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RESEARCH OF BIOENERGY POTENTIAL ON IMPROVING ENERGY EFFICIENCY AND ENVIRONMENTALITY IN TRANSPORT PROJECTS

The article considers the problems of energy efficiency management of the rolling stock of the transport sector. The operation and operation of vehicles are analyzed and it is determined that road transport is the main consumer of energy resources in the transport sector, which is about 90%. Road transport requires 6.5 times more fuel than rail, and 5 times more fuel than sea or river.

It has been studied that the transport sector has a negative impact on environmental friendliness due to high emissions. To successfully solve this problem, it is necessary to use bioenergy, which will increase the energy efficiency and environmental friendliness of the transport sector and is a strategy for the development of the transport sector of the country and the European Union.

An analytical review of legislative acts, namely EU directives and national transport strategy for the period up to 2030, which regulate the promotion of energy efficiency in transport.

The main groups of tools and the use of information technology are considered, which allow to achieve the set goals in the development of energy efficiency in transport.

The impact of alternative fuels resulting from the processing of biological waste or biological raw materials for the country's transport sector, in particular road transport, which will significantly reduce CO2 emissions, has been studied. Biofuels are able to provide clean energy for all modes of transport and are currently the most important type of alternative fuel. Its influence on improving the energy efficiency and environmental friendliness of the transport sector has been studied.

Keywords: *energy efficiency, information technologies, transport sector, bioenergy, monitoring, diagnostics, environmental friendliness.*

Introduction. Ukraine's transport sector is a critical sector for reducing greenhouse gas emissions. Transport accounts for about 19% of the world's energy use and a quarter of CO2 emissions related to the fuel and energy sector. The entire transport system of Ukraine is dependent on imports of oil and gas, which leads to increased energy efficiency in transport. In recent years, there has been a decrease in energy consumption. If we talk about road transport, it is the main consumer of energy resources in the transport sector, which is about 90%.

Comparing the transportation of the same cargo on different modes of transport, road transport requires 6.5 times more fuel than rail, and 5 times more than sea or river [1].

In the European Union (EU), the transport sector is one of the biggest air pollutants, a source of

greenhouse gas emissions, and has a negative upward trend. According to [1], from 1990 to 2012, emissions in the EU increased by 20%.

To achieve the targets set by the EU Transport White Paper, emissions must be reduced by 67% by 2050. The current EU transport system cannot be called sustainable either in terms of energy consumption or the types of energy resources used.

To ensure the energy efficiency of the transport complex, it is necessary to use alternative fuels from renewable raw materials. What is the basis of the strategy for the development of the transport sector in terms of improving energy efficiency and environmental friendliness.

The purpose and objectives of the study. The aim of the study is to analyze the impact of the use of alternative fuels from renewable raw materials for the efficient operation of the transport sector and increase energy efficiency and environmental climate of our country.

Objectives of the study: 1. To analyze the problems of the impact of the transport sector on environmental friendliness and energy. 2. Investigate solutions that will increase energy efficiency. 3. Investigate the impact of alternative sources of fuel from renewable raw materials on improving energy efficiency and environmental friendliness of the country's transport sector.

Materials and methods of research. The strategy of development of the transport sector of the country and the EU is to ensure the energy efficiency of the transport complex is the use of bioenergy. Therefore, the EU is trying to build a legislative framework that would maximize the development of energy efficiency in transport. In particular, key EU legislation in this area:

Directive 2009/28/EC on the promotion of the use of renewable energy sources establishes a general legal framework for the production and promotion of energy from renewable sources. Among other things, it sets a target for the use of 10% of RES energy in the transport sector.

Directive 2014/94/EC "On the development of infrastructure for alternative fuels". The key objectives of the directive are: reducing the dependence of EU transport systems on oil, reducing greenhouse gas emissions under the EU Climate and Energy Package, improving urban air quality, increasing the competitiveness of the European economy, stimulating innovation and economic growth. The directive sets out the steps to be taken to develop the EU's single transport market, namely the deployment of a network of electricity and bio-filling stations, the development of harmonized EU standards and common technical specifications, and the provision of relevant, consistent and understandable information to consumers [2-3].

Directive 2009/30/EC on fuel quality introduces mechanisms for monitoring and reducing greenhouse gas emissions. The provisions of the Directive apply to all types of petrol, diesel and biofuels used in motor vehicles, as well as diesel used for off-road vehicles.

Directive 2009/33/EC "On the development of environmentally friendly and energy efficient vehicles" is aimed at the widespread introduction of environmentally friendly cars. It stipulates that the energy and environmental consequences of the use of cars throughout their lives should be taken into account when purchasing cars, as provided for in the Public Procurement Directives and the Civil Service Regulation. If such impacts are to be monetized and taken into account when deciding to purchase a car, the costs associated with operating the car must be calculated according to the general rules set out in the Directive. EU Regulation №443/2009 requires a reduction in CO2 emissions from new cars to an average of 120 g / km and a further reduction to 95 g / km from 2020. This requirement alone will achieve more than 30% of the emission reduction target for the non-ETS sector. The main goal of the Roadmap to a Single European Transport Area is to define a long-term strategy for the development of the EU transport system in order to make it more efficient, safe and secure. The roadmap is designed for 2050 with intermediate targets for 2020 and 2030 and sets ambitious targets for energy efficiency, reduction of oil dependence and greenhouse gas emissions, and technological development.

The National Transport Strategy for the period up to 2030, which was adopted by our Government in 2018, is dedicated to the issue of increasing energy efficiency and environmental friendliness of transport, namely:

improving pedestrian infrastructure, parking areas, limiting the speed of vehicles and developing infrastructure for bicycles;

establishing the obligation to comply with environmental standards;

introduction of economic incentives for the transition of freight and passenger traffic to more environmentally friendly rail and water transport; • introduction of a system of tolls from road users depending on the ecological class of the car;

introduction of economic measures to stimulate the use of more environmentally friendly modes of transport in cities (electric cars, public transport, bicycles);

stimulating the use of alternative energy sources, as well as environmental modes of transport and special equipment, etc..

To develop energy efficiency in transport, the so-called main groups of tools are used, with which you can achieve your goals. Consider these groups of tools. The most effective group of tools are fiscal instruments, which operate on the principle of paying more for less environmentally friendly transport and reducing the cost of purchasing or using more energy-efficient and environmentally friendly cars. In particular, the fuel tax has been introduced in many countries around the world and has a significant impact on the energy efficiency of used cars. Another group that is no less effective is the infrastructure tools that introduce charging station networks that will reduce emissions. Another area of work to reduce emissions from transport should be the development of infrastructure for cyclists and pedestrians. EU administrative countries have been requiring mandatory certification of cars according to environmental standards since 1988. Today, the EU has Euro-6 standards that set minimum environmental requirements for cars manufactured or imported into the EU. In Ukraine, the introduction of Euro-6 standards was postponed until 2020. To monitor the current technical condition of cars in many EU countries introduced a mandatory roadworthiness test, which, including compliance with environmental requirements is also checked. If the level of harmful emissions is exceeded, the car will not pass the technical inspection and will not be allowed to operate.

The next group of information tools. Improving energy efficiency and environmental friendliness in transport is impossible without raising the awareness of end users. That is why it is important to conduct information campaigns on the use of bioenergy and transport.

Therefore, the development strategy provides for the mandatory use of liquid biofuels (biocomponents) in the field of transport.

The main purpose of the draft Law is to create an effective legislative mechanism for the development of a competitive market for the production and use of bioethanol and biocomponents in transport in Ukraine.

The draft law is aimed at implementing the provisions of Directive 2009/28 / EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources in energy consumption of RES in transport and the implementation of Ukraine's commitments. accession to the Energy Community [4-7].

The project proposes to legislate the mandatory content of liquid biofuels (biocomponents) in all volumes of automotive gasoline released from places of fuel production, places of wholesale trade in fuel and places of retail sale of fuel, except for gasoline with an octane number of 98 and above and gasoline supplied for the needs of the Ministry of Defense, the State Reserve and for the creation of minimum reserves of oil and petroleum products.

According to the project, from May 1, 2022, the content of liquid biofuels in all volumes of gasoline should be at least 5 percent.

Biofuels have been around for many years. In fact, people have been using vegetable oil-based diesel engines for much longer than petroleum-based diesel fuel. Over the last decade, biofuels have come to the fore as a key way to address our carbon footprint and our dependence on fossil fuels.

According to the 2014 EU Fuel Directive, biofuels are currently the most important type of alternative fuel, accounting for 4.7% of the total fuel used by EU vehicles in 2011. It will also significantly reduce CO2 emissions. Biofuels are able to provide clean energy for all modes of transport.

Biofuels are an alternative type of fuel that results from the processing of biological waste or biological raw materials. For road transport, it can be in the form of biodiesel or biogasoline, where a certain amount of biofuel is mixed with traditional gasoline or diesel fuel. In fact, EU Directive 2009/30 / DC allows the mixing of ethanol with gasoline up to 10% of the volume and content of FAME (biodiesel methyl ester of fatty acids made from natural fats) in diesel fuel not more than 7%. In April 2018, the UK government announced its goal to double the current amount of bio-matter in diesel fuel from 4.75% to 9.75% by 2020 and then to 12.4% by 2032. Most fuels already include some bio-raw materials, and we don't even realize it.

Sources of biofuels include corn, sugar cane, palm oil, rapeseed oil, soybeans and ethanol. Crop-based sources, such as rapeseed oil, help to "remove" CO2 from the atmosphere during the growing process, helping to compensate for CO2 emissions from oil combustion. For example, bioethanol is classified as carbon-neutral because any CO2 released during production is removed from the environment by the crops themselves. However, the use of raw materials for fuel has some disadvantages. Withdrawal of land that was previously used for growing crops may affect the price of crops. Biodiesel currently uses about 30,000 square kilometers of arable land across the EU, and is expected to increase in the future.

Companies around the world are investing and implementing biofuels in a variety of ways. In the UK, the global fast food corporation McDonald’s is converting vegetable oil from their kitchens into biodiesel, which they use to refuel more than half of their trucks. The United States recycles waste from Auckland, California. In Australia, a Queensland refinery produces biofuels from recycled tire waste. Laboratory tests have shown that this diesel is no different from a diesel derived from fossil fuels, and has all the necessary characteristics.

The growing use of biofuels has a significant impact on lubricants. In any engine, a small amount of fuel goes into the oil. The current generation of engines with low emissions and higher performance operates at higher temperatures. This means that lubricants also work at higher temperatures than in the past [8, 11]. Biofuels are less stable than other fuels and are easily oxidized. The combination of higher temperatures and biofuels causes increased oxidation, which in turn creates carbon deposits in the engine and reduces the viscosity of the lubricant. Biodiesel, like all fuels, gets into the oil pan, where it contributes to the deterioration of oil quality.

With regard to lubricants, the wider use of biofuels raises two key issues. The first is the deposits formed as a result of oxidation, they limit the flow of oil and lead to increased wear and, consequently, reduce engine life. Second, the increase in carbon deposits due to oxidation in the grooves of the piston rings, which limit the movement of the rings and increase the friction and wear of the cylinders. These deposits are abrasive on the parts they come in contact with and lead to higher component wear.

As engines and fuels change, lubricants must adapt to new conditions. To solve the problem of oxidation created by fuel, motor oils are developed using high-quality base oils and additives to increase resistance to oxidation [9-10]. Currently, this applies to oils that are designed and tested for vehicles running on 20% biofuels. However, if the engine was running on 100% biofuel, it would need a completely different oil, as well as different intervals for its replacement.

Any car engine oil contains 70 to 80% base oil, so it is possible to increase the use of renewable materials, as do fuel companies. They can be obtained from vegetable sources such as rapeseed oil or palm oil.

Secondary lubricants can also play a big role. Engine oil does not wear out - it is contaminated with deposits in the engine. With proper collection, treatment and cleaning procedures, used engine oil can be converted to high quality base oil and mixed with high quality lubricants.

«One gallon of used engine oil provides the same 2.5 liters of [base] oil as 42 gallons of crude oil». US Environmental Protection Agency

In the short term, biofuel use is expected to continue to grow. In the long run, electric cars will dominate [12-14]. This will require further innovation in the lubricants industry, as electric vehicles do not require standard motor oils at all. However, they need advanced cooling systems and transmission lubricants to ensure efficient operation of vehicles. Meanwhile, the recommendations for users remain the same: use the right high-quality oil from a well-known supplier, which includes the latest additives to combat the effects of biodiesel and meet all the needs of modern engines. The balance of each additive in the finished lubricant is very complex and is the result of many studies and tests. The slightest over-processing of an element by only 0.001% can destroy the whole balance.

In the early 2000s, some biodiesel consumption was already recorded, especially in Germany and France. In the period from 2004 to 2010 there was a significant increase in biofuels to the overall level of 4% (in terms of energy content) of transport energy. However, growth halted until 2016, probably due to uncertainty over the restrictions on indirect land use change (ILUC). In recent years (following the publication of the ILUC Directive), growth has resumed. On average, biodiesel (FAME and HVO together) accounted for 6.4% of diesel energy consumption in 2019. Bioethanol averaged 3.7% of gasoline energy consumption [15-16].

About 30% of biofuels consumed in the EU-28 in 2019 are classified as "modern biofuels", ie they are produced from residues and waste (including used oils for biodiesel). They can be doubled to achieve 10% RES in transport at EU level.

The share of electricity (one third of which is renewable) is 1.7% of total energy consumption by transport. This is mostly the case for rail transport - the use of electricity in motor vehicles in 2019 is still insignificant (0.08% of total energy consumption in transport), but growth can be expected in the coming years.

Conclusions. The work of the country's transport industry is analyzed, in particular the problem of impact on the environment and energy. The shortcomings of the impact of the functioning of the transport sector on the environment have been identified. It is proposed to solve the problem by using bioenergy, namely biodiesel and biogas. The development of bioenergy makes it possible to expand the range of available energy sources, strengthen the country's energy security, promote energy independence of the state, improve the environment. The experience of using this type of biofuel in different countries of the world is analyzed and it is determined that the EU will reduce the evaporation of fossil fuels by 50% by 2030, and by 100% by 2050. It is determined that the increase of energy efficiency and environmental friendliness is possible through the use of alternative fuels from renewable raw materials**.**

REFERENCES

1. Dombrovska G.P. & Demyanenko T.I. (2010). Al′ternatyvna enerhetyka – novi innovatsiyni tekhnolohiyi [Alternative energy - new innovative technologies]. *Vestnyk NTU "KHPY": Tekhnichnyy prohres ta efektyvnist' vyrobnytstva - Bulletin of NTU "KhPI": Technical progress and production efficiency, 16,* 54-59. Retrieved from http://archive.kpi.kharkov.ua/View/19861/ [in Ukrainian].

2. Bioenerhetychna asotsiatsiya Ukrayiny. Dorozhnya karta rozvytku bioenerhetyky v Ukrayini do 2050 roku ta Plan diy do 2025 roku [Bioenergy Association of Ukraine. Roadmap for the development of bioenergy in Ukraine until 2050 and the Action Plan until 2025]. *uabio.org*, Retrieved from https://uabio.org/wp-content/uploads/2020/11/Zvit-D5.-Dorozhnya-karta-rozvytkubioenergetyky-v-Ukrayini-do-2050-roku-i-Plan-dij-do-2025.pdf [in Ukrainian].

3. Begun S.V. (2020). Rozvytok bioenerhetyky v Ukrayini: zastosuvannya dosvidu YES. [Development of bioenergy in Ukraine: application of EU experience]. Enerhetychna ta tekhnohenna bezpeka. Seriya «Natsional′na bezpeka - Energy and man-madeSecurity. National Security Series», 28,1-19 [in Ukrainian].

4. Melnychenko, O.I., Kulbovskiy, I.I., Holub, H., & Kharuta, V. (2020). Aspekty metrolohichnoho zabezpechennya tekhnolohichnykh protsesiv informatsiyno-vymiryuval′nykh system v proektakh infrastruktury transportu [Aspects of metrological support of technological processes of information and measuring systems in transport infrastructure projects]. *Visnyk Natsional'noho transportnoho universytetu: Tekhnichni nauky - Bulletin of the National Transport University: Technical Sciences, 1 (46),* 226-235 [in Ukrainian].

5. Association Agreement between the European Union and its Member States, of the one part, and Ukraine, of the other part. Retrieved from https://eur-lex.europa.eu.

6. European Energy Security Strategy. Brussels, 28.5.2014. COM (2014) 330 final. Retrieved from https://www.eesc.europa.eu/resources/docs/european-energy-security-strategy.pdf.

7. Kaletnik G., Honcharuk I., Okhota Y. (2020). The Waste-Free Production Development for the Energy Autonomy Formation of Ukrainian Agricultural Enterprises. Journal of Environmental Management & Tourism. V. 11. №. 3 (43). P. 513-522.

8. Holub, H., Kulbovskiy, I.I. (2016). Doslidzhennya ta analiz normatyvnoyi ta normatyvno-tekhnichnoyi dokumentatsiyi, yaki zabezpechuyut′ informatsiynu bezpeku SMART GRID system [Research and analysis of normative and normative-technical documentation that ensure information security of SMART GRID systems]. *Informatsiyno-keruyuchi systemy na zaliznychnomu transporti - Information and control systems for railway transport, 3*, 50 – 57.

9. Maack J. Scenario analysis: A tool for task managers. Social Development Paper. 2001. No. 36. World Bank, Washington, DC. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.199.1964.

10. Medipally S. R., F. Md. Yusoff S. Banerjee, M. Shariff. Microalgae as Sustainable Renewable Energy Feedstock for Biofuel Production. BioMed Research International. 2015. March (22). Retrieved from http://dx.doi.org/10.1155/2015/519513.

11. OECD-FAO Agricultural outlook 2020-2029. Retrieved from https://www.oecd.org/publications/oecd-fao-agricultural-outlook-19991142.htm

12. Pryshliak N., Tokarchuk D. Socio-economic and environmental benefits of biofuel production development from agricultural waste in Ukraine. Environmental & Socio-economic Studies. 2020. V. 8. №. 1. P. 18-27.

13. Shpykuliak O., Bilokinna I. (2019). Green cooperatives in the formation of an institutional mechanism of evelopment of alternative power engineering in the agrarian sector of the economy. Baltic Journal of Economic Studies. V.5 № 2. P. 249-255. https://doi.org/10.30525/2256-0742/2019-5-2-249-255

14. Luk'ianykhina O.A. & Vakulenko I.A. (2011). Vyznachennya napryamiv rozvytku al′ternatyvnoyi enerhetyky v konteksti vyrobnytstva biopalyva [Defining areas of alternative energy in the context of biofuels production]. *Visnyk Sums'koho derzhavnoho universytetu - Bulletin of Sumy State University, 1*, 27 – 33 [in Ukrainian].

15. Pivnyak G.G. & Scraper F.P. (2013). Al′ternatyvna enerhetyka v Ukrayini [Alternative energy in Ukraine]. Dnipropetrovs′k: Nats. hirn. un-t. D.: NHU [in Ukrainian].

16. WBA Global Bioenergy Statistics (2020, December 30). Retrieved from http://www.worldbioenergy.org/uploads/201210%20WBA%20GBS%202020.pdf.

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ДОСЛІДЖЕННЯ ПОТЕНЦІАЛУ БІОЕНЕРГЕТИКИ НА ПІДВИЩЕННЯ ЕНЕРГЕТИЧНОЇ ЕФЕКТИВНОСТІ ТА ЕКОЛОГІЧНОСТІ В ПРОЄКТАХ ТРАНСПОРТУ

У статті розглянуто проблеми управління енероефективністю рухомого складу транспортного сектору. Проаналізовано роботу та експлуатацію транспортних засобів та визначено, що автомобільний транспорт є основним споживачем енергетичних ресурсів у транспортному секторі, що становить близько 90%. Для перевезень автомобільним транспортом потрібно у 6,5 разів більше палива, ніж залізничним, і у 5 разів більше ніж морському чи річковому.

Досліджено, що транспортний сектор має негативний вплив на екологічність, завдяки великому обсягу викидів. Для успішного рішення даної проблеми необхідно застосування біоенергетики, що дозволить підвищити енергоефективності і екологічность транспортного

сектору та є стратегією розвитку транпортного сектору країни і країн Європейського Союзу.

Проведено аналітичний огляд законодавних актів, а саме: директив ЄС та національної транспортної стратегії на період до 2030 року, які регламентують стимулювання розвитку енергоефективності на транспорті.

Розглянуті основні групи інструментів та використання інформаійних технологій, які дозволяють досягти поставлених цілей в розвитку енергоефективності на транспорті.

Досліджено вплив альтернативного виду палива, який отримується в результаті переробки біологічних відходів або біологічної сировини для транспортного секору країни, зокрема автомобільного транспорту, що сприятиме істотному скороченню викидів CO2. Біопаливо здатне забезпечити чисту енергію для всіх видів транспорту та в даний час є найбільш важливим типом альтернативних видів палива. Досліджено його вплив на підвищення енергоефективності та екологічноті транспортного сектору.

Ключові слова: *енергоефективність, інформаційні технології, транспортний сектор, біоенергетика, моніторинг, діагностика, екологічність.*