain substitution, was 3.6 times. Thus, there was no increase in the physical volume of environmental protection expenditures in the Russian Federation as a whole. This is evidenced by the indicator of environmental expenditures' share in the gross domestic product, which shows a steady decline from 1.3% in 2003 to 0.7% in 2012-2016 (Fig. 2).

According to experts of natural resources' Ministry of the Russian industry, it is necessary to spend 1.5–2% of GDP on environmental modernization. At the same

time, the current environmental legislation is designed in such a way that it is more profitable for enterprises to pay for excess emissions than to introduce new environmentally friendly technologies. Industrial enterprises receive three types of permits from Russian natural supervision— for emissions into the atmosphere, discharges into water bodies and waste disposal. The maximum penalty for organizations for violation of environmental legislation is 200 thousand rubles. However, in environmental practice, large fines account for no more than 7% of cases. There are no mechanisms to encourage and promote projects on environmental protection in licensing agreements for maintenance activities. For example, a company that carries out environmental investments and minimizes emissions may not receive tax preferences, etc. Environmental legislation to date only formally encourages businesses to reduce negative impacts on the environment, and to a certain established norm. As a result the industrial enterprises do not put forward the goal of reducing emissions below the established norms.

The current situation hinders the development of new environmentally friendly technologies. In our opinion, the solution is seen in the development of legislative mechanisms for environmental management. It is necessary to create a legal framework and conditions under which compliance with regulations and standards will be economically beneficial for producers. The key role should be assigned to environmental regulation and expertise, state environmental control and audit, environmental certification. The promising management eco-toolkit of the developed countries involve: (Serditova 2013)

- Eco-Label environmental certification system (880/92/EEC);
- Life environmental certification system (*Life*);
- Environmental management and audit system (EU EMAS);
- Name, Shame and Fame strategy (*name, shame and fame*).

In addition to mandatory, there are voluntary environmental initiatives related to the deepening of environmental orientation of producers, their motivation for production without environmental violations. In this case, it is possible to form a system of environmental brands, which are based on the guarantee of the production of environmentally friendly

products through the use of environmentally friendly technologies.

Assessment of the Level for Environmental Purposes' Expenditures, Depending on the Degree of Market Orientation and Financial Stability of Petrochemical Industries

Russian export-oriented manufacturers have to meet international environmental requirements. In this case, the achieved environmental technologies are an effective competitive advantage. Interesting in this case is the clustering of industrial enterprises in the areas of motivation in ensuring environmental safety. From a theoretical point of view, there are three main types of enterprises according to the degree of interest in the greening of production:

1. Group A is the main group of companies potentially interested in ensuring their own environmental safety. This group includes export-oriented enterprises that successfully compete in the world market. This group of companies needs to comply with the standards of the European Union and other international organizations. Environmentally responsible companies have a better chance of successful development and sustainability, invest in environmentally friendly technologies and strive to meet the requirements of ISO 14001 standards (environmental management system), OHSAS 18001 standards (industrial safety and health management system).
2. Group B-companies focused mainly on the domestic market. Their interest in production greening is still much lower, but it will arise as the cost of natural resources increases and the profitability of environmentally sound technologies increases. All this will help to increase profits and identify competitors through more efficient use of production resources, improving product quality.
3. Group C-low-profit or loss-making enterprises with an unstable financial position, often not having the means to carry out activities for the greening of production. However, the use of nature-intensive and environmentally unfriendly technologies can increase the financial problems of this group of companies. The solution of environmental problems can give a synergetic effect, lead in parallel to positive economic and environmental results by reducing environmental pollution, reducing current

Table 2. The Share of expenditures for environmental safety and the level of products' export capacity for processing industries in the petrochemical cluster of the Republic of Tatarstan in 2016

	Share of environmental safety costs in total production expenditures of enterprises, %	Export capacity of production (share of export products in the volume of shipped products), %	Type of enterprises according to the degree of interest in the greening of production
Production of petroleum products	0,593	78,4	Group A
Chemical production	0,691	52,2	Group B
Manufacture of rubber and plastic products	0,036	10,5	Group C

production expenditures and increasing the profitability of the company.

On the example of processing enterprises of oil and gas chemical cluster in the Republic of Tatarstan one can estimate the level of expenditures for environmental purposes according to the degree of market orientation and financial stability of production. The studied array includes 35 enterprises of the following economic activities: production of petroleum products, chemical production, and production of rubber and plastic products. The share of environmental safety expenditures (waste water treatment, air emissions, and solid waste and similar activities) in total production costs of enterprises, combined with the export intensity of products by industry as a whole, is presented in **Table 2**.

As can be seen, the productions of petroleum products and chemical industries have a relatively close level of environmental expenditures and have a high share of export-intensive products. These industries represent a major petrochemical company of advanced technological level of SC *TANECO*, JSC *TAIF-NK*, PSC *Nizhnekamskneftekhim*, PSC *Kazanorgsintez*, and OJSC *Ammonium*, PSC *Nafis cosmetics*, highly competing in foreign markets and having high profitability. Enterprises in the production of petroleum products were put into operation no more than 5-7 years ago, have highly effective wastewater treatment systems, conform to the environmental standards of international level. At the same time, among these industries there are large-scale enterprises that have been operating for about 40-50 years and require gradual modernization of equipment and environmental technologies.

Large-scale productions of rubber and plastic products are in the worst financial position, unstable in the foreign and domestic markets (JSC *Kazan Plant of Synthetic Rubber - Silicone*, CSC *QUART*, etc.). In this type of activity investment projects on restructuring of the operating productions and construction of new

modern complexes on processing of polymers are realized.

According to the results of the study, the production can be attributed to the types of enterprises proposed above by the degree of interest in improving environmental safety. If to consider the subspecies of economic activity in these industries, one can see that the theoretical assumptions about the dependence of enterprises' environmental responsibility, expressed in this case, by the share of expenditures for environmental protection activities, the degree of export orientation of companies and their competitiveness are confirmed by practical data (**Fig. 3**).

At the bottom of the graph with a specific weight of environmental expenditures within the range of 0.007–0.024% the productions of perfumes, cosmetics, detergents, fragrances are located belonging to group B, but having difficulties with both entering the foreign market in the future, and problems with sales in the domestic market due to high competition and a large volume of imported products. The situation on other subspecies of petrochemical industries can also be interpreted taking into account the financial condition of enterprises at the moment, the current market conditions and other factors. However, the more detailed assessment of enterprises' interest in ensuring environmental safety requires a comprehensive analysis of all areas of activity. For example, the production of petroleum products belonging according to our assessment to group A with high environmental responsibility shows the value of the share of expenditures for environmental purposes in 0.048%, which is not high relatively to the studied activities of groups B and C. This situation is due to the fact that the enterprises producing petroleum products are relatively young; technically and technologically meet all the requirements of environmental standards. In this regard, they do not require significant investment to improve environmental safety; they have only the current expenditures of wastewater treatment, atmospheric emissions and other environmental objectives (Mikhailov and Mikhailova 2007).

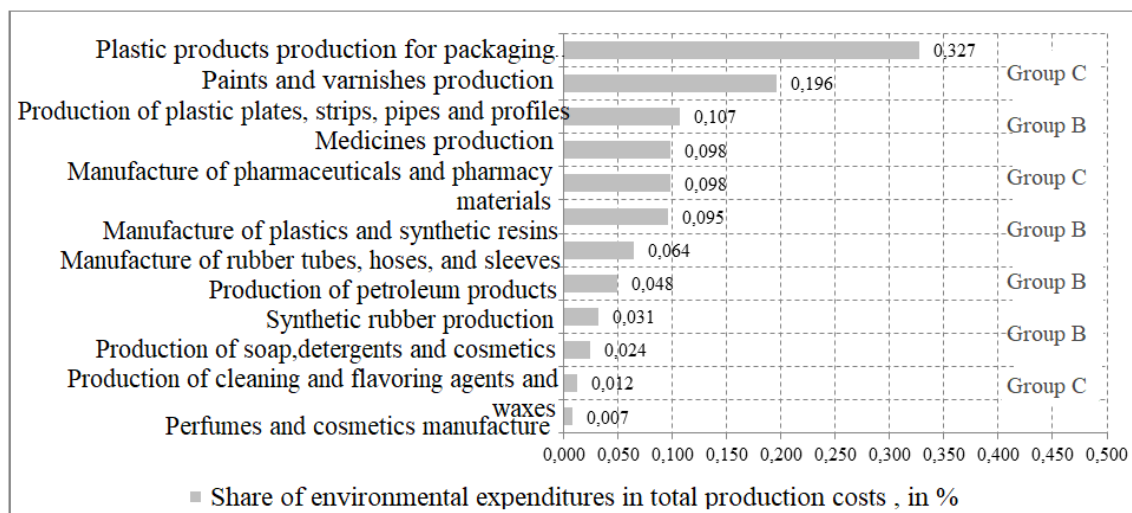


Fig. 3. The level of expenditures for ensuring environmental safety in the subspecies of economic activity in petrochemical industries of the Republic of Tatarstan

Currently, the economic and environmental interests of producers in the organization of measures for the production greening do not always coincide. There is an objective need for the formation of scientific and legislative bases for the regulation of modern market mechanisms for the production greening at minimal expenditures. The transition to environmental technologies is beginning to be seen as a real competitive advantage, the only possible development of production and technological policy of the manufacturer.

CONCLUSION

Thus, as a result of the conducted research the following scientific and practical results were obtained.

1. It is proved that the increasing technogenic stress increases the significance of the environmental component of the enterprises' production activities. The current trends in the implementation of sustainable development concept are summarized, among which there are pseudo-environmental phenomena that are not related to the objective improvement of the productions' greening. The basic directions are allocated for improving the environmental sustainability of enterprises on the basis of which the conceptual model of the process of industrial production's greening is proposed, which included the possibility of diagnostics of technical parameters of production and assess the economic effect of implemented conservation activities.
2. The article summarizes the trends of investment in environmentally oriented activities typical for the European Union and CIS countries, shows the importance of financial mechanisms in the implementation of environmental problems. On the basis of data on emissions of the most common pollutants, the assessment of environmental stress level in the studied States. A weak positive correlation is revealed between expenditures for environmental protection and improvement of the environment that was caused, first and foremost, by the initial step in greening the economy and low coverage of manufacturers that realize the implementation of green technologies.
3. The absence of positive dynamics of environmental protection expenditures in the Russian Federation over a ten-year period was revealed. There were no positive changes in the financing of environmental modernization of Russian enterprises; the share of environmental expenditures in the gross domestic product showed a steady decline. Modern legislation lacked effective mechanisms for promoting and encouraging environmental projects.
4. The main types of enterprises are shown according to the degree of interest in the production greening, where the main criterion is the orientation of producers to the external or internal market, as well as the level of financial stability and self-sufficiency. Theoretical assumptions are substantiated by analytical research of processing enterprises of the

petrochemical cluster of the Republic of Tatarstan. The close dependence of the level of products' export capacity and the share of environmental expenditures in the total costs of producers is revealed. Export-oriented producers under the influence of foreign consumers are forced to actively introduce environmental technologies. The domestic market is also gradually realizing the advantage

of environmentally friendly products, but it is not yet active enough.

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