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ANALYSIS OF THE POTENTIAL AND PERSPECTIVES OF THE DEVELOPMENT OF BIOMASS TECHNOLOGIES IN UKRAINE

This article provides an in-depth analysis of the potential and prospects for the development of biomass technologies in Ukraine. An overview of the current state of biomass use in the energy, industrial and agricultural sectors of the country is being carried out. The article examines in detail different types of biomass such as wood, agricultural residues, biological waste, etc., and their potential for producing energy and other useful products. Particular attention is paid to technological innovations in the field of biomass processing, including processes of biogasification, pyrolysis and hydrothermal conversion. The authors analyze the ecological and economic aspects of using biomass as an energy source, considering its impact on reducing greenhouse gas emissions and ensuring the country's energy independence. In addition, the article examines important legislative and strategic initiatives aimed at supporting the development of biomass use in Ukraine, and puts forward proposals for further steps to stimulate this direction. In general, the article serves as a valuable source of information for scientists, experts and decision-makers interested in the development of sustainable energy and the use of renewable energy sources in Ukraine.

Recommendations for the further development of the use of biomass in Ukraine are formulated, taking into account the importance of solving environmental problems and energy independence. Summarizing, the article not only offers an in-depth analysis of the potential and prospects for the development of biomass technologies, but also defines the ways for the practical realization of this potential in the conditions of modern energy and environmental challenges.

Keywords: *biomass, renewable energy sources, development potential and prospects, energy security, sustainable development.*

Introduction. The modern world is facing unprecedented challenges related to climate change, energy security and ecosystem sustainability. In this context, the development of renewable energy sources and the creation of effective systems for the use of natural resources become an important task. One of the potential solutions is the development of biomass technologies. Biomass includes organic materials such as wood, straw, manure, and other biological wastes that can be used to produce energy, heat, fuel, and biochemical products. The use of biomass can help reduce greenhouse gas emissions, reduce dependence on imported energy sources, and create new opportunities for the development of agriculture and the bioeconomy in Ukraine. This article is devoted to the analysis of the potential and prospects for the development of biomass technologies in Ukraine. Existing technologies of biomass use, advantages and limitations of their implementation, as well as possible ways of promoting the development of this sector in the country are considered. The conducted analysis will help to understand how biomass can become an important component of sustainable development of Ukraine and contribute to the achievement of energy efficiency and environmental goals.

Main goal and tasks. *The main goal* of this article is a thorough analysis of the potential and prospects for the development of biomass technologies in Ukraine, taking into account modern challenges related to energy security, climate change and sustainable development. The specific tasks of the research include the following: conducting an overview of the current state of biomass technology use in Ukraine, including existing projects, the volume of biomass energy production, and the types of biomass used; determine the advantages and limitations of using biomass in the context of energy efficiency, environmental requirements, and economic sustainability; identify potential industries and applications of biomass technologies that may become important in Ukraine, including the production of biofuels, heat, electricity, and biochemical products; consideration of foreign experience and best practices in the field of biomass use and determination of the possibilities of their adaptation to Ukrainian conditions; developing recommendations and strategic steps for the government, business and the public to promote the development of biomass technologies in Ukraine, including measures to raise awareness, create favorable conditions for investment, and support research and development of this sector. This article is designed to promote understanding and discussion of the opportunities and challenges associated with the use of biomass in Ukraine, and to promote the development of a sustainable, ecological and energy-secure economy.

Material and research results. The modern world is experiencing a number of global challenges related to climate change, energy security and sustainable development. One of the possible solutions to overcome these challenges is the use of biomass as a source of energy and raw material for the production of various products. Ukraine, with its large natural resources and potential in the agricultural sector, has a unique opportunity to develop biomass technologies that will contribute to sustainable development and improvement of the ecological situation. Ukraine is one of the countries where biomass potential is huge. A large part of land resources is used for

agricultural production, which creates large volumes of biological waste, such as straw, manure and other plant and animal residues. This waste can be used to produce biomass energy, biofuel, and other products. In addition, the Forest Fund of Ukraine provides an opportunity to use wood as a source of biomass. The forest industry has the potential to develop technologies for the production of biofuels and other wood-based products.

The International Renewable Energy Agency (IRENA) has developed a forecast for the introduction of RES until 2050. IRENA suggests that RES could account for 60% or more of the total final energy consumption of many countries. For example, China can increase the share of RES in energy consumption from 7% in 2015 to 67% in 2050. In the EU, this share can increase from 17% to more than 70%. In India and the USA, the amount of energy from RES in the total energy consumption can reach two thirds or more. According to IRENA forecasts, bioenergy will play a key role in the implementation of the "green" energy transition and the reduction of greenhouse gas emissions in the world. IRENA estimates that the share of biomass in the final consumption of renewable energy will be almost half in 2030 and 40% in 2050. The agency's conclusion: without doubling energy production from biomass by 2050, it is impossible to keep the global temperature rise on Earth within 2 0C. Analytical company Ecofys has developed an ambitious scenario of achieving 95% of final energy consumption in the world from RES by 2050. It is important to note that according to this scenario, as in IRENA forecasts, about 40% of all renewable energy will be provided by biomass.

According to the European Commission, in order to achieve the ambitious goal of reducing greenhouse gas emissions to zero, the share of bioenergy in the total energy mix should be at least 20% (about 30% of all RES) in 2050. According to IRENA's forecast, the production of electricity in the world during 2015-2050 will almost double in 2018 with provision of 85% of the total volume at the expense of RES. Ecofys estimates that the share of biomass in global electricity production will be about 12%. In the EU electricity sector, according to various scenarios (80-100% "green" electricity by 2050), the share of biomass in electricity production will be 10-12%. Today, biomass provides about 17% of the EU's total need for heat and cold, which corresponds to 87% of the contribution of all RES. Over the past 20 years, the volume of heat consumption from biomass in Europe has increased by 1.7 times - from 52 to 90 million tons per year. It is predicted that the significant contribution of bioenergy to the production of renewable heat will remain in the long term.

There are many examples of successful implementation of similar modern bioenergy projects in the world and in the EU. For example, in the center of Stockholm with a population of 2.3 million people, one of the world's largest biomass thermal power plants operates (130 MWtel + 280 MWt). Biomass provides 80% of the city's heat needs and 20% of energy for transport. By 2030, the transition of the city to 100% RES is planned. Vilnius (550,000 people) operates the largest biomass thermal power plant in Eastern Europe (70 MWtel + 164 MWt). Bioenergy provides 85% of the city's need for heat and 25% of its need for electricity. By 2040, it is planned to achieve 100% of thermal energy from RES in Vilnius. In Copenhagen, 98% of the housing stock (including the private sector) is connected to a fully competitive district heating system. Several large biomass CHP plants with a total thermal capacity of 1.3 GW operate in the city. Biomass currently provides 90% of Copenhagen's heat needs and 20% of energy in the transport sector. By 2040, it is planned to achieve 100% of all energy from RES. There is also an opinion that in the future it is possible to reach almost 100% share of electricity use in heating and transport, therefore there is no room left for biomass in these sectors. The prospects of bioenergy in the electric power sector are seen in the combined production of heat and electricity (biomass thermal power plant), as well as through the use of biomethane to balance power systems with a high share of RES. Biomethane production potential in Ukraine is estimated at 7.8 billion m3/year. This amount is more than enough for the complete conversion of the necessary gas shunt generation to biomethane.

The study of climatic conditions and resources of renewable sources in Ukraine, as well as the current experience of their use in the world, allows us to determine biomass energy as one of the most promising vectors of renewable energy for the next 20-25 years. In the energy sense, biomass means the production of electrical and thermal energy (as well as liquid and gaseous fuel) from organic substances of vegetable and animal origin that contain carbon (wood waste, peat, straw, plant residues of agriculture, organic part of solid household waste, etc.). [1]

The main methods of obtaining biomass energy include: burning of raw materials of plant origin (wood, straw, husks, etc.); incineration of municipal solid waste; use of vegetable oils as fuel for internal combustion engines; biopreservation or decomposition of organic substances of plant or animal origin in anaerobic conditions with the formation of biogas, ethanol, butanol, etc.; thermochemical conversion (pyrolysis, gasification, synthesis) of solid organic substances (peat, wood, etc.) with the production of "synthesis gas", synthetic gasoline.

Today, biomass is the *fourth largest source of energy worldwide*. The content of biomass in the biosphere is very large - 800 billion. tons. 200 billion tons are recovered annually. The global economic potential of biomass use is 3.27 billion tons of conventional fuel. In particular, for Russia, it is approximately 15% of the total. Therefore, in the future, it will play an important role in meeting the world's energy needs. [2]

Biomass can make a significant contribution to the direct substitution of fossil fuels in the production of thermal energy. In Ukraine, there are a number of barriers that prevent the widespread involvement of biofuels in this sector. As a result of the monopoly position of enterprises in the district heating (DH) sector and imperfect

legislation, there are the following problematic issues in the district heating sector in Ukraine: lack of prerequisites for competition, lack of incentives to increase the efficiency of heat energy production, the existence of barriers to access to heat networks of independent CH producers (including producers of CHP from biomass), high tariffs for CHP, low investments in the modernization of CH systems, lack/insufficiency of investments as a result of the imperfection of the existing tariff formation mechanisms.

The results of research conducted in the state of Iowa (USA) revealed an interesting comparison between different biomass and fossil fuels. Thus, for high-temperature and power plants, biomass cannot compete with coal, although agricultural residues can be supplied at a lower cost. Also, fuels used in transport and obtained from biomass cannot always compete with fuels obtained from oil. Although in the future, with the increase in the price of fossil fuels and the improvement of biomass processing technologies, the situation may change rapidly. In addition to the costs of collecting and transporting fuel from biomass, the final cost of its energy will also be affected by the cost of equipment, its maintenance and operation. Such system costs will in turn depend on the size and type of processing system. For small-scale electricity production, biomass can be more cost-effective than fossil fuels, but again it depends on the situation. So, for example, power-based gasifiers for electricity generation in remote areas of India are cheaper than diesel-based energy production, which is confirmed by their growing number. For large-scale biomass energy production, studies show that only cheap waste fuel can be competitive with coal-based energy production, since the cost of electricity using hybrid willows as fuel can be about twice the cost of electricity , produced from coal. This explains why the vast majority of US electricity generation is based on forest waste. [5]

Modern technologies using biomass are still in the initial stages of development and commercialization. The reason here is a large number of barriers that must be removed. For example, the low price of oil on the international market was until recently the main obstacle to the development of many renewable energy systems. Also, the situation may worsen with subsidies that may be provided for fossil fuels.

The current situation with energy supply in Ukraine is very similar to that which existed in Denmark before 1976, when it was an extremely poor European country, because most of the money earned by fishing, shipbuilding and agriculture was spent mainly on the purchase of energy resources. Since 1976, the Danish government has taken a course for the intensive development of PEK. Large-scale implementation of wind and solar energy, technologies for the use of biomass, biogas and energy saving in production, Denmark has transformed from a poor country to a rich one in 12-15 years, its population has a high level of social security, and the government implements an independent policy on the world stage. [7]

Denmark's experience in modernizing the fuel and energy complex is currently being actively used by numerous EU member countries on the basis of the relevant EU directive, as well as the USA, India, and China. Ukraine should make a breakthrough in the same direction as the leading countries. It is easier to bet on the development of renewable energy in Ukraine, since the first stage has already been passed. In our country, unlike other states of the former USSR, the leadership declaratively stimulates its development. The problems of organic waste processing are particularly relevant for Ukraine compared to all other CIS countries and most European countries. Firstly, it is a country with a highly developed agricultural, food and processing industry, and secondly, it is a largely urbanized state. The share of traditional fuels in the total national energy use of Ukraine will decrease when conditions are created for increasing the consumption of biomass energy. The advantage of fossil fuels, particularly coal, over biomass would be significantly less in terms of market price if environmental costs were factored into fuel pricing. Since today there is a problem of large-scale use of fossil fuels in relation to the impact on the environment, it is not appropriate to exclude it from the energy assessment. In order to increase the percentage of biomass consumption in the total resource, as well as for it to play an important role in the energy sector of Ukraine, it is necessary to overcome a number of problems and make effective improvements.

It is worth highlighting *the key challenges* that may arise when implementing new biomass technologies: subsidies and low (non-world) prices for primary fuel; lack of a national coordinating agency for renewable energy; high prices for biomass and installations; lack of information for the population; lack of understanding of the impact on health; lack of suitable projects for local traditions in some regions; lack of local support services; futures investments. [9]

Extremely important for Ukraine is the large-scale application of technologies for the use of plant biomass both through direct burning and its conversion to biogas, biodiesel, generator or pyrolysis gas, which can act as full-fledged substitutes for natural gas, coal, motor fuels, other petroleum products and primary energy sources. At the same time, valuable organic fertilizers can be produced, which are extremely necessary to preserve humus in Ukrainian chernozems, increase their fertility, and limit the "poisoning" of the earth by herbicides. From the energy and economic point of view, the most appropriate method of biomass utilization is gasification with the subsequent production of synthesis gas from almost any carbon raw material. In particular, Ukraine has the opportunity to use the potential of raw materials for the production of synthesis gas in the amount of approximately 36 million tons. p., which is approximately 22% of the need for fuel and energy resources.

Biomass utilization technologies. Biomass utilization technologies include processes of biogasification, production of biofuel, bioproducts and heat. Biogasification, for example, allows you to turn organic materials into

biogas, which can be used to produce electricity and heat. Biofuel, like biodiesel, can be obtained from vegetable raw materials and is used in motor vehicles and other areas.

Advantages and limitations of using biomass. The use of biomass has its advantages and limitations. Benefits include reduced greenhouse gas emissions, reduced energy dependence on imported sources, and improved air quality. However, limitations include high infrastructure costs, competition with other forms of energy production, and potential negative impacts on biodiversity. Prospects for the development of biomass technologies in Ukraine The use of biomass technologies can contribute to the diversification of energy sources and the reduction of the carbon footprint. The development of the biomass industry will also create new jobs and contribute to the development of the agricultural sector. However, certain measures are needed to achieve these prospects, such as creating an enabling legal environment, supporting innovation and research, and attracting investment. It is also important to give weight to environmental aspects and follow a sustainable approach in the development of biomass technologies. [10]

In Ukraine, 5 million tons of straw are regenerated annually. From 1 million tons of straw, you can get 100,000 tons of ethyl alcohol, 140 million m3 of methane, and tens of tons of fertilizers. According to the calculations of the National Academy of Sciences, the use of only 20% of straw resources (this amount of straw is lost annually) makes it possible to fully meet the needs of the population, primarily rural, in electrical and thermal energy. In order to use these potential opportunities of straw, it is necessary to establish the production of equipment for its collection and packaging, boilers and other energy equipment for use. When all biomass resources are involved in the Ukrainian fuel and energy balance, a real basis will appear for the modernization and optimization of the coal industry so that it becomes safe for the life and work of miners, profitable and not burdensome for the state budget, and takes its proper place in the PEB and did not destroy the environment. The next reserve of Ukraine's fuel resources is the forest, the potential of which is not yet satisfactorily used, as dry and substandard wood that rots is not used, and forests are overgrown with shrubs. At the same time, schools, preschools, rural hospitals, as well as some industrial enterprises are not properly heated in the winter. Therefore, for their heating, it is necessary to adjust the production of heating equipment for local types of fuel

The financial costs of biomass energy technologies depend to a large extent on the cost of biomass fuel, which in turn depends on the location and type of fuel. For example, the range of costs for biomass residues such as sunflower husks, straw varies from negative values, in those situations where they are used as waste, and have a cost that is related to their location to the processing facility where it can be used as an energy resource. Ukraine's energy problems are expected to contribute to the use of cheap biomass resources and the introduction of new technologies for its utilization, which in turn will contribute to solving environmental and economic problems. Thus, striving to reduce the man-made load on the surrounding natural environment, it is necessary to simultaneously find opportunities to reduce the threat of bankruptcy of specific business entities. At the same time, one should take into account the fact that in the territories of industrial zones, various wastes of economic activity in the form of biomass of industrial, plant and agricultural origin, solid household waste, etc., are systematically accumulated. In most cases, the specified types of waste are suitable for energy utilization, in the implementation of which two goals are achieved: alleviating to a certain extent the threat of bankruptcy of entities of economic activity that use energy-utilized waste due to the lower cost of the latter, compared to traditional fuel energy resources and the relevant territory is freed from waste of this type, which is systematically accumulated. Energy dependence on the world oil and gas market is likely to promote the use of biomass as a way to increase energy security throughout the world, including Ukraine. The rate of future use of biomass as an energy source will depend on the measures that need to be taken to remove the barriers listed above. According to the RES development program in the EU countries, by 2010 the share of biomass in its total contribution should be 74%, which will be equal to 9% of the total consumption of primary energy carriers. It follows that Ukraine should also set similar goals for itself and should not lag behind Europe in this matter. Therefore, it is necessary to begin the large-scale implementation of priority measures for the use of biomass immediately, since further delay is unacceptable.

In order to strengthen the energy sustainability of Ukraine, OJSC "Naftogaz of Ukraine" has started preparatory work on the construction of thermal power plants in Lviv and Zhytomyr that will run on biomass (wood chips) and solid secondary fuel. The total capacity of the facilities will be 90 MW of thermal energy and 11 MW of electrical energy. The planned period of commissioning of facilities in the city of Lviv - I quarter. 2023, in the city of Zhytomyr - IV quarter. In 2023, Naftogaz of Ukraine intends to build 9 bio-CHP plants and bio-boiler plants in 8 regions of Ukraine, which will have a total capacity of 250 MW of thermal energy and 52 MW of electricity. The company plans to become the largest heat generator from biomass by 2027, as well as replace about 2 billion cubic meters. natural gas.

In recent years, a number of important and essential steps have been taken to develop the production of alternative fuels in Ukraine: on October 21, 2021, Law of Ukraine No. 1820-IX "On Amendments to Certain Laws of Ukraine Regarding the Development of Biomethane Production" was adopted, which established the legislative basis for development of the biomethane market in Ukraine and its export, thanks to the use of the biomethane registry. Resolution No. 823 of the Cabinet of Ministers of Ukraine dated July 22, 2022 No. 823 of the Cabinet of Ministers of Ukraine approved the Procedure defining the requirements for the functioning of the biomethane

register and instructed the State Agency for Energy Efficiency and Energy Saving to ensure its creation and operation. The Law of Ukraine of May 31, 2022 No. 2284-IX "On Amendments to the Tax Code of Ukraine and other laws of Ukraine regarding the stimulation of the production of denatured ethyl alcohol" entered into force, which provides for the possibility temporarily, for the period of the legal regime of martial law, for subjects businesses that have a license for the production of undenatured ethyl alcohol to produce denatured ethyl alcohol and/or bioethanol on the basis of a license for the production of undenatured ethyl alcohol, and business entities that have a license to produce denatured ethyl alcohol to produce bioethanol. On April 1, 2022, the project of the Law of Ukraine "On Amendments to the Tax Code of Ukraine and other legislative acts of Ukraine regarding the payment of a single contribution and accounting for denatured ethyl alcohol and products for chemical and technical purposes" dated March 30, 2022 No. 7233 was taken as a basis. It is proposed reduction of VAT to 7% and abolition of excise tax on alternative fuels until martial law is lifted. The draft law provides for a mandatory share (at least 10%) of the liquid biofuel content in automobile gasoline (at the same time, it should be postponed until martial law is lifted). The Law of Ukraine dated June 20, 2022 No. 2320-IX "On Waste Management" will facilitate the establishment of biomass production based on organic household waste thanks to the implementation of a separate collection system.

Factors influencing the bioenergy industry of Ukraine. The underdeveloped fuel market in Ukraine - the creation of a biofuel market and the development of legal acts that will regulate its activity are a necessity. Monopoly position on the heat supply market - it is urgently necessary to introduce a competitive thermal energy market based on the model of a single buyer and to start work on by-laws that will guarantee the implementation of the law. Complicated access to heat networks - it is necessary to update the legal framework, provide for an exceptional list of grounds for refusal of connection, as well as provide for the need to provide the TKE with a full description of the system for assessment by a potential manufacturer of the possibility of connection. We also face the problem of insufficient biomass on the market, which leads to higher prices. The problem can be solved by creating a biofuel trading system, a single electronic platform for biofuel trading. State-owned enterprises will have the obligation to sell part of the raw materials through this system, and those who use the "green" tariff and the incentive tariff for heat will be obliged to buy biomass through this platform. This is a guarantee of quality, a good price and the presence of interested players on the market. Low investment attractiveness of bioenergy projects. The period of validity of the "green" tariff is not enough for the payback of bioenergy projects. Attention should also be paid to the possibility of extending the "green" tariff to make it higher for low-power installations. Lack of stimulation for the cultivation of energy crops - today, farmers do not have a sufficient level of motivation and stimulation to attract significant amounts of investment in the development of projects for the cultivation of energy crops due to low profitability. It is also necessary to lease land for such projects without auctions, to extend the lease term by at least 20 years, and to provide for a one-time subsidy of UAH 25,000 per hectare. The state will bear the costs and help establish the plantations, but for the next 20 years they will provide local fuel, create jobs, and improve local development through the payment of taxes. Complicated access to logging residues makes it extremely important to ensure the transportation of such residues to the nearest roads and to prohibit their burning in the forest.

Increasing the volume of biomethane production in Ukraine. In the future, this gas can be fed into a gas pipeline and used for heat, electricity and transport. In Ukraine, it is possible to obtain biomethane not only from traditional silage and manure. Modern technologies allow the use of agricultural residues, straw, etc. It is necessary to create a register where each produced cube of biomethane will be recorded and each consumed cube will be written off.

Conclusions. The potential for the development of biomass technologies in Ukraine is huge, and this industry can become an important tool for achieving energy efficiency, reducing emissions, and developing a sustainable economy. With the right measures and strategic planning, Ukraine can use its biomass potential to improve the quality of life of its citizens and ensure a sustainable future. In order to create a competitive biofuel market in Ukraine, it is necessary to ensure the free access of enterprises of all forms of ownership to waste or by-products of forestry and agriculture, as well as to establish a biofuel exchange for the implementation of transactions of purchase and sale of various types of biofuel.

The development of biomass technologies in Ukraine has great potential and can become an important factor in achieving energy sustainability, reducing greenhouse gas emissions, and sustainable development of the country. Based on the analysis, the following conclusions can be drawn: Ukraine has a significant potential for the use of biomass due to large volumes of agricultural production and forest resources. The use of biomass reduces dependence on imported energy sources and contributes to the development of agriculture. Biomass utilization technologies include biogasification, biofuel production, biochemical processes, and others. They can be used to produce electricity, heat, biofuel and other products. The advantages of using biomass are to reduce greenhouse gas emissions, improve air quality and promote the development of the agricultural sector. However, there are limitations such as high infrastructure costs and competition with other energy sources. The prospects for the development of biomass technologies in Ukraine are quite impressive and have a real chance to be realized by

attracting additional investment, but require comprehensive measures, such as creating a favorable legislative environment, supporting research and innovation, and attracting investment. It is important to remember that the development of biomass technologies should take place within the framework of a sustainable approach, taking into account environmental aspects and social benefits. In general, the development of biomass technologies in Ukraine is a promising direction that can contribute to the achievement of a number of economic, environmental and energy goals. It is necessary to pay attention to further research and development of this industry in order to improve energy security and sustainable development of Ukraine.

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АНАЛІЗ ПОТЕНЦІАЛУ ТА ПЕРСПЕКТИВ РОЗВИТКУ ТЕХНОЛОГІЙ БІОМАСИ В УКРАЇНІ

У даній статті проводиться глибокий аналіз потенціалу та перспектив розвитку технологій використання біомаси в Україні. Здійснюється огляд сучасного стану використання біомаси в енергетичному, промисловому та сільськогосподарському секторах країни. В статті детально розглядаються різні види біомаси, такі як деревина, сільськогосподарські залишки, біологічні відходи тощо, та їх потенціал для виробництва енергії та інших корисних продуктів. Окрема увага приділяється технологічним інноваціям у сфері обробки біомаси, включаючи процеси біогазування, піролізу та гідротермальної конверсії. Автори аналізують екологічні та економічні аспекти використання біомаси як джерела енергії, розглядаючи його вплив на зменшення викидів парникових газів та забезпечення енергетичної незалежності країни. Додатково, стаття розглядає важливі законодавчі та стратегічні ініціативи, спрямовані на підтримку розвитку використання біомаси в Україні, і висуває пропозиції щодо подальших кроків для стимулювання цього напрямку. В цілому, стаття служить цінним джерелом інформації для науковців, експертів та приймачів рішень, зацікавлених у розвитку сталої енергетики та використанні відновлювальних джерел енергії в Україні.

Сформульовано рекомендації для подальшого розвитку використання біомаси в Україні, враховуючи важливість вирішення екологічних проблем та енергетичної незалежності. Узагальнюючи, стаття не лише пропонує глибокий аналіз потенціалу та перспектив розвитку технологій біомаси, але й визначає шляхи для практичної реалізації цього потенціалу в умовах сучасного енергетичного та екологічного викликів.

Ключові слова: *біомаса, відновлювальні джерела енергії, потенціал та перспективи розвитку, енергобезпека, сталий розвиток.*

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