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Energy supply of Ukrainian enterprises: barriers and prospects for the implementation of bioenergy projects

Abstract: The article is devoted to the analysis of the state of energy supply of Ukrainian enterprises in the conditions of military aggression, global challenges, and European integration aspirations of Ukraine. The problems of the centralized energy system inherited from the USSR, which no longer meets the needs of the national economy, are highlighted, and the need to develop distributed generation based on renewable energy sources and bioenergy is emphasized. Particular attention is paid to the connection between energy security, economic stability, and sustainable development goals. The advantages of alternative energy for small and medium-sized businesses are highlighted, in particular, the possibilities of energy independence of enterprises, diversification of energy supply sources, and participation in the formation of local energy markets. The article analyzes the current state and dynamics of the development of the renewable energy sector in Ukraine, identifies barriers and prospects for the implementation of bioenergy projects, especially the construction of biomethane plants. The experience of Ukraine and the EU countries in this area is compared, and European regulations on energy efficiency and environmental responsibility, which are mandatory

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for Ukraine's integration into the European market, are analyzed. The economic, environmental, and social aspects of the energy strategy of enterprises are considered, as well as the role of the agro-industrial complex in the production of biofuels. The need to attract investments, harmonize legislation, and exchange experience with the EU to strengthen Ukraine's energy security is emphasized.

Keywords: energy supply, bioenergy, renewable energy sources, energy efficiency

Introduction

As a result of the military aggression against Ukraine, representatives of business, cities, and territorial communities are forced to create their own independent generation. The philosophy of the brutal centralized energy system, inherited from the times of the USSR, currently does not meet existing needs, and in terms of Ukraine's integration into the European energy space, it is losing its viability; therefore, there is a need to implement new approaches of distributed generation, based on alternative energy sources and bioenergy.

The model of the centralized energy system of Ukraine historically performed the function of ensuring large-scale, planned energy supply to industrial, agricultural, and urbanized centers within a single energy infrastructure. Such construction of the energy sector had its technical and economic feasibility in the context of a centralized planned economy, but it turned out to be extremely vulnerable in the conditions of modern challenges – in particular, war, cyberattacks, climate risks, and changes in the market paradigm. The experience of the centralized energy model of Ukraine provides several strategic lessons for the future design of a distributed system. First, the energy system should be physically and functionally decentralized – with a larger number of local energy sources, which can autonomously or semi-autonomously supply consumers. Second, it is necessary to ensure the digital integration of systems – the development of smart-grid technologies, demand forecasting, and intelligent load management. Third, the strategic goal should be energy resilience – the ability of local subsystems to maintain functionality in the event of external shocks. The lesson of centralization is a warning against excessive dependence on a "single point of failure", and at the same time an impetus for the development of a network of resilient, flexible, and dynamic energy centers that form the basis of Ukraine's future energy security.

Modern transformation processes in the energy sector of Ukraine are taking place in conditions of extremely high turbulence caused by the full-scale armed aggression of the Russian Federation, which led to massive destruction of critical energy infrastructure. In conditions of loss of centralized power generation capacities and growing energy vulnerability of businesses, local governments, and households, there is a critical need to transition to decentralized energy supply systems.

The relevance of the research is substantiated by the simultaneous action of several large-scale challenges, which form an urgent need for the transformation of the energy system of Ukraine. The war caused massive damage to power plants and power transmission lines, reducing generating capacity by more than half, as a result of which the centralized system lost its ability to guarantee the energy security of enterprises and regions. All this caused the need for businesses to switch to autonomous energy sources.

In addition to security challenges, an important prerequisite for the relevance of the study is Ukraine's orientation towards integration into the European energy space. Successful implementation of obligations under the Association Agreement with the EU, participation in the European Green Deal, harmonization with the Directives on energy efficiency and sustainable development, synchronization with ENTSO-E – all this requires a deep modernization of the national energy policy and energy supply practices at the enterprise level.

Against this background, the development of renewable energy sources, in particular bioenergy, as a tool for ensuring energy and economic security of enterprises, reducing dependence on imported energy resources, and achieving sustainable development goals, is of particular importance. Despite the significant potential of biomass and solar energy in Ukraine, the practical implementation of decentralized energy generation systems under martial law remains limited due to a number of barriers: economic, regulatory, technical and institutional.

Thus, the relevance of the topic of the article is due to the transitional period in which the energy sector of Ukraine is located – between the ruins of a centralized model and the possibility of building a flexible, sustainable, decentralized system that meets European standards. This article is an interdisciplinary study at the intersection of economics, energy, ecology, and politics. It is particularly valuable in the context of modern warfare, as it provides both practical guidance for enterprises and a macro-level perspective for strategic energy planning.

In this study, the authors aim to show the vulnerability of the centralized energy system in the conditions of military operations; assess the potential of alternative and bioenergy for business; substantiate the economic, environmental, and social feasibility of decentralizing energy generation; highlight the requirements of the EU and the opportunities for Ukraine to integrate into the European energy market. The main question of this study is: how to ensure the energy security of Ukrainian enterprises by switching to renewable energy sources in conditions of war, achieving the goals of sustainable development, and integration into the European energy space?

In the process of the study, an empirical approach was used to search for relevant information and statistical data, and to determine the level of approximation of Ukrainian legislation in the field of energy to EU legislation. The use of analytical and comparative methods made it possible to compare indicators in the energy sector of Ukraine and the EU countries. Paying more attention to the topic of energy and the use of renewable energy sources in general corresponds to the principles of a systems approach, within which the study of energy takes place in the context of sustainable development, highlighting economic, social, and environmental aspects.

As research shows (Strielkowski 2025), biomethane in Ukrainian conditions can become a key element of the "green" hydrogen-methane cluster, oriented towards export and local substitution of gas imports. The problems and potential opportunities of bioenergy based on

European experience were explored in the publication by Wu and Pfenninger (2022), which may be useful for analyzing the prospects and challenges of implementing bioenergy projects. A significant contribution to the quantitative assessment of the potential for biogas production was made by Kucher et al. (2022) in their publication, where, based on statistical data on crop residues, manure, poultry droppings, and food industry waste, the possibility of replacing up to 2.6 billion m³ of natural gas per year is substantiated. The authors single out agricultural enterprises as key players in this market, indicating the technical and economic feasibility of building biogas plants in combination with the production of organic fertilizers. Practical experience of biogas projects in Ukraine was also analyzed in the work of Havrysh et al. (2020), which examined several cases of operating biogas plants. The National Energy and Climate Plan for the period until 2030, among its main goals, provides for achieving a 27% share of renewable energy sources in total final energy consumption (Ministry of Economy of Ukraine 2024). In particular, technological solutions, problems of connection to energy networks, regulatory barriers, and financing options were investigated. Thus, the scientific literature clearly records both the technical and economic possibilities of implementing biogas and biomethane plants at Ukrainian enterprises, as well as the necessary political and regulatory steps to accelerate this process.

Research devoted to the study of models of energy supply of Ukrainian enterprises in accordance with the requirements of European integration is not only theoretically relevant, but also practically significant. It is aimed at identifying real mechanisms and tools for the formation of flexible, energy-efficient, and risk-resistant energy supply systems that meet both current challenges and strategic vectors of the country's development. Thus, the topic of this study corresponds to the priority scientific areas of Ukraine and the EU, and the results obtained can be used to develop recommendations both at the level of individual enterprises and for the formation of state policy in the energy sector in the context of transformation and recovery.

1. Analysis of the current state of energy supply of Ukrainian enterprises

The current realities and politico-economic challenges facing Ukraine have brought the issue of energy dependence to the forefront, thereby elevating the problem of both national energy security and energy security in business operations. A high reliance on imported energy resources poses a critical threat to national security as a whole, since uninterrupted industrial activity cannot be maintained without a stable energy supply. A number of government decisions aimed at addressing this issue on a national scale – particularly efforts to stimulate energy efficiency through raising tariffs to market levels in accordance with EU requirements – have triggered a chain reaction that resulted in increased heating and electricity costs for both households and enterprises.

An analysis of the current state of energy provision for Ukrainian enterprises reveals that the assessment of enterprise-level energy security remains a methodological challenge. Existing methodologies primarily address national energy security or are tailored to enterprises within the energy sector. However, they offer limited applicability for assessing the energy security of business entities that are not directly engaged in energy generation.

In general, energy dependence can be considered a key indicator of energy security, as evaluating the quality of energy supply is considerably complex. Based on this indicator, most enterprises (with the exception of those utilizing renewable energy sources) are energy-dependent, as they neither produce their own energy nor have a choice of suppliers – currently, the majority of entities lack the ability to select their electricity provider.

In recent years, renewable energy has experienced significant development in Ukraine. The main catalyst for this growth was the sharp increase in tariffs, prompting both households and small businesses to seek ways of conserving financial resources. According to the State Agency for Energy Efficiency and Energy Saving of Ukraine, nearly 15,000 Ukrainian households installed solar systems in 2021 – almost double the number in 2020. By the end of 2021, approximately 45,000 households in Ukraine were utilizing solar panels, reducing their electricity bills. The total capacity of such solar installations exceeded 1.2 GW (State Agency on Energy Efficiency and Energy Saving of Ukraine 2022).

During 2020–2021, an increasing number of renewable energy facilities were commissioned in Ukraine. However, the onset of war significantly disrupted the sector. According to the Razumkov Centre, wind and solar power generation declined by more than half compared to pre-war levels (Razumkov Centre 2022).

Prior to the full-scale war, Ukraine operated 34 wind farms comprising 699 wind turbines. The share of newly commissioned wind energy capacity in 2021 was 30.6%, or 358.8 MW – 2.5 times more than in 2020 (144.2 MW). Additionally, in 2021, 21 MW (1.79%) of biogas plants were commissioned – double the figure for 2020 – and 43.1 MW (3.68%) of biomass plants, also doubling the previous year's growth in bioenergy capacity (Razumkov Centre 2022).

According to the Ukrainian Wind Energy Association, since the start of the full-scale war, more than three-quarters of wind energy capacity in Ukraine has been halted. Out of a total of 1,673 MW, approximately 1,462 MW are currently non-operational, and five turbines located at the Myrne, Syvash, and Novotroitske wind farms in the Kherson region have been destroyed (Razumkov Centre 2022).

Comparing wind and solar energy production, it is noteworthy that by autumn 2022, nearly all wind power stations and about half of solar installations had ceased operation. This was due to both destruction and the occupation of territory where some facilities were located (Ekonomichna Pravda 2023, May 24).

The scarcity and high cost of energy resources have pushed the issue of alternative energy to the forefront in Ukraine. At the same time, the development of renewables and energy diversification is a crucial tool for mitigating risks to both national energy security and societal stability.

It can be argued that, despite having both the rationale and the potential for renewable energy development, Ukraine significantly lags behind developed countries in this area. Nevertheless,

the active expansion of renewable energy could strengthen the country's energy resilience and positively influence its social stability.

The Institute for Renewable Energy of the National Academy of Sciences of Ukraine has developed an Atlas of Renewable Energy Potential in Ukraine, which outlines the country's total technically achievable annual renewable energy potential as 68.9 million tonnes of oil equivalent (toe), including: wind energy – 15.0 million toe; solar energy – 4.2 million toe; large hydropower – 4.9 million toe; small hydropower – 2.1 million toe; bioenergy – 21.7 million toe; geothermal energy – 8.4 million toe; and ambient energy – 2.65 million toe (Teslenko 2016).

The most promising renewable energy sources in Ukraine include bioenergy, hydropower, and geothermal energy (see Table 1), with the most favorable region being the Black Sea coastal area (Odesa, Mykolaiv, Kherson, and Donetsk regions) (Dudchenko 2010).

Table 1. Forecast indicators of the development of the use of non-traditional and renewable energy sources by main directions of development [million t/year]

Tabela 1. Prognozowane wskaźniki rozwoju wykorzystania nietradycyjnych i odnawialnych źródeł energii według głównych kierunków rozwoju [mln ton/rok]

Directions of development	Level of development by years				
	2005	2010	2020	2030	2005/2030 [%]
Off-balance energy sources, total	13.85	15.96	18.5	22.2	+ 60
Including coal mine methane	0.05	0.96	2.8	5.8	+ 11500
Renewable energy sources, total	1.661	3.842	12.054	35.53	+ 2040
Including:					
Bioenergy	1.3	2.7	6.3	9.2	+ 608
Solar energy	0.003	0.032	0.284	1.1	+ 36567
Small hydropower	0.12	0.52	0.85	1.13	+ 842
Geothermal energy	0.02	0.08	0.19	0.7	+ 3400
Wind energy	0.018	0.21	0.53	0.7	+ 3789
Energy environment	0.2	0.3	3.9	22.7	+ 11250
Total	15.51	19.83	30.55	57.73	+ 272

Source: Dudchenko 2010.

Today, over 99% of businesses in Ukraine are small and medium-sized enterprises, and the evaluation of their economic performance has specific characteristics due to their organizational structure and relatively small scale. Often, the management of such enterprises does not pay sufficient attention to issues related to energy supply. Moreover, in most cases, the owners of micro-enterprises (with fewer than 10 employees) focus exclusively on financial performance and profitability.

Even now, after a sharp and significant increase in tariffs, energy prices in Ukraine remain among the lowest in Europe. For example, according to Eurostat data, in 2022, the residential electricity tariff in Ukraine was still the lowest among European countries (Eurostat 2025). However, the standard of living in Ukraine differs significantly from that in European countries. At the same time, energy tariffs for medium-sized households are higher than those for medium-sized enterprises.

The low efficiency of Ukraine's energy sector is further evidenced by the structure of its energy consumption, which is dominated by coal (34%), natural gas (30%), and nuclear fuel (24%) – resources primarily used for electricity and heat generation. Oil accounts for only 10% of total energy consumption. This structural imbalance, combined with the depreciation of the national currency, explains why the global decline in oil prices had little to no effect on Ukraine – fuel prices in fact increased domestically.

In addition to systemic inefficiencies within the energy sector, the Ukrainian industry remains highly energy-intensive. Despite marginal improvements, the country's industrial energy efficiency still lags behind not only that of European nations but also of many other global economies. The industrial sector consumes more than half of the nation's total electricity output. A regional breakdown of electricity consumption reveals that the highest levels are recorded in areas with a high concentration of industrial enterprises – primarily in the eastern, and to a lesser extent, southern and central oblasts.

This structural composition results in a significant divergence between Ukraine and global benchmarks in terms of fuel and energy consumption. As shown in Table 2, Ukraine exhibits an exceptionally high dependence on natural gas and a disproportionately low share of renewable energy sources (Makohon 2016). Furthermore, nuclear power occupies a notably prominent position in Ukraine's energy mix, reflecting another distinctive feature of the national energy profile.

Table 2. Structure of fuel and energy consumption in Ukraine and worldwide, 2022 [%]

Tabela 2. Struktura zużycia paliw i energii w Ukrainie i na świecie w 2022 r. [%]

Indicator	World as a whole	Ukraine	EU countries	USA
Natural gas	23.49	29.77	21.25	33.08
Oil	30.94	16.57	38.04	37.69
Coal	26.85	22.25	11.99	10.29
Uranium	3.99	23.98	9.42	7.63
Renewable energy sources	14.2	7.45	19.29	11.32

Source: Makohon 2016.

The ongoing full-scale war, now entering its third year, has had a profoundly detrimental impact on Ukraine's energy sector. The country's energy infrastructure remains critically vulnerable and continues to operate under emergency conditions, both in terms of electricity

generation and grid stability. A United Nations report notes that Ukraine's electricity generation capacity has more than halved – from 37.6 GW to 18.3 GW as of April 30, 2023 (Ekonomichna Pravda 2020, October 6).

In recent years, multiple efforts have been undertaken to enhance energy independence. However, a rapid reorientation of resource import sources remains technically unfeasible. For example, Ukraine's seaports lack the infrastructure necessary to handle the volume of coal imports required to fully offset domestic shortfalls.

2. Ukraine – EU cooperation in the field of renewable energy

On March 16, 2022, a historic milestone was reached: Ukraine's power grid was permanently disconnected from its Soviet-era legacy – the energy systems of Russia and Belarus. Against the backdrop of Russia's military invasion, and more than a year ahead of schedule, Ukraine's energy system was fully synchronized with the Continental European Network ENTSO-E (UNDP Ukraine 2023).

One of the most pressing priorities for Ukraine today is achieving energy independence. The loss of occupied territories, many of which contain major coal mining operations, along with political challenges, has forced the state to seek alternative sources of fuel imports. In the early 2000s, Ukraine was able to meet only about 60% of its primary energy supply through domestic sources, including 21.8–25.6% from coal, 9.2–11.3% from natural gas, 2.6–2.8% from oil and petroleum products, and 11.5–16.0% from energy generated at nuclear and hydroelectric power plants (Makohon et al 2014). This imbalance underscores the misalignment between Ukraine's resource potential and the structure of its primary energy supply.

Unfortunately, the implementation of reforms currently faces significant challenges due to the urgent need to restore the national energy system. Nonetheless, the reform agenda includes key initiatives such as decentralization, with an emphasis on the development of small-scale generation that is less vulnerable to missile and drone attacks. Another strategic direction is the expansion of green energy, as Ukraine's development trajectory is increasingly aligned with the European Union. Promoting renewable energy is crucial to enhancing energy efficiency. A favorable investment climate would allow for greater volumes of foreign direct investment in this sector. A successful example is the establishment of the Pavlohrad industrial park in the Dnipropetrovsk region. The availability of infrastructure (including an international highway and river port) and land (20 hectares allocated for high-tech facilities) has attracted interest from two European countries aiming to set up production lines for solar panels, synthetic gas, and methanol.

While the traditional energy market in Ukraine is heavily monopolized and largely inaccessible to new entrants, the renewable energy sector remains relatively young and open to new players. For this reason, small and medium-sized enterprises have the opportunity to enter

this market segment. Considering global trends and the ambitions of international organizations to raise the share of renewables to 96% by 2050, the renewable energy sector represents a highly promising direction.

In the European Union, environmental organizations have voiced strong opposition to the extraction of shale gas, despite the potential economic benefits. For instance, France has introduced a moratorium on shale gas extraction within its territory. Given these challenges, the role of renewable energy is increasingly critical. Scientists argue that within the next 10 to 20 years, electricity generation from extractive (fossil-based) sources may become obsolete, and it will be more economically viable for consumers and businesses to generate and store their own electricity locally.

This evolving context underscores the growing necessity for Ukraine to cooperate with EU countries in the renewable energy sector. This cooperation is being facilitated under the framework of the Energy Community Treaty, which entered into force for Ukraine in 2011, and through the ongoing harmonization of Ukrainian legislation with that of the European Union. Ukraine's alignment with the European Green Deal – a strategic initiative aimed at achieving climate neutrality across the European continent by 2050 – is a key component of this process.

The European Union has established stringent energy efficiency requirements for businesses aimed at reducing energy consumption and minimizing environmental impact. These requirements are an integral part of the European Green Deal and call for the integration of circular economy principles, reduction in resource use, and the implementation of environmentally sustainable technologies. For Ukrainian enterprises seeking to integrate into the European market, compliance with these standards is essential. This includes conducting energy audits, implementing energy management systems, and modernizing infrastructure to meet EU benchmarks. These actions will not only ensure regulatory compliance but will also enhance business competitiveness, resilience, and sustainability.

Ukraine's aspirations for EU accession necessitate the alignment of its national energy legislation with the following key legal acts of the European Union:

Starting in 2025, European companies will be required to comply with new sustainability reporting obligations under the Corporate Sustainability Reporting Directive (CSRD) (European Commission 2023). The CSRD is a new directive of the European Union that mandates comprehensive transparency from companies in the areas of environmental, social, and corporate governance (ESG). This directive significantly expands the scope of sustainability disclosures and sets rigorous standards for corporate accountability in sustainability performance.

As Ukraine moves toward deeper integration with the European economic space, it is imperative for Ukrainian companies to begin aligning with these new ESG reporting requirements. In particular, if a European company owns a subsidiary in Ukraine or if a Ukrainian enterprise functions as a subsidiary of an EU-based parent company, those Ukrainian entities will also be required to comply with CSRD standards. Moreover, Ukrainian businesses operating within the EU or integrated into European corporate groups or holdings will be subject to the same reporting obligations.

Table 3. EU directives in the field of energy efficiency

Tabela 3. Dyrektywy UE w dziedzinie efektywności energetycznej

Directive	Content
Directive 2012/27/EU	Establishing minimum energy efficiency requirements. Each Member State is required to set energy efficiency targets for 2020. Member States must adopt National Energy Efficiency Plans and update them every three years. Large enterprises are required to carry out regular energy audits to identify opportunities for improving energy efficiency. The implementation of energy management systems in accordance with international standards such as ISO 50001 is encouraged.
Directive 2010/31/EU	Establishes minimum energy efficiency requirements for existing and new buildings, introduces a system of certification of energy efficiency of buildings, and also obliges member states to take measures necessary for periodic inspection of heating and air conditioning systems.
Directive 2010/30/EU	Provision of information to consumers about the energy efficiency indicators of goods
Directive 2009/28/EU	Establishing the share of renewable sources in the EU energy balance structure at a level of at least 20%. Obliges EU member states to formulate an action plan in the energy sector.
Directive 2010/75/EU	About industrial emissions
Directive 2003/87/ EU	Introduction of a greenhouse gas emissions trading scheme within the Community
Directive 2009/125/ EU	Establishes requirements for products that consume energy or affect energy consumption

Source: compiled by the authors according to (FEAO 2016).

In the broader context of European integration, a key area of cooperation is the exchange of best practices in transitioning to sustainable energy systems and the decentralization of energy generation, as demonstrated by European enterprises. This collaboration is critical not only for ensuring regulatory compliance but also for enhancing the resilience and long-term sustainability of Ukrainian business models.

3. Strategic perspectives of bioenergy development in the context of cooperation with the EU

Biogas is an important renewable energy source that increasingly contributes to Europe's transition toward a low-carbon energy system and a circular economy. Through the upgrading process, biogas can be refined into biomethane, which is fully compatible with existing natural gas infrastructure. In this way, biomethane offers an effective alternative for the production of heat, electricity, and transport fuels.

The European Union actively supports biomethane development under the REPowerEU strategy, which targets the production of 35 billion cubic meters of biomethane annually by 2030. Ukraine, with its well-developed gas transmission infrastructure and significant production potential, could become a key supplier of biomethane to the EU – contributing up to 20% of the projected volume (Institute of Renewable Energy of Ukraine 2025).

As of early 2024, the installed capacity of biomethane plants in Europe had reached 6.4 billion cubic meters per year, reflecting rapid sectoral growth (Bioenergy Association of Ukraine 2025c). Bioenergy plays a significant role in the EU economy and labor market. In 2019, it accounted for approximately one million direct and indirect jobs, making it the largest employer among all renewable energy sectors. With the ongoing energy transition, this figure is expected to grow to over 1.5 million jobs by 2050. Unlike other renewable energy sources that often rely on imported technology or inputs, bioenergy enhances energy security. In 2019, it contributed 40 billion EUR to the EU's GDP, a figure projected to reach 70 billion USD by 2050 (Bioenergy Association of Ukraine 2025c).

The European Bioenergy Association has released its new statistical report, *Bioenergy Landscape 2024*, which provides an in-depth analysis of the role of bioenergy within the European energy sector. Notably, the bioenergy sector enabled a reduction of 300 million tonnes of CO_2 emissions in 2022, underscoring its critical role in achieving the EU's climate goals. The integration of bioenergy with carbon capture and storage technologies (BECCS) has the potential to sequester millions of tonnes of CO_2 annually, further accelerating progress toward decarbonization targets. Thanks to European technological expertise and the extensive use of locally sourced biomass, BECCS can also enhance the industrial competitiveness of the EU (SAF Ukraine 2025).

A particularly promising actor in the deployment of renewable energy is the agro-industrial complex. Agricultural enterprises benefit from direct access to renewable feedstock materials that they themselves continuously regenerate. Moreover, rural farms typically possess sufficient rooftop space (on warehouses, barns, and administrative buildings) suitable for installing solar panels. Importantly, financial feasibility is also present: profitable agricultural enterprises often achieve profitability margins between 30–45%, providing the capital capacity for investment in alternative energy technologies.

At the same time, the conducted researches show that agriculture is one of the smallest energy consumers. Thus, this industry can create competition in the energy market due to its own energy production and sales, including to the population under direct contracts. The greatest potential for Ukraine is biomass energy. This is primarily due to the availability of raw materials – crop and livestock waste in agriculture. Currently, only about 9.5% of the possible potential is used.

In Europe, solid biomass is used to a greater extent, and biogas to a lesser extent. In Ukraine, the situation is similar, with wood biomass being the leader in biofuels; however, the Energy Strategy until 2035 provides for an increase in the share of resources such as straw and stalks – that is, agricultural products.

At the same time, it is agricultural enterprises that have sufficient prospects for transitioning to the field of energy generation. This is evidenced by the fact that out of

40 MW of operating biogas plants in Ukraine (as of January 2018), 25 MW are agricultural, which is more than 60%.

Biomethane production in Ukraine has significant potential and development prospects, given the country's agrarian profile and the availability of relevant resources. Having practically free raw materials, agricultural enterprises can form practically autonomous centers in rural areas, thus forming a new energy infrastructure and ensuring both their own needs and the needs of the population, increasing the level of their own energy independence and the energy independence of the region. At the same time, both small and medium-sized and large enterprises can become energy generators, with the latter having more financial opportunities for larger-scale activities.

In 2020, 49 biogas plants were operating in Ukraine, and as of the beginning of 2022, their number increased to 77 (Bioenergy Association of Ukraine 2025a). The total biomethane production potential is 9634 million cubic meters (Fig. 1).

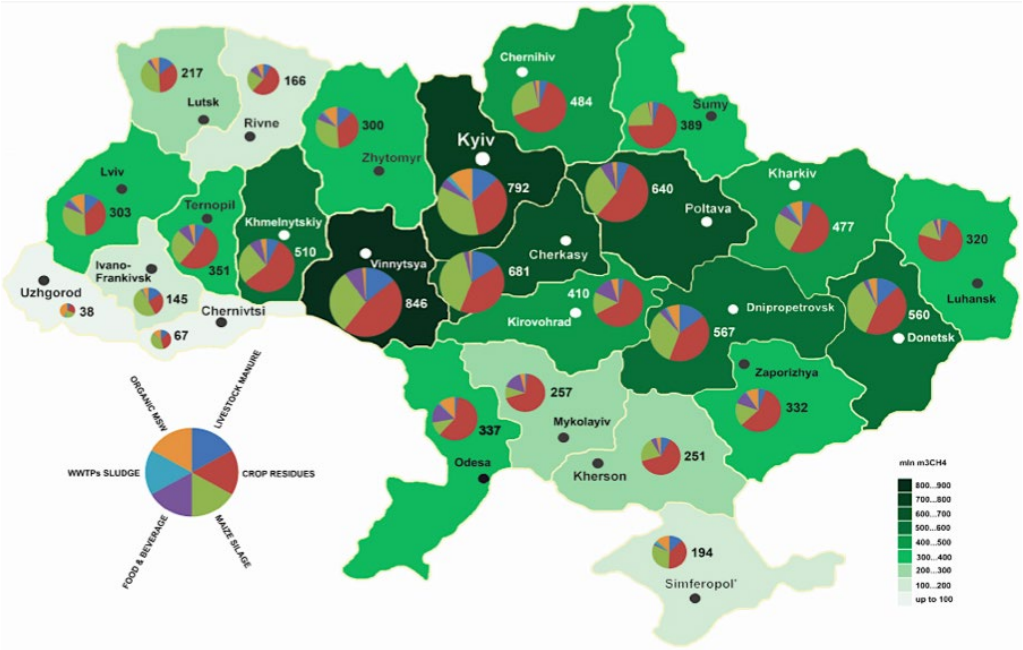

Fig. 1. Biomethane production potential by regions of Ukraine [million cubic meters]
Source: Bioenergy Association of Ukraine (2025)

Rys. 1. Potencjał produkcji biometanu według regionów Ukrainy [w milionach metrów sześciennych]

In Europe, 75% of biogas is produced from agricultural waste, 17% from organic waste from private households and enterprises, and another 8% from sewage treatment plants (Bioenergy Association of Ukraine 2025a). In Ukraine, the highest level of economic feasibility is achieved by cattle farms (feasibility is 97%). Most large agricultural enterprises today have

their own bioenergy complexes, in particular, such as the agro-industrial holding Myronivskyi Khliboproduct, the agro-holding Astarta, the Goodvalley company, the Agroliga company, the agro-holding Mriya, etc. Being agro-holdings with complex production, large enterprises use energy for their own needs. Meanwhile, medium and small enterprises, having the potential and minimal needs for heat and electricity, can act as energy-generating companies and provide energy to the population, especially in rural areas. As an example, since September 2024, the first biomethane plant of the Vitagro group of companies has been operating in Ukraine. The second biomethane plant of the company "Hals Agro" has been operational since November. Today, these two plants are pumping biomethane into Ukraine's underground gas storage facilities and have already accumulated over 1 million m^3 of biomethane there (Bioenergy Association of Ukraine 2025b).

And already in February 2025, the holding "Myronivskyi Khliboproduct" (MHP) exported biomethane through gas pipelines to Germany. MHP plans to export 35 million cubic meters of biomethane per year. This enterprise was the first among enterprises on the biomethane production market to receive a certificate of environmental management according to the ISO 14001:2015 standard "Environmental Management Systems". The certification applies to a branch of the separate division "Biogas Complex", which is part of LLC "Vinnytsia Poultry Farm" and specializes in the production of biogas with the subsequent production and export of biomethane (UA Energy 2025).

In addition, certification is becoming a key factor for entering the promising European biomethane market, the potential of which is estimated at 4.8 billion USD by 2031. According to a report by the European Commission, the need for biomethane in EU countries by 2030 is 35 billion m^3, which significantly exceeds the current production of 6.4 billion m^3. Therefore, European countries are ready to export biomethane, the quality and compliance of which is confirmed by all necessary certifications (UA Energy 2025).

Biomethane production opens up prospects for Ukrainian farmers, allowing them to diversify sources of income through the sale of energy or biomethane. It will also provide an opportunity to reduce energy costs by using their own fuel and improve the environmental situation through waste disposal and reducing greenhouse gas emissions, which generally meet the goals of sustainable development. The main obstacles to the development of the biomethane market in Ukraine are the need for significant investments in the construction and modernization of production facilities, which, in the conditions of a full-scale war, is problematic for most Ukrainian enterprises. The key in this aspect is to reduce initial investments and spread risks across a larger number of partners. In this context, several models and mechanisms are being considered that allow projects to be implemented using international assistance, government incentive programs, soft loans, and innovative financial instruments.

One of the important directions is the use of international grant programs and technical aid. Programs such as ReACT4UA and energy security support projects provide the opportunity to receive grants and partial co-financing, which significantly reduces the amount of own resources of enterprises. In particular, the ReACT4UA initiative, funded by the governments of

Germany and Norway, provides SMEs with grants of up to 20,000 EUR for the implementation of decentralized energy supply projects, including bioenergy (Pimenov et al. 2025).

At the same time, the USAID Energy Security Project provides expert support for the development of the biomethane market, preparing Ukrainian producers to comply with EU requirements regarding sustainability and gas origin.

State support also plays a decisive role in stimulating investment in renewable energy sources. Legislative initiatives that provide benefits for investment projects (in particular, in the form of tax holidays, import duty exemptions, and preferential resource leases) contribute to attracting additional funds from the state, reducing investment risk for enterprises. Law of Ukraine No. 3311-IX provides for a number of investment incentives – tax breaks, compensation for the cost of connecting to the networks, simplified land use, import duty exemptions, tax holidays, compensation for the cost of connecting to the gas network, and preferences in land and forest leases.

The National Renewable Energy Action Plan until 2030 provides for financing the biomethane sector at the level of ~ 2 million USD, part of these funds are to support small projects (SAF 2024).

Cooperation with international financial institutions, such as the European Bank for Reconstruction and Development, the European Investment Bank, and the International Finance Corporation, can also facilitate the implementation of projects to build biomethane plants. These institutions, together with Ukrainian banks and government agencies, create a framework for financing programs that include concessional credit lines and credit and financial instruments for the implementation of projects in the field of biomethane.

Modular and partnership models of project implementation occupy a special place. Standardized installations and container technologies allow enterprises to launch projects with lower capital investments due to the serial production of equipment and the use of used technologies. In addition, the creation of agro-industrial hubs or cooperative structures allows combining the resources of several enterprises, which leads to the sharing of equipment, optimization of operating costs, and increased efficiency of biomass use (Enterprise Europe Network 2024). Modern digital financial instruments, in particular the tokenization of infrastructure projects, can provide an additional source of financing by attracting small investors through crowdfunding mechanisms, which helps to increase the liquidity and transparency of investments (Tian et al. 2022).

An important factor is also the need to adapt national legislation to European standards, for Ukrainian enterprises to undergo the necessary certification and create favorable conditions for investors, which again faces the need to stop hostilities on the territory of Ukraine.

Despite the gradual harmonization of Ukrainian energy legislation with the EU acquis, in particular in the field of electricity, energy efficiency, and renewable energy sources, a number of critical discrepancies remain today, which slow down integration into the single energy market of the European Union. In particular, the incomplete implementation of the REMIT (Wholesale Energy Market Integrity and Transparency) regulation is noted, since a full package of secondary legislation has not been adopted, which complicates the full application of European standards. At the same time, the main priorities are the adoption of

the Electricity Integration Package, the launch of NEMO operators and the EU purchase, and sale market (Lorkowski 2024).

In the field of energy efficiency, the EU requirement for annual thermal modernization of at least 3% of the area of public buildings remains unfulfilled, and there is no approved long-term strategy for the renewal of the building stock (EUEA 2021).

In addition, the launch of mechanisms to support distributed generation and the system of guarantees of origin of electricity from renewable sources has not been completed. These gaps require urgent legislative regulation and institutional strengthening to ensure compliance with European standards.

The simplest in terms of implementation and from a financial point of view is biomass energy – energy obtained from the combustion of organic materials (plants). According to researchers, it has the potential is to provide 7–9% of the country's energy needs. The share of bioenergy among all renewable energy sources in 2020 was 75% (Bioenergy Association of Ukraine 2025a). Biomass for energy has three directions (Fig. 2):

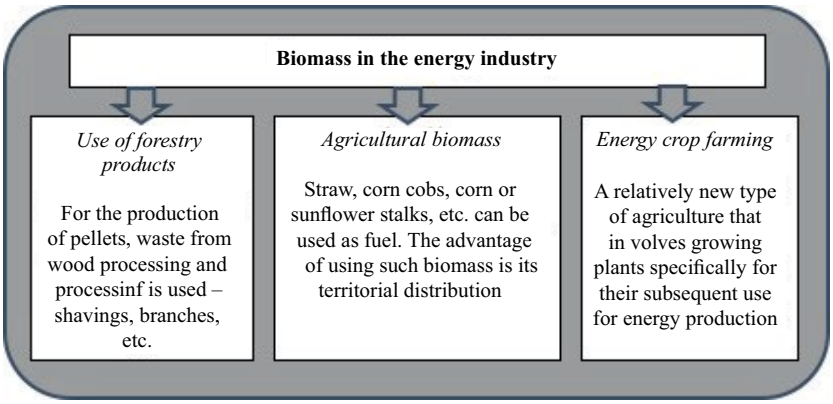

Fig. 2. Directions of using biomass in energy
Source: authors' representation

Rys. 2. Wykorzystanie biomasy w energetyce

One of the most common energy crops is the energy willow. The key advantage of this type of biomass lies in its ability to be cultivated on land unsuitable for growing food crops. However, returns and profits from the cultivation of energy willow are expected only after a 3–4-year period.

Energy crop production is not only an integral component of alternative energy development but also contributes to environmental protection and restoration. This is achieved through land reclamation, forest conservation, prevention of soil erosion, and other ecological benefits. In addition to energy willow, other promising crops include sweet sorghum, miscanthus, switchgrass, maize, and sugar beets. According to expert assessments, the cultivation of perennial energy crops on 2.0 million hectares could yield fuel equivalent to 16.3 billion cubic meters of natural

gas. At the same time, sectoral ministries estimate that in Ukraine there are approximately 4 million hectares of low-yielding lands, unsuitable for conventional agricultural use, which can be utilized for growing energy crops.

Given the strategic intention to reduce dependence on gas imports by increasing domestic gas production and decreasing industrial gas consumption – from 8.5 billion cubic meters in 2021 to 4.5 billion cubic meters in 2022 – the use of biogas by agricultural enterprises represents a substantial opportunity for financial savings and a critical step towards enhancing the country's energy independence.

In this context, an agricultural enterprise can function both as a supplier and as a consumer of renewable fuel and energy resources. In addition, biomass can be utilized in the production of bioethanol, where the traditional crop – maize – plays a primary role.

Biogas production in agriculture serves not only as a source of alternative fuel (biomethane) but also enables the implementation of zero-waste production cycles through the utilization of manure. Moreover, manure processing yields both fuel and fertilizer for further agricultural use.

According to data from the European Biogas Association, the total biogas and biomethane production in 2021 amounted to 18.4 billion cubic meters. This represents 4.5% of the European Union's natural gas consumption for that year. Specifically, biomethane production increased by 20% in 2021, reaching 3.5 billion cubic meters. Denmark is the leader in this sector, replacing 24% of its natural gas usage with biogas and biomethane. A significant advantage of this sector within alternative energy lies in the versatility of raw materials: manure, energy crops, agricultural residues, industrial food and beverage waste, sewage sludge, and the organic fraction of municipal solid waste.

Currently, Europe produces 18 billion cubic meters of biogas and biomethane annually. Industry experts forecast a fourfold increase by 2030. Germany leads in the number of biomethane facilities with 232 plants, followed by France and the United Kingdom.

Electricity generation through biomethane combustion varies depending on the technology employed. In gas engine-based systems, biomethane is fed into a gas engine that drives an electric generator, producing electricity. The residual heat can be utilized for heating purposes or industrial processes (cogeneration). In large-scale energy projects, biomethane can be combusted in gas turbines, where mechanical energy from the turbine rotation is converted into electricity. An alternative method involves the interaction of biomethane with oxygen in a chemical reaction that generates electricity without combustion. This technology offers high efficiency and low emissions. The electricity produced can be used for on-site needs or supplied to the grid for commercial distribution. Furthermore, biogas can be used by decentralized modular combined heat and power plants (CHP) for local electricity and heat supply, or purified and upgraded to biomethane for injection into existing gas transmission networks (Fletcher 2017). Upgraded biogas can also serve as vehicle fuel, replacing natural gas, be utilized in large-scale central CHP plants, or in highly efficient gas condensing boilers for heat production (Holub et al. 2017).

In the European Union, the turnover of the bioeconomy sector exceeded 1.8 trillion EUR, reflecting both economic and social significance, as it employs approximately 10% of the working

population. Renewable energy sources play a crucial role in the global energy sector. According to European data, bioenergy accounts for 65% of all renewable energy sources. In countries such as Luxembourg, Cyprus, and Ireland, the share of biomass within the total renewable energy mix fluctuates around 30–40%, while in Estonia, Latvia, Lithuania, Hungary, and Poland, this share reaches 80–95%.

In 2020, the contribution of renewable energy sources to the European Union's energy balance was expected to reach 20%. Moreover, under the new strategy adopted by the European Council in October 2014, this share is projected to increase to 27% by 2030. Thus, biomethane power plants represent a promising direction for Ukraine, as they contribute to enhancing energy independence, reducing reliance on gas imports, and fostering the development of renewable energy.

4. Discussion

The results of the analysis show that the implementation of bioenergy technologies at Ukrainian enterprises has both significant potential and a number of systemic barriers. A comparison with European practices (Wu and Pfenninger 2022) allows us to conclude that national bioenergy strategies should be adapted to local conditions, but at the same time take into account the positive experience of integrating bioenergy into the overall decarbonization policy.

The quantitative assessment of the potential of biogas production in Ukraine, presented by Kucher et al. (2022), provides an empirical basis for planning large-scale investments in this segment. In particular, the possibility of replacing more than 2.6 billion m^3 of natural gas per year demonstrates not only the energy but also the economic feasibility of actively involving agricultural enterprises in the implementation of biogas projects. At the same time, combining biogas production with organic fertilizers allows achieving additional agro-economic effects.

Practical aspects of the implementation of already operating biogas plants in Ukraine, described by Havrysh et al. (2020), highlight the regulatory difficulties, technological limitations, and issues of connection to energy networks. These problems require targeted state policy to support the industry, in particular through the mechanisms of the "green tariff", targeted lending, and simplification of connection procedures.

In the long term, biomethane can play an important role as an element of the green hydrogen-methane cluster (Strielkowski 2025). Its export potential, as well as the ability to partially replace imported energy carriers, allows us to consider biomethane not only as a local energy alternative but also as a geoeconomic resource.

Thus, the results of the study are consistent with the conclusions of the scientific literature and confirm the need for a comprehensive approach to the development of bioenergy in Ukraine – a combination of technical, financial, regulatory, and political components. Increasing energy independence through alternative sources requires intersectoral cooperation, government support, and effective implementation strategies.

Conclusions

The energy supply of Ukrainian enterprises is a critically important factor, especially in the conditions of the energy crisis caused by Russian aggression and the destruction of the energy infrastructure. The full-scale war in Ukraine paradoxically acts as a trigger for energy transformation. The destruction of centralized infrastructure has brought the issue of energy security to the forefront, forcing enterprises to rethink their power sources. This creates a unique window of opportunity for the forced introduction of renewable energy, which was implemented slowly in peacetime. The main aspects of energy security include the transition to renewable energy sources, increasing energy efficiency, modernization of infrastructure, and the introduction of new technologies. However, such energy security faces some problems, in particular, the low energy efficiency of many enterprises and the need for significant investments in the transition to sustainable energy solutions.

Ukrainian enterprises, especially small and medium-sized ones, have the potential not only to consume, but also to generate energy. The transition to a model of self-energy supply allows for the formation of a new energy economy, decentralized and resistant to threats. This is a paradigm shift: from the model of "dependence on the supplier" to the model of "energy independence and sustainable development".

Bioenergy is a strategic resource of agrarian Ukraine, since the agricultural sector can become the locomotive of energy independence. Biomethane, biogas, biomass – all these are resources that can already be used within the framework of decentralized generation today. Therefore, the strategic direction of ensuring sustainable energy supply is the active introduction of renewable energy sources by Ukrainian enterprises, which in the future will lead to a reduction in energy dependence on gas and coal imports, stability of energy supply even in crisis conditions, and a reduction in operating costs of enterprises thanks to energy-efficient technologies.

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References

Bioenergy Association of Ukraine 2025a. Biomethane potential in Ukraine. [Online:] https://uabio.org/potentsial-biometanu-v-ukrayini/ [Accessed: 2025-09-15].

Bioenergy Association of Ukraine 2025b. Sun, wind, biogas: how "green" energy will help Ukraine survive in 2025. [Online:] https://uabio.org/news/17170/ [Accessed: 2025-09-15].

Bioenergy Association of Ukraine 2025c. Biofuels, biogas and the contribution of bioenergy to Europe's socio-economic performance. [Online:] https://uabio.org/materials/17360/ [Accessed: 2025-09-15].

Dudchenko, O. 2010. Alternative energy sources in the Ukrainian Black Sea region. [Online:] https://niss.gov.ua/doslidzhennya/nacionalna-bezpeka/alternativni-dzherela-energoresursiv-v-ukrainskomu-prichornomori [Accessed: 2025-09-15].

Ekonomichna Pravda 2020. Debt restructuring of “Naftogaz”. Ekonomichna Pravda. [Online:] https://www.epravda.com.ua/columns/2020/10/6/665959/ [Accessed: 2025-09-15].

Ekonomichna Pravda 2023. What is left of “green” energy in Ukraine. Ekonomichna Pravda. [Online:] https://www.epravda.com.ua/publications/2023/05/24/700431/ [Accessed: 2025-09-15].

Enterprise Europe Network 2024. The Ukrainian agency specializes in finding business partners (investors, equipment manufacturers, and biomethane buyers) for collaboration in the biomethane production sector and the supply of biomethane. [Online:] https://een.ec.europa.eu/partnering-opportunities/ukrainian-agency-specializes-finding-business-partners-investors-equipment [Accessed: 2025-09-15].

EUEA 2021. The Law “On Energy Efficiency” came into force in Ukraine. [Online:] https://euea-energyagency.org/en/news/market-news/the-law-on-energy-efficiency-came-into-force-in-ukraine/ [Accessed: 2025-09-15].

European Biogas Association 2015. Biogas and biomethane – the products of efficient and sustainable use of resources. [Online:] https://www.europeanbiogas.eu/wp-content/uploads/2015/05/2015-EBA-Mission-and-Vision.pdf [Accessed: 2025-09-15].

European Biogas Association 2025. [Online:] https://www.europeanbiogas.eu/ [Accessed: 2025-09-15].

European Commission 2023. Corporate Sustainability Reporting Directive. [Online:] https://finance.ec.europa.eu/regulation-and-supervision/financial-services-legislation/implementing-and-delegated-acts/corporate-sustainability-reporting-directive_en [Accessed: 2025-09-15].

Eurostat. Electricity prices for household consumers – bi-annual data (from 2007 onwards). [Online:] https://ec.europa.eu/eurostat/databrowser/view/NRG_PC_204/default/table?lang=en [Accessed: 2025-09-15].

Eurostat 2016. Energy balance sheets 2016. [Online:] https://ec.europa.eu/eurostat/documents/3217494/9172750/KS-EN-18-001-EN-N.pdf/474c2308-002a-40cd-87b6-9364209bf936 [Accessed: 2025-09-15].

FEAO 2016. Energy security: European experience. [Online:] https://feao.org.ua/wp-content/uploads/2016/11/Energy_Security_Final_27.11.pdf [Accessed: 2025-09-15].

Fletcher, K. 2017. European Biogas Association reports 17,376 biogas plants in EU. Biomass Magazine. [Online:] http://biomassmagazine.com/articles/14141/european-biogas-association-reports-17-376-biogas-plants-in-eu [Accessed: 2025-09-15].

Havrysh et al. 2020 – Havrysh, V., Kalinichenko, A., Mentel, G. and Olejarz, T. 2020. Commercial Biogas Plants: Lessons for Ukraine. *Energies* 13(10), DOI: 10.3390/en13102668.

Holub et al. 2017 – Holub, H.A., Kukharets, S.M. and Marus, O.A. 2017. Bioenergy systems in agricultural production. Kyiv: NUBiP Ukrainy.

Institute of Renewable Energy of Ukraine 2025. [Online:] https://ive.org.ua [Accessed: 2025-09-15].

Kaletnik et al. 2017 – Kaletnik, H.M., Skoruko, P. and Branitskyi, Y.Y. 2017. Organizational and economic principles of organizing biofuel production in Vinnytsia region. *Ekonomika. Finansy. Menedzhment: Aktualni Pytannia Nauky i Praktyky* 5, pp. 7–25.

KLO 2025. Innovations. KLO Official Website. [Online:] https://klo.ua/ua/innovation [Accessed: 2025-09-15].

Kucher et al. 2022 – Kucher, O., Hutsol, T., Glowacki, S., Andreitseva, I., Dibrova, A., Muzychenko, A., Szeląg-Sikora, A., Szparaga, A. and Kocira, S. 2022. Energy Potential of Biogas Production in Ukraine. *Energies* 15(5), DOI: 10.3390/en15051710.

Lorkowski, A. 2024. Ukraine’s energy reforms and integration: a path forward. [Online:] https://ceenergynews.com/voices/ukraines-energy-reforms-and-integration-a-path-forward [Accessed: 2025-09-15].

Makohon, Y.V., 2016. Innovations in the energy sector at Ukrainian enterprises. *Ekonomichnyi Visnyk NTUU “KPI”* 13, DOI: 10.20535/2307-5651.13.2016.80629.

Makohon, Y.V. and Anysymov, A.E. 2014. Energy innovations in the old industrial region of Ukraine. *Mineralni Resursy Ukrainy* 1, pp. 28–35.

Ministry of Economy of Ukraine 2024. National energy and climate plan for the period until 2030. [Online:] https://me.gov.ua/Documents/Detail?lang=uk-UA&id=17f558a7-b4b4-42ca-b6622811f42d4a33&title=NatsionalniiPlanZEnergetikiTaKlimatuNaPeriodDo2030-Roku [Accessed: 2025-09-15].

Pimenow et al. 2025 – Pimenow, S., Pimenowa, O., Moldavan, L., Udova, L., Wasilewski, M. and Wasilewska, N. 2025. Transforming Agriculture into Energy: Unlocking Ukraine's Bioenergy Potential for Sustainable Post-Conflict Recovery. *Energies* 18(5), DOI: 10.3390/en18051212.

Razumkov Centre 2022. Ukraine's renewable energy sector before, during and after the war. [Online:] https://razumkov.org.ua/statti/sektor-vidnovlyuvanoyi-energetyky-ukrayiny-do-pid-chas-ta-pislya-viyny [Accessed: 2025-09-15].

SAF 2024. Goals for Bioenergy Development: National Renewable Energy Action Plan until 2030. [Online:] https://saf.org.ua/en/news/2030/ [Accessed: 2025-09-15].

SAF Ukraine 2025. Bioenergy in Europe and greenhouse gas emission reduction. [Online:] https://saf.org.ua/news/2225/ [Accessed: 2025-09-15].

State Agency on Energy Efficiency and Energy Saving of Ukraine 2022. [Online:] https://saee.gov.ua/uk/news/4085 [Accessed: 2025-09-15].

Strielkowski, W. 2025. Efficient low-carbon development in green hydrogen and ammonia economy: a case of Ukraine. [Online:] https://doi.org/10.48550/arXiv.2503.22326 [Accessed: 2025-09-15].

Sustainability degrees. What is sustainable business. [Online:] https://www.sustainabilitydegrees.com/what-is-sustainability/sustainable-business [Accessed: 2025-09-15].

Teslenko, O.I. 2016. Technical and economic feasibility study for the construction of a biofuel CHP plant with an electric capacity of 6 MW based on the "Tavriyska" boiler house in Kherson. [Online:] http://www.city.kherson.ua/upload/4.pdf [Accessed: 2025-09-15].

Tian et al. 2022 – Tian, Y., Wang, C., Asutosh, A., Woo, J. and Adriaens, P. 2022. Blockchain-enabled tokenization for sustainable and inclusive infrastructure investment. DOI: 10.48550/arXiv.2208.04709.

UA Energy 2025. Ukraine is preparing to enter the European biomethane market. [Online:] https://ua-energy.org/uk/posts/ukraina-hotuietsia-vykhodyty-na-ievropeiskyi-rynok-biometanu [Accessed: 2025-09-15].

Ukrainian Association of Renewable Energy 2016. Prospects for economic growth and increasing energy security in Ukraine. [Online:] http://uare.com.ua/novyny/541-perspektivi-ekonomichnogo-zrostannya-ta-pidvishchennya-energetichnoji-bezpeki-ukrajini.html [Accessed: 2025-09-15].

Ukrenerho 2025. Report on the assessment of compliance (sufficiency) of generating capacities. [Online:] https://ua.energy/zvit-z-otsinky-vidpovidnosti-dostatnosti-generuyuchyh-potuzhnostej/ [Accessed: 2025-09-15].

UNDP Ukraine 2017. Energy Agriculture in Ukraine: An Alternative Path to Alternative Energy [Online:] https://undpukraine.exposure.co/post-245557 [Accessed: 2025-09-15].

UNDP Ukraine 2023. Towards a Green Transition of the Energy Sector in Ukraine. [Online:] https://www.undp.org/ukraine/publications/towards-green-transition-energy-sector-ukraine [Accessed: 2025-09-15].

Wu, F. and Pfenninger, S. 2022. Challenges and Opportunities for Bioenergy in Europe: National Deployment, Policy Support, and Possible Future Roles. DOI: 10.1016/j.biteb.2023.101430.

Wysokiska-Senkus, A. and Raczkowski, K. 2013. Economic security in the context of sustainability. *Rural Deveopment* 6(1), pp. 454–462.

Yakovlieva, N. In three years, the share of bioenergy in Ukraine's energy balance has almost tripled. Eco Town. [Online:] http://ecotown.com.ua/news/Za-try-roky-chastka-bioenerhetyky-v-enerhetychnomu-balansi-Ukrayiny-zrosla-mayzhe-vtrychi/ [Accessed: 2025-09-15].

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Zaopatrzenie przedsiębiorstw ukraińskich w energię: bariery i perspektywy realizacji projektów bioenergetycznych

Streszczenie

Artykuł poświęcony jest analizie stanu zaopatrzenia w energię ukraińskich przedsiębiorstw w warunkach agresji militarnej, globalnych wyzwań i dążeń Ukrainy do integracji europejskiej. Podkreślono problemy scentralizowanego systemu energetycznego odziedziczonego po ZSRR, który nie spełnia już potrzeb gospodarki narodowej, oraz potrzebę rozwoju rozproszonego wytwarzania energii w oparciu o odnawialne źródła energii i bioenergię. Szczególną uwagę zwrócono na związek między bezpieczeństwem energetycznym, stabilnością gospodarczą i celami zrównoważonego rozwoju. Podkreślono zalety energii alternatywnej dla małych i średnich przedsiębiorstw, w szczególności możliwości dotyczące niezależności energetycznej przedsiębiorstw, dywersyfikacji źródeł dostaw energii oraz udziału w tworzeniu lokalnych rynków energii. W artykule przeanalizowano aktualny stan i dynamikę rozwoju sektora energii odnawialnej w Ukrainie oraz zidentyfikowano bariery i perspektywy realizacji projektów bioenergetycznych, zwłaszcza budowy zakładów produkcji biometanu. Porównano doświadczenia Ukrainy i krajów UE w tej dziedzinie oraz przeanalizowano europejskie przepisy dotyczące efektywności energetycznej i odpowiedzialności za środowisko, które są obowiązkowe dla integracji Ukrainy z rynkiem europejskim. Rozważono ekonomiczne, środowiskowe i społeczne aspekty strategii energetycznej przedsiębiorstw, a także rolę kompleksu rolno-przemysłowego w produkcji biopaliw. Podkreślono potrzebę przyciągnięcia inwestycji, harmonizacji przepisów i wymiany doświadczeń z UE w celu wzmocnienia bezpieczeństwa energetycznego Ukrainy.

Słowa kluczowe: zaopatrzenie w energię, bioenergia, odnawialne źródła energii, efektywność energetyczna