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MECHANISMS OF STATE STIMULATION OF THE IMPLEMENTATION OF PUBLIC-PRIVATE PARTNERSHIP REGARDING THE INTRODUCTION OF WASTE-FREE TECHNOLOGIES FOR THE PRODUCTION OF BIOFUELS AT AGRICULTURAL AND PROCESSING ENTERPRISES OF UKRAINE

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Mechanisms of state stimulation of the implementation of public-private partnership regarding the introduction of waste-free technologies for the production of biofuels at agricultural and processing enterprises of Ukraine

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ABSTRACT

The purpose of this monograph is to theoretically substantiate and methodologically develop the basic principles and practical mechanisms of state stimulation of the implementation of public-private partnership for the implementation of waste-free technologies for the production of biofuels at agricultural and processing enterprises of Ukraine.

The subject of the study is a complex of theoretical, methodological and applied aspects in the field of biofuel production management on the basis of public-private partnership.

The object of the study was chosen to be the management of biofuel production on the basis of public-private partnership.

The methodological basis for the study was the dialectical method of understanding the patterns of economic development, a systematic approach, abstract-logical and theoretical generalization when studying literary sources and generalizing the theoretical provisions of the study.

The practical part of the work is built on the basis of the works of leading domestic scientists, foreign specialists, and practitioners in the field of biofuel production management on the basis of public-private partnership.

The method of the monograph is the application of theoretical and practical principles and problematic aspects of the organization of management of biofuel production on the basis of public-private partnership.

In accordance with the set goal, the following task was solved:

– to study the conceptual apparatus of the issues of forming bioenergy potential;

– to study the regulatory and legal principles of developing public-private partnership in the field of biofuel production;

– to analyze methodological approaches to assessing the efficiency of biofuel production on the basis of public-private partnership;

– to assess the bioenergy potential of Ukraine;

– to analyze the ecological and economic aspects of developing bioenergy

potential in Ukraine;

– to assess the practice of applying public-private partnership in the field of biofuel production in Ukraine

– to develop a mechanism for state stimulation of the implementation of public-private partnership for the implementation of waste-free technologies for biofuel production at agricultural and processing enterprises of Ukraine;

– to study the ecological and economic aspects of developing bioenergy potential in Ukraine;

– to investigate the features of investment process management in the field of biofuel production on the basis of public-private partnership.

The theoretical and methodological basis of the study was the methods of observation, comparison, analysis and synthesis, modeling of economic phenomena, fundamental works of domestic and foreign economists in the field of biofuel production management.

The use of biomass for energy production is a promising direction in modern energy. Biomass can be processed into various types of fuel, such as biodiesel and biogas. The development of bioenergy reduces the reduction of traditional energy sources, reduces greenhouse gas emissions and creates new jobs. Public-private partnership is an effective tool for attracting investment and stimulating the development of this sector.

The practical significance and scientific novelty of the work arises from the fact that the theoretical conclusions and generalizations made in them can be used in the process of ensuring the development of biofuel production on the basis of public-private partnership.

The monograph was prepared as part of scientific research in the implementation of the state topic: "Development of bio-organic technologies for growing agricultural crops for the production of biofuels and ensuring energy independence of the agro-industrial complex" (state registration number 0123U100311).

CONTENTS

INTRODUCTION

The development of biofuel production in Ukraine is a strategically important task that contributes to energy independence, reducing greenhouse gas emissions and improving the environmental situation. Public-private partnership is an effective tool for attracting investments and new technologies to this sector.

Analysis of existing incentive mechanisms indicates the need for their improvement. Green tariffs, although an important incentive, require further development and expansion of the circle of their beneficiaries. Tax breaks and credit lines can also be more effective if their tariff policy is clear.

The development of bioenergy in Ukraine is a strategic direction for ensuring energy security, reducing dependence on imported energy sources and improving the environmental situation. Public-private partnership (PPP) is an effective tool for attracting investments and new technologies to this sector. However, for the successful implementation of such projects, a comprehensive system of state support is necessary.

Biomass is a universal source of energy. It can be burned in its natural form (wood, straw) or processed into liquid (biodiesel) and gaseous (biogas) fuels. Biological processing methods are the most promising. Bioenergy is not only an alternative to traditional energy sources, but also a path to sustainable development. Many countries are actively developing this area, attracting private investment through public-private partnerships.

Using biomass as fuel is an environmentally friendly and renewable way to obtain energy. It can be burned directly or processed into liquid and gaseous fuels. Biological methods of biomass processing are the most promising due to their efficiency and environmental friendliness. The development of bioenergy helps to reduce dependence on fossil fuels, reduce greenhouse gas emissions and create new jobs. Public-private partnerships are an effective tool for stimulating this process.

The works of a number of scientists are devoted to the study of various aspects of the development of alternative energy: Kaletnika G.M., Goncharuk I.V., Tokarchuk D.M., Bondarenko V.M., Logoshi R.V., Gontaruk Ya.V., Furman I.V., Berezyuka

S.V., Pryshlyak N.V., Yemchik T.V., Lutkovska S.M. and others. It is worth noting that they all note the importance of such studies. However, in economic science, the issue of the development of biofuel production on the basis of public-private partnership has not been fully investigated. Given such uncertainty, the need for scientific substantiation of the management of biofuel production on the basis of public-private partnership becomes of significant importance.

Scientists have made a significant contribution to the theoretical and methodological perspective of the study of the specified problem, many of its methodological and applied aspects have been solved. However, some issues of this multifaceted problem have been insufficiently studied. In particular, the issue of stimulating biofuel production on the basis of public-private partnership remains debatable.

The purpose of the monograph is to determine the theoretical and practical principles and problematic aspects of organizing the management of biofuel production on the basis of public-private partnership.

In accordance with the goal, the following tasks were solved:

– to study the conceptual apparatus of the issues of forming bioenergy potential;

– to study the regulatory and legal principles of the development of public-private partnership in the field of biofuel production;

– to analyze methodological approaches to assessing the efficiency of biofuel production on the basis of public-private partnership;

– to assess the bioenergy potential of Ukraine;

– to analyze the ecological and economic aspects of the development of bioenergy potential in Ukraine;

– to assess the practice of applying public-private partnerships in the field of biofuel production in Ukraine

– to develop a mechanism for state stimulation of the implementation of public-private partnerships for the implementation of waste-free technologies for the production of biofuels at agricultural and processing enterprises of Ukraine;

– to investigate the ecological and economic aspects of the development of

bioenergy potential in Ukraine;

– to investigate the features of managing investment processes in the field of biofuel production on the basis of public-private partnerships.

The theoretical and methodological basis of the study was the methods of observation, comparison, analysis and synthesis, modeling of economic phenomena, fundamental works of domestic and foreign economists in the field of managing biofuel production.

The use of biomass for energy production is a promising direction in modern energy. Biomass can be processed into various types of fuel, such as biodiesel and biogas. The development of bioenergy contributes to reducing dependence on traditional energy sources, reducing greenhouse gas emissions and creating new jobs. Public-private partnership is an effective tool for attracting investment and stimulating the development of this sector.

SECTION 1
SCIENTIFIC AND THEORETICAL PRINCIPLES OF MANAGING BIOFUEL PRODUCTION ON THE BASIS OF PUBLIC-PRIVATE PARTNERSHIP

The problem of energy security is one of the most urgent for Ukraine. Dependence on imports of traditional energy carriers makes our country vulnerable to external factors and price fluctuations on the world market. An alternative energy source that can significantly reduce this dependence is biodiesel. Biodiesel production not only contributes to energy independence, but also has a number of other advantages, such as reducing emissions of harmful substances into the atmosphere, stimulating the development of agriculture and creating new jobs.

The development of biodiesel production in Ukraine depends on many factors, including:

State policy: the presence of a clear and consistent state policy aimed at supporting biofuel production is one of the key factors. This includes the development and implementation of relevant regulatory and legal acts, providing financial support to producers, establishing mandatory biofuel admixtures to traditional fuels, etc.

Raw material base: the availability of sufficient raw materials for biodiesel production is critically important. In Ukraine, the main raw material for biodiesel production is rapeseed. However, the potential for using other oilseeds, such as sunflower, soybean and rapeseed, is also significant.

Production technologies: the level of development of biodiesel production technologies directly affects its cost and quality. The introduction of modern technologies allows to increase production efficiency and reduce the negative impact on the environment.

Investments: attracting investments is a necessary condition for the development of biodiesel production. This applies to both direct investments in the construction of new production facilities and investments in research and development of new technologies.

Logistics: the development of infrastructure for storage and transportation of biodiesel is an important factor in ensuring its stable supply to the market.

Energy security is currently one of the most important components of the country's economic security, since only with reliable provision of fuel and energy resources is the full functioning of all economic and state institutions possible. In the modern world, energy is the basis of practically all spheres of life and not only plays a decisive role in the country's economic progress, but also serves as the basis for ensuring the sustainable development of society as a whole. At the same time, it is impossible to consider the level of energy supply of the state (society) to be completely reliable under any socio-political conditions. In the context of globalization, the positions of states that are energy donors are characterized by increased instability, unpredictability, political selfishness and aggressiveness. As a result, countries that were and remain energy consumers are faced with the need to develop their own systems for ensuring energy security, the effectiveness of which must balance the dysfunctional influences (challenges, threats, dangers) produced by the international environment.

The forecast of scientists that by 2050 we can expect a doubling of the demand for energy resources makes it appropriate to study energy security as a functional component of the economic and national security of the state.

Bioenergy potential is a complex concept that characterizes the ability of a certain territory, region or country to produce energy from biomass. It includes not only the available biomass resources (vegetation, agricultural and forestry waste), but also the technological, economic and institutional potential for its conversion into energy.

The main components of bioenergy potential:

– resource potential: the quantity and quality of available biomass;

– technological potential: availability and level of development of technologies for biomass processing;

– economic potential: economic feasibility of biofuel production, investment attractiveness;

– institutional potential: legislative framework, state support.

The main problems of forming bioenergy potential:

– lack of investment: high cost of construction of bioenergy plants;

– competition with other sectors: use of agricultural land for growing energy crops;

– logistical problems: collection, transportation and storage of biomass;

– seasonality of biomass production: uneven supply of raw materials;

– lack of developed infrastructure: insufficient network of biomass collection and processing. The main resource components of bioenergy potential are presented in Table. 1.1.

Biomass is a broad concept that covers various organic materials that can be used as a renewable energy source. This resource is extremely diverse both in its composition (chemical and physical properties) and in its application potential.

Table 1.1

Resource components of bioenergy potential

Concept	Definition	Role in the formation of bioenergy potential	Example
Biomass	Any organic matter derived from living organisms that can be used as a source of energy.	The main raw material for the production of biofuels.	Wood, straw, agricultural waste.
Biofuel	Fuel derived from biomass.	An energy carrier that replaces traditional fuels.	Wood pellets, biodiesel, biogas.
Energy crops	Plants specifically grown for biofuel production.	A source of biomass with high energy value.	Miscanthus, sunflower, rapeseed.
Bioenergy plant	Equipment for converting biomass into energy.	Ensures the conversion of biomass into useful energy.	Biomass boiler house, biogas plant.
Biomass efficiency	The ratio of energy obtained to energy used to produce biofuel.	An indicator of the economic feasibility of using biomass.	Number of kilowatt-hours of energy obtained from 1 ton of biomass.

Source: based on [1-18]

Crops, perennial plants and various agricultural and forestry wastes can serve as raw materials for biofuel production. It is worth noting that different types of biomass have different calorific values, which affect the efficiency of their use (Table 1.2).

Biomass is an organic material derived from living organisms and can be used

as a source of energy. It is an important component of renewable energy and has a wide range of applications. Let's look at the main types of biomass in more detail:

Wood: this is the most common type of biomass. It includes: wood: tree trunks, branches, which are used as fuel or for the production of wood pellets; wood processing waste: sawdust, shavings, bark, which can be used to generate heat or produce paper; agricultural: this is agricultural waste, such as:

– straw: stalks of cereal crops (wheat, barley, corn) remaining after harvesting;

– stalks of other crops: sunflower, corn, cotton;

– food industry waste: pulp, bran, shells;

– energy crops: specially grown plants for biomass production (miscanthus, willow, poplar);

– forest: includes logging waste, forest litter, branches.

Table 1.2

Types of biomass

Main type	Subtype	Example
Forest biomass	Primary forest products	Stump wood
	Primary forest waste	Residuals from forestry activities (chips, branches, stumps, etc.)
	Secondary forest waste	Residuals from forestry activities (sawdust, bark, etc.)
Energy crops	Oily, sugary and starchy	Rapeseed, sunflower, corn and grain crops
	Energy grasses	Miscanthus, millet, sugar cane
	Fast-growing plants	Willow, poplar
Main type	Primary agricultural waste	Straw of various types of agricultural crops
	Secondary agricultural waste	Residuals from industrial processing of agricultural crops (husks, pulp)
	Manure	Cattle, pigs, poultry
Organic waste	Tertiary residues	Biodegradable household and sewage waste

Source: adapted from [1-18]

Animal biomass:

– manure and droppings: livestock waste that can be used for biogas production.

Microbial biomass:

– biomass of microorganisms (bacteria, algae) grown in bioreactors. Used for the production of biofuels and other biologically active substances.

Bioenergy potential is proposed to be considered as a production system that represents the use of available and strategically possible biomass, which is expressed in the potential capacity to produce energy sources of a certain composition, technical compliance and quality in the required volume. It is important to note that the economic efficiency of a bioenergy project depends on the complex impact of all these factors. Assessing the economic feasibility of the bioenergy potential of a resource requires a complex assessment taking into account the economic feasibility of using the bioenergy potential (Table 1.3).

Table 1.3

Economic aspects of bioenergy: table of factors

Economic factor	Description	Impact on bioenergy
Cost of raw materials	Biomass price (energy crops, agricultural waste, forest waste).	Directly affects the cost of biofuels.
Cost of technologies	Investments in biomass processing equipment, construction of bioenergy plants.	Determines the initial investment and payback period of the project.
Energy efficiency	Efficiency of biomass to energy conversion technologies.	Affects the amount of energy obtained from a unit of biomass and, accordingly, economic efficiency.
Social costs	Expenses on labor protection, social programs for employees.	Affects the total costs of biofuel production.
Environmental costs	Expenses on wastewater treatment, waste disposal, compensation for environmental damage.	Increases the cost of biofuel production.
Government support	Subsidies, tax breaks, loans for bioenergy projects.	Reduces investment risks and stimulates the development of the industry.
Price of energy carriers	Prices for traditional energy carriers (gas, oil).	Determines the competitiveness of biofuels.
Markets	Volumes and prices for biofuels on domestic and foreign markets.	Affects the profitability of bioenergy enterprises.
Transport costs	Cost of transportation of biomass and biofuels.	Affects the cost of biofuels, especially for remote regions.
Seasonality of biomass production	Change in the quantity and quality of biomass during the year.	Requires additional costs for storage and processing of biomass.

Source: own research

The formation of bioenergy potential is a complex multifaceted process that requires an integrated approach. The combination of theoretical knowledge and practical skills will allow for the effective use of biomass as an energy source and contribute to the development of a sustainable energy sector.

It should be noted that the development of biofuel production requires significant investment resources, and in conditions of martial law, state incentives cannot provide adequate support, therefore, it is advisable to develop mechanisms for public-private partnerships. The development of PPPs in the field of biofuel production can stimulate the development of bioenergy in Ukraine, contribute to reducing dependence on imported energy sources and improve the environmental situation in the country [10, p. 293]. Effective resource management is a key factor in the success of biogas and digestate production projects. The implementation of the right system can help projects achieve their goals and contribute to the development of sustainable energy and agriculture [11]. The advantages and disadvantages of PPPs are presented in Table 1.4.

In general, PPP is a promising tool for the development of bioenergy, but its successful implementation requires careful planning, a transparent management mechanism and effective control.

Public-private partnership (PPP) in the field of biofuel production is an effective mechanism that combines the resources and competencies of the state and the private sector to achieve common goals in the development of renewable energy.

The main regulatory act regulating these relations at the legislative level is the Law of Ukraine "On Public-Private Partnership" (No. 2404-VI of 01.07.2010).

In this Law, the following terms are used in the following meaning:

– public-private partnership – cooperation between the state of Ukraine, the Autonomous Republic of Crimea, territorial communities represented by relevant state bodies that, in accordance with the Law of Ukraine "On Management of State Property Objects", manage state property objects, local governments, the National Academy of Sciences of Ukraine, national sectoral academies of sciences (state partners) and legal entities, except state and municipal enterprises, institutions, organizations (private partners), which is carried out on the basis of a contract in the manner established by

this Law and other legislative acts, and meets the characteristics of public-private partnership defined by this Law;

Table 1.4

Advantages and disadvantages of public-private partnerships (PPPs) for the development of bioenergy

Advantages of PPP for bioenergy development	Disadvantages of PPPs for Bioenergy Development
Attracting investment: The private sector can provide significant investments necessary for the implementation of large-scale bioenergy projects.	Risks for the State: The State assumes certain financial risks in the event of project failure.
Management efficiency: The private sector, as a rule, has greater flexibility and efficiency in project management, which can lead to lower costs and improved quality of services.	Potential conflicts of interest: There may be disagreements between public and private partners regarding project objectives, profit sharing, and risks.
Technology transfer: Cooperation with private companies can facilitate the transfer of new technologies and innovations in the field of bioenergy.	Market monopolization: Large private companies may gain a dominant position in the market, which may lead to higher biofuel prices.
Dissemination of best practices: PPP allows for the involvement of international experience and best practices in projects.	Bureaucratic barriers: Complicated procedures for concluding and implementing PPP contracts may slow down project implementation.
Reducing the burden on the state budget: Part of the financing of projects is assumed by the private sector.	Transparency and control: Lack of proper control may lead to corruption and inefficient use of funds.
Stimulating infrastructure development: The implementation of bioenergy projects can contribute to the development of infrastructure in regions.	Insufficient qualification of state bodies: Lack of experience in implementing such projects may lead to errors and inefficient use of resources.

Source: own research

– financing agreement – an agreement between a private partner and a lender(s) or their representatives, concluded for the purpose of financing a project implemented under the terms of a public-private partnership;

– lender – any financial institution, international financial organization that has provided or intends to provide debt financing or issued a guarantee to a private partner for the fulfillment of its obligations under a contract concluded within the framework of a public-private partnership;

– operational readiness fee – payments stipulated by a contract concluded within the framework of a public-private partnership in favor of the private partner, paid after

the acceptance of the public-private partnership facility into operation, the amount of which depends on the achievement by the private partner of the performance indicators specified in the contract concluded within the framework of a public-private partnership;

– performance indicators – quantitative and qualitative indicators of the reliability and availability of the public-private partnership object that must be achieved as a result of the implementation of the project implemented under the terms of the public-private partnership, taking into account its goal and objectives;

– direct contract – an agreement between the public partner, the private partner and the creditor(s) that determines the procedure and conditions for changing the private partner, and may also provide for the obligations of the parties to the agreement related to the change of the private partner, the fulfillment of the private partner's financial obligations to the creditor(s) and other provisions aimed at preventing the termination of the agreement concluded within the framework of the public-private partnership;

– advisor – an individual and/or legal entity that, under the agreement, assumes obligations to provide services in the process of preparing the project implemented under the terms of the public-private partnership;

– socially significant services – services aimed at ensuring public interests and needs, provided to an unlimited number of users (consumers) and/or the provision of which must be ensured by state authorities, local self-government bodies or state, municipal enterprises, institutions, organizations, business associations, 50 or more percent of the shares (shares) of which belong to the state, territorial community or the Autonomous Republic of Crimea.

Several persons may act on the side of the private partner in an agreement concluded within the framework of a public-private partnership, who may be private partners in accordance with this Law. Relations between private partners and the procedure for determining a private partner to represent the interests of other private partners in relations with the public partner are determined by the terms of the agreement concluded between private partners or the terms of the agreement concluded

within the framework of a public-private partnership. Such persons are jointly and severally liable for the obligations stipulated in the contract concluded within the framework of a public-private partnership.

In addition to the winner(s) of the competition to determine the private partner, a legal entity established to implement the public-private partnership may act as a private partner, if this is provided for by the terms of the relevant competition.

The winner(s) of the competition shall bear full responsibility for the fulfillment of obligations under the contract concluded within the framework of the public-private partnership.

By decision of the public partner, a state, municipal enterprise, institution, organization, business association, 100 percent of the shares (shares) of which belong to the state, territorial community or the Autonomous Republic of Crimea, which may be entrusted with the fulfillment of individual obligations under the contract concluded within the framework of the public-private partnership, may participate on the side of the public partner in the contract concluded within the framework of the public-private partnership. The state partner bears subsidiary liability for the obligations of such an enterprise, institution, organization or business association in accordance with the agreement concluded within the framework of a public-private partnership.

Several state authorities and/or local self-government bodies, the National Academy of Sciences of Ukraine, and sectoral academies of sciences may simultaneously act as state partners in an agreement concluded within the framework of a public-private partnership. The rights and obligations of the aforementioned persons regarding their joint participation in the agreement concluded within the framework of a public-private partnership are determined by the agreement concluded between them.

Such an agreement must be concluded by the time of approval of the tender documentation and may contain information about the rights and obligations in the agreement concluded within the framework of a public-private partnership, including the distribution of rights to the public-private partnership facility after its commissioning, and other conditions. A copy of such an agreement must be attached to the agreement concluded within the framework of a public-private partnership.

The characteristics of a public-private partnership include:

1) creation and/or construction (new construction, reconstruction, restoration, major repairs and technical re-equipment) of a public-private partnership facility and/or management (use, operation, maintenance) of such a facility;

2) long-term relationship (from 5 to 50 years);

3) transfer of part of the risks in the process of implementing the public-private partnership to the private partner;

4) investment by the private partner in the public-private partnership facility.

All investment projects that meet the characteristics of a public-private partnership must be implemented only with the application of the requirements of this Law.

Legal principles of public-private partnership

1. The legal principles of public-private partnership are the Constitution of Ukraine, the Civil Code of Ukraine, the Economic Code of Ukraine, this Law, other legislative acts of Ukraine, as well as international treaties of Ukraine, the consent to be bound by which has been granted by the Verkhovna Rada of Ukraine.

2. If international treaties of Ukraine, the consent to be bound by which has been granted by the Verkhovna Rada of Ukraine, establish rules other than those provided for by this Law, the rules of the international treaty shall apply.

3. Relations arising in connection with public-private partnership cannot be established or changed by other laws of Ukraine, except for laws containing exclusively norms on amendments to this Law.

4. The legislation on public procurement does not apply to relations arising in connection with the selection of a private partner and the execution of a contract concluded within the framework of public-private partnership, and with the provision of state support for the implementation of public-private partnership.

Basic principles of public-private partnership

1. The basic principles of public-private partnership include:

– equality before the law of public and private partners;

– prohibition of any discrimination in the rights of public or private partners;

– coordination of interests of public and private partners in order to obtain mutual

benefit;

– ensuring higher efficiency of activities than in the case of implementation of such activities by a public partner without involving a private partner;

– immutability throughout the entire term of the agreement concluded within the framework of public-private partnership, the purpose and form of ownership of objects that are in state or municipal ownership or belong to the Autonomous Republic of Crimea, transferred to the private partner;

– recognition by public and private partners of the rights and obligations stipulated by the legislation of Ukraine and determined by the terms of the agreement concluded within the framework of public-private partnership;

– fair distribution between the public and private partners of risks associated with the implementation of contracts concluded within the framework of public-private partnership; determination of the private partner on a competitive basis, except in cases established by law.

This law is a fundamental document that regulates relations between the state and the private sector in the implementation of joint projects. It defines the legal, organizational and financial principles of public-private partnership (PPP) in Ukraine (Table 1.5).

Table 1.5

Main characteristics of the Law "On Public-Private Partnership"

Provisions of the Law	Description
Definition of PPP	Long-term cooperation between the state and the private sector to create or operate infrastructure facilities or provide services.
Objectives of PPP	Attracting investment, improving the quality of services, efficient use of funds, stimulating innovation.
PPP Principles	Long-term, mutual benefit, transparency, competition, efficiency, responsibility, risk balancing.
Scopes of Application	Transport, utilities, healthcare, education, energy, etc.
Forms of PPP	Concession, construction-transfer-operation agreement, infrastructure management agreement.
Implementation Procedure	Tenders, contract conclusion, implementation control.
Rights and Obligations of the Parties	Defined by law for the state and the private partner.
Risk Management	Risk reduction mechanisms for both parties.

Source: systematized based on [21]

The main objectives of the Law:

– creating favorable conditions for attracting investments in the development of infrastructure and other sectors of the economy;

– improving the quality of public services;

– increasing the efficiency of the use of public funds;

– stimulating innovation and the introduction of new technologies.

Key provisions of the Law:

– definition of PPP: the law provides a clear definition of PPP as long-term cooperation between the state and the private sector, aimed at the creation or operation of infrastructure facilities or the provision of services;

– PPP principles: the following main principles of PPP are specified: long-term, mutual benefit, transparency, competition, efficiency, responsibility, risk balancing;

– scope: the law provides for the application of PPP in various areas, such as: transport, utilities, healthcare, education, energy, etc.;

– forms of PPP: the law defines various forms of PPP, such as: concession, construction-transfer-operation agreement, infrastructure facility management agreement, etc.;

– procedure for implementing PPP projects: the legislation establishes a detailed procedure for the preparation, implementation and implementation of PPP projects, including holding competitions, concluding contracts, and monitoring the fulfillment of obligations.

– rights and obligations of the parties: the law defines the rights and obligations of the state and the private partner within the framework of PPP projects;

– risk management mechanisms: various mechanisms for managing risks that may arise during the implementation of PPP projects are provided.

The Law “On Public-Private Partnership” is an important tool for modernizing infrastructure, improving the quality of life of the population, and attracting investment into the economy of Ukraine. It creates a legal basis for cooperation between the state and business, contributing to the development of a market economy and increasing the country's competitiveness.

Despite the importance of the Law, its implementation in Ukraine faces certain difficulties, such as:

– imperfection of legislation in certain aspects of PPP;

– lack of sufficient experience in implementing such projects.

– corruption and inefficiency of public administration (Table 1.6).

Table 1.6

Advantages and challenges of PPP

Aspect	Advantages	Challenges
For the state	Attracting investment, improving the quality of services, reducing the budget burden.	Lack of experience, corruption, regulatory risks.
For the private sector	Stable income, access to infrastructure, long-term contracts.	Political risks, regulatory uncertainty, high initial investment.
For society	Infrastructure improvements, new jobs, technology development.	Possible increase in service tariffs.

Source: systematized based on [21]

The main differences between public-private partnerships and other instruments are:

– public-private partnerships involve closer interaction between the state and the private sector than foreign direct investment;

– public-private partnerships allow for private investment in projects that may not be of interest to private investors under other conditions (for example, infrastructure projects);

– public-private partnerships involve risk sharing between the state and the private sector, which reduces risks for both parties;

– public-private partnerships can be a more effective tool for modernizing state-owned enterprises and increasing their efficiency (Table 1.7).

Thanks to an active state policy and the involvement of international technical assistance, Ukraine has every chance of becoming a leader in the region in the development of PPPs.

The choice of investment attraction tool depends on the specific conditions of the project, the goals of the investor and the state. Each tool has its own advantages and disadvantages:

– public-private partnership is advisable to use for financing large infrastructure projects that require significant investments and long-term commitments;

– foreign direct investment is an effective tool for attracting capital for the development of production, technological innovation and the creation of new jobs;

– public investment is advisable to use for financing projects that are of important social or strategic importance for the state.

Table 1.7

Comparison of PPPs with other instruments for attracting investment

Characteristics	Public-Private Partnership (PPP)	Foreign Direct Investment (FDI)	Public investments
Interaction subjects	State (central or local) and private sector	Foreign company and domestic company or state	State
Goal	Attracting private investment to finance and manage projects, sharing risks and responsibilities	Attraction of capital for the development of production, technological renewal, creation of new jobs	Financing of projects of social or strategic importance for the state
Forms of cooperation	Concession, Build, Transfer and Operate (BOOT) contract, Finance, Build and Operate (BOO) contract, Management contract	Creation of joint ventures, acquisition of shares of existing enterprises, greenfield investments	Budget financing, state guarantees, lending to state-owned enterprises
Risks	Political risks, changes in legislation, regulatory risks, risks of non-fulfillment of contractual obligations	Currency risks, expropriation risks, risks of changes in tax legislation	Budget risks, inefficient use of funds
Advantages	Attracting private investment, new technologies, effective asset management, sharing risks	Inflow of foreign capital, transfer of technology, creation of new jobs	Control over strategic sectors of the economy, social responsibility
Disadvantages	Complexity of concluding contracts, long process of project preparation, possible conflicts of interest	Dependence on the world market situation, displacement of domestic producers	Budgetary constraints, inefficiency of public administration

Source: systematized based on [21]

Thus, public-private partnership is a powerful tool for attracting investment and developing the economy. However, its effectiveness depends on many factors, including the quality of project preparation, the level of institutional development, macroeconomic stability and the investment climate of the country.

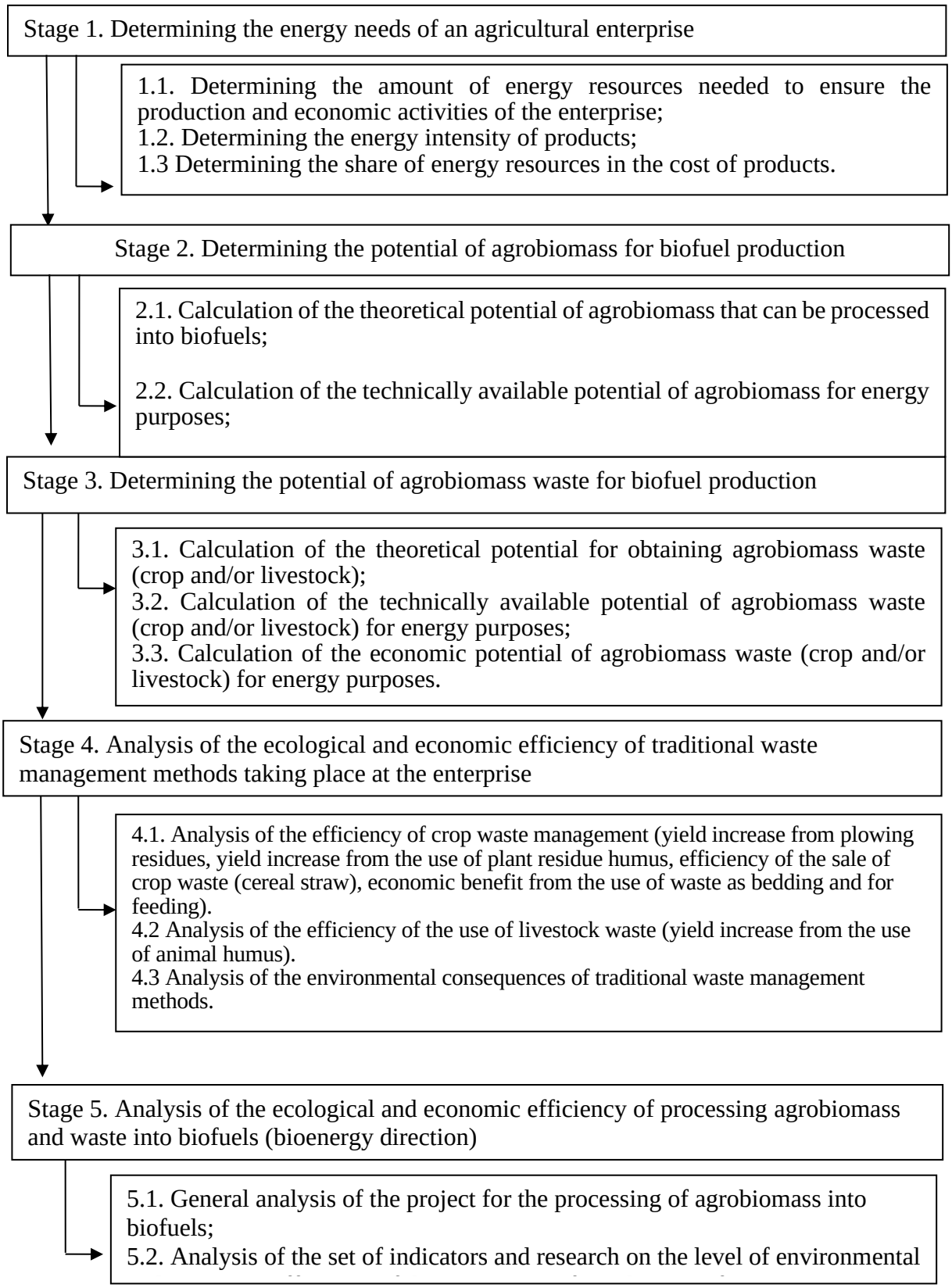

Fig. 1.1. Stages of determining the ecological and economic efficiency of using agrobiomass for biofuel production

Source: improved by the author based on the reviewed literature [36-37]

Fig. 1.1 proposes a methodology for calculating the environmental and economic efficiency of using agrobiomass for biofuel production at the level of an individual agricultural enterprise, consisting of an algorithm of successive stages. Methodological approaches to the concept of ecological and economic efficiency remain not fully defined, therefore, Romanchuk S.V. proposes to apply a general approach to the methodology for determining ecological and economic efficiency, which will comprehensively cover the problem of increasing the ecological and economic efficiency of waste processing [20, p. 325]:

EE = a * ((P – CB)* ZS) + (b* EK) + (c *ZV)/TC*100%

where a, b, c are weighting factors for the indicator;

P – the price of natural gas sales at the sugar factory, taking into account all taxes and fees, transportation, etc., UAH/1 thousand m3;

CB – the cost of producing its own biogas, taking into account operating and capital costs for its production, UAH/1 thousand m3;

ZS – total gas consumption necessary for the operation of the plant, thousand m^3;

TC – total costs of production of sold products, UAH;

EC – savings on storage, transportation and disposal of waste, UAH;

ZV - reduction of carbon dioxide emissions due to the use of biogas, avoided costs, reduction of fines and payment of environmental taxes, UAH.

Biofuel production at an agricultural enterprise should be closely linked to its energy needs. To determine the optimal volume of production, it is necessary to conduct an economic analysis and calculate potential profitability. Based on the data obtained, the structure of sown areas should be planned, allocating a certain part for growing energy crops. Biofuel needs can be determined by analyzing fuel costs for performing various agricultural works.

The full flowering of Ukraine's bioenergy potential is possible only with active state support. Financial assistance, tax breaks and favorable legislation are key elements that will attract investments and accelerate the development of the industry. Taking into account the factors considered and the proposed formulas, I. Furman proposed a universal method for assessing bioenergy potential:

$BEP = \Sigma(Q_i * \eta_i * A_i * K_i * F_i)$

where: BEP is the bioenergy potential (in conventional energy units, for example, GJ/year);

Q_i is the calorific value of the i-th type of biomass (kJ/kg);

η_i is the efficiency coefficient of the conversion of the i-th type of biomass into energy;

A_i is the amount of available i-th type of biomass (kg/year);

K_i is a coefficient that takes into account losses during storage, transportation and processing of the i-th type of biomass;

F_i is a coefficient that takes into account other factors, such as seasonality, cost, and environmental consequences of using the i-th type of biomass.

Summation (Σ): Takes into account the variety of types of biomass that can be used.

Calorific value (Q_i): Determines the amount of energy that can be obtained from burning a unit of biomass mass.

Efficiency factor (η_i): Takes into account energy losses during the conversion of biomass into useful energy (thermal or electrical).

Amount of available biomass (A_i): Determines the total amount of biomass that can be used.

Loss factor (K_i): Takes into account biomass losses during harvesting, storage, transportation and processing.

Factor of other factors (F_i): Allows you to take into account other factors that may affect the bioenergy potential, such as the seasonality of biomass production, the cost of its processing, environmental restrictions, etc.

Advantages of this formula:

Versatility: Can be used to assess the potential of different types of biomass.

Comprehensiveness: Takes into account a wide range of factors that affect the bioenergy potential.

Flexibility: The F_i factors allow you to take into account the specific features of each specific case.

The application of this methodology will allow assessing the potential for bioenergy development in a specific region, developing optimal biomass utilization strategies, and making informed decisions regarding investments in bioenergy projects [22, p. 61].

However, in our opinion, assessing the efficiency of biofuel production on the basis of public-private partnerships (PPPs) is a complex process that requires the use of various methods and indicators. This is due to the multifaceted goals of such projects, which include not only economic aspects, but also social and environmental ones.

Main methodological approaches:

Financial and economic analysis:

Calculation of economic efficiency: net present value (NPV), internal rate of return (IRR), profitability index (PI).

Cost and income analysis: comparison of planned and actual indicators, identification of deviations.

Assessment of the financial sustainability of the project: analysis of liquidity, solvency, financial independence.

Social analysis:

Employment impact assessment: creation of new jobs, wage level.

Analysis of the impact on local communities: development of infrastructure, social programs.

Assessment of the social responsibility of the enterprise: compliance with labor legislation, environmental standards.

Environmental analysis:

Environmental impact assessment: analysis of greenhouse gas emissions, water consumption, waste generation.

Monitoring compliance with environmental standards: verification of compliance of production with the requirements of environmental legislation.

Assessment of resource efficiency: analysis of energy efficiency, material intensity of production.

Institutional analysis:

Evaluation of the effectiveness of project management mechanisms: analysis of the distribution of powers, decision-making processes.

Assessment of transparency and accountability: analysis of mechanisms for controlling the use of funds, access to information.

Analysis of the interaction of the state and the private sector: assessment of the effectiveness of the partnership, conflict resolution.

Performance indicators:

Economic: profit, profitability, payback period of investments, creation of new jobs.

Social: standard of living of the local population, infrastructure development, social responsibility of the enterprise.

Environmental: reduction of greenhouse gas emissions, energy saving, reduction of waste.

Institutional: transparency, accountability, management efficiency.

Important aspects of the assessment:

A comprehensive approach: the assessment should take into account all aspects of the project: economic, social and environmental.

Dynamic nature: the effectiveness of the project should be assessed throughout its life cycle.

Comparative analysis: comparison of project results with planned indicators and similar projects.

Stakeholder engagement: involving representatives of the state, private sector, and the public in the assessment process.

Using modeling methods:

Various models can be used to assess the effectiveness of biofuel production projects, such as:

Economic and mathematical models: for forecasting production, costs, and revenues.

Environmental models: for assessing the impact of the project on the

environment.

Socio-economic models: for assessing the impact of the project on regional development.

Developing a methodology for assessing the effectiveness of biofuel production under public-private partnerships: a detailed approach

Understanding the complexity of the task

Assessing the effectiveness of biofuel production within the framework of PPPs requires a comprehensive approach that takes into account economic, social, environmental, and institutional aspects. The assessment methodology should be flexible and adapted to the specific conditions of the project.

Therefore, a methodology based on a combination of quantitative and qualitative assessment methods is needed:

1. Determination of assessment criteria

Economic: profit, return on investment, payback period, creation of new jobs, impact on the region's GDP.

Social: standard of living of the local population, infrastructure development, social responsibility of the enterprise.

Environmental: reduction of greenhouse gas emissions, energy saving, reduction of waste, preservation of biodiversity.

Institutional: transparency, accountability, management efficiency, stability of partnership.

2. Selection of indicators For each criterion, specific indicators are selected that will be quantitatively assessed. For example:

Economic: net present value (NPV), internal rate of return (IRR), profitability index (PI), unit production cost indicator.

Social: number of jobs created, wage level, investments in the social sphere.

Environmental: CO2 emissions, water consumption, amount of waste disposed of, area of land allocated for bioenergy crops.

3. Data collection DTo calculate the indicators, data is collected from various sources:

Financial statements of the enterprise

Statistical reports

Results of sociological research

Environmental monitoring data

Interviews with project participants

The modern world is faced with acute environmental problems and an energy crisis. Energy production by traditional methods leads to significant environmental pollution and depletion of natural resources. Alternative energy sources, in particular bioenergy, are becoming increasingly relevant. However, the widespread introduction of energy crops is accompanied by a number of environmental, economic and social challenges.

Energy crop production is a strategically important industry that combines environmental and economic advantages. Its development is aimed at the production of biomass used to obtain biofuels and other types of bioenergy.

It should be noted that for planning and organizing the production of bioenergy crops, the general condition of the relevant rural territories should be taken into account.

We agree with the opinion of I. Furman, who states that a comprehensive approach to assessing the condition and development of rural areas includes a number of indicators in the following areas: assessment of rural infrastructure; assessment of human potential; assessment of the effectiveness of agricultural management in rural areas; determining the state of use of natural resource potential of rural areas; analysis of soil quality and potential productivity during their degradation; assessment of the general condition of rural areas according to international standards [1, p. 52].

For the development of bioenergy crop production, it is quite promising to create favorable conditions for the development of small processing enterprises based on farms for processing agricultural products into food and biofuels by conducting training courses on the basis of the association of agricultural advisory services during initial trainings [2].

It should be noted that the cultivation of energy crops, with proper stimulation

from the state, can develop on the basis of farms. Currently, farms are the basis for the effective functioning of Ukrainian agriculture. The advantages of farming over other forms of management are that in them the main motive for the employee's labor activity is the farmer's personal interest, which is manifested in the results of effective functioning, which sets him the task of working better, using available resources more efficiently.

The limited area of agricultural land, fluctuations in prices for agricultural products, the need for greening the agro-industrial sector, as well as the urgent need to solve the problems of waste disposal of agro-industrial enterprises, make one of the most promising options for using the raw material base of the agro-industrial complex for biogas production, namely the use of by-products and waste from agriculture, the food and processing industries of the agro-industrial sector.

A significant negative environmental impact is exerted by raw materials of animal origin. So, currently, in Ukraine there is an acute issue - the disposal and safe processing of waste products from poultry farms, pig farms and cattle farms

The relevant statements are confirmed by the research of I. Goncharuk, who notes that the use of the potential of the agricultural sector will make it possible to almost completely meet the needs of not only this sector of the economy, but also the entire country in gas oils thanks to the production of biofuels, and the potential for bioethanol production can be partially used for export.

Sustainable development of the agricultural sector is impossible without energy-efficient technologies for growing crops. An important role in this is played by the development of innovative systems for applying organic fertilizers, which would reduce the use of expensive mineral fertilizers and increase yields. At the same time, I. Furman states that the full flowering of Ukraine's bioenergy potential is possible only with active state support. Financial assistance, tax breaks and favorable legislation are key elements that will attract investments and accelerate the development of the industry [1]. One of the main directions of TG development should be the implementation of energy saving projects and the use of renewable energy sources with the support of state and regional energy saving programs, including through awareness

of employees of institutions regarding the possibilities of obtaining additional financing from various sources (including international ones).

However, in order to implement the relevant development directions, it is necessary to analyze the ecological and economic feasibility of growing bioenergy crops.

So, the environmental benefits of producing ecological crops are as follows:

- reduction of greenhouse gas emissions due to the replacement of fossil fuels with biofuels, which contributes to the reduction of carbon dioxide and other greenhouse gases into the atmosphere and helps to combat harmful climate change;

- improvement of air quality is ensured by the use of biofuels, which reduces air pollution by harmful substances formed during the combustion of traditional fuels;

- preservation of biodiversity through the cultivation of energy crops on marginal lands can contribute to the preservation of natural ecosystems and biodiversity of the state;

- improving soil quality (certain energy crops can improve soil structure, enrich it with organic matter and reduce erosion).

The economic advantages of growing bioenergy crops include:

- creation of new jobs (the development of bioenergy will contribute to the creation of new jobs in agriculture, the processing industry and related sectors;

- reduction of dependence on energy imports due to the production of biofuels, dependence on oil and gas imports is reduced, which significantly increases the country's energy security;

- stimulation of the development of rural areas (growing energy crops can become an additional source of income for agricultural enterprises and stimulate the development of rural areas);

- increase in the added value of agricultural products due to the processing of biomass into biofuels, the added value of agricultural products can be significantly increased and the competitiveness of the agricultural sector can be increased

Despite significant advantages, the production of energy crops also has its challenges, such as:

- competition for land resources: the cultivation of energy crops can compete for land resources with food production;

- high production costs (biofuel production can be economically efficient only under certain conditions, such as the availability of appropriate infrastructure and state support;

- seasonality of biomass production (biomass production is seasonal, which makes it difficult to ensure a stable supply of biofuels).

It should be noted that the choice of energy crops for cultivation for the purpose of obtaining biofuels is a complex process that depends on many factors, such as climatic conditions, the availability of fertile land, prices for fertilizers and energy carriers, as well as technological capabilities for biomass processing.

Each of the crops considered has its own advantages and disadvantages, namely:

- corn is a high-yielding crop, but requires significant fertilizer costs;

- sunflower is valuable for its high oil content, but requires fertile soils;

- willow is fast-growing and unpretentious, but occupies large areas.

It should be noted that the optimal choice of energy crop for cultivation depends on specific conditions:

- for regions with fertile soils and a developed biomass processing infrastructure, corn and sunflower may be appropriate;

- for regions with limited resources and large areas of unused land, willow is promising.

In our opinion, the prospects for the development of energy crop production are associated with: further improvement of biofuel production technologies; development of new varieties of energy crops with high yields and adapted to different climatic conditions; creation of effective biomass logistics and storage systems; expanding biofuel markets and methods of their processing into energy.

Energy crop production is an important area of renewable energy development, which has significant potential to reduce dependence on fossil fuels, improve the environmental situation and stimulate the development of rural areas. Analysis of the ecological and economic aspects of energy crop production demonstrates the

significant potential of this area for the transition to a more sustainable energy system. Replacing traditional fuels with biofuels contributes to reducing greenhouse gas emissions, improving air quality and preserving biodiversity. At the same time, energy crop production creates new jobs, reduces dependence on energy imports and stimulates the development of rural areas. However, to successfully realize the potential of bioenergy, it is necessary to take into account a number of challenges. Among them: competition for land resources with traditional agriculture, high initial investments, seasonality of biomass production and the need to develop appropriate infrastructure. The choice of a specific energy crop to grow depends on many factors, including climatic conditions, soil quality, availability of markets, and technological capabilities for processing. It is important to conduct a thorough analysis of each specific case before making a decision to implement bioenergy projects.

The study reviewed the research of scientists in the field of bioenergy [1-30], namely the use of biomass as an energy source and the study of the main scientific aspects to understand this issue, namely:

1. Biological aspects: conducting agricultural research by studying different plant species, their productivity, soil and climate requirements for effective cultivation for the purpose of obtaining biomass; developing genetically modified crops with increased biomass yield and altered composition for optimal use for energy purposes; researching optimal methods of forest cultivation to obtain woody biomass with minimal impact on ecosystems.

2. Ecological aspects: the possibility of providing ecosystem services by assessing the impact of biomass production on ecosystem services, such as climate regulation, biodiversity conservation and provision of clean water; studying the flow of carbon in systems using biomass to assess their impact on climate change; studying the impact of biomass production and combustion on air, water and soil quality;

3. Economic aspects include assessing the economic efficiency of various biofuel production technologies, taking into account the costs of cultivation, collection, processing and transportation; studying the demand and supply of biofuels, determining pricing and developing effective mechanisms to support production;

studying the impact of bioenergy development on employment, rural development and social justice;

4. Technological aspects: which should take into account the processes of developing new technologies for the effective conversion of biomass into various types of biofuels (bioethanol, biodiesel, biogas); assessing the energy efficiency of various biofuel production technologies; developing equipment and infrastructure for the production, storage and transportation of biomass and biofuels;

5. Political aspects include analyzing state policy in the field of renewable energy, developing mechanisms to support biofuel production; studying international treaties and agreements regulating biofuel trade and their impact on national markets.

Therefore, assessing the efficiency of biofuel production on the basis of PPP is a complex task that requires the use of an integrated approach. The choice of specific methods and indicators depends on the objectives of the project, its scale and other factors. Regular assessment of efficiency allows you to identify problems, make necessary adjustments and ensure the long-term stability of the project.

SECTION 2
ASSESSMENT OF THE STATE'S BIOENERGY POTENTIAL AND PRACTICE OF PUBLIC-PRIVATE PARTNERSHIP APPLICATION IN THE FIELD OF BIOFUEL PRODUCTION

The problem of energy security is one of the most urgent for Ukraine. Dependence on imports of traditional energy sources makes our country vulnerable to external factors and price fluctuations on the world market. An alternative energy source that can significantly reduce this dependence is biodiesel. Biodiesel production not only contributes to energy independence, but also has a number of other advantages, such as reducing emissions of harmful substances into the atmosphere, stimulating the development of agriculture and creating new jobs.

In the context of the military invasion of the Russian Federation, rising energy prices, and disruption of logistics routes for the sale of agricultural products, it is necessary to improve the management of bioenergy resources of the agricultural industry.

Bioenergy resources are biomass, which, according to the Law of Ukraine “On Alternative Fuels”, is a biologically renewable substance of organic origin that undergoes biological decomposition (wastes of agriculture (crop and livestock farming), forestry and technologically related industries, as well as the organic part of industrial and household waste [23].

As noted by G. Kaletnik, without threatening the food security and export potential of the state, about 10 million hectares of agricultural land can be used for growing energy crops with their subsequent processing into biofuels, in order to ensure the energy independence of the agro-industrial complex and Ukraine [24, p. 11].

However, to calculate the potential of agro-biomass for biofuel production, it is necessary to analyze the production volumes of the main crop products (Table 2.1). Despite the martial law and a significant drop in the volume of grain cultivation in 2023 (62.6% of 2021 volumes), there is still significant potential for these crops for the production of solid biofuels and bioethanol.

It should be noted that rapeseed production volumes increased by 12.9%, and taking into account the significant increase in gas oil prices and disruption of the logistics chains of agricultural exports, the processing of these products into biodiesel is economically feasible.

Table 2.1

Dynamics of production volumes (gross yield) of the main agricultural crops[1,2,]

thousand tons

	Farms of all categories		Enterprises		Households of the population	
	2023	2023 in % to / 2022	2023	2023 in % to / 2023	2023	2023 in % to / 2022
Grain and legume crops	53863,1	62,6	42315,3	60,7	11548,8	70,8
Soybean	3443,0	98,6	3129,5	100,0	314,5	86,7
Winter rapeseed and colza (spring rapeseed)	3317,8	112,9	3301,4	113,5	16,4	53,1
Winter rapeseed	3250,7	113,7	3235,1	114,4	15,6	50,7
Colza (spring rapeseed)	67,1	84,7	66,3	84,4	14,8	103,2
Sunflower	11328,4	69,1	9988,7	70,3	1339,7	61,5
Factory sugar beet	9941,6	91,6	9507,3	91,8	433,3	86,7

1. Data are provided without taking into account the territories temporarily occupied by the Russian Federation and parts of the territories where hostilities are (were) being conducted

2. Information is based on reports actually submitted by enterprises (the reporting level was 82%) and re-estimates of indicators.

Source: calculated by the authors based on data [25, 26]

Considering that the basis for biogas production is livestock waste, the number of farm animals was analyzed without taking into account the occupied territories of the Russian Federation (Table 2.2).

It should be noted that the main livestock population is concentrated in households, which makes it possible to create small auxiliary biogas plants for biogas production for the own needs of households. Despite the state of war, the number of sows tends to grow, which in the future will increase the volume of pig production, and will also make it possible to increase the volume of biogas production from pig farms.

A significant part of livestock farming is concentrated in private farms, and the growth of the pig population creates additional opportunities for biogas production. This will allow not only to meet the energy needs of households, but also to increase the volume of biogas production at industrial enterprises.

Table 2.2

Number of farm animals as of January 1, 2023, thousand goals

	Farms of all categories			Enterprises			Households of the population		
	2023[1,2]	2022	2023 in % to 2022	2023[1,2]	2022	2023 in % to 2022	2023[1,2]	2022	2023 in % to /
Cattle	2307,1	2644,0	87,3	942,1	1003,4	93,9	1365,0	1640,6	83,2
including									
cows	1352,8	1544,0	87,6	394,2	424,6	92,8	958,6	1119,4	85,6
heifers from 1 year to 2 years old	230,2	258,0	89,2	152,6	162,1	94,1	77,6	95,9	80,9
heifers from 2 years old and older	67,1	78,9	85,0	42,9	48,3	88,8	24,2	30,6	79,1
breeding bulls	3,7	4,8	77,1	0,5	0,5	100,0	3,2	4,3	74,4
Pigs	4948,3	5608,8	88,2	3144,6	3576,9	87,9	1803,7	2031,9	88,8
including									
primary sows	351,7	333,6	105,4	254,4	220,8	115,2	97,3	112,8	86,3
Poultry	180457	202243	89,2	101819	113478	89,7	78638	88764	88,6

1 Data are provided without taking into account the territories temporarily occupied by the Russian Federation and parts of the territories where hostilities are (were) underway as of 01.01.2023.

2 Information is based on reports actually submitted by enterprises (the reporting level was 88%) and re-estimates of indicators. Source: calculated by the authors based on data [25, 26]

It is advisable to study their structure to determine the level of use of fuel and energy resources in agriculture (Table 2.3). It should be noted that the main costs of fuel and energy resources in agriculture are diesel fuel 1.31 million tons, which in terms of conventional fuel is more than 1.9 million tons of equivalent fuel out of 2.4 million tons of equivalent fuel used by agricultural enterprises in 2022. Unfortunately, due to martial law and the ban on the publication of more current data, it is impossible to conduct an analysis in 2022 and 2023. Therefore, to ensure the energy independence of agricultural formations, the most appropriate is the production of biodiesel from oilseeds.

Table 2.3

Structure of use of fuel and energy resources in agriculture in 2022

	Units of measurement	Total	including			
			for conversion into other types of fuel and energy	for non-energy purposes (as raw material)	final consumption	losses during transportation, distribution and
Coal	t	36107	28097	–	8010	–
	t u.p.	27080	21072	–	6008	–
Briquettes, pellets and similar solid fuels from peat	t	к/с	к/с	–	2373	–
	t u.p.	к/с	к/с	–	1187	–
Natural gas	thousand m³	333398	178663	–	154735	–
	t u.p.	386742	207249	–	179493	–
Crude oil, including oil obtained from bituminous minerals	t	216	–	–	216	–
	t u.p.	309	–	–	309	–
Motor gasoline	t	88373	к/с	к/с	88360	8
	t u.p.	131676	к/с	к/с	131656	11
Gasoline (diesel fuel)	t	1314641	296	к/с	1314312	31
	t u.p.	1906229	429	к/с	1905753	45
Mid-range petroleum distillates, other mid-range fractions	t	576	–	–	576	–
	t u.p.	835	–	–	835	–
Petroleum oils and lubricants	t	15955	–	15084	872	–
	t u.p.	21859	–	20665	1194	–
Fuel briquettes and pellets from wood and other natural raw materials	t	37920	27700	–	10220	–
	t u.p.	21728	15872	–	5856	–
Firewood	m³d.	к/с	159714	к/с	83432	–
	t u.p.	к/с	42324	к/с	22109	–
Wood shavings and chips	t u.p.	50715	46504	–	4211	–
	t / t	18257	16742	–	1516	–
Other solid biofuels of plant origin	t u.p.	73226	44501	к/с	27747	к/с
	thousand m³	24604	14952	к/с	9323	к/с
Liquid biofuels	t u.p.	к/с	к/с	–	–	–
	t u.p.	к/с	к/с	–	–	–
Biogas	Units of measurement	к/с	к/с	–	–	–
		к/с	к/с	–	–	–
Total in agriculture	t	2407373				

c/s - data are not published in order to ensure compliance with the requirements of the Law of Ukraine "On State Statistics" regarding the confidentiality of statistical information

Source: calculated by the authors based on data [25]

Analysis of the structure of fuel and energy resources use in the processing industry of the agro-industrial complex made it possible to state the main share of natural gas and gas oils in the overall structure (Table 2.4). The analysis confirms the need to process oilseeds into biodiesel, and waste from processing enterprises and livestock farming into biogas.

Table 2.4

Structure of fuel and energy resources use in the processing industry of the agro-industrial complex in 2022

	Units of measurement	Total	including			
			for conversion into other types of fuel and energy	for non-energy purposes (as raw material)	final consumption	losses during transportation, distribution and storage
Coal	t	70616	29075	–	41540	–
	t u.p.	52962	21807	–	31155	–
Natural gas	thousand m³	к/с	573647	–	180834	к/с
	t u.p.	к/с	665431	–	209767	к/с
Motor gasoline	t	к/с	к/с	–	14798	–
	t u.p.	к/с	к/с	–	22049	–
Gasoline (diesel fuel)	t	114869	1015	–	113854	–
	t u.p.	166560	1472	–	165088	–
Light petroleum distillates, other light fractions	t	663	к/с	к/с	к/с	–
	t u.p.	961	к/с	к/с	к/с	–
Middle petroleum distillates, other middle fractions	t	к/с	650	–	к/с	–
	t u.p.	к/с	942	–	к/с	–
Petroleum oils and lubricants	t	1355	–	1319	36	–
	t u.p.	1856	–	1807	49	–
Liquefied propane and butane	t	29062	к/с	к/с	26042	–
	t u.p.	45627	к/с	к/с	40885	–
Fuel briquettes and pellets from wood and other natural raw materials	m³ dense.	110081	104428	–	5653	–
	t u.p.	63076	59837	–	3239	–
Firewood	t u.p.	71484	56388	–	15096	–
	t	18943	14943	–	4000	–
Wood shavings and chips	t u.p.	31607	29699	к/с	к/с	–
	t	11379	10692	к/с	к/с	–
Other solid biofuels of plant origin	t u.p.	к/с	1048238	к/с	8334	–
	thousand m³	к/с	352208	к/с	2800	–
Biogas	t u.p.	19672	19672	–	–	–
	t u.p.	33835	33835	–	–	–
Total	t	1435829				

Source: calculated by the authors based on data [25]

Thus, the total consumption of fuel and energy resources by the agro-industrial complex formations amounted to 3.84 million tons of equivalent or 2.69 million tons of equivalent. At the same time, according to the State Statistics Service of Ukraine, the total consumption of fuel and energy resources in Ukraine amounted to 86.4 million tons of equivalent, that is, the total consumption of agro-industrial complex enterprises of the relevant resources amounted to only 3.1% of the total.

At the same time, as of 2023, the total electricity consumption in the state amounted to more than 83.8 billion kWh, but the share of agricultural enterprises in this indicator was only 2.5% and the share of the agro-industrial complex processing industry was 4.8%, which in total amounted to more than 6.18 billion kWh (7.4% of the total) (Table 2.5).

Table 2.5

Electricity consumption for 2023, thousand kWh

Types of economic activity	Total electricity usage	including			Electricity losses in power grids
		for the production of products (performance of work)	for the own needs of energy-generating enterprises (installations)	electrical energy in cooling systems	
Total	83888551	57605869	12005520	541924	10520990
In %	100	100	100	100	100
Agriculture	2111363	1911507	7642	22296	2260
In %	2,5	3,3	0,1	4,1	0,0
Food production	4065887	3614935	43935	239883	5564
In %	4,8	6,3	0,4	44,3	0,1

Source: calculated by the authors based on data [3]

Based on the analysis, the bioenergy potential of agrobiomass of crop products was determined (Table 2.6). Previous studies indicate that the volume of biodiesel production will be when processing rapeseed in the export volume in 2023 will make it possible to obtain more than 1.2 million tons of biodiesel with a total cost of over 39.6 billion UAH [27, p. 66].

In our opinion, it is advisable to process at least 20 million tons of grain products into bioethanol, which is caused by too low prices for grain products. In our opinion, the production of biodiesel from sunflower is impractical due to the high demand for

oil from this crop, therefore, only the production of solid biofuel from waste is advisable. Growing sugar beets makes it possible to obtain both bioethanol and biogas during anaerobic fermentation of post-harvest residues in biogas plants based on sugar refineries.

As D. Tokarchuk notes, the production of biogas from organic waste produced in agriculture has significant advantages over other areas of their use. An important factor is that biogas technologies are not only a way to energy autonomy of agricultural enterprises, but also a basis for solving environmental, agrochemical and other issues, and this is their high profitability and competitiveness [28, p. 79].

Table 2.6

Potential for biofuel production from the main crop products

	Production volume, thousand tons	Crop area, thousand hectares	By-product output (straw, tops)		Planned volume of transfer for biofuel production, thousand tons	Biofuel yield from 1 ton	Potential volume of biofuels			
			t/ha Total, thousand t	t/ha Total, thousand t			Solid biofuels, thousand tons	Biodiesel, thousand tons	Bioethanol, thousand tons	Biogas, million m^3
Grain and legume crops	53863,1	12171	25	1346577,5	20000	0,4	1346577	-	8000	-
Winter rapeseed and colza	3317,8	1186	3	9953,4	2670,8	0,45	9953,4	1201	-	-
Sunflower	11328,4	5293	21	237896,4	-		237896,4	-	-	-
Factory sugar beet	9941,6	184	35	347956	4000	0,6/ 0,45			2400	208,7
Total	X						1594427	1201	10400	208,7

Source: calculated by the authors based on data [25, 26]

The main resources for biogas production are waste from livestock and agro-processing enterprises (Table 2.7).

Analysis of the biogas potential in Ukraine shows that food industry and livestock waste can provide the production of over 3.2 billion m³ of biogas annually. The greatest potential is concentrated in the livestock sector, in particular in the use of cattle, pig and poultry manure.

As previous studies show, the use of bioenergy potential as an alternative fuel

source contributes to the rational use and protection of natural resources, such as land, fuel and energy resources and water. This contributes to the restoration of ecological balance and increases environmental safety [32, p. 79].

Table 2.7

Potential for biogas production from waste from the agro-processing industry and livestock products

Potential of livestock waste				
Livestock products	Livestock size, thousand heads	Waste generation per 1 goal per year, t	Volume of biogas generation from 1 ton of raw material, m^3	Total potential, billion m^3
Cattle	2307,1	20	32	1,476
Pigs	4948,3	6	42	1,247
Poultry	180457,6	0,112	97	1,96
Waste from the agricultural processing industry				
Molasses	355886,8		630	0,224
Beet pulp	4382717,7		170	0,745
Bard	682912,4		45	0,307
Total, billion m3	3,236			

Source: calculated by the authors based on data [25, 29-31]

The use of advanced technologies for transporting liquid digestate and its injection application will reduce the costs of agricultural formations and increase the humus content in the soil. At the same time, the use of a flexible active harrow with loosening teeth, which has shown the advantages of loosening and crushing the soil compared to conventional harrows, will improve soil cultivation after the introduction of digestate [33].

Therefore, taking into account the total potential of agrobiomass in the agro-industrial complex of Ukraine, it was determined that its use will make it possible to obtain 3.444 billion m3 of biogas (waste from livestock, the processing industry of the agro-industrial complex and sugar beet tops), 1.2 million tons of biodiesel, 10.4 million tons of bioethanol, 1.59 billion tons of solid biofuels from post-harvest residues.

Using the potential of the agro-industrial complex will make it possible to almost completely meet the needs of not only this sector of the economy, but also the entire country in gas oils through the production of biofuels, and the potential for bioethanol

production can be partially used for export. The production of biogas and solid biofuels from waste will make it possible to ensure both electricity production and use for hot water supply of households and enterprises.

As a result of the study, the following can be outlined:

- processing of rapeseed in the export volume into biodiesel will make it possible to fully provide the agro-industrial sector with the necessary gas oils and partially - other sectors of the economy;

- production of solid biofuels from post-harvest residues of grain and industrial crops will make it possible to reduce the import of energy carriers to ensure hot water supply of households;

- processing of 35-40% of the volume of grain crops harvested into bioethanol will make it possible to completely abandon the import of gasoline and partially direct this type of biofuel for export;

- the use of biogas production technologies in Ukraine is promising for solving the problems of processing agricultural waste, ensuring the ecological safety of the state, increasing soil fertility through the use of digestate and increasing the level of energy security of rural areas;

- the main raw materials for biogas production should be agricultural waste, agro-processing enterprises and post-harvest residues (straw, tops, etc.).

Bioenergy in Ukraine has significant potential for development, especially given the large volumes of agricultural waste and the availability of land resources. However, the development of this sector is associated with a number of environmental and economic aspects that must be taken into account when making decisions.

Environmental aspects:

Reduction of greenhouse gas emissions: Bioenergy contributes to the reduction of greenhouse gas emissions, since the combustion of biomass releases approximately the same amount of carbon dioxide that was absorbed by plants during growth.

Waste utilization: The use of agricultural and food industry waste for bioenergy production contributes to their utilization and reduces environmental pollution.

Biodiversity conservation: Proper management of land used for energy crops can

contribute to biodiversity conservation.

Water pollution: Biofuel production can lead to water pollution if appropriate environmental standards are not followed.

Land competition: Energy crops can compete for land with other agricultural sectors, which can affect food security.

Economic aspects:

Job creation: The development of bioenergy contributes to the creation of new jobs, especially in rural areas.

Reducing dependence on energy imports: Replacing part of fossil fuels with biofuels can reduce Ukraine's dependence on energy imports.

Stimulating agricultural development: The production of energy crops can become an additional source of income for agricultural enterprises.

Investment: The development of bioenergy attracts investment, which can contribute to economic growth.

Production costs: The cost of producing biofuels can be higher than the cost of fossil fuels, which requires additional incentives for the development of this sector.

The main challenges for the development of bioenergy in Ukraine are:

Lack of investment: Lack of investment is one of the main barriers to the development of bioenergy in Ukraine;

Insufficient infrastructure development: Lack of necessary infrastructure for collecting, transporting and processing biomass;

High cost of technologies: Modern biofuel production technologies can be quite expensive.

Lack of clear state policy: insufficient clarity and stability of state policy in the field of bioenergy.

Prospects for the development of bioenergy in Ukraine are associated with:

Technological development: constant improvement of biofuel production technologies will reduce their cost and increase efficiency.

State support: development and implementation of state programs to support bioenergy.

Cooperation with international organizations: attraction of international donors and organizations to finance projects in the field of bioenergy.

The main environmental and economic indicators of biofuel production are presented in Table 2.8.

Table 2.8

The main environmental and economic indicators of biofuel production

Biofuel type	Raw materials	Efficiency (efficiency coefficient)	Environmental impacts
Biodiesel	Vegetable oils (sunflower, rapeseed)	85-90%	Reduces greenhouse gas emissions, but may have negative impacts on agriculture
Biobutanol	Corn, sugar beet	70-80%	Less toxic than traditional fuels, but requires significant amounts of water
Biogas	Livestock waste, organic waste	50-60%	Reduces methane emissions, produces organic fertilizers

The main ecological and economic aspects of biofuel production have been investigated and systematized based on the data in Table 2.9.

Table 2.9

Ecological and economic aspects of the production of the main types of biofuels

Aspect	Economic impacts	Environmental impacts
Biofuel production	Job creation, reduced dependence on oil imports, boosted agriculture	Reduced greenhouse gas emissions, waste disposal, competition for land, possible water pollution
Biomass use for heating	Reduced heating costs, new markets for agricultural products	Reduced pollutant emissions, increased demand for firewood, which may lead to forest degradation
Impact on agriculture	Additional income for farmers, development of new technologies	Competition for land, possible reduction in food crop areas, soil erosion

The development of bioenergy in Ukraine has great potential to reduce dependence on energy imports, create new jobs and improve the environmental

situation. However, to achieve these goals, it is necessary to solve a number of problems related to investments, infrastructure and public policy.

Today, the share of biofuel production in leading countries of the world is steadily growing, and in the USA, the production of bioethanol and biodiesel is 46.7% and 18.4%, respectively (Table 2.10).

Table 2.10

Share of biofuel production and main types of raw materials

Country Name	Share of production, %		Share of production, raw %	
	bioethanol	biodiesel	bioethanol	biodiesel
USA	46,7	18,4	corn	soybean oil, used cooking oil
EU	4,9	30,7	sugar beet, wheat, corn	rapeseed oil, palm oil, used cooking oil
Brazil	26,3	13,1	sugar cane, corn	soybean oil
China	8,4	2,8	corn, cassava	used cooking oil
India	2,9	0,4	sugar cane, corn, wheat, rice	used cooking oil
Canada	1,6	0,8	corn, wheat	canola oil, used cooking oil, soybean oil
Indonesia	40,1	17,5	molasses	palm oil
Argentina	0,9	3,6	molasses, sugar cane, corn	soybean oil
Thailand	1,4	3,0	molasses, cassava, sugar cane	palm oil
Colombia	0,4	1,3	sugar cane	palm oil
Paraguay	0,5	0,02	corn, sugar cane	soybean oil

Source: Systematized based on [36-43]

Biofuel is a fuel obtained from organic matter (biomass). It is one of the alternatives to traditional fossil fuels and is increasingly gaining popularity in the world due to its renewability and potential for reducing greenhouse gas emissions. The share of biofuels in the global energy balance is constantly growing. However, the exact percentage may vary depending on the region and type of biofuel. In general, biofuels account for several percent of total energy consumption. In Ukraine, biofuel production has some potential, but is still developing slowly. The main reasons are:

– lack of investment: lack of funds for the construction of new plants and

modernization of existing ones;

– high production costs: the price of biofuels is still higher than the price of traditional fuels;

– lack of clear state policy: lack of incentives for the development of bioenergy.

The bioeconomy sector in Ukraine employs a total of 1.32 million workers (about 17% of the employed), with over 66% of people

employed in the bioeconomy working in the agricultural sector and in food production (Table 2.9.).

Potential contribution of the bioeconomy sector in Ukraine to the national economy. The bioeconomy, which is based on the use of biomass as a raw material, has significant potential for development in Ukraine and can make a significant contribution to the national economy. We present the main aspects of this potential:

Table 2.9

Potential contribution of the bioeconomy sector in Ukraine to the national economy

Sector of the national economy Agriculture	Value added by type of economic activity			Number of employees by type of economic activity		
	million UAH	Share, %		Persons Share, %	Persons Share, %	
		bioeconomy	national		bioeconomy	national
Forestry and logging	260183,23	43,90	8,28	462976	35,00	6,27
Fisheries	9547,88	1,61	0,30	56004	4,23	0,75
Food production	590,33	0,09	0,02	4802	0,36	0,06
Textile production	157945,28	26,65	5,02	354380	26,79	4,80
including leather production	17665,42	2,98	0,56	18730	1,41	0,25
Manufacture of wood and paper products	3848,34	0,64	0,12	21402	1,61	0,29
Furniture production	34827,70	5,87	1,10	105862	8,00	1,43
Construction of buildings	10422,23	1,75	0,33	46771	3,53	0,63
Manufacture of chemicals and chemical products	62988,30	10,62	2,01	151876	11,48	2,05
including production of other basic organic chemicals	25931,09	4,37	0,82	63557	4,80	0,86
Waste collection, treatment and disposal	2400,24	0,40	0,07	8503	0,64	0,12
Total bioeconomy sector	6287,17	1,06	0,20	27642	2,09	0,37
Total national economy	592637,27	-	18,86	1322505	-	17,92
Sector of the national economy	3140864,36	-	-	7379539	-	-

Source: [25-26]

Economic benefits:

Creation of new jobs: the development of bioenergy, biotechnology and bio-based products will stimulate the creation of new jobs, especially in rural areas;

Increased exports: bioeconomy products such as biofuels, bioplastics and biofertilizers can become competitive on the world market, increasing the country's export opportunities;

Reduced imports: replacing part of fossil fuels with biofuels will reduce Ukraine's dependence on energy imports and improve the country's energy security;

Development of new industries: the bioeconomy can stimulate the development of new industries such as biotechnology, pharmaceuticals and the production of food additives;

Increased value added: value-added processing of agricultural products will increase the income of producers and the state.

Environmental benefits:

Reduced greenhouse gas emissions: replacing fossil fuels with biofuels helps reduce greenhouse gas emissions and combat climate change;

Waste utilization: use of agricultural and food industry waste for the production of bioenergy and bioproducts;

Biodiversity conservation: proper management of land resources used for growing energy crops can contribute to the conservation of biodiversity;

Soil quality improvement: the use of organic fertilizers obtained as a result of biomass processing improves soil quality and fertility.

Social benefits:

Rural development: the bioeconomy can stimulate the development of rural areas, creating new jobs and improving the living standards of the population.

Increasing energy independence of regions: bioenergy production at the local level can ensure energy independence of regions.

Public-private partnership (PPP) is a promising tool for the development of the bioenergy sector in Ukraine. It allows combining financial, technological and managerial resources of the state and the private sector to implement large-scale

projects.

Advantages of PPP in the bioenergy sector:

Investment attraction: the private sector can provide significant investments for the construction and modernization of production facilities.

Technology transfer: cooperation with international companies allows for the introduction of modern biofuel production technologies.

Risk sharing: project risks are shared between the state and the private partner.

Effective management: the combination of state support and private entrepreneurship ensures effective project management.

Areas of application of PPP in bioenergy:

Construction of new production facilities: joint financing and management of the construction of new biofuel production plants.

Modernization of existing enterprises: investments in the modernization of equipment and technological processes to increase production efficiency.

Research and development: joint financing of scientific research to create new types of biofuels and technologies.

Infrastructure creation: construction of warehouses for biomass storage, pipelines for transporting biofuels and other infrastructure facilities.

Unfortunately, there is no widespread practice of using PPP in the bioenergy sector in Ukraine yet. However, there are some examples of successful cooperation between the state and the private sector in this area.

Joint projects with international companies: Some Ukrainian enterprises implement joint projects with foreign partners for the production of biofuels.

Support for state programs: The state can provide financial support and benefits for projects implemented with the participation of the private sector.

Barriers to PPP development

Insufficient legislative framework: lack of clear and transparent rules for the implementation of PPP projects.

Corruption: possibility of corruption schemes in the distribution of public funds.

Insufficient trust between the state and business: lack of long-term trust relations

between state bodies and private companies.

Ways to develop PPP in Ukraine

Improvement of legislation: development and adoption of new laws that would regulate relations between the state and the private sector in the field of bioenergy.

Creation of a favorable investment climate: reduction of administrative barriers, simplification of the procedure for obtaining permits and licenses.

Support for small and medium-sized businesses: provision of financial and consulting assistance to small and medium-sized enterprises engaged in the production of biofuels.

Conducting information campaigns: dissemination of information about the advantages of PPP and investment opportunities in bioenergy.

Public-private partnership is an effective tool for the development of the bioenergy sector in Ukraine. With the help of PPP, it is possible to attract the necessary investments, introduce modern technologies and create new jobs. However, for the successful implementation of PPP projects, it is necessary to overcome a number of barriers and create favorable conditions for investment, which require the use of an appropriate mechanism (Table 2.10).

Unfortunately, at the moment in Ukraine there are no large-scale successful cases of public-private partnership (PPP) in the field of biofuel production. This is due to a number of reasons, including:

Unstable economic situation: frequent changes in legislation, currency fluctuations and other economic factors complicate long-term investment planning;

Lack of clear state policy: insufficient support from the state, lack of long-term programs for the development of bioenergy;

Corruption: the possibility of corruption schemes in the distribution of public funds and the granting of permits;

Insufficient awareness: many entrepreneurs do not have sufficient information about the possibilities of PPP and the conditions for its implementation;

However, there are individual initiatives and projects that can be considered as potential examples of PPP in this area:

Cooperation with international companies: Some Ukrainian enterprises cooperate with foreign companies that have experience in biofuel production. Such partnerships may include joint investments, technology transfer and product marketing.

Support for government programs: Some Ukrainian companies receive government support for the implementation of biofuel production projects. These can be preferential loans, tax breaks, or direct investments.

Table 2.10

A comprehensive mechanism that covers various aspects of public-private sector cooperation

PPP Aspect	Benefits for the state	Benefits for the private sector	Possible risks	Recommendations
Financing	Attracting additional investments, reducing the budget burden	Joint financing reduces investment risks	Possibility of corruption in the distribution of funds, inefficient use of budget funds	Transparency of project selection procedures, independent financial control
Project Management	Optimizing the use of resources, increasing management efficiency	Participation in decision-making, influence on the project implementation process	Possible differences in the goals and interests of partners, difficulty in coordinating actions	Clear division of responsibilities, effective mechanisms for resolving conflicts
Technology	Access to the latest technologies, increasing innovation	Rapid implementation of technologies, access to the market	Risk of technological dependence, possibility of technology leakage	Protection of intellectual property, development of national technologies
Risks	Sharing risks between the state and the private sector	Reduction of investment risks due to state support	Political risks, change in legislation, unforeseen circumstances	Risk insurance, flexible contracts
Social Aspects	Creating new jobs, developing infrastructure	Positive company image, social responsibility	Social tension if the project does not meet the expectations of the local community	Involving the public in discussing projects, ensuring social responsibility of business

Source: own research

Pilot projects: Some regions of Ukraine are implementing pilot projects for biofuel production with the participation of local enterprises and local governments.

Potential directions for the development of PPPs in the bioenergy sector in Ukraine:

Creation of special economic zones: Creation of zones with a preferential tax regime for enterprises engaged in the production of biofuels.

Development of government support programs: Development of long-term programs for the development of bioenergy with clearly defined goals and mechanisms for their achievement.

Creation of investment funds: Creation of special funds for financing projects in the field of bioenergy.

Cooperation with international financial institutions: Attracting funds from international banks and funds to finance projects.

The development of public-private partnerships (PPPs) in the bioenergy sector in Ukraine is constrained by a number of factors. Some of the most significant ones and ways to overcome them are systematized in Table 2.11, namely:

Economic barriers:

High investment costs: creating new biofuel production facilities requires significant investments that are not always available to Ukrainian enterprises;

Unstable economic situation: political instability, currency fluctuations and changes in legislation deter investors;

Lack of long-term forecasts: uncertainty about the further development of the biofuel market complicates investment planning;

High cost of credit: high interest rates on loans make investments in bioenergy less attractive.

Regulatory barriers:

Complicated permit procedures: bureaucratic procedures and the need to obtain a large number of permits significantly complicate the implementation of projects;

Insufficient transparency of legislation: changes in legislation and unclear regulatory norms create additional risks for investors;

Lack of a unified state approach: the lack of a clear state policy in the field of bioenergy complicates the coordination of actions of various authorities;

Insufficient support from the state: insufficient funding of state support programs for bioenergy.

Table 2.11

Barriers to the development of PPPs in the bioenergy sector in Ukraine and potential ways to overcome them

Barrier	Detail	Potential ways to overcome
Economic	High investment costs, unstable economic situation, lack of long-term forecasts, high cost of credit	State support programs, including preferential lending, guarantees and subsidies; * Creation of special funds for financing renewable energy projects; Involvement of international financial institutions; Creation of a favorable investment climate.
Regulatory	Complicated permit procedures, unstable legislation, lack of a unified state approach, insufficient support from the state	Simplification of the procedure for obtaining permits and licenses; Development of clear and stable legislation aimed at supporting bioenergy; Creation of a single state body responsible for the development of renewable energy; Development and implementation of standards and norms in the field of bioenergy.
Technological	Lack of modern technologies, insufficient number of qualified personnel	Cooperation with international companies and scientific institutions; Support for scientific research and development in the field of bioenergy; Creation of training programs for training specialists.
Other	Competition with traditional fuels, seasonality of biomass production, lack of developed infrastructure	Introduction of a system of "green tariffs" and other incentives for bioenergy producers; Development of infrastructure for the collection and transportation of biomass; Creation of bioenergy clusters.

Technological barriers:

Lack of modern technologies: many Ukrainian enterprises do not have access to modern biofuel production technologies;

Insufficient number of qualified personnel: shortage of specialists in the field of bioenergy.

Other barriers:

Competition with traditional fuels: high price of biofuels compared to traditional fuels.

Seasonality of biomass production: instability of supply of raw materials for biofuel production.

Lack of developed infrastructure: insufficient development of transport and

energy infrastructure.

To overcome these barriers, it is necessary to:

Create a favorable investment climate: reduce administrative barriers, ensure stability of legislation, introduce tax benefits for investors.

Develop a long-term strategy for the development of bioenergy: identify priority areas of development, develop mechanisms for financing projects.

Increase energy efficiency: stimulate energy conservation and the introduction of energy-efficient technologies.

Develop research and development: invest in research into new biofuel production technologies.

Cooperate with international organizations: attract international experience and investments.

The introduction of such measures will create favorable conditions for the development of PPPs in the bioenergy sector and contribute to achieving energy independence of Ukraine.

For the successful development of PPPs in the biofuel production sector in Ukraine, it is necessary to:

– create a favorable investment climate;

– develop a clear and transparent legislative framework;

– ensure effective management of public funds;

– increase the level of trust between the state and business;

– involve international experts and investors in cooperation.

It should be noted that the absence of large-scale PPP projects in this area does not mean the absence of potential. Ukraine has significant resources for the development of bioenergy, and PPPs can become an effective tool for achieving this goal.

SECTION 3.
IMPROVEMENT OF MECHANISMS OF STATE STIMULATION OF THE IMPLEMENTATION OF PUBLIC-PRIVATE PARTNERSHIP IN THE FIELD OF BIOFUEL PRODUCTION ON THE BASIS OF WASTE-FREE TECHNOLOGIES

Biofuel is becoming an increasingly important source of energy, due to its environmental friendliness, sustainability and potential for replacing fossil fuels. The development of biofuel production in Ukraine is stimulated by state policy, which provides for the creation of favorable conditions for investment in this area. One of the forms of state support is public-private partnership (PPP), which allows attracting private investment to biofuel production projects.

Enterprises that plan to start or expand biofuel production on the basis of PPP face a number of problems related to the management of investment resources. These problems include:

- lack of experience: many enterprises do not have experience working with PPPs, which can lead to errors in project planning and implementation;

- complexity of procedures: procedures for concluding and implementing PPP contracts can be complex and time-consuming;

- need for coordination: implementation of PPP projects requires effective coordination of actions between state bodies and private partners;

- financing: attracting investment in PPP projects can be a difficult task, especially for small and medium-sized enterprises;

- risks: PPP projects can be associated with various risks, such as political changes, changes in prices for raw materials and energy, and environmental risks.

The development of biofuel production requires attracting appropriate investment resources, however, in conditions of martial law, both the state and enterprises are limited in this type of resources, which necessitates the use of public-private partnership measures in the implementation of projects focused on biofuel production. The development of bioenergy in Ukraine is a strategic direction for

ensuring energy security, reducing dependence on imported energy sources and improving the environmental situation. Public-private partnership (PPP) is an effective tool for attracting investments and new technologies to this sector. However, for the successful implementation of such projects, a comprehensive system of state support is necessary.

Today, the following mechanisms for stimulating PPPs in the bioenergy sector operate in Ukraine:

“Green tariffs”: this mechanism provides for the establishment of a guaranteed price for electricity generated from renewable energy sources, which makes investments in such projects more attractive;

Tax incentives: reducing the tax burden on enterprises engaged in the production of biofuels;

Credit lines: providing preferential loans for the implementation of biofuel production projects;

State programs: developing and financing state programs aimed at the development of bioenergy (Table 3.1).

Table 3.1

Main mechanisms for stimulating public-private partnerships in the field of biofuel production in Ukraine

Incentive mechanism	Incentive Subject	Conditions for obtaining	Expected results	Performance indicators
"Green tariffs"	Producers of electricity from renewable sources	Electricity production from biomass, compliance with technical standards	Increase in electricity production from renewable sources, reduce greenhouse gas emissions	Volume of electricity produced, reduction of CO2 emissions
Tax benefits	Agricultural enterprises	Investment in biofuel production technologies	Stimulate investments in bioenergy, reduce the cost of biofuels	Volume of investments, volume of biofuel produced

A green tariff is an economic mechanism that provides for the establishment by the state of a guaranteed price for electricity generated from renewable energy sources

(RES). This price is usually higher than the market price, which allows to compensate for the additional costs associated with the production of "green" electricity.

Electricity generation from RES: enterprises or households that produce electricity using solar panels, wind turbines, biogas plants, etc. are currently entitled to a "green tariff".

Selling electricity at a fixed price: producers sell all or part of the electricity they produce to the grid at a set "green tariff".

Compensation of the difference: if the "green tariff" is higher than the market price for electricity, consumers compensate for the difference through a special fund or by including appropriate payments in electricity tariffs.

Stimulating the development of renewable energy: ensuring a stable income for producers of "green" electricity, which stimulates investment in this sector. Reducing greenhouse gas emissions: replacing traditional energy sources with renewable ones helps reduce air pollution and slow down climate change.

Increasing energy independence: the development of renewable energy reduces dependence on energy imports.

Creating new jobs: the development of the renewable energy sector contributes to the creation of new jobs, especially in rural areas.

Advantages of green tariffs:

Stability for investors: a guaranteed price for electricity reduces risks for investors and stimulates long-term investments. Accelerating the transition to a "green" economy: contributes to achieving sustainable development goals and combating climate change. Cost sharing: the costs of developing renewable energy are shared among all electricity consumers.

Despite the presence of certain support mechanisms, additional measures are needed for the successful development of PPPs in the bioenergy sector (Table 3.2.):

Simplifying the permit procedure: reducing bureaucratic barriers for investors;

Ensuring the stability of investment conditions: ensuring the long-term stability of "green tariffs" and other support measures;

Expanding the circle of PPP participants: involving small and medium-sized

enterprises, farms in projects;

Supporting scientific research and development: creating favorable conditions for the development of new biofuel production technologies;

Developing infrastructure: building and modernizing infrastructure for collecting, transporting and processing biomass;

Increasing energy efficiency: stimulating the implementation of energy-efficient technologies at enterprises.

Table 3.2

Proposals for improving mechanisms for stimulating the development of bioenergy in Ukraine

Aspect of improvement	Proposal	Expected result
Financial incentives Regulatory environment	Expanding the "green tariffs" program to new types of biofuels and bioenergy installations	Attracting more investment in the bioenergy sector
	Creating a special fund to finance innovative projects in the field of bioenergy	Supporting the development and implementation of new technologies
	Providing preferential loans and guarantees for investment projects	Reducing financial risks for investors
Infrastructure	Simplifying the procedure for obtaining permits and licenses	Reducing time and costs for project implementation
	Ensuring the stability of legislation and "green tariffs"	Increasing the investment attractiveness of the sector
	Creating a single state body responsible for the development of renewable energy	Improving coordination of actions of various authorities
Human resources and technology	Developing infrastructure for the collection, transportation and processing of biomass	Reducing the cost of biofuels
	Creating bioenergy clusters	Concentrating production, scientific research and innovation
Collaboration Aspect of improvement	Supporting scientific research and development in the field of bioenergy	Creating new technologies and products
	Creating training programs for training specialists	Providing the industry with qualified personnel
Financial incentives	Expanding cooperation with international organizations	Attracting international investment and technologies
	Creating a platform for the exchange of experience between market participants	Strengthening cooperation between government agencies, business and scientific institutions

We have developed proposals for improving incentive mechanisms:

Creating a special fund: creating a fund to finance innovative projects in the field

of bioenergy;

Expanding the circle of entities eligible for "green tariffs": including not only large producers, but also small and medium-sized enterprises in this circle;

Developing mechanisms for supporting local communities: involving local communities in the implementation of bioenergy projects;

Cluster creation: creation of bioenergy clusters to combine the efforts of enterprises, scientific institutions and authorities;

Expanding cooperation with international organizations: attracting international investments and technologies (Table 3.3).

Table 3.3

Improving mechanisms for stimulating the development of bioenergy in Ukraine

№	Proposal	Expected result
1	Creation of a special fund to finance innovative projects in the field of bioenergy	Stimulating the development and implementation of new technologies, increasing the energy efficiency of biofuel production.
2	Expanding the circle of entities eligible for "green tariffs", including small and medium-sized enterprises	Attracting more participants to the market for electricity production from renewable energy sources, developing competition.
3	Development of mechanisms to support local communities in the implementation of bioenergy projects	Involving local communities in the decision-making process, increasing the level of energy self-sufficiency of regions.
4	Creation of bioenergy clusters	Concentration of production, scientific research and innovation, increasing the efficiency of resource use.
5	Expanding cooperation with international organizations	Attracting foreign investments, technologies and experience, increasing the competitiveness of Ukrainian bioenergy in the world market.

Simplifying the procedure for obtaining permits and licenses: Reducing the administrative burden on business, reducing project implementation times.

Ensuring the stability of legislation and "green tariffs": Increasing the investment attractiveness of the sector, reducing risks for investors.

Supporting scientific research and development: creating favorable conditions for the development of new biofuel production technologies.

Creating training programs for training specialists: providing the industry with qualified personnel.

Developing infrastructure for collecting, transporting and processing biomass:

reducing the cost of biofuels.

Therefore, the implementation of public-private partnership in the field of bioenergy is an important step towards achieving energy independence of Ukraine. For the successful development of this direction, it is necessary to create favorable conditions for investment, simplify the procedures for obtaining permits and ensure the stability of legislation. The above measures will help overcome existing barriers and stimulate the development of bioenergy in Ukraine.

The development of biofuel production in Ukraine is a strategically important task that contributes to energy independence, reducing greenhouse gas emissions and improving the environmental situation. Public-private partnership is an effective tool for attracting investments and new technologies to this sector.

An analysis of existing incentive mechanisms indicates the need for their improvement. Green tariffs, although an important incentive, require further development and expansion of the circle of their beneficiaries. Tax breaks and credit lines can also be more effective if their tariff policy is clear. For the successful development of biofuel production on the basis of public-private partnership, it is necessary to:

Create a favorable investment environment: simplify permit procedures, ensure stability of legislation and "green tariffs".

Increase financial support: expand financing programs, create special funds for innovative projects.

Involve local communities: develop mechanisms for involving local communities in the implementation of bioenergy projects.

Develop infrastructure: invest in the construction and modernization of infrastructure for the collection, transportation and processing of biomass.

Support scientific research and development: stimulate the creation of new biofuel production technologies.

Cooperate with international partners: attract foreign investments and technologies.

The key elements of the successful implementation of public-private partnership

in the field of bioenergy are:

A clear development strategy: defining priority areas, goals and objectives.

Effective coordination of actions: creating a single coordination body.

Transparency and accountability: ensuring openness of decision-making processes.

Monitoring and evaluation: regular assessment of the effectiveness of implemented measures.

As noted by V. Vovk, Ukraine faces an important task of implementing waste-free technologies and developing biofuel production to reduce the negative impact on the environment and ensure the country's energy security. Mechanisms for state stimulation of PPPs in these areas are key to achieving the country's strategic goals in the field of bioenergy [44, p. 352].

Public-private partnership is understood as a mechanism for coordinating goals and ensuring a balance of interests between the public and private sectors within the framework of the implementation of socially important projects, the result of which is mutual benefit [45, p. 12]. Ukraine has some experience in implementing PPP projects in the field of biofuel production, but it has not yet become widespread due to the aggression of the Russian Federation.

Currently, there are the following challenges and prospects for the development of PPPs in the biofuels sector in Ukraine:

Challenges:

– insufficient legal framework: lack of clear legislation regulating PPP activities in the biofuels sector.

– bureaucratic barriers: complex and lengthy procedures for approval and obtaining permits.

– low level of awareness: insufficient awareness of potential investors about the benefits of PPPs.

Prospects:

– improvement of legislation: development and adoption of laws that stimulate the development of PPPs in the biofuels sector.

– information campaign: raising awareness of the benefits of PPPs for investors and potential partners.

It is necessary to introduce effective methods of managing investment resources for enterprises operating in the biofuels sector on the basis of PPPs to ensure:

- simplification of the procedure for concluding and implementing PPP agreements;

- ensuring effective coordination of actions between state bodies and private partners;

- promoting investment in PPP projects.

To solve problems related to the management of investment resources, a number of methods can be used:

- staff training: train enterprise personnel in methods of effective management of investment resources within the framework of PPP;

- development of methodological recommendations: development of methodological recommendations on the management of investment resources for enterprises operating in the field of biofuel production on the basis of PPP;

- creation of information resources: create information resources containing information on PPP, procedures for concluding and implementing PPP agreements;

- provision of consulting assistance: provide consulting assistance to enterprises on issues of investment resource management within the framework of PPP;

- support for scientific research: support scientific research on issues of investment resource management within the framework of PPP.

The mechanism for managing investment resources of enterprises for the production of biofuels on the basis of public-private partnership should include the main components, namely planning and assessment, project financing itself, ensuring the implementation of this project and monitoring and analysis of results (Table 3.4).

Implementing an effective investment resource management mechanism can help enterprises operating in the field of biofuel production on a PPP basis to achieve their goals, increase the profitability of projects and contribute to the development of sustainable energy.

Table 3.4

Components of the investment resource management mechanism of enterprises for the production of biofuels on a public-private partnership basis

1. Planning and Evaluation:
Goal Setting: Defining clear and measurable goals for the PPP biofuel project.
Needs Assessment: Conducting a detailed analysis of the project's investment resource needs, including financing, equipment, raw materials, human resources, etc.
Resource Analysis: Assessing available investment resources, both public and private.
Investment Plan Development: Developing a detailed investment plan that includes: Investment volume and sources, investment schedule, expected investment results, risk management strategies
2. Financing:
Investment Raising: Attracting investment from various sources, such as government support programs, bank loans, private company investments, etc.
Financial Management: Effective management of the project's financial resources, including cost planning, cost control, accounting, etc.
Financial Performance Monitoring: Regularly monitoring the project's financial performance, such as return on investment, payback period, net profit, etc.
3. Project Implementation:
Project Management: Effective management of the biofuel production project, including planning, execution, control and monitoring.
Risk Management: Identification, assessment and minimization of risks associated with the project, such as changes in raw material prices, political changes, environmental risks, etc.
Partner Communication: Effective communication and cooperation with government agencies and private partners throughout all stages of project implementation.
4. Monitoring and Analysis:
Data Collection: Collection of data on actual investments, costs, project results, etc.
Data Analysis: Conducting data analysis to assess the effectiveness of investment resource management.
Reporting: Preparing reports on the results of investment resource management for stakeholders.
Mechanism Improvement: Improving the mechanism for managing investment resources based on the data obtained and analysis.
Important Aspects:
Transparency: Ensuring transparency and accountability in the use of investment resources.
Responsibility: defining clear roles and responsibilities for managing investment resources.
Flexibility: willingness to change and adapt the investment resource management mechanism to changing conditions.
Collaboration: creating an atmosphere of trust and cooperation between government agencies and private partners.

Source: systematized on the basis of [44-51]

The development of PPP in the field of biofuel production can stimulate the development of bioenergy in Ukraine, contribute to reducing dependence on imported energy sources and improve the environmental situation in the country.

One of the priority areas for increasing the efficiency of investments in agriculture is recognized as strengthening the role of local authorities in investment

processes in agriculture. The system of public-private guarantees can act as a mechanism for attracting credit resources to finance investment projects. Changes in state support for the investment process to provide guarantees meet the interests of both the state, united territorial communities, and the private sector.

The introduction of an effective mechanism for managing investment resources can lead to a number of positive results for enterprises operating in the field of biofuel production on the basis of public-private partnership (PPP):

1. Reducing project costs: effective planning and assessment of project needs allow optimizing the costs of investment resources.

2. Acceleration of project implementation: clear planning and coordination of actions of state bodies and private partners allow to reduce the time required for project implementation.

3. Increasing project profitability: attracting investments based on a clear investment plan allows to maximize the return on investment.

4. Increasing biofuel production volumes: attracting investment resources allows enterprises to expand production capacities and increase biofuel production volumes.

5. Reducing the negative impact on the environment: using biofuels instead of fossil fuels allows to reduce greenhouse gas emissions and other environmental pollution.

6. Improving the country's energy security: increasing biofuel production volumes allows to diversify energy sources and reduce dependence on fossil fuel imports.

7. Increasing the level of trust and cooperation: introducing transparent and accountable mechanisms for managing investment resources helps to increase the level of trust between state bodies and private partners.

In general, the implementation of an effective mechanism for managing investment resources can significantly improve the performance of biofuel production projects based on PPP principles and contribute to the development of sustainable energy, economy and environment.

Managing investment resources of enterprises engaged in biofuel production is

a complex process that requires an integrated approach. This issue becomes especially relevant in the context of public-private partnership (PPP), where the efficient use of funds is a key factor in the success of the project.

Specifics of managing investment resources in the field of biofuel production

Long-term nature of projects: biofuel production projects often have a long payback period, which requires long-term financial planning.

High cost of technologies: modern equipment for biofuel production is quite expensive, which requires significant investments.

Instability of prices for raw materials and finished products: prices for agricultural raw materials and biofuels can fluctuate significantly, which affects the financial results of the project.

Government regulation: The activities of enterprises in the bioenergy sector are subject to significant government regulation, which can influence investment decisions.

PPP allows attracting private investment in bioenergy, while the state assumes certain obligations, such as:

Providing land: for growing energy crops or locating production facilities.

Providing tax benefits: reducing the tax burden on enterprises engaged in the production of biofuels.

Guaranteeing product sales: for example, through the "green tariffs" mechanism.

Key aspects of managing investment resources within the framework of PPP:

Development of a detailed business plan: the business plan should contain a detailed market analysis, an assessment of costs and revenues, identification of financing sources and calculation of the project payback period.

Creating an effective project management system: it is necessary to identify responsible persons, develop a work schedule and a control system.

Attracting qualified personnel: for the successful implementation of the project, specialists in the field of bioenergy, finance, and project management are needed.

Risk management: it is necessary to identify possible risks associated with the implementation of the project and develop measures to minimize them.

Monitoring and assessing effectiveness: regular monitoring of project implementation and assessing its effectiveness allows for timely detection of deviations from the plan and making necessary adjustments.

Investment resource management tools are:

Budgeting: drawing up a detailed project budget that allows you to control costs and revenues;

Financial analysis: regular analysis of the project's financial indicators to assess its effectiveness;

Project management systems: using specialized software for planning, controlling, and managing projects;

Insurance: insuring risks associated with the implementation of the project.

Therefore, managing investment resources in the field of biofuel production is a complex but necessary process. Effective use of funds is a key factor in the success of projects in this area. PPP creates favorable conditions for attracting investments in bioenergy, but requires a high level of professionalism and responsibility from project participants.

Biodiesel production in Ukraine is becoming increasingly relevant against the backdrop of global climate change, rising prices for petroleum products, and the need for energy independence. This direction of development of the agro-industrial complex has both significant environmental benefits and economic potential.

Environmental benefits of biodiesel production:

Reduction of greenhouse gas emissions: less carbon dioxide is emitted when burning biodiesel than when burning diesel fuel from oil, since the carbon dioxide released when burning biodiesel was previously absorbed by the plant during photosynthesis;

Reduction of dependence on fossil fuels: biodiesel production helps reduce dependence on imported oil and other fossil fuels, which increases the country's energy security.

Improving air quality: the use of biodiesel leads to a reduction in emissions of harmful substances into the atmosphere, such as sulfur dioxide, nitrogen oxides and particulate matter.

Promoting the carbon cycle: the production of biodiesel is part of the natural carbon cycle, since the carbon dioxide released during its combustion is absorbed by plants to produce biomass.

Economic benefits of biodiesel production:

Creating new jobs: the development of biodiesel production contributes to the creation of new jobs in agriculture, the processing industry and related industries.

Increasing the added value of agricultural products: the processing of agricultural raw materials into biodiesel allows you to increase the added value of products and increase the income of agricultural enterprises.

Reducing the cost of importing energy carriers: replacing part of imported diesel fuel with domestic biodiesel allows you to reduce the cost of importing energy carriers and improve the country's balance of payments.

Stimulating the development of rural areas: the development of biodiesel production can become a driving force for the development of rural areas and increase their economic attractiveness.

Problems and prospects for the development of biodiesel production in Ukraine

Despite significant potential, the development of biodiesel production in Ukraine faces a number of problems, such as:

High production costs: biodiesel production is more expensive than the production of traditional diesel fuel.

Insufficient investment attractiveness: investors are often hesitant to invest in biodiesel production due to the instability of legislation and high risks.

Competition with other types of biofuels: there is competition in the biofuel market with other types of biofuels, such as bioethanol.

Limited feedstock: To ensure the sustainable development of biodiesel production, it is necessary to expand the area under oilseed crops.

Biodiesel production, although considered more environmentally friendly than

traditional diesel, has its own impacts on the environment and biodiversity. These impacts can be both positive and negative, and depend on many factors, such as:

Type of feedstock: The use of certain crops for biodiesel production can have different environmental impacts. For example, growing oilseed crops on land previously used for food crops can lead to food shortages and higher food prices.

Production technologies: The choice of biodiesel production technology also affects its environmental performance. Some technologies may be more energy-intensive or produce more waste.

Land management: The irrational use of land for energy crops can lead to soil erosion, loss of fertility and a decrease in biodiversity.

Water and fertilizer use: Biodiesel production requires significant amounts of water and fertilizer, which can negatively impact water resources and soil quality.

Positive impacts:

Reduced greenhouse gas emissions: Burning biodiesel produces less carbon dioxide than burning diesel fuel from oil.

Reduced dependence on fossil fuels: Biodiesel production helps reduce dependence on imported oil and other fossil fuels.

Promoted agricultural development: Biodiesel production can stimulate agricultural development and create new jobs.

Negative impacts:

Competition for land: Growing energy crops can compete for land with food production, which can lead to higher food prices and food shortages in some regions.

Biodiversity loss: Large-scale monoculture farming can lead to a decline in biodiversity by replacing natural ecosystems.

Water and soil pollution: Improper use of fertilizers and pesticides in growing energy crops can lead to pollution of groundwater and surface water.

Soil erosion: Irregular use of land can lead to soil erosion, which reduces its fertility and water holding capacity.

Minimizing negative impacts:

To minimize the negative impacts of biodiesel production on the environment

and biodiversity, the following measures should be taken:

Using agricultural waste as raw material: Instead of growing new crops, agricultural waste such as straw, sunflower husks, etc. can be used to produce biodiesel.

Implementing environmentally friendly technologies: Using modern technologies that minimize the use of water, fertilizers and energy.

Creating buffer strips: Growing energy crops in compliance with crop rotation rules and creating buffer strips to preserve biodiversity.

Support for local producers: support for local biodiesel producers who use environmentally friendly technologies and care about preserving the environment.

Biodiesel production has both positive and negative consequences for the environment and biodiversity. In order to maximize positive effects and minimize negative ones, it is necessary to develop and implement comprehensive measures aimed at the sustainable development of bioenergy.

The prospects for the development of biodiesel production are as follows:

State support: development and implementation of state programs to support biodiesel production.

Creation of clusters: joining the efforts of scientists, manufacturers, processors and state bodies to jointly solve the problems of the industry.

Introduction of new technologies: application of modern technologies that allow reducing the cost of biodiesel production.

Expansion of the raw material base: activation of research in order to expand the raw material base for biodiesel production.

Thus, biodiesel production in Ukraine has significant potential for development and can become an important element of the country's energy strategy. However, to achieve success, it is necessary to solve a number of problems related to economics, technology, and public policy.

At the same time, the development of biodiesel production in Ukraine is a complex process that requires coordinated work of state bodies, business and the public. For effective management of this process, a set of measures is required aimed at stimulating production, ensuring product quality and minimizing negative impact on

the environment. The main elements of the management mechanism are as follows:

Legal regulation:

Legislative framework: development and improvement of legislation regulating the production, use and trade of biodiesel.

Quality standards: establishment of clear quality standards for biodiesel that meet international requirements.

Licensing: introduction of a licensing system for biodiesel producers.

Financial incentives:

Preferential taxation: provision of preferential taxation conditions for biodiesel producers.

State financing programs: development and implementation of state financing programs for investment projects in the field of bioenergy.

Credit lines: creation of special credit lines for enterprises engaged in the production of biodiesel.

Support for research and development:

Funding for research: allocating funds to bioenergy research, developing new technologies, and improving production efficiency.

Cooperation with scientific institutions: collaborating with scientific institutions to develop and implement innovative solutions in biodiesel production.

Infrastructure development:

Creation of logistics centers: construction and modernization of logistics centers for storage and transportation of biodiesel.

Development of a gas station network: expansion of the gas station network selling biodiesel.

Quality and safety control:

Certification system: implementation of a biodiesel quality certification system.

Environmental control: creation of an effective system of environmental control over the production and use of biodiesel.

Information support:

Dissemination of information: active dissemination of information about the

benefits of using biodiesel among consumers and producers.

Creation of information resources: development and support of information resources containing data on the biodiesel market, production technologies, and investment opportunities.

International cooperation:

Participation in international projects: participation in international projects on the development of bioenergy. Exchange of experience: exchange of experience with other countries with a developed biodiesel production industry (Table 3.5).

Table 3.5

Main elements of the mechanism for managing the development of biodiesel production in Ukraine

Mechanism Element	Brief description	Examples in Ukraine	Possible problems
Legislative Regulation	Legal framework defining the rules for the production, use and trade of biodiesel.	Laws of Ukraine "On Renewable Energy Sources", "On Biofuels", etc.	Insufficient clarity of some norms, complexity of procedures, obsolescence of some provisions.
Financial Incentives	Measures stimulating investment in the industry, such as tax breaks, subsidies, loans.	VAT exemption for biofuels, state investment support programs.	Possibility of abuse, inefficient use of funds, dependence on budget allocations.
Support for Research and Development	Financing scientific research, cooperation with scientific institutions.	Programs of the Ministry of Education and Science of Ukraine, cooperation with universities.	Insufficient funding, lack of long-term programs.
Infrastructure Development	Creating conditions for the production, storage and transportation of biodiesel.	Construction of new plants, modernization of oil depots, expansion of the gas station network.	High capital investments, need for integration into existing infrastructure.
Quality and Safety Control	Certification systems, environmental control.	State Service for Food Safety and Consumer Protection, laboratory research.	Insufficient number of accredited laboratories, complexity of certification procedures.
Information Support	Dissemination of information about the benefits of biodiesel, creation of information resources.	Information campaigns, websites, publications.	Insufficient awareness of consumers and manufacturers, lack of a single information portal.
International Cooperation	Participation in international projects, exchange of experience.	EU programs to support the development of renewable energy.	Dependence on external factors, bureaucratic procedures.

Source: own research

Important aspects for the successful development of biodiesel production in Ukraine:

Sustainable development: combining economic, social and environmental aspects of the development of the industry.

Support for local production: stimulating the development of local production of raw materials for biodiesel production.

Partnership between the state and business: creating an effective mechanism for interaction between the state and business to solve common tasks.

Informing the public: Conducting information campaigns to raise public awareness about the benefits of using biodiesel.

The development of biodiesel production is an urgent task that requires a balanced approach that takes into account not only economic, but also social and environmental aspects. Achieving a balance between these three components is key to the sustainable development of the industry.

Main areas for ensuring balance:

Environmentally friendly production:

Choice of raw materials: priority should be given to the use of agricultural waste and energy crops grown on marginal lands in order to minimize competition with food production.

Optimization of technological processes: application of modern technologies that allow to reduce water and energy consumption, minimize emissions of harmful substances.

Waste disposal: development of effective systems for the disposal of production by-products.

Social responsibility:

Job creation: support for the development of rural areas, creation of new jobs in the village.

Support for local communities: involvement of local communities in biodiesel production projects, ensuring transparency and openness of processes.

Fair remuneration: ensuring decent working conditions for industry workers.

Economic efficiency:

State support: provision of financial incentives, tax breaks, guarantees for investors.

Infrastructure development: construction and modernization of factories, warehouses, transport routes.

Creation of a favorable investment climate: reduction of administrative barriers, simplification of permit procedures.

Integrated approach to management:

Strategic planning: development of long-term industry development strategies taking into account all aspects.

Monitoring and evaluation: regular monitoring of the impact of biodiesel production on the environment and society, conducting an assessment of the effectiveness of the implemented measures.

Adaptation to change: readiness to adapt to new conditions and challenges.

Achieving a balance between the economic, social and environmental aspects of the development of biodiesel production is a complex task that requires joint efforts of the state, business and the public. It is important to take into account that the situation is constantly changing, therefore it is necessary to constantly review and adapt the development strategies of the industry. A possible balance between these aspects by taking appropriate measures is presented in Table 3.6.

For the effective development of biodiesel production in Ukraine, it is necessary to attract significant investments. There are a number of financial instruments that can stimulate this process:

– direct financing of projects for the construction and modernization of biodiesel production, as well as support for research and development in this area;

– provision of state guarantees on loans for enterprises operating in the bioenergy sector. This reduces risks for banks and makes loans more accessible to businesses;

– providing loans at reduced interest rates for investments in biodiesel production.

Table 3.6

Balance between economic, social and environmental aspects of biodiesel production

Aspect	Positive impacts	Potential negative consequences	Ways to balance
Economic	Job creation, agricultural development, reduced dependence on oil imports, increased biodiesel exports	Competition with other sectors of the economy, increased prices for agricultural products, dependence on state support	Creation of bioenergy clusters, investment programs, support for small and medium-sized businesses, diversification of production
Social	Rural development, improved quality of life, reduced social tension	Conflicts over land, population migration, impact on public health (in case of poor-quality production)	Involvement of local communities in decision-making, ensuring transparency of production, creation of social programs for the local population
Environmental	Reduced greenhouse gas emissions, reduced air pollution, use of renewable energy sources	Competition for land with food production, loss of biodiversity, pollution of soil and water resources	Use of marginal lands, crop rotation, wastewater treatment, use of environmentally friendly technologies

Source: own research

Therefore, effective management of the development of biodiesel production in Ukraine requires a comprehensive approach, including legal regulation, financial incentives, support for scientific and research work, infrastructure development, quality and safety control, information support and international cooperation. The implementation of these measures will ensure the sustainable development of the industry and contribute to the achievement of energy independence of Ukraine.

The mechanism for managing the development of biodiesel production to ensure the energy security of the state is a set of interrelated measures, tools and structures aimed at stimulating, regulating and coordinating the process of biodiesel production in order to reduce dependence on imported energy carriers, reduce greenhouse gas emissions and increase the country's energy security.

As noted above, the key elements of such a mechanism include:

Legal framework: legislation that regulates the production, use and trade in biodiesel, establishes quality standards, defines the rights and obligations of market

participants.

Financial instruments: a set of financial support measures, such as subsidies, tax breaks, loans, guarantees, aimed at stimulating investments in biodiesel production.

Institutional mechanisms: state bodies responsible for the formation and implementation of bioenergy policy, as well as other stakeholders (business associations, scientific institutions, etc.).

Market mechanisms: emission trading systems, mandatory biofuel admixtures in traditional fuels, other market instruments that stimulate demand for biodiesel.

Scientific and technical support: research and development of new biodiesel production technologies, increasing production efficiency, creating new types of raw materials.

Information support: collection, processing and dissemination of information on the state of the industry, development trends, and scientific research results.

The purpose of such a mechanism:

Reducing dependence on imported energy sources: ensuring the country's energy security by developing its own biofuel production.

Reducing greenhouse gas emissions: contributing to achieving climate goals and reducing negative environmental impacts.

Agricultural development: stimulating the production of agricultural raw materials for biodiesel production.

Job creation: contributing to economic development and increasing employment.

Energy efficiency improvement: encouraging the use of energy-efficient technologies in biodiesel production.

The main goal of the biodiesel production management mechanism is to create conditions for the sustainable development of the industry, which would combine economic, social and environmental interests.

It should be noted that the countries of the European Union have significant experience in developing biodiesel production and implementing effective mechanisms for its support. Their experience is a valuable source of knowledge for

Ukraine in the process of improving its own policy in this area.

Key aspects of European experience:

Strict environmental standards: the EU has strict requirements for the quality of biofuels and their impact on the environment. This encourages producers to implement modern technologies and use environmentally friendly raw materials.

Certification systems: biofuel certification systems have been introduced, which confirm its sustainability and compliance with environmental requirements.

State support: EU countries provide significant financial support to biofuel producers through subsidies, tax breaks, loan guarantees, etc.

Mandatory biofuel admixtures: Many EU countries have mandatory quotas for adding biofuels to traditional fuels, which stimulates demand for biodiesel.

Infrastructure development: The EU invests in the development of infrastructure for the production, storage and transportation of biofuels.

Cooperation between countries: EU countries actively cooperate in the field of bioenergy, exchange experience and coordinate their actions (Table 3.7).

Table 3.7

Systematization of the experience of EU countries in the development of biodiesel production

Country	Key support measures	Achievements	Challenges
Germany	Significant state investments, tax breaks, infrastructure development, strict environmental standards	High level of biofuel production, developed infrastructure, leadership in technologies	Competition with other types of energy, seasonal fluctuations in raw material production
France	Ambitious plans for the development of bioenergy, support for small and medium-sized enterprises, research development	Increasing share of biofuels in the energy balance, development of agriculture	Dependence on raw material imports, need to balance food and energy production
Sweden	Active state support, high level of biomass use for energy production, development of innovative technologies	High level of use of renewable energy sources, reduction of greenhouse gas emissions	Seasonal fluctuations in biomass production, need to adapt to climate change

Source: own research

Some of the best in this area are the mechanisms for stimulating the development of biodiesel production in the following countries:

1. Germany: One of the leading countries in biofuel production. Germany actively uses biomass to produce electricity and heat, as well as biofuels.

2. France: has implemented ambitious plans for the development of bioenergy, in particular, increasing the share of biofuels in the country's energy balance.

3. Sweden: has achieved significant success in the development of bioenergy thanks to active state support and innovative technologies.

4. Austria: is known for its ambitious goals for the development of renewable energy sources.

5. Denmark: one of the leaders in the production of biofuels from agricultural waste.

6. Italy: has significant potential for the production of biofuels from olive waste.

Therefore, the mechanism for managing the development of biodiesel production is a dynamic system that requires constant improvement to effectively achieve the set goals. Below are some key areas that can contribute to its development:

1. Expanding the raw material base

Active use of agricultural waste: use of straw, sunflower husks, food industry waste as raw materials for biodiesel production;

Development of energy crop cultivation: creation of favorable conditions for growing crops such as rapeseed, sunflower, rapeseed on marginal lands.

Research on new types of raw materials: expansion of the list of vegetable oils suitable for biodiesel production, and development of technologies for their processing.

2. Improving production technologies

Support for scientific research: financing projects aimed at developing new, more efficient and environmentally friendly technologies for biodiesel production.

Introduction of energy-saving technologies: reduction of energy intensity of biodiesel production.

Utilization of by-products: development of technologies for utilization of by-products of production, such as glycerin, to obtain additional products.

3. Expanding sales markets

Supporting biodiesel exports: facilitating the entry of Ukrainian producers into

international markets.

Stimulating domestic demand: introducing mandatory biofuel additives into traditional fuel, developing infrastructure for refueling cars with biodiesel.

4. Improving the financial support system

Differentiation of financial instruments: using different financial instruments depending on the scale of the project, the stage of its implementation and other factors.

Simplifying access to financing: reducing administrative barriers to obtaining loans and grants.

Expanding sources of financing: attracting funds from international financial institutions, private investors.

5. Strengthening environmental control

Implementing strict environmental standards: ensuring that biodiesel production complies with international standards.

Regular monitoring of environmental impact: conducting environmental due diligence of projects, monitoring emissions of harmful substances.

6. Infrastructure development

Construction and modernization of plants: creating modern production facilities.

Expansion of the gas station network: ensuring the availability of biodiesel for consumers.

Development of logistics: creation of an effective biodiesel transportation system.

7. Strengthening the role of the state

Creating a clear and stable policy: developing a long-term strategy for the development of the industry.

Coordination of the activities of various authorities: ensuring consistency of actions at the central and local levels.

Support for scientific and research work: financing research aimed at solving current problems in the industry.

8. Cooperation with international organizations

Exchange of experience: studying the experience of other countries in the

development of biodiesel production.

Attracting international investment: cooperation with international financial institutions (Table 3.8).

Table 3.8

Systematization of areas for improving the mechanism for managing the development of biodiesel production

Direction of improvement	Specific measures	Expected results
Expanding the raw material base	Active involvement of agricultural waste, development of energy crop cultivation, research into new types of raw materials	Increase in biodiesel production volumes, reduce cost, reduce pressure on arable land
Improving production technologies	Support for scientific research, implementation of energy-saving technologies, utilization of by-products	Increase in production efficiency, reduce emissions, obtain additional products
Expanding sales markets	Support for biodiesel exports, stimulation of domestic demand	Increase in sales volumes, stabilize biodiesel prices
Improving the financial support system	Differentiation of financial instruments, simplification of access to financing, expansion of financing sources	Attract investment, reduce risks for investors
Strengthening environmental control	Implementation of strict environmental standards, regular monitoring of environmental impact	Reduce negative impact on the environment, improve the image of Ukrainian biodiesel
Developing infrastructure	Construction and modernization of plants, expansion of the gas station network, development of logistics	Reduce transport costs, improve product quality
Strengthening the role of the state	Creation of a clear and stable policy, coordination of the activities of various authorities, support for scientific and research work	Creating a favorable investment climate, increase the efficiency of public administration
Cooperation with international organizations	Exchange of experience, attraction of international investments	Update domestic legislation, access to new technologies

Source: own research

Improving the mechanism for managing the development of biodiesel production is a necessary condition for ensuring the energy security of the state, the development of agriculture and reducing the negative impact on the environment.

To achieve these goals, it is necessary to focus on the following key aspects:

– expanding the raw material base through the use of agricultural waste and new types of vegetable oils;

– introducing modern technologies to increase production efficiency and reduce

costs;

– creating a favorable investment climate by providing financial support, simplifying administrative procedures and ensuring stable policies;

– strengthening environmental control to minimize the negative impact on the environment;

– developing infrastructure to ensure effective logistics and sales of biodiesel;

– cooperating with international organizations to exchange experience and attract investment.

A systematic approach to improving the management mechanism, based on clearly defined goals and specific measures, will allow Ukraine to become a leader in biodiesel production and ensure energy independence

In the conditions of war and energy crisis in Ukraine, caused by the refusal of imports from the Russian Federation and Belarus, the development of biodiesel production is an urgent need. Using the potential of rapeseed and creating small processing enterprises will allow to quickly provide the country with alternative fuel, reduce dependence on imports and stabilize energy prices. After all, the cost of biodiesel production is significantly lower than the cost of traditional diesel fuel, and its reserves are limited. In addition, the transition to biofuels will contribute to improving the environmental situation. As G.M. Kaletnik notes, Ukraine is an energy-deficient country, therefore the development of bioenergy is a strategic task.

G. Kaletnik argues that Ukraine, given historical and modern realities, is faced with an acute problem of energy shortage. The growing dependence on imported energy and the unstable geopolitical situation require urgent action. Expanding the use of bioenergy is not only a path to energy independence, but also an opportunity to modernize the economy and reduce the negative impact on the environment. To do this, it is necessary to create favorable conditions for the development of the bioenergy market and actively introduce energy-efficient technologies [27, p. 128].

As G.V. Zhuk begins, the production of biodiesel fuel is not recorded in statistical data in Ukraine, although the potential is estimated at 2 million tons/year, since the raw materials for biodiesel production are technical oil, as well as rapeseed

and soybeans, that is, crops that we grow and actively export. This volume, by the way, could replace 20% of the diesel imported by Ukraine [28, p. 23].

The Research Laboratory of Bioenergy of the Educational and Scientific Center of the National Academy of Sciences of Ukraine conducts research and practical implementation of best practices in biodiesel production, and provides consultations on the production and use of biofuels to educational and scientific research institutions of the region. It is advisable to modernize the existing laboratory by including equipment for processing oilseeds in the production cycle. Currently, specialists have developed and calculated a chain of processing oilseeds into meal and biodiesel for the own needs of farms [29].

The introduction of innovative technologies for biodiesel production, developed by the Vinnytsia National Agrarian University, opens up new prospects for agriculture. The creation of energy cooperatives and small processing enterprises based on these technologies will not only satisfy the needs of farmers in fuel, but also stimulate the development of rural areas. Thanks to close cooperation with scientists and equipment manufacturers, we will be able to create effective and cost-effective solutions for each farm.

According to the research of Kupchuk I.M., with the cost of rapeseed at 14,160 UAH/t (purchase price in agricultural enterprises), transportation costs at the level of 40 UAH/t km, the cost of processing will be 900 UAH/t. Total production costs will be 16,260 UAH with a planned biodiesel output of 450 kg, for the production of which an additional 2,050 UAH will be invested. The cost of selling by-products will be 5,900 UAH, with the cost of biodiesel being 33 UAH/kg or 28.44 UAH/l. (Fig. 3.1.) [30, p. 152].

Considering the prices of diesel fuel and its constant shortage on the market, the corresponding price is extremely competitive.

When producing biofuel from rapeseed, preference should be given to the "Perseus" hybrid, since its methyl ester has a higher calorific value by 9.11% higher than the similar indicator for the "Lagonda" hybrid, which ensures more efficient use of biofuel [30, p. 153].

To improve the properties of biofuel, it is possible to saturate it with hydrogen, since a larger number of hydrogen molecules in the compound gives a higher calorific value. To improve the properties of biofuel, various processing technologies can be used, for example, catalytic processing, hydrogenation, hydrogen reduction and others, which allow to increase the calorific value and reduce the content of harmful substances

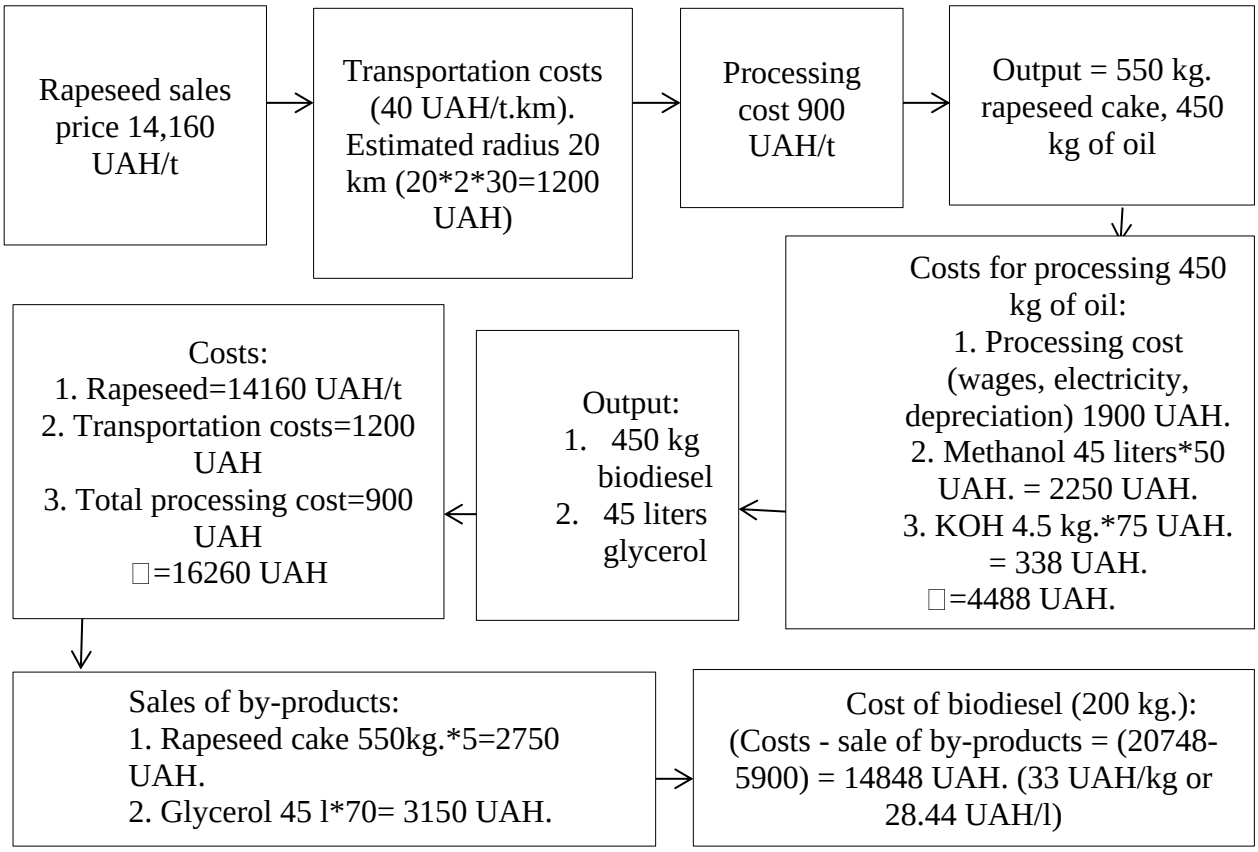

Fig. 3.1. Calculation of the economic feasibility of processing rapeseed into biodiesel

Source: [30, p. 152].

Potential producers of biodiesel can be 2,134 medium-sized agricultural enterprises and more than 89,000 small and micro-enterprises in the agricultural sector (Table 3.9). The use of diesel fuel in 2023 in Ukraine amounted to over 6.1 million tons, of which 1.77 million tons in the agricultural sector. Without changing the engine design, up to 10% of biodiesel fuel can be added to traditional petroleum diesel. Thus, the demand for biodiesel fuel in Ukraine is more than high, and there are no offers on the market (Fig. 3.1).

Having systematized the research of Kupchuk I.M. [47] and data from the State Statistics Service of Ukraine [24], it was found that the processing of rapeseed in the volume of exports of this crop in 2023 will make it possible to obtain over 1.2 million tons of biodiesel with a total cost of over 39.6 billion UAH. And by-products in the form of rapeseed cake in the amount of 1.47 million tons worth over 8.8 billion UAH. and technical glycerin - 120 thousand tons for 9.6 billion UAH. The total volume of possible production will be over 58 billion UAH. which is 20.2 billion UAH. more than the cost of rapeseed sales at 2022 prices.

Table 3.9

Number of operating agricultural enterprises with a division into large, medium, small and micro-enterprises in 2023

Total, units	large enterprises		medium-sized enterprises		small businesses		of which microenterprises	
	%	(%) of the total number of operating enterprises	%	(%) of the total number of operating enterprises	%	(%) of the total number of operating enterprises	%	(%) of the total number of operating enterprises
49452	36	0,1	2134	4,3	47282	95,6	42042	85,0

Source: compiled by the authors based on [31]

The potential volume of biodiesel production based on gas oil consumption in Ukraine will be over 1 million tons. In particular, in Vinnytsia region, over 120 thousand tons.

The planned indicators are quite attractive given the high prices for diesel fuel and seasonal price fluctuations and problems with exports due to martial law. In addition, when processing rapeseed as a by-product, agricultural formations will receive rapeseed cake, which will make it possible to partially provide livestock with concentrated feed. As well as technical glycerin, which is also in demand on the market among manufacturers of cosmetics and the pharmaceutical industry. The main producers of biodiesel should be agricultural enterprises and farms, which make up more than 70% of the total number of agricultural formations and have a need to replace traditional gas oils with biodiesel. A significant number of enterprises and their

geographical diversity will positively affect the development of biodiesel production even when launching production at 20-30% of the total number of enterprises.

It should be noted that the cost of selling rapeseed by agricultural enterprises is much lower than the export price, and the prospects for processing within the framework of production cooperatives into biodiesel and oilcake will make it possible to increase the state's GDP and ensure energy independence of agriculture, which is especially relevant in conditions of martial law.

The main non-market competitive advantage of biodiesel production is the ability to provide energy, environmental and social effects. Indirect competitors for potential biodiesel producers may be gas stations, but according to calculations, products manufactured at the expense of designed production facilities will have a price advantage.

According to Furman I. V., improving investment and innovation activities in the agricultural sector requires improving the existing mechanisms for attracting investments [32, p. 46]. Research by Tokarchuk D. M. shows that Ukraine has sufficient land areas to guarantee energy security when using agricultural raw materials for biofuel production without threatening food security [33, p. 171].

Based on the analysis, the bioenergy potential of agrobiomass of the agricultural and industrial complex of Ukraine was determined and it was concluded that its use will make it possible to obtain 3.444 billion m3 of biogas (waste from livestock, the processing industry of the agricultural and industrial complex and sugar beet tops), 1.2 million tons of biodiesel, 10.4 million tons of bioethanol, 1.59 billion tons of solid biofuels from post-harvest residues. (Table 3.10).

Therefore, the main directions of development of biodiesel production as a direction of ensuring food security of the state should be:

- introduction of a system of incentives for agricultural producers focused on compensation of 40% of the cost of equipment purchased from Ukrainian producers for the production of biodiesel;

- establishment of quotas for the export of rapeseed and rapeseed oil at the level of 30-40% of the total harvest;

- development of public-private partnership between scientific institutions and private investors aimed at developing progressive technologies for growing rapeseed and producing biodiesel;

- development of methanol production at alcohol plants in order to ensure biodiesel production.

Table 3.10

Potential for biofuel production from major crop products

	Production volume, thousand tons	Crop area, thousand hectares	By-product output (straw, tops)		Planned volume of transfer for biofuel	Biofuel yield from 1 ton	Potential volume of biofuels			
			t/ha	Total, thousand tons			Solid biofuels, thousand	Biodiesel,	Bioethanol, thousand	Biogas, million
Grain and legume crops	53863,1	12171	25	1346577,5	20000	0,4	1346577	-	8000	-
Winter rapeseed and colza	3317,8	1186	3	9953,4	2670,8	0,45	9953,4	1201	-	-
Sunflower	11328,4	5293	21	237896,4	-		237896,4	-	-	-
Factory sugar beet	9941,6	184	35	347956	4000	0,6/0,45			2400	208,7
Total	X						1594427	1201	10400	208,7

Source: systematized on the basis of [33-67]

The implementation of the relevant directions will make it possible to significantly increase the energy independence of the state economy and give impetus to the development of related industries focused on ensuring the relevant production.

As a result of the implementation of the proposed measures in the medium term, the following effects are possible for the energy security of Ukraine:

- increase the state's GDP through the processing of rapeseed into biodiesel;

- create additional jobs in rural areas;

- provide the livestock industry with concentrated feed (rapeseed cake);

- increase the capacity of alcohol plants through the production of methanol (a component for the production of biodiesel);

- reduce the cost of growing major crops through the use of cheaper biodiesel fuel;

- partially satisfy the needs of related industries in alternative fuel in the form of biodiesel;

- provide industry with technical glycerin.

- Assessing the efficiency of biodiesel production is a complex process that includes the analysis of various indicators, ranging from economic to environmental. The main methodological approaches to such an assessment are given below:

1. Economic efficiency:

Calculation of production costs: Determination of all costs associated with the production of biodiesel, including raw materials, energy, labor, depreciation of equipment, etc.

Profitability analysis: Comparison of the income received from the sale of biodiesel with the costs of its production.

Calculation of the break-even point: Determination of the volume of production at which the income covers all costs.

Assessment of investment attractiveness: Calculation of indicators such as net present value (NPV), internal rate of return (IRR), etc.

2. Environmental efficiency:

Life cycle analysis: Assessment of the environmental impact at all stages of production, from raw material extraction to waste disposal.

Calculation of greenhouse gas emissions: Comparison of greenhouse gas emissions from the combustion of biodiesel with emissions from the combustion of traditional fuels.

Water Impact Assessment: Analysis of water use in production and the impact of wastewater on the environment. Biodiversity Impact Assessment: Analysis of the impact of biodiesel production on natural ecosystems.

3. Energy efficiency:

Calculation of energy balance: Determination of the ratio of energy obtained from biodiesel to the energy spent on its production.

Assessment of the efficiency of conversion of raw materials into biodiesel.

4. Social efficiency:

Employment impact analysis: Estimation of the number of jobs created and their quality.

Assessment of the impact on local communities: Analysis of the social consequences of the development of biodiesel production.

5. Technological efficiency:

Analysis of the efficiency of technological processes: Estimation of equipment productivity, energy consumption, use of raw materials.

Assessment of equipment reliability: Analysis of the frequency of equipment failure and the cost of its repair.

Assessment methods:

Expert assessments: Used to assess qualitative indicators, such as social impact.

Mathematical modeling: Used to predict and optimize production processes.

Statistical analysis: Used to process large amounts of data and identify patterns.

Balance methods: Used to analyze material and energy flows.

Life cycle analysis (LCA): Allows you to assess the full impact of a product on the environment throughout its entire life cycle.

It is important to note that the choice of assessment methods depends on the specific objectives of the study and the available information.

For a more detailed analysis of the efficiency of biodiesel production, it is recommended to use an integrated approach that includes the use of different assessment methods.

Estimating the efficiency of biodiesel production is a complex process that involves the use of various indicators and formulas. Accurate calculations require reliable data on costs, production volumes, energy consumption, etc. The assessment of the efficiency of biodiesel production should be comprehensive and include both economic and environmental, social and technological aspects. Efficiency indicators can change over time under the influence of various factors, so regular monitoring is necessary.

Biodiesel production has not only economic and environmental consequences, but also significant social impacts. Let's take a closer look:

Positive social impact:

Job creation: The development of biodiesel production creates new jobs in agriculture (oilseed cultivation), processing industry and related sectors (logistics, transport).

Support for local communities: Investments in biodiesel production can stimulate the development of infrastructure in rural areas, increase tax revenues to local budgets and improve the quality of life of the local population.

Reduction of import dependence: The expansion of biodiesel production reduces the country's dependence on oil imports, which contributes to energy security.

Promotion of agricultural development: Biodiesel production stimulates the development of agriculture, contributing to an increase in oilseed production and increasing farmers' incomes. Improvement of the environmental situation: The use of biodiesel helps reduce air and water pollution, which has a positive impact on people's health. Innovative development: The development of biodiesel production stimulates the development of new technologies and innovations in energy.

Evaluating the efficiency of biodiesel production is a multifaceted task that requires an integrated approach.

Biodiesel production has significant potential for solving social problems, but at the same time it can lead to negative consequences. In order to maximize the positive social impact, it is necessary to develop and implement comprehensive measures aimed at ensuring balanced development. The proposed assessment model is universal and can be adapted to the specific conditions of biodiesel production. Its use will allow to obtain a more complete and objective picture of the efficiency of production and to identify areas for its further improvement.

Thus, we have presented theoretical and methodological generalizations and a new solution to the scientific problem of organizing the management of biodiesel production to ensure energy security and made the following conclusions.

Energy security, being one of the most important components of economic

security, is able to ensure the sustainable development of the Ukrainian economy. The main directions for solving this problem are: reducing energy dependence, diversifying sources of supply, increasing energy efficiency and ensuring social stability. The national energy sector must be transformed from a subsidized and problematic sector to an economically profitable, competitive and flexible sector of the economy, and new opportunities for searching and implementing innovative developments in the field of extraction, processing, production, transformation, supply and consumption of fuel and energy resources must be realized.

Regulatory and legal support for biodiesel production in Ukraine creates favorable conditions for the development of this industry. However, for further development, it is necessary to solve a number of existing problems and improve the regulatory framework.

Biodiesel production has significant potential for solving social problems, but at the same time it can lead to negative consequences. In order to maximize the positive social impact, it is necessary to develop and implement comprehensive measures aimed at ensuring balanced development. The proposed assessment model is universal and can be adapted to the specific conditions of biodiesel production. Its use will allow to obtain a more complete and objective picture of production efficiency and identify areas for its further improvement.

The possibility of processing rapeseed in the export volume in 2023 of this agricultural crop will ensure the receipt of more than 1.31 million tons of biodiesel with a total cost of more than 39.61 billion UAH. In addition, by-products will be produced, which include rapeseed cake in the volume of 1.47 million tons with a cost of more than 8.81 billion UAH, and technical glycerin in the amount of 120 thousand tons worth 9.61 billion UAH. In total, the cost of manufactured products will be over UAH 58.12 billion, which exceeds the cost of selling rapeseed at 2023 prices by UAH 20.28 billion.

The prospects for the development of biodiesel production are as follows:

State support: development and implementation of state programs to support biodiesel production.

Creation of clusters: joining the efforts of scientists, manufacturers, processors

and state bodies to jointly solve the problems of the industry.

Introduction of new technologies: application of modern technologies that allow reducing the cost of biodiesel production.

Expansion of the raw material base: activation of research to expand the raw material base for biodiesel production.

Thus, biodiesel production in Ukraine has significant potential for development and can become an important element of the country's energy strategy. However, to achieve success, it is necessary to solve a number of problems related to the economy, technology and state policy.

Effective management of the development of biodiesel production in Ukraine requires a comprehensive approach, including legal regulation, financial incentives, support for research and development, infrastructure development, quality and safety control, information support and international cooperation. The implementation of these measures will ensure sustainable development of the industry and contribute to achieving energy independence of Ukraine.

To achieve an increase in biodiesel production, it is necessary to focus on the following key aspects:

– expanding the raw material base through the use of agricultural waste and new types of vegetable oils;

– introducing modern technologies to increase production efficiency and reduce costs;

– creating a favorable investment climate by providing financial support, simplifying administrative procedures and ensuring stable policies;

– strengthening environmental control to minimize negative environmental impact;

– developing infrastructure to ensure effective logistics and sales of biodiesel;

– cooperating with international organizations to exchange experience and attract investment.

A systematic approach to improving the management mechanism, based on

clearly defined goals and specific measures, will allow Ukraine to become a leader in biodiesel production and ensure energy independence.

The main directions of developing biodiesel production as a direction for ensuring the state's food security should be:

– the introduction of a system of incentives for agricultural producers focused on compensating 40% of the cost of equipment purchased from Ukrainian producers for the production of biodiesel;

– the establishment of quotas for the export of rapeseed and rapeseed oil at the level of 30-40% of the total harvest;

– the development of public-private partnerships between scientific institutions and private investors aimed at developing advanced technologies for growing rapeseed and producing biodiesel;

– the development of methanol production at alcohol plants in order to ensure biodiesel production.

We have developed proposals in the field of improving state incentive mechanisms, namely:

Financial incentives:

Direct subsidies: providing state subsidies for the construction and modernization of biogas plants, the purchase of equipment and technologies.

Tax benefits: reducing taxes on the profits of enterprises investing in biofuel production.

Loan guarantees: state guarantees for banks that provide loans for the implementation of biofuel production projects.

Preferential lending: providing loans at a reduced interest rate for enterprises that implement waste-free technologies.

Administrative measures:

Simplification of procedures: simplifying the procedures for obtaining permits and licenses for the construction and operation of biogas plants.

Development of standards: development and implementation of national standards for biofuels and biogas plants.

Creation of information resources: development and support of information resources that provide enterprises with access to up-to-date information on technologies, markets and financial instruments.

Creating a favorable legislative environment:

Legislative support: development and improvement of legislation that stimulates the development of bioenergy and the implementation of waste-free technologies.

Biofuel market regulation: creation of an effective mechanism for regulating the biofuel market that ensures stable prices and sales of products.

Support for scientific research:

Financing of scientific research: financing of scientific research aimed at developing new biofuel production technologies and increasing their efficiency.

Cooperation with scientific institutions: cooperation with scientific institutions to transfer technologies to enterprises.

Energy efficiency programs:

Development of cogeneration: stimulation of cogeneration, i.e. simultaneous production of electricity and heat based on biogas.

Support for energy audits: financial support for conducting energy audits at enterprises to identify potential for energy saving and use of biofuels.

Public-private partnership mechanisms

Concessions: transfer by the state of enterprises or infrastructure facilities for the production of biofuels into a concession.

Joint ventures: creation of joint ventures with the participation of the state and the private sector.

Public-private partnerships: implementation of investment projects with the participation of the state and the private sector on the basis of long-term contracts.

Expected results: increase in biofuel production, reduction of greenhouse gas emissions, improvement of the environmental situation, creation of new jobs, increase in the country's energy independence.

Implementation of the above mechanisms will stimulate the development of bioenergy in Ukraine, promote the introduction of waste-free technologies and ensure

the achievement of sustainable development goals (Table 3.11).

Table 3.11

Mechanisms of state support for PPPs in the field of biofuel production based on waste-free technologies

Mechanism	Description	Goal
Financial incentives	Subsidies, tax breaks, loan guarantees	Increase investment, reduce risks for investors
Administrative support	Simplification of procedures, granting of permits	Rapid implementation of projects
Legislative support	Development of special laws and regulations	Creating a favorable investment climate
Information support	Providing information on investment opportunities	Attracting investors

Source: own research

Existing mechanisms for state stimulation of PPPs in the bioenergy sector, although they have positive aspects, do not always ensure sufficient efficiency. Among the main problems are:

Insufficient funding: The volumes of state subsidies and credit guarantees are often insufficient for the implementation of large-scale projects.

Complicated procedures for obtaining permits: Bureaucratic barriers complicate the process of introducing new technologies.

Lack of long-term strategy: There is not always a clear strategy for the development of bioenergy for the long term.

Insufficient awareness of entrepreneurs: Many entrepreneurs do not have sufficient information about the possibilities and advantages of implementing waste-free technologies.

We have developed proposals for improving these mechanisms:

1. Expanding the range of financial instruments:

Introducing tax credits: providing enterprises with the opportunity to deduct the costs of implementing waste-free technologies from the amount of income tax.

Creation of investment funds: creation of special funds for investing in biofuel production projects.

Guaranteeing bank loans for international projects: attracting international

financial institutions to finance projects.

2. Simplifying administrative procedures:

"Single window" for investors: creating a single center for providing administrative services for investors in the bioenergy sector.

Process automation: implementing electronic document flow and automating permit procedures.

Reducing the number of required permits: optimizing the list of permits required for project implementation.

3. Developing a long-term strategy for bioenergy development:

Identifying priority areas: identifying priority areas for bioenergy development, taking into account the potential of the regions.

Creating a roadmap: developing a detailed roadmap for implementing the strategy, including specific measures and deadlines.

4. Raising awareness:

Conducting information campaigns: organizing seminars, conferences, and exhibitions to inform entrepreneurs about the possibilities of implementing waste-free technologies.

Creation of an online platform: development of an online platform that will contain information on available financial instruments, technologies and regulatory framework.

5. Support for scientific research:

Financing of scientific projects: allocating funds to research in the field of bioenergy, in particular to the development of new technologies and materials.

Cooperation with scientific institutions: creation of joint laboratories and research centers.

6. Creation of a favorable investment climate:

Stable tax policy: ensuring the stability of tax legislation in the long term.

Investment protection: ensuring the protection of investments from illegal actions.

Transparency of procedures: Ensuring transparency of tendering and contracting

procedures (Table 3.12).

Table 3.12

Comparison of existing and proposed mechanisms

Aspect	Existing mechanisms	Proposed mechanisms
Funding	Subsidies, credit guarantees	Tax credits, investment funds, international financing
Administrative procedures	Permits, licenses	Single window, automation, reduction of permits
Strategic planning	Lack of a clear strategy	Long-term strategy with a roadmap
Information	Insufficient awareness	Information campaigns, online platform
Scientific research	Limited funding	Support for scientific projects, cooperation with scientific institutions
Investment climate	Instability, opacity	Stable tax policy, investment protection, transparency of procedures

Source: own research

The implementation of the proposed measures will allow creating more favorable conditions for the development of bioenergy in Ukraine, attracting additional investments and accelerating the transition to a "green" economy, and improving mechanisms for state stimulation of the implementation of public-private partnerships for the implementation of waste-free technologies for the production of biofuels at agricultural and processing enterprises in Vinnytsia region and Ukraine.

CONCLUSIONS

The paper presents theoretical and methodological generalizations and a new solution to the scientific task of organizing the management of biofuel production on the basis of public-private partnership with the use of waste-free technologies and draws the following conclusions.

1. Public-private partnership is a promising tool for the development of bioenergy, but its successful implementation requires careful planning, a transparent management mechanism and effective control.

2. The choice of an instrument for attracting investment in biofuel production on the basis of public-private partnership depends on the specific conditions of the project, the goals of the investor and the state. Each instrument has its own advantages and disadvantages:

– public-private partnership is advisable to use for financing large infrastructure projects that require significant investments and long-term commitments;

– foreign direct investment is an effective tool for attracting capital for the development of production, technological renewal and the creation of new jobs;

– public investment is advisable to use for financing projects that are of important social or strategic importance for the state.

3. Evaluating the efficiency of biofuel production on the basis of public-private partnership is a complex task that requires an integrated approach. The choice of specific methods and indicators depends on the project objectives, its scale and other factors. Regular assessment of efficiency allows you to identify problems, make necessary adjustments and ensure the long-term stability of the project.

4. As a result of the study, the following can be outlined:

- processing of rapeseed in the export volume into biodiesel will make it possible to fully provide the agro-industrial sector with the necessary gas oils and partially - other sectors of the economy;

- production of solid biofuels from post-harvest residues of grain and industrial crops will make it possible to reduce the import of energy carriers to ensure hot heating

and water supply of households;

- processing 35-40% of the volume of grain crops harvested into bioethanol will make it possible to completely abandon the import of gasoline and partially direct this type of biofuel for export;

- the use of biogas production technologies in Ukraine is promising for solving the problems of processing agricultural waste, ensuring the ecological safety of the state, increasing soil fertility through the use of digestate and increasing the level of energy security of rural areas;

- the main raw materials for biogas production should be waste from agriculture, agricultural processing enterprises and post-harvest residues (straw, tops, etc.).

5. The bioeconomic sector of Ukraine employs a total of 1.32 million workers (about 17% of the employed), while more than 66% of people

employed in the bioeconomy work in the agricultural sector and in the production of food products

6. For the successful development of public-private partnership in the field of biofuel production using waste-free technologies in Ukraine, it is necessary to:

– create a favorable investment climate;

– develop a clear and transparent legislative framework;

– ensure effective management of public funds;

– increase the level of trust between the state and business;

– involve international experts and investors in cooperation.

It should be noted that the absence of large-scale PPP projects in this area does not mean the absence of potential. Ukraine has significant resources for the development of bioenergy, and PPP can become an effective tool for achieving this goal.

7. An analysis of existing incentive mechanisms indicates the need for their improvement. Green tariffs, although an important incentive, require further development and expansion of the circle of their beneficiaries. Tax breaks and credit lines can also be more effective if their tariff policy is clear. For the successful development of biofuel production on the basis of public-private partnership, it is

necessary to:

– create a favorable investment environment: simplify permit procedures, ensure the stability of legislation and “green tariffs”;

– increase financial support: expand financing programs, create special funds for innovative projects;

– involve local communities: develop mechanisms for involving local communities in the implementation of bioenergy projects;

– develop infrastructure: invest in the construction and modernization of infrastructure for the collection, transportation and processing of biomass;

– cooperate with international partners: attract foreign investments and technologies.

The key elements of the successful implementation of public-private partnerships in the field of bioenergy are:

A clear development strategy: defining priority areas, goals and objectives; effective coordination of actions: creating a single coordination body; transparency and accountability: ensuring openness of decision-making processes; monitoring and evaluation: regular assessment of the effectiveness of implemented measures.

8. The development of biofuel production in Ukraine is a strategically important task that contributes to energy independence, reducing greenhouse gas emissions and improving the environmental situation. Public-private partnerships are an effective tool for attracting investments and new technologies to this sector. An analysis of existing incentive mechanisms indicates the need for their improvement. Green tariffs, although an important incentive, require further development and expansion of the circle of their beneficiaries. Tax breaks and credit lines can also be more effective if they are accompanied by a clear tariff policy of the state.

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