Environmental Security in the Transport Sector: Analysis of the Current Situation in Azerbaijan

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***Abstract*—The presented article examines the existing environmental problems in the field of road transport in Azerbaijan and their causes. The harmful effects of vehicles on the environment and ways to overcome these problems are analyzed on the basis of statistical computations. Using the special Eco Transit World software, which allows automatic calculation of energy consumption, carbon emissions, air pollutants and external costs for three types of transport services, including trains, trucks and ships, the level of environmental impact in the field of cargo transportation in Azerbaijan has been assessed. The paper concludes with particular proposals for strengthening the transport system of Azerbaijan and ensuring the environmental safety of vehicles.**

Keywords—vehcles, pollution, European environmental standards, Eco Transit World software, CNG engines

I. Introduction

As an independent and strategically important sector of the national economy, transport, being the object of achieving and managing commercial results, also serves to meet the needs of the country's economy for all types of transactions as well as cargo and passenger traffic. The purpose of transport is to ensure the dynamics of the movement of goods and labor resources. The role of transport in ensuring the normal functioning and developing the economy is undeniable, however there are both advantages and disadvantages. As the operation of vehicles is directly related to the environment, the increase in their number is causing the activities of various types of pollution in an anthropogenic way, especially in the atmosphere. Large amounts of toxic gases are released into the atmosphere every day, and as a result of high man-made impact on the ambient, there is a serious threat to the health of wildlife. In this regard, environmental security remains a global modern problem.

Understanding the laws of nature allows us to develop complex measures to predict many changes that may occur in nature. Efficient, planned use and protection of natural resources is one of the main tasks of society. Despite the fact that the law strictly prohibits the irregular use of natural resources, in many sectors of the economy, including transport, the misuse of natural resources creates the basis for harmful changes in the environment, such as air pollution, greenhouse and noise effects, electromagnetic pollution, deterioration of human and animal health. Maritime transport mostly affects the hydrosphere, air transport – the atmosphere, and electric transport – the biosphere, causing harmful substances such as water, soil pollution, carbon monoxide, oxides, heavy compounds and vapors into the atmosphere. As a result, not only the greenhouse effect, but also the acid rain, the number of diseases increases, there are problems with the health of wildlife, and the ecological balance is disturbed.

The article discusses the current situation with the environmental situation in the world associated with the growth of vehicles, measures taken in connection with the integration of developing countries into the global economy, European requirements in connection with the deterioration of the environment. The article presents a discussion of the article topic in the case of Azerbaijan, the authors propose specific recommendations for reducing environmental harm in the republic.

II. Literature Review

It is known that vehicles intended for international passenger and cargo transportation should, first of all, comply with the basic parameters defined by international agreements, road safety and environmental requirements, as well as the obligations for the storage of cargo and the protection of passenger health.

Long-term operation of vehicles leads to deterioration of their technical condition and adjustment parameters of internal combustion engines. The number of harmful substances released into the atmosphere is growing faster than

the wear and tear of vehicles. The paper [1] on the base of statistical calculations shows that, for example, it is possible to keep the level of harmful emissions in new cars for only 1-3 years according to the level guaranteed by the manufacturer. In [2] the authors insist on fact that current malfunctions and violations of regulations during operation lead to deterioration of toxicity indicators and fuel economy. Unfavorable road conditions, low quality of fuels and lubricants lead to rapid wear of vehicle hubs and units, increased fuel consumption and toxic emissions. Lack of quality of maintenance and repair, low level of modern equipment and capable specialists often have a negative impact on the full recovery of vehicles. As a result, the efforts of the automotive industry in the production of improved engines that meet the requirements of environmental standards are not realized.

The action plan developed to solve this problem addresses the issue of bringing fuel and lubricants produced in Azerbaijan, as well as fuels used in transport, to European standards to meet the requirements for harmful substances emitted into the atmosphere from vehicles. The date of application of the mentioned Euro standards is related to environmental factors; the growing interest in CNG (Compressed natural gas) cars with electric motors and natural gas in the world [3] reckons also due to these factors. Towards the end of the last century, rising living standards in the developed world led to an increase in the number of vehicles, resulting in traffic jams, leaving cars behind industrial facilities and becoming a major threat to the environment.

In order to fight for the improvement of the environment in the world since 1992, modern environmental safety standards have been adopted to determine the levels of toxicity of gas emissions from car engines. In Azerbaijan since 1999 the "Law on Environmental Safety" [4] developed. In accordance with these standards, there are various EURO environmental benchmarks, which are characterized by a reduction in the number of harmful substances emitted into the atmosphere by cars. [5] details that the numbers 0, 1, 2, 3, 4, 5 and 6 in the title of the standard, which are inversely proportional to the number of pollutants emitted into the environment during the operation of a vehicle that meets the requirements of those standards, i.e. an increase in the figure characterizes a low amount of pollutants.

The paper [6] euro environmental standards (Euro 0-6) determines the amount of exhaust gases (hydrocarbons, carbon monoxide, nitrogen oxides, etc.) emitted into the atmosphere by cars. These standards were first introduced in Europe in 1991. The first standard, called Euro-0, was replaced in 1992 by the Euro-1 standard. If the Euro-0 standard forbade the release of more than 10 g/h of exhaust gas into the atmosphere, the Euro-1 environmental standard prohibited the release of about twice as less exhaust gas – 4.9 g/h. In 1995, the Euro-2 environmental standard was adopted, which prohibits the emission of exhaust gases more than 2.5 g/h. Starting that year, European countries, the United States and Japan switched to Euro-2. The Euro-3 standard set the rate at 1.5 g/h since 2000; the Euro-4 standard set the rate at 0.8 g/h since 2005. The Euro-5 standard, which set 0.6 g/s since September 2009, came into force. Since 2014, Euro-5 has given way to the Euro-6 standard.

It should be noted that currently the EU member states apply the more advanced Euro-5 standard. Euro standards make high demands on both the fuel composition and the technical condition of the cars. Since 2014, the implementation of the Euro-6 environmental standard for the number of harmful substances emitted into the atmosphere from car engines in Europe has begun. The paper [7] indicates that according to this standard, which applies to all cars produced from 2015 to date, emissions are reduced by 67% compared to the previous standard. This figure is achieved only by the installation of special equipment in the exhaust system of the car, and therefore it is not intended to apply any new standard on the composition of the fuel. Each type of fuel specified in the standards differs in the amount and composition of harmful substances released into the atmosphere during combustion. As mentioned above, an increase in the serial number indicated in the name of the standard is an indication of an increase in fuel quality. In this case, its use not only causes less damage to the environment, the car's engine and fuel system, but also allows to fully achieve the performance of the car.

The Euro standard covers not only the environment, but also the safety of vehicles and fuel quality. During the transition from one standard to another, the norm for harmful substances released into the atmosphere is tightened by an average of about half.

As [8] shows, Euro-3 standard has been applied in Azerbaijan since 2014. As regards to the changes in the country's market caused by new standards, it is normal for gasoline prices to rise after the transition. The implementation of another Euro standard costs $ 1 billion. Therefore, if the demand for motor fuel in the country is growing, and production of better products and meeting European standards are preferrable, the price of gasoline should increase accordingly. This tendence, which serves to improve the quality of gasoline in the future from Euro-3 to Euro-4 and from Euro-4 to Euro-6, and at the same time reduce the amount of gas emitted into the atmosphere, is a global trend that will be an important event in reducing environmental disasters. In the end, [9] determines that the implementation of the new standards will achieve significant results in the renewal, rejuvenation of the car fleet in our country and the prevention of future environmental disasters.

Currently, in [10] the authors confirm that the most reliable, environmentally friendly and economical type of all available insist that fuels is CNG. This is pure methane (CH4). It is the only fuel that meets the requirements of Euro 5 environmental standards when the smoke is released into the air unprocessed. Natural gas does not contain aldehydes and other air toxins. The paper [11] shows that CNG engines make 30% less noise than other fuel-powered engines, and that natural gas produces very little greenhouse effect.

The increase in hot weather conditions and traffic jams of obsolete cars in the summer, as well as burns and breakdowns due to other malfunctions, in addition to increasing environmental problems, also create problems for road users.

III. Analysis of Important Current Indicators in the Transport Sector

The integration of independent states into the world economic system has a great impact on international relations and increases the economic efficiency of transport. Global processes, such as access to world markets, require the efficient use of labor in the transport sector. In addressing this issue and according to official statistics the distribution of the

main vehicles used in Azerbaijan over the past 5 years is as follows (Table 1):

TABLE I. NUMBER OF VEHICLES, END OF YEAR, UNITS

	2016	**2017**	**2018**	**2019**	**2020**
Total	**1 330 551**	**1 342 324**	**1 370 574**	**1 418 404**	**1 473 563**
Passen-ger cars	1 136 983	1 147 437	1 170 672	1 214 093	1 264 542
Private cars	1 082 597	1 094 729	1 118 480	1 158 448	1 204 682
Buses	30 958	30 788	30 704	30 783	30 757
Trucks	141 525	142 857	147 343	150 547	154 659
Special purpose vehicles	11 158	11 024	11 232	11 924	11 613
Others	9 927	10 218	10 623	11 057	11 992
Motor-cycles	3 290	3 077	3 206	4 069	4 594

Sources: The State Statistical Committee of the Republic of Azerbaijan [12]

Based on the statistics for 2020, it was determined that 59.1% of cargo transportation in the transport sector in Azerbaijan falls to cars, and 29.7% – to pipelines. The share of passenger transportation by road is the second largest after sea transportation (60.7%). If we take into account that there are currently 30 757 internal combustion engines and 154 659 trucks in Azerbaijan, which are the main source of air pollution, it is not difficult to imagine the level of environmental danger.

Let's look at the age structure of the vehicle fleet for May 2021 (Table 2). The number of buses and trucks with a service life of more than 10 years in 2020 once again confirms this fact.

TABLE II. THE AGE STRUCTURE OF THE VEHICLE FLEET

Distribution by type of vehicle					
		Cars	**Buses**	**Trucks**	**Special purpos e cars**
2019	**Total**	**1 214 093**	**30 783**	**30 783**	**11 924**
	Up to 5 years	51 170	1 756	3 057	555
	5 to 10 years	223 890	3 584	16 708	2 489
	More than 10 years	939 033	25 443	130 782	8 880
2020	**Total**	**1 264 542**	**30 757**	**154 659**	**11 613**
	Up to 5 years	510 48	1 296	3 198	591
	5 to 10 years	220 129	3 632	15 724	2 245
	More than 10 years	993 365	25 829	135 737	8 777

Sources: The State Statistical Committee of the Republic of Azerbaijan [12]

Most of the cars in our country, which is experiencing a transition period of the economy in the process of globalization, are cars manufactured in the CIS countries. In addition, for more than 10 years, the country has been importing cars that are banned from operation in those countries due to the limit of their service life and environmental suitability. According to all key indicators (economy, reliability, safety, environmental suitability), car models lag behind industrialized countries by 8-10 years.

As a result of the operation of such vehicles, fuel consumption and the amount of harmful substances released into the atmosphere increase. In addition, the privatization of the vast majority of the car fleet in the country has had a negative impact on the environment as a result of the weakening of its material and technical base.

According to Natig Zarbaliyev, chairman of the Azerbaijan Automobile Dealers Association, which unites official importers and dealers of about 40 foreign car brands, as well as local car manufacturers, "the number of cars over 10 years old in the country is 80%. More than 300 000 were produced 20 years ago, more than 130 000 were produced 30 years ago, and more than 100 000 were produced 40 years ago" [13].

According to the law, cars with a service life of more than 10 years must be inspected annually, the purpose of this act is to prevent the commissioning of unusable cars or to eliminate malfunctions.

In countries with developed automotive industries, such as Russia, expired cars are purchased by the state and a certain amount of money is transferred to the citizen's account in return [13]. Due to the underdevelopment of the automotive industry in Azerbaijan, it is impossible to solve the problem in this way. In this regard, the issue of timely technical inspection of cars should be taken more seriously, and legislative norms related to their withdrawal should work.

According to some experts, the process of decommissioning non-compliant cars can be carried out in stages, and the compensation paid by the state for such cars will not have a significant impact on the state budget due to the low cost of cars [14].

If we take into account that two thirds of the cars currently used in the country are concentrated in Baku, it becomes clear how urgent are the problems in the field of environmental protection.

There are too many cars in the car market in Azerbaijan that do not meet Euro-5 and Euro-6 environmental standards due to their technical capabilities. Fuel produced in Azerbaijan meets Euro-2 requirements in accordance with environmental standards. However, currently developed countries already apply Euro-6 environmental standards, and refineries in the region (Turkmenistan, Kazakhstan and Russia) produce fuel in Euro-5 standards [15].

Every day, the number of unusable cars is growing due to the large number of imported vehicles that do not meet any safety requirements and environmental standards. Regardless of the country from which the car is imported, a document of all technical, safety and environmental requirements signed by the relevant authority of that country must be submitted. Otherwise, the import of these environmentally undesirable cars to the Azerbaijani market should be stopped, or the duties on these cars should be increased. Moreover, the import and sale of "old" cars should not be stimulated [16].

The pandemic has also affected the delay in the production of diesel and gasoline in Azerbaijan, which will meet Euro-5 standards. It is planned to develop in 2021-2022 this standard at the country's fuel producer Oil Refinery named after Heydar Aliyev and to increase production to 7.5 million tons in 2024-2025. One of the main goals of the project is to improve the environmental situation in Baku.

There are a number of risks to the environment in production processes, mainly during the operation of old facilities, and modernization will also minimize such risks. For this purpose, the application of modern and international standards of technology is envisaged.

If the prices of the current AI-92 gasoline, which accounts for 95% of the Azerbaijani gasoline market, change, consumers' interest in alternative fuels will increase. On the other hand, the price of diesel, which is mostly used in the public transport and commercial sectors, will undoubtedly increase. The way out of this situation is to increase the number of cars running on natural gas.

CNG is used in road transport around the world. According to forecasts, the number of CNG-powered cars in the world will exceed 100 million by 2030 [13]. High growth dynamics is characterized by factors such as its economic accessibility to a wide range of consumers and minimal impact on the environment. Advanced European countries have already developed a strategy to abandon diesel and alternatively to natural gas. In this regard, there are clear prospects for expanding the use of CNG in the transport sector of a country rich in natural gas, such as Azerbaijan, due to the simplicity of its processing and low costs.

In addition to being the main provider of economic development, transport also contributes to the growth of greenhouse gas emissions. According to official statistics, harmful emissions from motor vehicles have a larger share in air pollution in our country, and in 2020 this waste amounted to 661.0 thousand tons or 81.6 percent (Fig.1) [17].

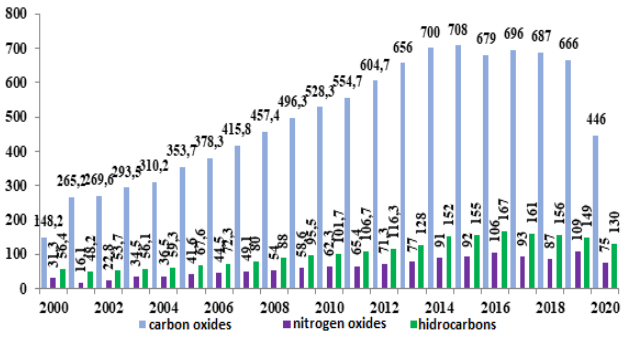

Fig. 1. The content of pollutants emitted into the atmosphere by road transport, thousand tons

Source: [17]

In 2018, a total of 172 400 tons of air pollutant emissions were registered in Azerbaijan, of which 16 700 tons are CO2 emissions. The transport, warehousing and communications sectors accounted for 23.7% of total air pollutant emissions and 4.7% of total CO2 emissions in the same year [18].

Azerbaijan allocated $ 8.5 billion in 2008 and $ 2 billion in 2010 for the development of the transport sector. However, a large part of the funding is directed to the development of highway infrastructure, which is unlikely to contribute to the reduction of CO2 emissions from the sector [19]. Between 2011 and 2016, the Government of Azerbaijan planted 549 000 trees and ornamental shrubs on public lands along highways to reduce the impact of harmful pollutants on the atmosphere [20].

One of the biggest challenges to mitigating climate change is to enable emerging economies to lift people out of poverty and at the same time reduce greenhouse gas emissions. To this end, the International Transport Forum's Decarbonising Transport in Emerging Economies project has helped developing countries' governments identify ways to reduce transport CO2 emissions and achieve climate goals. One of the four countries participating in this project is Azerbaijan, and the others are Argentina, India and Morocco. In 2016, transport accounted for 30% of CO2 emissions in the Organization for Economic Co-operation and Development (OECD).

The International Transport Workers' Federation estimates that transport emissions in OECD member countries are expected to decline by 1% annually by 2030 and by 2% in non-OECD countries [19]. This is due to the faster growth of demand for transport in these countries. Per capita transport CO2 emissions in developing countries are still well below the OECD average. CO2 per capita in India is about twenty-one percent of the average OECD country [21].

This project will support the organization of current and future transport activities and the assessment of transport emissions, taking into account the relevant characteristics of the participating countries.

IV. Environmental Impact Assessment of Cargo Transportation

Determining energy consumption during cargo transportation and selecting alternatives for the optimal implementation of this process is a matter of interest for every enterprise or company manager. On the other hand, the issue of assessing the number of harmful substances released into the environment during cargo transportation is equally important.

Eco Transit World [22] is the most widely used software in the world for the automatic calculation of energy consumption, carbon emissions, air pollutants and external costs for any type of transport services. It is based on the factors that determine the level of environmental impact in the field of cargo transportation. By selecting these factors in the interests of the enterprise, the user can determine the optimal situation, compare energy consumption and the amount of waste polluting the environment between the types of vehicles.

The implementation mechanism of the program is characterized by the following steps:

Step 1. **Mode selection.** One of the standard and advanced modes is selected for the actual calculation. The standard mode is intended for "fast" calculations, and the advanced mode allows for a more accurate description of the transport chain.

Step 2. **Definition of goods.** The weight, number and type of cargo (wholesale, medium goods, light goods) to be transported are specified.

Step 3. **Determination of the points of departure and destination (delivery)**. By choosing between the city, railway station, port and airport (through Google Maps and zip code), the type of destination is determined.

Step 4. **Determination of the route.** One or more types of vehicles (train, plane, ship, truck, ferry), as well as the transport chain are selected. Advanced mode allows to specify technical and operational details. The emission class for trucks, the weight of the train for rail transport, or the load rating of the vehicle can also be determined individually.

Step 5. **Determination of the point of destination (delivery).** The destination is determined by making the choices listed in step 3.

After entering all the relevant parameters, the button labeled "Calculate" is pressed to start the calculation.

Step 6. **The results of the calculation** are presented in the form of bar charts and tables. The route can be tracked via Google Map or exported as Google Earth Route.

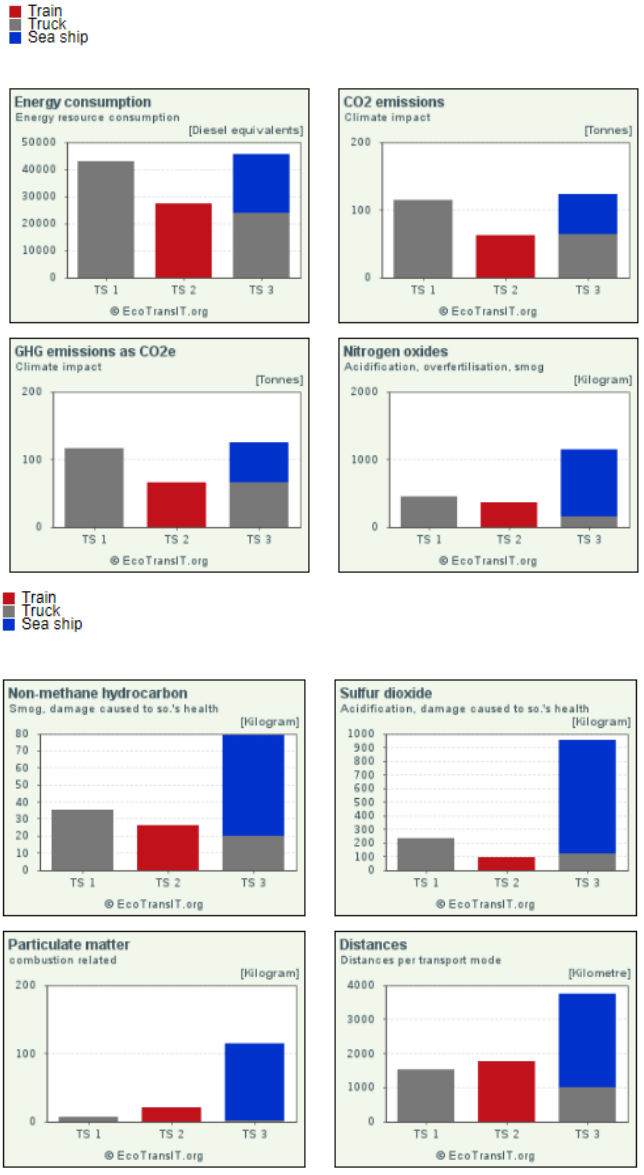

Fig. 2. Energy consumption and the amount of harmful waste

Source: Eco Transit World software calculation result

Made in Germany, this software allows to calculate energy costs and carbon emissions worldwide virtually for all modes of transport.

In calculations the transportation of 100 containers, each weighing 10 tons, from the Baku Railway Station to the Turkoglu region of Turkey is presented.

Appropriate technical parameters for estimating the energy consumption and environmental impact of three modes of transport, including trains, trucks and ships, are presented in the Eco Transit World program interface.

The user is free to choose the technical parameters. The diagrams showing the amount of electricity consumption and carbon emissions used to transport cargo on a selected route by Euro-4 diesel-equivalent fuel truck as well as the distance traveled by all three modes of transport are given in Figure 2.

Being the most promising mode of transport in modern times, the railway meets many standards in terms of speed and price, especially environmental requirements. In the example we saw, this fact proved itself once again. The results of the calculations showed that it is more profitable to transport cargo by train on the chosen route, both in terms of energy consumption and the level of environmental pollution.

Due to the need to make comparisons in solving specific problems, accurate indicators of the above-mentioned technical parameters are needed. Figure 3 shows the quantitative indicators of electricity consumption and the amount of waste dumped on the selected route.

Energy consumption (WTW)
Energy resource consumption

	TS 1	TS 2	TS 3
	[Diesel equivalents]		
Truck	42,752	0	24,334
Train	0	26,974	0
Sea ship	0	0	21,109
Sum:	**42,752**	**26,974**	**45,443**

CO2 emissions (WTW)
Climate impact

	TS 1	TS 2	TS 3
	[Tonnes]		
Truck	114	0	65
Train	0	62	0
Sea ship	0	0	58
Sum:	**114**	**62**	**123**

GHG emissions as CO2e (WTW)
Climate impact

	TS 1	TS 2	TS 3
	[Tonnes]		
Truck	116	0	66
Train	0	65	0
Sea ship	0	0	59
Sum:	**116**	**65**	**125**

Nitrogen oxides (WTW)
Acidification, overfertilisation, smog

	TS 1	TS 2	TS 3
	[kilogram]		
Truck	435	0	166
Train	0	352	0
Sea ship	0	0	980
Sum:	**435**	**352**	**1,146**

Non-methane hydrocarbon (WTW)
Smog, damage caused to so.'s health

	TS 1	TS 2	TS 3
	[kilogram]		
Truck	35	0	20
Train	0	26	0
Sea ship	0	0	58
Sum:	**35**	**26**	**79**

Sulfur dioxide (WTW)
Acidification, damage caused to so.'s health

	TS 1	TS 2	TS 3
	[kilogram]		
Truck	229	0	130
Train	0	88	0
Sea ship	0	0	822
Sum:	**229**	**88**	**952**

Particulate matter (WTW)
combustion related

	TS 1	TS 2	TS 3
	[kilogram]		
Truck	5.85	0	3.31
Train	0	19.98	0
Sea ship	0	0	111.07
Sum:	**5.85**	**19.98**	**114.38**

Distances (WTW)
Distances per transport mode

	TS 1	TS 2	TS 3
	[km]		
Truck	1,523	0	1,026
Train	0	1,772	0
Sea ship	0	0	2,718
Sum:	**1,523**	**1,772**	**3,744**

Fig. 3. Accurate indicators on the selected route

Source: Eco Transit World software calculation result

As can be seen from Figure 3, only the amount of waste emitted by the train to the environment within the selected technical parameters is low, fuel consumption is low, in this regard, it is more appropriate to deliver the selected cargo by train to the destination.

With the help of Eco Transit World software, it is very convenient to calculate the cost of transporting goods from one point to another anywhere in the world, as well as in the case of a chain route.

V. CONCLUSION

Today, the Republic of Azerbaijan actively participates in the implementation of international transport policy. Undoubtedly, in connection with the restoration of the "Historical Silk Road" under the "TACIS-TRACECA" program, the amount of harmful substances emitted during the transportation of international cargo by road will increase and aggravate the environmental situation in the country. Therefore, the implementation of important tasks such as strengthening the transport system of Azerbaijan and ensuring the environmental safety of vehicles requires great responsibility from the relevant authorities. For this purpose, it is necessary to increase the number of permanent ecological posts at border checkpoints of the republic, at the entrances and exits of major cities, as well as on highways. Also, the regulations governing the state environmental control and its implementation should be effectively applied. Normative acts should reflect the mechanism of interaction between the bodies exercising state control and clarify the rules and tariffs for payment for environmental pollution. In order to meet the requirements for vehicles and ensure environmental safety more effectively, a program for the gradual adoption of Euro environmental standards and an incentive system to reduce the harmful effects of road transport on the environment and accelerate the process of fleet renewal should be developed. In order to prevent the release of toxic gases from vehicles into the atmosphere, the movement of expired cars in the city should be restricted and the car fleet should be renewed.

In order to ensure the normal operation of transport networks, their appropriate infrastructure should be created and a modern automated monitoring system should be established in Baku and other major cities in order to improve atmospheric air monitoring.

It is advisable to discuss incentive projects related to import duties and VAT exemption for environmentally friendly vehicles, electric vehicles, as well as hybrid vehicles, and CNG vehicles, as well as taking the necessary measures to prevent the import of expired vehicles into Azerbaijan, and spare parts for them, the technical parameters of which do not meet modern standards, as well.

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