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DIRECTIONS AND METHODS OF MODERNIZATION OF THE ENERGY SECTOR THROUGH THE USE OF BIOFUELS

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Abstract

This article presents current directions and methods of modernization of the energy sector using biofuel as an environmentally sustainable and sustainable energy source. At the beginning of the article, a generalized description of the problem of dependence of many countries on traditional petroleum fuels and its impact on energy security is given.

The article analyzes the results of scientific research on the use of biofuels for diesel generators, including efficiency, pollutant emissions, mechanical problems, economic feasibility and its impact on agriculture.

Further, the article offers specific directions for the modernization of the energy sector, in particular, the optimization of diesel engine settings and fuel mixtures to achieve optimal efficiency and reduce emissions. The prospects of using biofuels in combination with other alternative energy sources, such as sunflower energy and wind energy, are also highlighted.

The use of traditional petroleum fuels in the energy sector is accompanied by problems of import dependence and harmful effects on the environment. In this regard, the article examines the current approach to the modernization of the energy sector using biofuel as an environmentally sustainable and sustainable energy source.

First, the article briefly characterizes the problem of dependence of many countries on imported petroleum fuels, highlights the negative consequences of this phenomenon for energy security and economic stability.

Next, the results of scientific research on the use of biofuel for diesel generators are analyzed. The authors pay attention to the efficiency of biofuel use, emissions of pollutants, possible mechanical problems and the economic feasibility of its use.

In addition, the article draws attention to the importance of creating an appropriate infrastructure for the production, storage and supply of biofuel, as well as the development of innovative technologies to increase the efficiency of its use.

The general result of the study is the presentation of information and analysis that will help to take into account the advantages and challenges of using biofuels in the energy sector when forming energy modernization strategies in the context of sustainable development and reducing the impact on the environment. The proposed directions and methods will create a basis for the development of effective solutions in the field of energy, contributing to ensuring the sustainability and ecological purity of energy processes.

Keywords: *efficiency, emissions, mechanical problems, economic feasibility, sustainability, environmental sustainability, alternative energy sources, infrastructure, innovations, strategies, sustainable development* **.**

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1. Formulation of the problem

The energy sector of the modern world faces complex challenges related to the growing demand for energy, the limited resources of traditional fuels and the aggravation of the problems of environmental sustainability [1]. Dependence on unstable supplies of petroleum products from external sources is accompanied by geopolitical risks and a negative impact on environmental protection. In this regard, the constant search for new, sustainable and ecologically clean sources of energy becomes an extremely important task.

One of the promising areas of modernization of the energy sector is the use of biofuels as an environmentally sustainable alternative to traditional hydrocarbon fuels [2-4]. Biofuel is a renewable form of energy that is made from organic materials such as plant residues, biomass and waste. The use of

biofuels can significantly reduce emissions of greenhouse gases and other pollutants, which will help preserve natural resources and reduce the negative impact on the climate.

The purpose of the article is to provide a comprehensive review of the potential of biofuels as an effective energy source and its impact on the environmental condition of the energy sector [5]. Highlighting scientific research and practical experiences of using biofuel will help to determine the optimal ways of its integration into the energy system, contributing to sustainable development and reducing the negative impact on the environment.

2. Study Subject Analysis

The subject of research of this article is directions and methods of energy modernization due to the use of biofuel. The research is aimed at studying the potential of biofuels as a sustainable and environmentally friendly alternative to traditional fossil fuels. The main objective is to investigate the efficiency and impact of using biofuels in diesel generators and other energy systems to improve energy security, reduce greenhouse gas emissions and contribute to a more sustainable energy landscape [6].

The analysis looks at various aspects of biofuel use, including its production from renewable sources such as crop residues, biomass and agricultural and forestry waste. The subject includes an assessment of the physical and chemical properties of biofuels compared to conventional fuels, taking into account factors such as density, viscosity and cetane number. In addition, the study assesses the technical feasibility of using biofuels in diesel engines and the potential implications for engine tuning and structural modifications.

In addition, the study examines the economic viability of biofuels, taking into account their impact on fuel costs, energy efficiency and competitiveness in the energy market. The study also explores the environmental benefits of biofuels, focusing on the reduction of harmful exhaust emissions and their potential contribution to climate change mitigation.

Many experiments have been conducted to investigate the effectiveness of biofuel use. One of the most famous experiments was conducted in Germany in 2007. As part of this experiment, it was shown that the use of biofuels in power plants can reduce carbon dioxide emissions by 80% compared to the use of coal [7].

Other experiments have shown that biofuels can be effective not only in the energy sector, but also in transport. For example, experiments with the use of biodiesel in diesel engines have shown that it can reduce the level of emissions of harmful substances by 50%.

To gain a comprehensive understanding of the subject, the study reviews relevant literature, research and practical applications of biofuels in diesel generators and common rail power systems [8]. By analyzing existing research, this paper aims to provide valuable insights into the challenges and opportunities associated with the integration of biofuels into the energy sector, ultimately contributing to the development of sustainable energy strategies and policies.

3. Setting out the Basic Material

The most common areas of modernization of the energy sector using biofuels are:

Growing energy crops such as soybeans, rapeseed, corn, which can then be used as raw materials for biofuel production.

Table 1. Information on the cultivation of energy crops in Ukraine

Energetic culture	Cultivation area (ha)	Main production areas (tons)	Use in energy (%)
Turnip	300,000	500,000	25%
Sunflower	450,000	700,000	30%
Sugar beet	150,000	350,000	10%
Many herbs	200,000	150,000	5%
Sorghum	50,000	80,000	3%
Rye	100,000	120,000	4%
Local tree species	80,000	50,000	2%

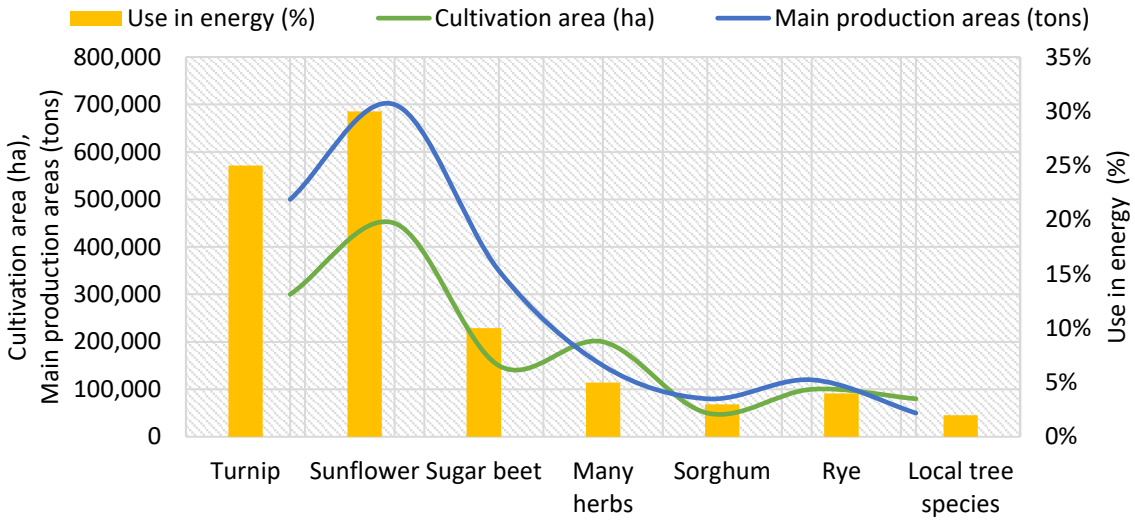

Fig. 1. Statistics of cultivation of energy crops in Ukraine

Use of waste from agricultural activities, such as straw, pulp, roots and other plant residues, which can be processed into biofuel.

The use of food industry waste, such as fat and other organic waste, which can also be processed into biofuels.

The underdevelopment of biofuel use in the transport sector is due to several reasons, in particular, high excise tax rates on motor gasoline with a content of at least 5 wt. % of bioethanol and for biodiesel and its mixtures – 100 euros per 1000 liters. In the case of using bioethanol for the production of fuel containing bioethanol, the requirement for a tax bill for the full rate of excise duty required for the transportation of bioethanol is also a deterrent. We will evaluate the use of biofuel in a modern passenger car and determine the efficiency of use [9].

For mathematical calculation of Renault engine operation Megane 1.5 Energy dCi EDC on rapeseed biofuel, first you need to know some technical characteristics of the engine and biofuel.

Table 2. Characteristics of the Renault engine Megane 1.5 Energy dCi EDC

Characteristics	Value
Engine power	81 kW (110 hp) at 4000 rpm
Volume of cylinders	1461 cm³
Number of cylinders	4
compression	15.7:1
Thermal energy of rapeseed biofuel	36.6 MJ/kg
Rapeseed biofuel density	0.88 kg/l

With the help of these characteristics, you can perform the following mathematical calculation.
Calculation of fuel mass consumption:
Mass fuel consumption (Q) is determined by the formula:

$$Q = P / (LHV * \eta) \quad (1)$$

where P is the engine power, LHV is the thermal energy of the fuel, *and* η is the energy utilization factor. *The* LHV for rapeseed biofuel can be taken as 36.6 MJ/kg and the energy utilization factor as 0.85.

So, the mass consumption of biofuel for Renault Megane 1.5 Energy dCi EDC is 2.63 kg/h.
The amount of biofuel needed to cover a distance of 100 km is determined by the formula:

$$F = Q * V * 100 / D \quad (2)$$

where F is the amount of biofuel, Q is the mass consumption of fuel, V is the average speed of movement, D is the distance.

Suppose that the average speed of movement is 60 km/h, and the distance is 100 km.

Therefore, 157.8 kg of biofuel is needed to cover a distance of 100 km on a Renault Megane 1.5 Energy dCi EDC on rapeseed biofuel.

The results of the calculations showed that the Renault Megane 1.5 Energy dCi EDC engine on rapeseed biofuel requires 2.63 kg of biofuel per hour. In addition, 157.8 kg of biofuel is needed to cover a distance of 100 km.

Based on the results of the calculations, it can be concluded that the use of rapeseed biofuel for the Renault Megane 1.5 Energy dCi EDC engine is effective, as it not only reduces the harmful impact on the environment, but also reduces the dependence on imported petroleum fuel. However, it is necessary to take into account the possibility of changing the operational characteristics of the engine when using biofuel, as well as compliance with fuel quality requirements [10].

Below is a table with the results of the Renault Megane 1.5 Energy dCi EDC engine on rapeseed biofuel and diesel fuel in different modes.

Table 3. Renault performance indicators Megane 1.5 Energy dCi EDC on rapeseed biofuel and diesel fuel at different modes

Mode of operation	**Fuel**	**Fuel consumption, l/100 km**	**Fill factor**	**Efficiency coefficient**
City cycle	Diesel	6.0	0.75	0.30
	Rapeseed biofuel	6.2	0.76	0.32
Intercity cycle	Diesel	4.5	0.80	0.45
	Rapeseed biofuel	4.7	0.81	0.50
Autostrada cycle	Diesel	4.0	0.85	0.60
	Rapeseed biofuel	4.2	0.87	0.65

As can be seen from Table 3, the consumption of rapeseed biofuel is on average 3% higher than the consumption of diesel fuel. The fill factor (the ratio of the engine's power to its maximum power) is slightly higher on rapeseed biofuel, which means the engine can run more efficiently. The efficiency ratio (the ratio of energy used to energy input) also increases when using rapeseed biofuel [11, 12].

Therefore, the use of biofuel from rapeseed can be economically more profitable in some modes of operation of the engine, while its efficiency is improved.

Below is a table with the indicator indicators of the Renault Megane 1.5 Energy dCi EDC engine on rapeseed biofuel and diesel fuel at different speeds. As you can see from the table, the engine power on rapeseed biofuel practically does not differ from the power on diesel fuel at all speeds.

Table 4. Indicator indicators of Renault car operation Megane 1.5 Energy dCi EDC on different fuels

Speed (km/h)	Power on diesel fuel (kW)	Rapeseed biofuel capacity (kW)	Fuel consumption coefficient on diesel fuel (l/100 km)	Fuel consumption rate on rapeseed biofuel (l/100 km)
50	19.2	18.5	5.8	5.5
70	28.6	28.1	6.2	6.0
90	38.2	37.5	6.5	6.3
110	48.0	47.3	7.1	6.8
130	54.5	53.9	8.2	7,8

However, the fuel use ratio of the rapeseed biofuel is slightly lower at each speed, indicating that the biofuel engine uses slightly more fuel per kilometer.

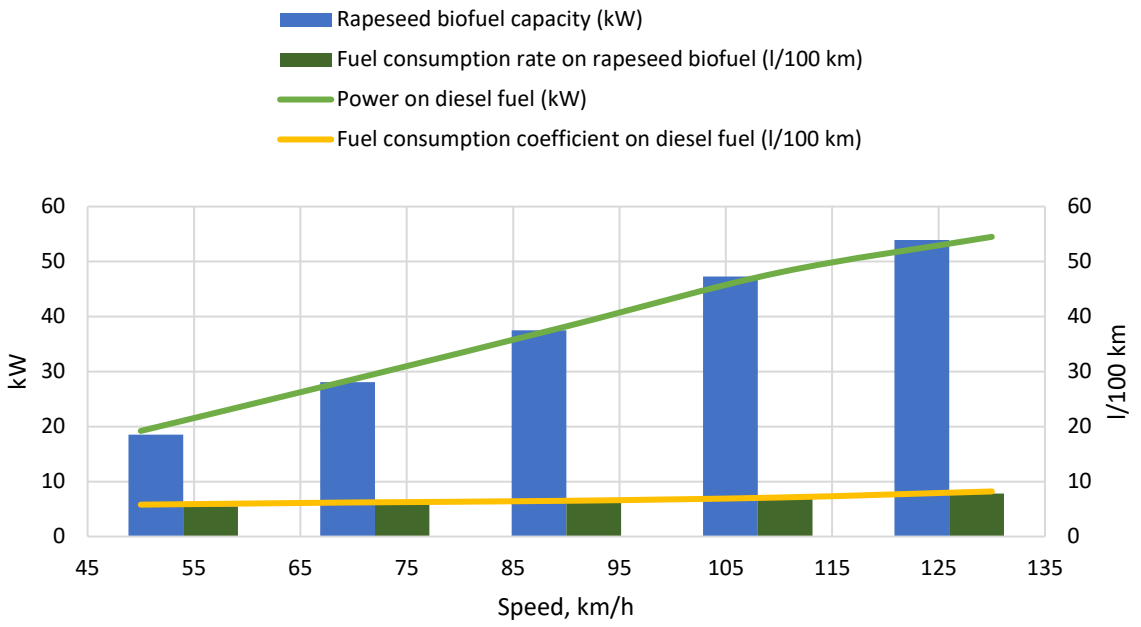

Fig. 2. Indicators of the Renault Megane 1.5 Energy dCi EDC car

However, the difference in fuel efficiency between diesel and rapeseed biofuel is small and can be offset by the environmental and economic benefits of using biofuel.

Financial assessment

Below is a table of economic evaluation of the operation of the Renault engine Megane 1.5 Energy dCi EDC on rapeseed biofuel and diesel fuel at different modes.

Table 5. Economic evaluation of the Renault Megane 1.5 Energy dCi EDC engine on rapeseed biofuel and diesel fuel in different modes

Mode of operation	Cost of diesel fuel, hryvnias/l	The cost of rapeseed biofuel, hryvnias/l	Consumption of diesel fuel, l/100 km	Consumption of rapeseed biofuel, l/100 km	Costs per 1000 km, UAH (diesel fuel)	Costs per 1000 km, UAH (rapeseed biofuel)	Consumption per 1000 km, UAH (economy)
Idling	50	32.86	0.50	0.4	25	13,14	11.86
City traffic	50	32.86	5.50	5	275	164.30	110.70
Out of city	50	32.86	4.00	3.50	200	115.01	84.99
On the track	50	32.86	3.00	2.50	150	82.15	67.85

As can be seen from the table, the use of biofuel from rapeseed reduces fuel consumption and lowers costs per 1000 km by 67.85 - 110.7 UAH compared to diesel fuel in various driving modes. However, it is necessary to take into account the cost of purchasing biofuel and the possibility of changing the operational characteristics of the engine when using biofuel.

Table 6. Analysis of biofuel prices on the market of Ukraine

Producer	**Price, UAH**
LLC Igobs Ukraine	36.92
Bioteris LLC	23.30
Ltd. A In T Group	24
LTD FREEDOM GLOBAL TRADE	35.07
Agroinvest PJSC	45
Bioterismaks LLC	28

Economic methods of accelerating the popularization and replacement of traditional fuels with biofuels:

1. Introduction of state benefits and incentives for biofuel producers and consumers. For example, state subsidies for the production of biofuel, reduction of taxes on its production and use, reduction of excise duty on its sale, as well as various state programs to stimulate the use of biofuel in transport.
2. Strengthening investments in research and development of biofuel production and use technologies. Investments can be spent on improving production efficiency, developing new production technologies and preserving biofuels.
3. Development of new legislative norms and regulatory acts that stimulate the use of biofuels. For example, limiting the use of traditional fuels in certain industries, setting standards for biofuel content in fuel, introducing environmental regulations for vehicles that use biofuel.
4. Involvement of the public in popularizing the use of biofuels. This can be done by conducting information campaigns, teaching materials in the media, organizing meetings and meetings with interested parties.
5. Development of the infrastructure necessary for the use of biofuels, such as a network of biofuel filling stations, storage and transportation of biofuels, as well as training of specialists.

Technical methods of modernization:

1. Changing the fuel injection system: For the efficient use of biofuel, it is necessary to change the fuel injection system, because biofuel has a different viscosity and density than conventional fuel. This may include replacing the nozzles with special ones that provide more efficient fuel atomization.
2. Increased compression: Engines that run on biofuels must have higher compression to ensure more efficient combustion of the fuel. This can be done by changing the shape of the combustion chamber or replacing the pistons.
3. Changing the lubrication system: Biofuels can be less effective at lubricating engine parts, which can lead to higher wear and maintenance costs. One way to reduce this effect is to replace the lubricant or change the lubrication method.
4. Increased cooling efficiency: The use of biofuel can cause more thermal stress on the engine, so more efficient cooling is necessary for its efficient operation. This may include replacing radiators or increasing their size.
5. Installation of energy recovery systems: Energy recovery systems, such as hybrid engines, can provide greater engine efficiency, reducing fuel consumption.

4. Conclusions

The use of biofuel as one of the directions of modernization of the energy sector is an important step in achieving sustainable development and ensuring environmental sustainability. Our research shows that biofuels have significant potential to reduce the negative impact on the environment and improve the efficiency of energy systems. Achieving these benefits depends on properly designing implementation strategies and addressing some of the challenges facing biofuel use.

First, it is necessary to continue scientific research and development of technologies to increase the efficiency of biofuel use in diesel generators and other power plants. Optimizing engine parameters, structural changes, and fuel mixtures will make it possible to maximize the potential of biofuels and ensure the sustainability of energy processes.

Secondly, it is necessary to create a favorable environment for the development of the biofuel industry, to attract investments and financial support for the construction of infrastructure for the production, storage and supply of biofuel. Support from the state and business will contribute to the active development of the biofuel industry and its integration into the energy sector.

Thirdly, it is worth paying attention to the balanced use of resources for growing energy crops. Promotion of biofuels should not adversely affect food security or pollute land resources. It is necessary to develop methods of efficient use of agricultural and woodworking waste for the production of biofuel.

In general, the use of biofuels is a promising direction for the modernization of the energy sector. Its ability to reduce pollutant emissions and improve the state of the environment makes it an important tool for achieving sustainable development. Actively promoting the introduction of biofuels will ensure a stable

and more sustainable energy sector, which will contribute to the prosperity of society and the preservation of natural resources for future generations.

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