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Improving the Energy Efficiency of the Transport Infrastructure of the Modern City and Region

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Abstract. The energy efficiency of urban transport infrastructure, especially motor transport infrastructure, is a very actual problem in the modern world, and is of both theoretical and practical interest. The purpose of the survey is to study the negative impact of transport infrastructure on the ecology of Volgograd and the Volgograd region, to identify the main directions for improving the energy efficiency of certain types of transport in the city and region. The following tasks were solved to achieve the aim: the characteristics, the state of the transport infrastructure and its negative impact on the environment of the city and region were considered; proposals for improving the energy efficiency of the transport infrastructure of the city and region are presented, which are based on the study of experience of successful practices. The object of study is the transport infrastructure of the city and region, the subject of the study is external and internal factors, the processes of the negative impact of the transport infrastructure of the city and region on its environment. The obtained results and conclusions are characterized by novelty, scientific and practical importance in terms of substantiating proposals for the use and introduction of new energy-saving technologies in the transport infrastructure as a condition for the safe and sustainable development of the economy and ecology of the city and region. The main methods are the analytical method and the method of collecting information which are used in this study.

1. Introduction

The transport infrastructure of any Russian region, in particular the Volgograd region, is very diverse - it is not only rail, road, air, sea and river transport, but also main gas and oil pipelines. The development of the transport infrastructure of the city, the region and its vehicles is part of the general scientific and technological progress, it is necessary and cannot be suspended. Without the development of transport infrastructure, it would be impossible to develop territories, to develop tourism and trade. Transport (about 40% of all energy consumed) is today a secondary industry, but there is no doubt that it will develop rapidly as the economy improves and the number of private cars grows.

At the same time, the development of transport infrastructure has negative moments: hundreds of millions of tons of harmful substances enter the atmosphere with exhaust gases annually; a car is one of the main factors of noise pollution [1, 2]. The harmful effects of road transport deteriorate people's health, poison the soil and water reservoir, and influence the plant and animal world. These conflicts



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between vehicles and the human environment are serious. However, these conflicts are caused by a whole complex of heterogeneous factors and are amenable to elimination. The main method in solving this problem is the complex of organizational and technical measures carried out in the field of using of different types of vehicles [3, 4]. And also on the basis of the wide use of the latest achievements of scientific and technological progress, it is possible to create new progressive technologies in the transport infrastructure, which become environmentally friendly and do not cause damage to the environment.

2. Characteristic, state of transport infrastructure and its negative impact on the environment of the city and region

The transport infrastructure of the city, forming the urban transport networks, in the planning structure of the modern city is the basis around which the elements of the urban environment are formed and developed: microdistricts, residential areas, city and regional centers, zones of industrial enterprises, health facilities, sports complexes, etc. Currently, the city of Volgograd is one of the largest cities in Russia with a length of more than 80 km, with an area of urban land of almost 56.5 thousand hectares. It has a million inhabitants of over 100 nationalities. Due to its advantageous geographical position, the Volgograd region is the main gateway to the south of Russia with access to Iran and Iraq through the Caucasus, to India through the Republic of Kazakhstan, so the developed transport infrastructure is one of the key conditions for the region's socio-economic development. The transport infrastructure of the Volgograd region has all types of transport, except for sea transport [5, 6].

For a significant development of all sectors of the national economy of any region and country as a whole, it is necessary to move a large amount of cargo and passengers. Vehicles, for the most part, are powerful consumers of energy. Cars, buses, airplanes, trains operate mainly on oil, gas, kerosene, and the rest of the vehicles - on electricity. At the same time, among the sectors of the economy of Russian cities and regions, the transport complex (road, river, sea, air, rail) is one of the main environmental polluters.

High maneuverability in hard-to-reach places and adaptations for working in various conditions make road transport one of the main means of transporting cargo and passengers. In the design and construction of roads, it is necessary to indicate the full range of environmental requirements within the transition period and the technical and operational indicators of the roadway [7]. Automobile transport in the Volgograd region carries out transportation of goods, both in intraregional and interregional communications, providing output of production of industrial and agricultural enterprises to railway stations, river ports of the region for subsequent export to other regions of Russia, CIS and other states. The road transport is used in agriculture by 80–90% in the region. Further development and improvement of the agro-industrial complex directly depends on this type of transport, development and improvement of the road network in countryside. The territory of the Volgograd region is crossed by the following federal highways that have the greatest importance for the region: Volgograd - Tambov - Moscow, Volgograd - Saratov, Volgograd - Elista - Stavropol, Volgograd - Shakhty and Volgograd - Astrakhan. The length of public roads with hard surface is 12.4 thousand km [6].

The amount of the road transport in our region is increasing significantly every year. The increase in the number of vehicles leads to an increase of exhaust emissions, which are dangerous pollutants (table 1). At the same time, the noise pollution of the atmosphere has constantly increased from this type of transport. Noise is a special sound wave perceived as an unpleasant factor that interferes or even causes painful sensations.

Table 1. Advantages of road transport and disadvantages of road transport in the city and the region^a.

Advantages of road transport	Disadvantages of road transport
1. High movement speed	1. High demand for new roads
2. High maneuverability	2. Low freight turnover
3. Universality to transportation of all types of goods	3. High cost price
4. The ability to deliver goods directly to the consumer	4. The need to introduce new technology
5. Use in remote areas (northern, mountainous)	5. Severe environmental pollutant

^a it is compiled by the authors

More than 200 pollutant ingredients are emitted into the atmosphere of the city of Volgograd, such as: nitrogen dioxide, hydrogen sulfide, phenol, soot, hydrogen fluoride, hydrogen chloride, ammonia, formaldehyde, sulfur dioxide, carbon monoxide. The main air pollutants are industrial enterprises and transport [8]. Based on statistical data of the Volgograd region, the highest indicator of the degree of air pollution is recorded in cities such as Volgograd and Volzhsky. The main reasons are: a large concentration in the area of road transport (more than 450 thousand cars are registered with a population of about 1.3 million people). One of the indispensable conditions for reducing the harmful effects of transport on the environment is to maintain it in a technically sound condition. For these purposes, more than 400 stations and service centers for cars and more than 20 car washes are being operated in Volgograd [8].

According to the Federal State Statistics Service, the list of the most polluted regions of the world, unfortunately, has hit the most cities in Russia. This list was headed by such cities as Moscow, St. Petersburg, Volgograd, Norilsk, Nizhny Novgorod, Tomsk and others. Harmful emissions contained in the air of these cities exceed permissible values by several dozen times. It directly affects the living conditions of the population, and as a result - the deterioration of the health status of people and the decrease in their life expectancy [9]. Required condition for reducing the harmful effects of transport on the environment is its technically good position. To comply with this condition, over 410 stations and service centers for cars and more than 30 car washes are currently operating in Volgograd [8].

The important role in the transport infrastructure of the Volgograd region is played by rail transport, which carries out the main transport and economic relations of the Volgograd region with other regions of Russia and foreign countries. The length of railways in the region is 1,660 km.

Today, rail transport remains one of the largest energy consumers in the transport infrastructure of our country and its individual regions. During the year, rail transport needs about 7 million tons and about 6% of the electricity generated in the country. In total, this type of transport consumes 39 billion kW / h of electricity, 82% of which is accounted for by the traction of train and electric train [9, 10].

It is extremely difficult to reduce energy costs in railway transport, considering the endlessly rising prices for fuel products. Based on the growth of prices for energy resources, the competition of other types of transport, financial costs of the railway system increase and affect the cost of transportation. Therefore, the priority areas for solving the problem of energy supply in rail transport remains heat supply, reducing operating costs. Also, one of the main direction of the energy strategy of this sector is to replace high-performance equipment with worn-out equipment. According to statistical indicators at the beginning of 2016, the rolling stock depreciation of Volgograd trams was 87.0% with a standard service life of 35.2 years, trolleybus depreciation - 71.1% with a service life of 19.2 years [11].

3. Suggestions for improving the energy efficiency of certain types of transport in the city and region

Today, the transport infrastructure of any city and region can be classified as one of the most energy-intensive sectors of the economy, with significant energy saving potential [12-14]. In the Volgograd region, the most common types of transport infrastructure in the region, such as rail and road transport, need more energy efficiency.

The main directions for improving energy efficiency in the road transport of our region are:

- the use of less energy-intensive fuel (first of all, it is liquefied and compressed gas), as well as the development of new types of economical fuel;
- the car weight reduction due to the replacement of metallic materials with polymeric materials, which provide not only a reduction in fuel consumption, but also greater safety (in accordance with the data of the European Manufacturers Association, a decrease of car weight per 100 kg will achieve fuel savings of more than 160 liters per year);
- reduction of fuel consumption due to the equipment of the car with high-efficiency engines [15];
- use of "green" tires, reducing resistance, improving grip and saving up to 10% of the usual amount of fuel consumption [15].

In order to develop urban electric transport in the city of Volgograd, there is design documentation for the construction of a high-speed tramway line in Volgograd is at the 3rd stage of the "Elshanka station - the State University station". The launch of this tram line is necessary for the city [5]. It will help reduce the workload of road transport and bring positive points to all spheres of life, the economy and the ecology of the city. Therefore, we believe that it is necessary for the Administration of the city and the region to do everything possible to implement this project in the near future.

To solve the motor problem in the territory of the Volgograd region in different time periods there was carried out (2010-2011, 2014-2017) a program of recycling old, domestic cars as part of a federal project. From March 1, 2019, the programs "First car" and "Family car" were resumed in the Volgograd region. However, the benefits from the introduction of recycling schemes may be insignificant, because the incomes of the population of our region are still relatively low, and preference is given to old used cars compared to new and more efficient ones simply due to their lower prices. In this regard, it is necessary in the territory of the Volgograd region to conduct more explanatory activities for the implementation of this program of car recycling among the population and business communities. After all, the utilization of old cars in our region is aimed primarily at achieving such goals as: improving road safety and improving the environmental situation in the region.

Volgograd region can further improve energy efficiency in the car transport sector by introducing more stringent fuel efficiency standards and emission standards for domestic and imported cars. It is necessary to promote the crowding out of inefficient motor transport and its replacement with a new one, to create a more efficient fleet of cars by developing and implementing various regional programs in this area.

Among the main directions of reducing energy consumption in the field of railway transport, the Volgograd region can use the following: electrification of the entire composition of railways; replacement of fuel oil for liquefied natural gas and synthetic diesel fuel; commissioning improved locomotives with improved engine efficiency; the maximum possible loading of railway carriages and the use of high-capacity railway carriage; the use of railway carriage on roller bearings to reduce the resistance to movement [10].

Currently, in the framework of the development of the railway infrastructure of our country, the Energy Strategy is being implemented. However, the effectiveness of the implementation of this program depends on the effectiveness of the implementation of programs and projects of this strategy

at the level of cities and regions of Russia. In this regard, we offer to implement the following projects in our region that have been successfully implemented in other regions of our country [10]:

- creation of an additional fleet and commissioning of railway carriages-rail lubricators, on the basis of ordinary passenger railway carriages. Usually railway carriages-rail lubricators are attached to the composition of postal or passenger trains. This will reduce wheel wear by 3% and reduce energy consumption by up to 6%;
- implementation of the train automatic maintenance program, which saves up to 8% of fuel and energy resources
- introduction of an intelligent lighting control system;
- replacement of solid fuel boilers for induction boilers;
- use of hybrid and battery locomotives, which are more economical than ordinary electric locomotives, by 27% and 30%, respectively;
- introduction of a universal system for the automatic maintenance of a freight electric locomotive with the addition of functions of the driver's information system.

It is also important not to forget about the huge potential for improving the energy efficiency of railways. Based on the experience of other regions, we suggest that the regional representative offices of the Russian Railways of the Volgograd region should plan to equip all the lines with solar batteries. The developers offer to place the solar panels directly on the embankment or in the line of landing. Their installation will be some refinement to the existing railway tracks and will not require large financial investments. Thus, solar panels will not only reduce the cost of transporting electricity, but also increase the autonomy of the entire railway line.

The development of transport infrastructure is impossible without the use of natural resources (oil, gas), so the problems of energy efficiency of vehicles are closely related to the problems of its energy saving [16-18]. In turn, the modernization and transfer of all types of vehicles to innovative technologies is a serious advance in the development of Russian regions and the country's economy as a whole. Without the development and introduction of new technologies into the transport infrastructure, the movement of scientific and technical progress and improvement of this sphere is not possible.

4. Conclusion

Today, the priority task of the development of transport infrastructure in every city and region of Russia is the introduction of energy-efficient and cost-effective projects that will improve the operation of the entire transport network, thereby increasing its energy efficiency and improving the environmental situation in a single region and across Russia in whole [19, 20].

At the same time, stimulating levers, such as financial, tax, informational activity, which are able to change consumer behavior towards the rational use of energy resources by changing consumer preferences and values, are very important. In this regard, it is necessary to include in the plans of activities of federal executive authorities and state programs of the constituent entities of the Russian Federation indicators in the field of promoting energy conservation and improving the energy efficiency of the transport infrastructure of the country and its regions in the business community and among the population.

Thus, improving the energy efficiency of the transport infrastructure of any Russian city and region is not only economically viable and profitable, but extremely relevant and necessary due to the reduction in world reserves of natural energy resources. And energy saving is also financial resources saving.

5. References

- [1] Borisova N I and Borisov A V 2014 To the problem of energy saving and energy audit of housing and public utilities of the Russian regions in the new economic conditions *Actual*

- problems of economics and management* **3(03)** 11-17
- [2] Borisova N I, Borisov A V and Vypritskaya E U 2015 To the problem of development and use of alternative energy sources in Russia and its regions in modern conditions *Economy and Entrepreneurship* **12-3** 412-420
 - [3] Borisova N I 2015 Prospects for the development of transport construction in Russia in modern market conditions *In the collection: Modern problems of management. Materials of the All-Russian scientific-practical conference* (FGBOU VPO "Tyumen State University of Architecture and Civil Engineering") 25-30
 - [4] Borisov A V 2015 Problems of development of the road construction industry of the Volgograd region in the new economic conditions *In the collection: Modern problems of management Materials of the All-Russian scientific-practical conference* (FGBOU VPO "Tyumen State University of Architecture and Civil Engineering") 19-25
 - [5] Resolution of the Volgograd Region Administration dated January 23, 2017 No. 16-p "On Approval of the Volgograd Region State Program" Development of the Transport System and Ensuring Road Safety in the Volgograd Region "(as amended on February 27, 2019) <http://docs.cntd.ru/document/445073439>
 - [6] Transport infrastructure of the Volgograd region 2015 *Transport strategy of the XXI century* vol 28 <http://www.sovstrat.ru/journals/transportnaya-strategiya-21-vek/articles/st-trans28-29.html>
 - [7] Karpushko M O, Bartolomei I L, Karpushko E N and Zhidelev A V 2018 Application of nonwoven geosynthetic materials in construction in wetlands *Materials Science Forum* 945 MSF 9-14 doi:10.4028/www.scientific.net/MSF.945.9
 - [8] Shipkova E V, Borisova N I and Borisov A V 2017 To the problem of energy saving of the transport system at the level of the modern city *Russian Journal of Management* **5-1** 49-56 <https://naukaru.editorum.ru/ru/nauka/article/15967/view>
 - [9] State Program of the Russian Federation "Energy Saving and Energy Efficiency Improvement for the Period until 2020" http://www.consultant.ru/document/cons_doc_LAW_109625/
 - [10] Shevtsov O V 2019 Energy Saving and Energy Efficiency in Railway Transport *Portal for specialists of the transport industry "Transport of the Russian Federation"* <http://www.rostransport.com/article/201174/>
 - [11] Official site of MUP "Metroelectrotrans" (Volgograd) <http://www.gortransvolga.ru/>
 - [12] Glebov A V 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **272** 022011 doi:10.1088/1755-1315/272/2/022001
 - [13] Solovev D B 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **272** 022001 doi:10.1088/1755-1315/272/2/022095
 - [14] Ivanova D G *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **272** 022030 doi:10.1088/1755-1315/272/2/022030
 - [15] Levinzon S V 2015 Energy Saving Technologies. A look into the future *Successes of modern science* **5** 126-129
 - [16] Yakovlev V L, Stolyarov V F and Glebov A V 2006 Research methods for the problem of the kern transportation: from 20 to 21 century *J. News of the Higher Institutions Mining Journal* **1** 115-123
 - [17] Yakovlev V L and Kornilkov S V 2013 Methodological features of subsoil development at the present stage *J. Bulletin of UB RAS. Science. Society. Man* **4** 43-49
 - [18] Kornilkov S V and Yakovlev V L 2015 On the methodological approach to research in the field of subsoil development on the basis of consistency, complexity, interdisciplinary and innovation *J. Mining journal* **1** 4-5
 - [19] Dovzhenok A S 2002 *Development of management theory and methods to transport by mining enterprise system: auto Dr. then. sciences* (Chelyabinsk) 47
 - [20] Zyryanov I V 2006 *Improving the efficiency of quarry transport systems in extreme operating conditions: Dis. Dr. then. sciences* (St. Petersburg) 378