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Analysis of the state, potential and marketing support of bioenergy development in Ukraine in the context of European and world experience

Abstract: The article analyzes the potential and marketing support for the development of bioenergy in Ukraine, taking into account European and world experience. It is determined that Ukraine has a significant bioenergy potential, which, however, is not fully realized due to a number of barriers. It is proven that one of the key problems is the ambiguous awareness of business and the population about the production of biofuels. Among large and medium-sized businesses in the agricultural and woodworking sectors, awareness is relatively high, while among the population, it remains limited.

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It has been determined that Ukraine has the potential of a raw material base for biofuels production, estimated at 22–25 mt of oil equivalent per year, of which the largest share is accounted for by agricultural residues. The main barriers to the development of biofuels production are identified, namely high initial investment, underdeveloped infrastructure, complex regulatory procedures, low awareness, and lack of qualified personnel.
It is substantiated that in the context of post-war reconstruction and European legislation, decentralization of electricity production using modern energy technologies is absolutely necessary. It has been determined that to improve the marketing support for bioenergy development in Ukraine, the following priority areas have been identified: first and foremost, conducting information and educational campaigns to raise awareness among the public and businesses regarding the benefits and opportunities of bioenergy; followed by the development and implementation of effective financial instruments, such as soft loans, grants, and subsidies for relevant projects; and finally, the improvement of the regulatory framework by simplifying licensing procedures and establishing stable rules for investors.

Keywords: bioenergy, marketing support, energy security, food security, post-war reconstruction

Introduction

In Ukraine, there is an ambiguous trend in the awareness of businesses and households about biofuels production at enterprises and in households. On the one hand, there is significant potential and interest, and on the other hand, there are gaps in understanding and practical application.

Among large and medium-sized businesses, especially in the agricultural and wood processing sectors, the level of awareness of biofuel production opportunities is relatively high. This is because these sectors have significant amounts of biomass (production waste, straw, sunflower husks, livestock waste) that can be used as feedstock. Many companies already realize the economic benefits of converting their waste into energy, as it reduces the cost of traditional energy sources and improves environmental performance.

Today, there are examples of successful biodiesel and bioethanol plants, although some capacity remains underutilized. This indicates that while knowledge of the technology and potential exists, there are other barriers (e.g., regulatory, financial, logistical) that prevent the full realization of this potential. Businesses are also aware of government support programs and preferential lending that encourage investment in bioenergy. However, smaller enterprises and those not directly related to the agricultural sector or wood processing may have less awareness.

Among the population, particularly in households, the level of awareness of biofuel production opportunities (e.g., pellets, briquettes from agricultural waste or wood for heating) is lower than among large businesses. While many people are familiar with the concept of biofuels as an alternative to gas or coal, there is limited understanding of technologies for producing them at home or using local waste for energy needs.

There is interest in energy independence and lower utility bills, which creates a demand for information on alternative heating sources. However, there is often a lack of practical knowledge about:

- the raw material base, namely, what kind of waste can be used (straw, sawdust, low-quality firewood, grain husks, etc.);
- available technologies because there are simpler and more affordable processing technologies for home use (e.g., pellet mills, briquette presses);
- economic benefits since there is no reliable data on the calculation of payback and savings when switching to biofuels of own production;
- a small number of state support programs. Although there are programs of interest-free loans for solar panels and wind turbines, awareness of support for the production of biofuels for own needs (e.g., for solid fuel boilers) may be lower.

It is also worth noting that there are few awareness-raising campaigns and demonstration projects, which are important for raising this awareness and building trust in biofuels.

In general, we can say that Ukraine has significant bioenergy potential, but its full unlocking depends on raising awareness and removing existing barriers. For business, this is often related to optimizing regulatory policy and access to finance, while for the population, it is related to disseminating practical knowledge, demonstrating successful cases, and making small-scale technological solutions available for home use.

Studies (Trypolska et al. 2023) have shown that Ukraine, despite its considerable experience in renewable energy development, faces challenges due to the war, and decentralization of electricity production using modern energy technologies is becoming absolutely necessary, which coincides with the requirements of European energy and climate legislation.

At the same time, as noted by Kucher et al. (2025), the transition to sustainable energy remains the most important for the EU economy, where the biogas sector can already provide a competitive and sustainable alternative to imported fossil gas through domestic production.

Studies (Koval et al. 2025) have found that the main sources of biomass for biogas production in Ukraine are plant residues (71.4%), manure (26.6%), and food waste (2.0%). The implementation of biogas projects will help reduce greenhouse gas emissions by 3.98 billion tons of CO_2 and increase profits from electricity sales.

The study (Akhambayev et al. 2025) concludes that an integrated approach that combines technological, economic, and social factors can significantly improve energy efficiency, reduce environmental impact, and contribute to the sustainable development of local communities.

At the same time, as noted by Pysarenko et al. (2024), in the post-war recovery strategy, the key areas of research are the adaptation of production to the requirements of the bioeconomy, the introduction of environmental technologies, and the development of efficient and cost-effective sales channels.

Previous studies (Hontaruk et al. 2024) have substantiated the need to develop biogas and digestate production at Ukrainian sugar factories focused on the further sale of biomethane on the energy market and for their own needs, which will partially ensure the energy security of the state under martial law.

In addition to the production of biofuels from agricultural waste, it is advisable to grow energy crops, as research (Mazur 2020) has determined that one of the key indicators that determines the value of pearl millet as a bioenergy crop is the energy yield from solid biofuels.

Studies (Tokarchuk et al. 2022) show that Ukraine can use about 11–12 million hectares of arable land to grow energy crops and then process them into biofuels.

At the same time, studies (Talavyria et al. 2025) show that the potential of agricultural waste alone in Ukraine in 2024 is 134.4 thousand tons, 1.8 thousand tons of biodiesel, and 4.1 million m^3 of biogas.

It should also be noted that an indirect effect of biofuel production will be the possibility of providing agricultural producers with organic fertilizers, and will have a positive effect on the development of organic production. As noted by Honcharuk et al. 2025, organic farming is developing dynamically in Ukraine, and the area of land under organic farming is increasing every year, and the use of digestate will increase the competitiveness of these products.

Studies (Kaletnik et al. 2025) have shown that organic fertilizer application can have a positive impact on soil restoration, as soil acidity changed from slightly acidic (5.4 pH) to close to neutral (6 pH) in one year of application.

Thus, despite the significant bioenergy potential of Ukraine, its full disclosure is constrained by low public awareness of home biofuel production and existing barriers to business, which require optimization of regulatory policy, dissemination of practical knowledge, and demonstration of successful cases. At the same time, the development of the biogas industry and the production of biofuels from agricultural waste and energy crops are critical for Ukraine's energy security and post-war recovery, as well as contribute to the reduction of greenhouse gas emissions and the development of organic farming.

Based on the above analysis of the awareness and potential of biofuels production in Ukraine, as well as the current challenges and opportunities facing the country, the following research objectives can be formulated:

- to study the structure of biofuels production in Ukraine as of 2024, including solid, liquid, and gaseous biofuels;
- characterize the potential of the raw material base for biofuels production in Ukraine;
- to highlight successful cases of enterprises and projects engaged in biofuel production in Ukraine;
- to conduct a comprehensive marketing analysis of key barriers and incentives affecting the development of alternative energy in Ukraine;
- to compare EU and Chinese practices in stimulating biogas production;
- identify priority areas for improving marketing support for bioenergy development in Ukraine.

1. Materials and methods

The study is based on the collection and analysis of information from official statistics, industry reports and publications, scientific research, and information from relevant ministries and agencies.

To achieve the set goals, the following research methods were used: systematic approach, marketing analysis, comparative analysis, tabular presentation of data, hierarchical analysis, and descriptive method.

The study is based on the collection and analysis of information from the following sources:

- data from the State Statistics Service of Ukraine to assess the potential of the raw material base, biofuel production volumes, and general economic indicators;
- statistical materials of the Bioenergy Association of Ukraine, which provide up-to-date information on the state of the industry, existing producers, and their capacities;
- analyzed articles and research by scientists covering the development of bioenergy, biogas technologies, as well as legal regulation and marketing aspects. Particular attention is paid to publications related to the experience of the EU and China in stimulating biogas production;
- data from the Ministry of Energy of Ukraine on state support programs and preferential lending for citizens and businesses were used.

The following research methods were used to achieve the set goals:

- a systematic approach that allowed us to consider bioenergy as a complex system interconnected with economic, environmental, social, and regulatory aspects;
- a marketing analysis of key barriers and incentives affecting the development of alternative energy in Ukraine. Economic, infrastructural, regulatory, administrative, social, psychological, technological, and human resources aspects are considered;
- the practices of stimulating biogas production in the EU and China are compared to identify effective approaches that can be adapted in Ukraine;
- a hierarchical analysis was used to identify priority areas for improving marketing support for bioenergy development in Ukraine, with high, medium, and low/long-term priorities.

This study focuses on the analysis of marketing support for the development of alternative energy in Ukraine, mainly bioenergy. Although global and European experience is used, the main focus is on the specifics of the Ukrainian market. The information is based on available public sources and reports as of 2024–2025.

2. Results

Ukraine has a dynamic but ambiguous situation in the field of biofuels production, characterized by significant potential, but also by significant barriers to its full disclosure.

As shown in Table 1, solid biofuels are the cornerstone of Ukraine's bioenergy sector, with the lion's share of pellet and briquette production (over 90%) focused on exports to the European Union. This emphasizes the significant potential of Ukraine as a supplier of energy feedstock, but also points to the need to develop the domestic market.

Table 1. Structure of biofuels production in Ukraine as of 2024

Tabela 1. Struktura produkcji biopaliw w Ukrainie w 2024 r.

Type of biofuel	Main raw material	Estimated capacity/ production volume (per year)	Main producers	Challenges
Solid biofuels				
Pellets, briquettes	Sawdust, wood chips, straw, sunflower husk, energy plants (willow, poplar)	2 million tons (export-oriented)	Small and medium-sized enterprises, agricultural holdings	Instability of raw materials, quality (ash content), export orientation (>90% to the EU)
Liquid biofuels				
Bioethanol	Corn, molasses	300 thousand tons (with potential up to 500 thousand tons)	About 22 plants (some of them are unstable), new private investments (e.g., OKKO)	Dependence on raw material prices, regulatory issues, competition with grain exports
Biodiesel	Rapeseed oil, sunflower oil, animal fats	100 thousand tons (with potential of 300–500 thousand tons)	About 14 large and 50 smaller plants	Market uncertainty, lack of stable domestic demand, competition with oil exports
Gaseous biofuels				
Biogas (for electricity/heat production)	Manure, organic waste, silage corn, sugar factory waste	200–300 MW of electricity capacity (installed)	Agroholdings, farms, sugar factories	High capital intensity, dependence on the "green" tariff, logistics of raw materials
Biomethane (purified biogas supplied to the gas network)	Manure, organic waste, silage	Potential of up to 1 bcm (at the initial stage)	First pilot projects, interest from European companies	Development is just beginning, high quality requirements, investments in infrastructure, legislative framework

Source: own research based on data from the Bioenergy Association of Ukraine.

In the liquid biofuels segment, bioethanol is produced mainly from corn and molasses. Although there are about 22 plants in the country, not all of them are operating at full capacity. Planned new investments, such as those by OKKO, indicate that this area is promising. Biodiesel production, while having a significant installed capacity, faces challenges from market uncertainty and competition from crude oil exports.

Gaseous biofuels are represented by biogas and biomethane. Biogas generated from organic waste is already used to produce electricity and heat, mostly by plants integrated into agricultural holdings. However, the real breakthrough is expected to come from the development of biomethane, a purified biogas that can be pumped directly into the gas transportation system. Although this area is just beginning to develop, its potential of up to 1 billion cubic meters indicates significant opportunities for energy independence and integration with European markets.

Ukraine has a significant, but still underutilized, raw material potential for biofuels production, which is a key step towards strengthening the country's energy independence. The total estimated energy potential is estimated at an impressive 22–25 million tons of oil equivalent per year. This demonstrates a real opportunity to significantly reduce dependence on traditional fossil fuels, which is especially important in the context of global energy challenges (Table 2).

Table 2. Potential of the raw material base for biofuels in Ukraine

Tabela 2. Potencjał surowcowy dla biopaliw w Ukrainie

Type of feedstock	Estimated energy potential (million tons of oil equivalent/year)	Main raw materials for production
Agricultural residues	14–15	Straw, corn stalks, sunflower husks
Wood biomass (waste, energy plantations)	6–7	Wood waste, unused forest resources, energy plantations
Other (manure, food industry waste, etc.)	2–3	Sources for biogas, industrial waste
Total potential	22–25	Significant potential, but subject to logistical and economic constraints

Source: compiled by the authors based on data State Statistics Service of Ukraine.

The heart of Ukraine's bioenergy potential lies in agricultural residues, which account for the largest share – 14–15 million tons of oil equivalent annually. Straw, corn stalks, and sunflower husks, as by-products of Ukraine's robust agricultural sector, are ideal candidates for processing into biofuels. This resource is not only renewed every year, but also allows for the efficient use of existing agricultural infrastructure for collection. However, it is important to keep in mind the logistical challenges and the need to consider their alternative use as organic fertilizers.

Table 3 provides specific examples of enterprises and projects involved in biofuel production in Ukraine. It illustrates the diversity of approaches to bioenergy in the country, from large industrial complexes to small farm initiatives, which is important for understanding the structure and potential of the industry.

Table 3. Characteristics of key biofuel producers in Ukraine as of 2024

Tabela 3. Charakterystyka głównych producentów biopaliw w Ukrainie w 2024 r.

Category	Company name	Type of biofuel	Raw materials	Estimated production volumes
Biogas complexes	MHP (Myronivsky Hliboproduct), in particular Ladizhyn ECO Generation and the station at Oril-Lider	Biogas (for electricity and heat production)	Chicken manure, poultry processing waste	The total electric capacity is over 20 MW, which ensures electricity production of about 160–180 GWh/year.
	BIOGAZ ENERGY LLC (Gnidavsky Sugar Plant)	Biogas (electricity, heat)	Beet pulp, sugar production waste	Electric capacity of about 6 MW, which ensures electricity production of about 40–50 GWh/year.
	Astarta-Kyiv (based at the Globyne Sugar Plant)	Biogas (electricity)	Waste from sugar production	The electric capacity is about 5 MW.
	Ukrainian Milk Company	Biogas (electricity)	Cattle manure	Electricity capacity of about 1.5 MW.
Production of pellets/ briquettes	Kronospan UA	Wood pellets/ briquettes	Wood processing waste (sawdust, shavings)	Tens of thousands of tons of pellets/briquettes per year.
	Ukrpeleta LLC and similar specialised producers	Wood pellets	Wood processing waste	From several thousand to tens of thousands of tons of pellets per year, depending on the scale.
	Farms and private initiatives	Agro pellets/agro briquettes	Straw, sunflower husk, corn stalks	From several tens to several hundred tons per year.
Bioethanol production	Biochim Group (Biochim OTC, elevator, bioethanol plant)	Bioethanol	Corn	The theoretical capacity could reach 50–100 thousand tons of bioethanol per year, but actual volumes may vary.

Source: compiled by the authors based on data State Agency on Energy Efficiency and Energy Saving of Ukraine (SAEE), Bioenergy Association of Ukraine.

In the segment of biogas complexes, leading companies are MHP (Myronivsky Hliboproduct) with its Ladyzhyn ECO Generation and Oril-Leader projects. These facilities produce biogas for further electricity and heat generation using chicken manure and poultry processing waste. As one of the largest biogas complexes in Europe, it demonstrates a closed cycle of production and waste utilization, providing an electric capacity of over 20 MW, which translates into about 160–180 GWh/year. Other significant players include BIOGAS ENERGO LLC (based at the Hnidavsky Sugar Plant), which processes beet pulp and other sugar production waste to generate about 6 MW of electricity (40–50 GWh/year). Astarta-Kyiv, with its unit at the Globinsky Sugar Plant, produces about 5 MW of electricity from sugar production waste. Ukrainian Dairy Company uses cattle manure to produce about 1.5 MW of electricity.

Kronospan UA is a significant player in the production of pellets and briquettes. This one of the largest wood-based panel producers in Ukraine uses its own woodworking waste (sawdust, shavings) to produce tens of thousands of tons of pellets/briquettes per year. Numerous specialized producers, such as Ukrpeleta LLC, process wood processing waste into wood pellets, with production volumes ranging from several thousand to tens of thousands of tons per year. The total annual production of wood pellets in Ukraine is hundreds of thousands of tons. An important component is farms and private initiatives that produce agro-pellets/agro-briquettes (from straw, sunflower husks, corn stalks) for their own needs or local sales, with volumes ranging from several tens to several hundred tons per year per farm.

In the bioethanol and biodiesel production segment, Biochem Group (Biochem) stands out. One of the largest bioethanol producers in Ukraine, it uses corn, and its theoretical capacity could reach 50–100 thousand tons of bioethanol per year, although actual volumes may vary. Some agricultural holdings and oilseed processing companies also produce biodiesel from rapeseed and sunflower. These are mostly small or medium-sized facilities integrated into agro-industrial complexes, with volumes ranging from several hundred to several thousand tons per year.

The data presented here emphasize the diversity and significant potential of the Ukrainian biofuels market, which is an important element of the country's energy independence and sustainable development.

We have conducted a comprehensive marketing analysis of the key barriers and incentives affecting the development of alternative energy in Ukraine. The analysis covers various aspects, from financial to social, which allows us to dive deep into this complex topic (Table 4).

As for the economic aspects, the bilateral nature of the financial impact is clearly evident. The main barriers are high initial investments, which require significant capital to start projects. Another significant obstacle is the long payback period, as investors have to wait a long time for a return on their investment, which reduces investment attractiveness. For some technologies, generation instability requires additional investment in power supply stabilization systems, increasing the total cost of the project. Competition with traditional energy sources, which have an established infrastructure and often offer lower, albeit unstable, prices, should not be forgotten.

At the same time, the incentives in this area are economic benefits in the long run, including lower operating costs for fuel and stable energy prices, making alternative energy attractive in the long run. Government support and incentives, such as feed-in tariffs, soft loans, subsidies, and tax breaks, play a significant role in making the industry more attractive for investment. Due to constant scientific and technological progress, the cost of technology is decreasing, as the cost of equipment for alternative energy sources is constantly decreasing. Another important opportunity is the sale of surplus energy to the grid, which creates additional income for producers, increasing the profitability of projects.

In terms of infrastructure, the main barrier is the underdeveloped infrastructure of electricity transmission and distribution networks. This creates significant difficulties for the integration of new, often decentralized, capacities. The corresponding incentive is to invest in the modernization and expansion of power grids, which is absolutely critical for the successful development of the industry.

Table 4. Marketing analysis of barriers and incentives for the introduction of alternative energy in Ukraine

Tabela 4. Analiza marketingowa przeszkód i czynników sprzyjających wdrażaniu energii alternatywnej w Ukrainie

Category	Barriers to implementation	Incentives for implementation
Economic	High initial investments	Economic benefits in the long run (reduced fuel costs, stable prices)
	Long payback period	Government support and incentives (green tariffs, soft loans, subsidies, tax breaks)
	Instability of generation requiring additional investments (for some technologies)	Reducing the cost of technologies through their development
	Competition with traditional energy sources with established infrastructure and possible lower prices	Possibility to sell surplus energy to the grid
Infrastructure.	Underdeveloped infrastructure of electricity transmission and distribution networks	Investments in modernization and expansion of energy networks
Regulatory and administrative	Complex procedures for obtaining permits	Creating a favorable regulatory environment (stable policy, clear rules)
	Lack of clear and stable state policy	Simplification of administrative procedures
	Bureaucratic delays	Establishing clear timelines for obtaining permits to launch alternative energy production projects.
Social and psychological	Low consumer awareness and distrust	Information and awareness campaigns
	Stereotypes and prejudices about new technologies	Demonstration projects and success stories
Technological and Human resources	Lack of qualified personnel for installation design and maintenance	Training and retraining programs
		Supporting the development of domestic equipment production
General	Creation of new jobs and development of related industries	Improving energy efficiency and energy saving as a concomitant process

Source: own research.

This aspect highlights the significant obstacles associated with public administration. These barriers include complex permitting procedures, as bureaucratic processes and permitting mechanisms are often overly complicated and time-consuming, slowing down project implementation. A significant problem is the lack of a clear and stable government policy, which causes uncertainty about future rules of the game and frequent changes in legislation, creating

risks for investors. Also worth noting are bureaucratic delays that lead to a general slowdown in processes due to administrative obstacles and the lack of efficiency of government agencies.

In contrast, the incentives are to create a favorable regulatory environment that provides for a stable and predictable government policy, as well as clear and understandable rules of the game for all market participants. An important step is to simplify administrative procedures, i.e., to optimize and accelerate permitting mechanisms, increase their transparency and accessibility.

In the social and psychological sphere, it is noted that low consumer awareness and distrust, as well as stereotypes and prejudices about new technologies, are the main barriers. To overcome them, awareness-raising campaigns, demonstration projects, and success stories are proposed that can effectively change public perception and increase trust.

The lack of qualified personnel for the design, installation, and maintenance of alternative energy systems is a major barrier. Incentives to overcome this problem include training and retraining programs, as well as support for the development of domestic equipment production, which will help create local expertise and reduce dependence on imports.

It is also worth highlighting the overall positive effects of the introduction of alternative energy. The incentives here include improving energy efficiency and energy saving as a concomitant and integral process that enhances the positive effect of alternative energy implementation. In addition, it contributes to the creation of new jobs and the development of related industries, which helps economic growth, economic diversification, and overall welfare.

In Table 5, we present an analysis of the various support programs available in Ukraine to encourage the adoption of alternative energy sources, both for individuals, businesse, and communities. These initiatives are designed to reduce the financial burden and accelerate the transition to more sustainable energy solutions.

Currently, interest-free loans for the installation of solar panels and wind turbines, including energy storage systems, are available to Ukrainian citizens. The amount of such support can reach up to UAH 480 thousand, with a zero interest rate and a maturity of up to 10 years, making investments in home alternative energy much more affordable.

Homeowners' associations (HOAs) can take advantage of grants under the Grindim program. This initiative covers the installation of solar panels and heat pumps. The maximum grant amount for solar panels is up to UAH 1 million, and for heat pumps, up to UAH 2 million. The Energy Efficiency Fund compensates a significant part of the costs, covering 70% of the project cost, which is a significant advantage for collective investment.

The "5–7–9" program offers preferential loans for small and medium-sized businesses that want to invest in energy equipment, including even gas generation. The maximum loan amount can reach UAH 150 million, and the loan rate is 7% with a term of up to 10 years, providing favorable conditions for modernization and energy efficiency of enterprises.

The Decarbonization Fund provides concessional loans to businesses and communities to implement decarbonization projects. This support covers solar power plants, heat pumps, and cogeneration units. The amount of loans can be up to UAH 25 million, with an interest rate of up to 9%, which stimulates the transition to clean and efficient energy sources at the community and large enterprise levels.

Table 5. Areas of state support for citizens and businesses to ensure energy independence

Tabela 5. Obszary wsparcia ze strony państwa dla obywateli i przedsiębiorstw w celu zapewnienia niezależności energetycznej

Type of support	Description of equipment	Amount of support/lending
Interest-free loans for citizens	Solar panels and wind turbines with storage systems	Amount up to UAH 480 thousand / 0% interest rate for up to 10 years
Grants to condominiums under the Grindim program	Solar panels, heat pumps	For solar panels up to UAH 1 million For heat pumps up to UAH 2 million The Energy Efficiency Fund compensates 70% of the project cost
Preferential loans "5–7–9" for SMEs	Energy equipment, including gas generation	The amount is up to UAH 150 million. Lending rate 7% with a term of up to 10 years
Concessional loans from the Decorbanization Fund for enterprises and communities	Solar stations, heat pumps, cogeneration units	Amount up to UAH 25 million / lending rate up to 9%
Preferential loans for large businesses	For the development of alternative generation, restoration of energy infrastructure	Amount up to EUR 25 million / interest rate 13.5%
Exemption of energy equipment from import duties and VAT	Tax exemption for individuals and businesses until January 01, 2026	Zero rate of VAT and import duty

Source: compiled by the authors based on data Website of the Ministry of Energy of Ukraine.

For large businesses, preferential loans are provided for the development of alternative generation and the restoration of energy infrastructure. The maximum loan amount in this case can reach EUR 25 million, and the interest rate is 13.5%, which allows for the implementation of large-scale projects aimed at energy independence and stability.

A general measure of support that applies to both individuals and businesses is the exemption of energy equipment from import duties and value-added tax (VAT). This benefit is valid until January 1, 2026, and means a zero rate of VAT and import duty, significantly reducing the cost of imported alternative energy equipment.

To improve the system of incentives for biofuels production in Ukraine, we have compared the practices of the EU and China in the field of biogas production incentives and systematized them in Table 6.

Both regions of the world are successfully developing biogas production, but their approaches differ. China relies on large-scale government programs and financial support, while the EU focuses on an integrated approach that combines legislative incentives, financing, and innovation. The analysis of China's and the EU's experience may be useful for other countries planning to develop biogas energy.

Table 6. Comparison of Chinese and EU practices in promoting biofuels production

Tabela 6. Porównanie praktyk stosowanych w Chinach i w UE w zakresie wspierania produkcji biopaliw

Aspect	China	European Union	Feasibility of implementation in Ukraine
Political strategy	National programs aimed at energy independence and environmental improvement	Integrated approach within the framework of the EU's common energy policy	Application of the EU's integrated approach to policy, combining national strategies with European standards and objectives. This will help harmonise legislation and gain access to European funds.
Financing	Public investments, subsidies, loans	Combination of public and private financial support, EU funds	Establishment of a system that combines state support (subsidies, preferential loans) with mechanisms to attract private investment. It is important to develop transparent rules and guarantees for investors.
Technologies	Emphasis on large-scale projects, use of local technologies	Focus on innovation, cooperation with scientific institutions	Implementing EU experience in cooperation with scientific institutions and focusing on innovation is key. This will enable Ukraine not only to implement existing technologies, but also to develop its own, more effective solutions.
Regulation	State regulation, development plans	Combination of legislation, market mechanisms and voluntary standards	Introduction of clear state legislation that simultaneously creates conditions for the development of market mechanisms (e.g., certificate trading systems) and introduces voluntary standards.

Source: compiled by the authors based on data China to launch rural pilot scheme for renewable energy (Tokarchuk et al. 2023; Kaletnik et al. 2022).

One example of support for the development of biogas production in China is the New Rural Energy Program. This program was launched in 2002 by the Chinese Ministry of Agriculture to promote the use of renewable energy sources in agriculture. One of the key initiatives of this program is to support the installation of biogas plants in households.

China and the EU have different approaches to the development of biogas energy, which gives Ukraine the opportunity to adapt the best practices of both regions. The Chinese model, based on large-scale government programmes and investments, could serve as a basis for the creation of national strategies and financial instruments. At the same time, the EU's experience, which focuses on innovation, integration, and cooperation between the private sector and scientific institutions, will help Ukraine to develop a transparent legislative framework and attract private investment, which is key to sustainable development. Combining these approaches will enable Ukraine not only to use its biological resources efficiently but also to harmonise its energy policy with European standards, which will promote energy independence and environmental safety.

In Table 7, a hierarchy of priority areas for improving marketing support for bioenergy development in Ukraine is presented.

Table 7. Areas of improvement of marketing support for bioenergy development in Ukraine (by priority)

Tabela 7. Obszary wymagające poprawy w zakresie wsparcia marketingowego dla rozwoju bioenergetyki w Ukrainie (według priorytetów)

Priorities/ years of implementation	Area of improvement	Detail and justification
High (2025–2026)	1. Overcoming low awareness and building trust (for households and small businesses)	Development and implementation of awareness-raising campaigns that emphasize practical knowledge about the raw material base (straw, sawdust, low-quality firewood, grain husks, etc.) and available technologies for home/ local use (pellet mills, briquette presses). Active promotion of demonstration projects and success stories to visualize the economic benefits and ease of use of biofuels. Providing reliable data and tools for calculating payback and savings when switching to biofuels of own production.
High (2025–2027)	2. Optimization of regulatory policy and administrative procedures	Ensuring clear, stable and predictable state policy in the field of bioenergy to reduce risks for investors. Simplification of bureaucratic processes and permitting mechanisms for biofuel projects. Developing and implementing a legislative framework to stimulate biomethane production, which will allow its injection into the gas transportation system and integration with European markets. Extension of the exemption of energy equipment from import duties and VAT after January 1, 2026.
Medium (2025–2026)	3. Development of financial instruments and state support	Further development and popularization of existing programs (interest-free loans for citizens, grants from Grindim condominiums, preferential loans "5–7–9" for SMEs, preferential loans from the Decarbonization Fund, preferential loans for large businesses). Stimulating the domestic biofuels market, especially solid biofuels, which is currently focused mainly on exports. Analyze barriers that lead to underutilization of existing bioethanol and biodiesel production capacities and develop programs to support them.
Medium (2025–2027)	4. Human resources and infrastructure development	Investments in modernization and expansion of electricity transmission and distribution networks to ensure integration of new, decentralized bioenergy capacities. Introduce and expand training and retraining programs for designing, installing and maintaining bioenergy systems. Support the development of domestic production of bioenergy equipment.
Low long-term (2025–2030)	5. Adaptation of international and European experience	Detailed study and adaptation of successful practices of the EU (integrated approach, focus on innovations, cooperation with scientific institutions) and China (large-scale government programs, financial support) in the field of stimulating biogas production. Taking into account the requirements of European energy and climate legislation and integrating Ukrainian bioenergy into the context of the EU Green Deal. Adaptation of production to the requirements of the bioeconomy and introduction of environmental technologies.

Source: author's vision.

The high-priority areas include the need to overcome the low awareness of the population and small businesses about the benefits of bioenergy, as well as the optimization of regulatory policy and administrative procedures. The rationale emphasizes the importance of developing awareness-raising campaigns and simplifying permitting mechanisms to create a favorable environment.

Medium priority is given to the development of financial instruments, including further popularization of existing programs to support and stimulate the domestic biofuels market. In addition, emphasis is placed on human resources and infrastructure development, which includes investments in the modernization of networks and the expansion of training programs.

The low/long-term priority is the adaptation of global and European experience, which is strategically important for the integration of Ukrainian bioenergy into the context of the EU's Green Deal and the introduction of innovative technologies.

Ukraine has made significant, albeit mixed, progress in bioenergy development, driven by the rich potential of its raw material base, especially in agriculture. The production of solid biofuels, mainly pellets and briquettes, is highly export-oriented, which emphasizes Ukraine's competitiveness in the international market, but also points to the need to boost domestic consumption. The development of liquid and gaseous biofuels, in particular biomethane, is at an early stage, but has great prospects for strengthening energy security and integration into the European gas transportation system.

Despite its potential, the industry faces a number of systemic barriers. Economic obstacles include high initial investments and long payback periods, while infrastructure challenges are related to underdeveloped energy networks. Regulatory and administrative barriers are also significant, manifested in complex procedures, unstable government policies, and bureaucratic delays. Social and psychological aspects, such as low consumer awareness and distrust, as well as a lack of qualified personnel, slow down the rapid adoption of bioenergy solutions.

To overcome these challenges and fully unlock the potential of Ukraine's bioenergy sector, a comprehensive approach is needed that prioritizes actions. This includes raising awareness and building public trust, optimizing regulatory policy to create a predictable and transparent environment, and further developing financial instruments and government support programs aimed at stimulating both production and domestic consumption of biofuels.

In addition, investments in human resources and infrastructure development, including the modernization of energy networks and the expansion of training programs, are strategically important. Equally important is the adaptation of global and European experience, which will allow Ukraine to integrate its bioenergy sector into the context of the EU's Green Deal and effectively implement advanced technologies. Implementation of these areas will contribute not only to economic growth but also to increased energy independence and sustainable development of the country.

Given the high cost of biomethane production, it is necessary to diversify financial instruments, moving away from the classic "green tariff" model, in order to attract investment (Table 8). The following is proposed:

- introduction of special state programmes with low interest rates, similar to successful European programmes, to reduce financial risks for investors;

- issuing government green bonds to attract capital from private and institutional investors;
- creation of a fund, to be financed by a CO_2 tax, to directly finance bioenergy projects of strategic importance to the state.

Table 8. Proposals for diversifying financial instruments and developing bioenergy in Ukraine

Tabela 8. Propozycje dotyczące dywersyfikacji instrumentów finansowych i rozwoju bioenergetyki w Ukrainie

Proposal	Description	Objectives and benefits
Preferential lending	Introduction of special state programs with low interest rates for biomethane production projects.	Reducing financial risks for investors, stimulating investment, accelerating project implementation.
Green bonds	Issuance of government bonds intended exclusively for financing environmental projects.	Attracting capital from private and institutional investors, increasing the investment attractiveness of green projects.
Decarbonisation fund	Creation of a fund to be financed by a CO_2 emissions tax.	Targeted financing of strategic bioenergy projects that contribute to the achievement of decarbonization goals.
Self-production mechanism	Enabling businesses and households to produce energy for their own needs and sell any surplus.	Improving energy sustainability, reducing the load on centralized networks, promoting decentralization and energy security.

Source: author's vision.

Particular attention should be paid to the development of decentralised generation. Self-production mechanisms should become the basis for improving energy sustainability, allowing businesses and private households not only to meet their own needs but also to sell surplus energy. This initiative helps reduce the load on centralised networks and improve Ukraine's overall energy security, which is critically important in the context of military challenges.

Conclusions

It has been established that Ukraine has a significant potential in the production of solid, liquid, and gaseous biofuels, with a significant part of solid biofuels (pellets and briquettes) being exported, and the production of liquid biofuels and biogas showing potential for growth, although it faces challenges in terms of full capacity utilization and market uncertainty.

It is determined that Ukraine has a huge potential of raw materials for biofuels, including agricultural residues (straw, corn stalks, sunflower husks), wood biomass, manure, and food industry waste, which together can provide a significant amount of energy equivalent.

Successful examples of functioning biogas complexes, pellet/briquette and bioethanol producers are presented, which confirms the practical realization of bioenergy potential in Ukraine and demonstrates opportunities for further development.

It has been found that the development of bioenergy in Ukraine is constrained by high investment costs, regulatory and bureaucratic obstacles, as well as low public awareness, while government support, economic benefits, and reduced technology costs are key incentives.

Priority areas are proposed, including optimization of regulatory policy, access to finance, dissemination of practical knowledge, demonstration of successful cases, development of the biogas industry, and implementation of an integrated approach to improve energy efficiency and sustainable development.

The first priority is to optimize the regulatory policy, which involves simplifying licensing procedures and developing transparent mechanisms of state support, for example, through feed-in tariffs, to attract investment and ensure sustainable development. The second priority is to ensure access to finance through the introduction of concessional lending programs and public-private partnership mechanisms for all market participants. Educational work is also important – disseminating practical knowledge and information among the population about the economic benefits, available raw materials, and simple biofuel production technologies. To stimulate implementation, it is necessary to demonstrate successful cases and promote the availability of small-scale technological solutions. The strategic direction is to develop the biogas industry and produce biofuels from agricultural waste and energy crops, which will increase energy security and create new sources of income. For comprehensive development, an integrated approach combining technological, economic, and social factors, including research and community involvement, should be implemented. Finally, the adaptation of production to the requirements of the bioeconomy and the development of efficient marketing channels are key to the post-war recovery and development of organic farming.

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Analiza stanu, potencjału i wsparcia marketingowego rozwoju bioenergetyki w Ukrainie w kontekście doświadczeń europejskich i światowych

Streszczenie

W artykule przeanalizowano potencjał oraz wsparcie marketingowe dla rozwoju bioenergetyki w Ukrainie, z uwzględnieniem doświadczeń europejskich i światowych. Stwierdzono, że Ukraina dysponuje znacznym potencjałem bioenergetycznym, który jednak nie jest w pełni wykorzystywany z powodu licznych przeszkód. Wykazano, że jednym z kluczowych problemów jest niejednoznaczna świadomość przedsiębiorców i społeczeństwa dotycząca produkcji biopaliw. Wśród dużych i średnich przedsiębiorstw z sektorów rolnego i drzewnego świadomość ta jest stosunkowo wysoka, natomiast wśród społeczeństwa pozostaje ograniczona.

Ustalono, że Ukraina dysponuje potencjałem surowcowym do produkcji biopaliw, szacowanym na 22–25 mln ton ekwiwalentu ropy naftowej rocznie, z czego największy udział mają odpady rolnicze. Zidentyfikowano główne bariery rozwoju produkcji biopaliw, a mianowicie wysokie nakłady inwestycyjne, słabo rozwiniętą infrastrukturę, skomplikowane procedury regulacyjne, niską świadomość oraz brak wykwalifikowanej kadry.

Ustalono, że w kontekście powojennej odbudowy oraz prawodawstwa europejskiego decentralizacja produkcji energii elektrycznej z wykorzystaniem nowoczesnych technologii energetycznych jest absolutnie konieczna. Ustalono, że w celu poprawy wsparcia marketingowego dla rozwoju bioenergetyki w Ukrainie określono następujące obszary priorytetowe: przede wszystkim prowadzenie kampanii informacyjnych i edukacyjnych mających na celu podniesienie świadomości społeczeństwa i przedsiębiorstw na temat korzyści i możliwości związanych z bioenergetyką; następnie opracowanie i wdrożenie skutecznych instrumentów finansowych, takich jak preferencyjne pożyczki, dotacje i subsydia na odpowiednie projekty; oraz wreszcie poprawa ram regulacyjnych poprzez uproszczenie procedur licencyjnych i ustanowienie stabilnych zasad dla inwestorów.

Słowa kluczowe: bioenergia, wsparcie marketingowe, bezpieczeństwo energetyczne, bezpieczeństwo żywnościowe, odbudowa powojenna