Economic aspects of energy efficient and environmentally safe directions for the development of rural areas

Collective monograph

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The monograph summarizes energy and environmental aspects of biofuel production from waste in the context of rural development; institutional aspects of the formation of a "green economy" in the agricultural sector are considered; attention is paid to energy auditing as a form of implementing the state policy on energy saving and energy efficiency.

The monograph includes the results obtained in the implementation of the state scientific work "Development of the concept of ensuring energy security and energy efficiency as priority areas for sustainable development of rural areas" (0121U109443), 2021-2022.

For researchers, agriculture specialists, ecologists, economists, entrepreneurs, teachers, students, graduate students.

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INTRODUCTION

Organization of rational nature management, energy conservation with minimal negative impact on the environment, the use of energy resources for reasonable and sufficient technological and household needs in all forms and forms are promising components of the development of modern society and rural areas in terms of sustainable development.

Sustainable rural development and ecology are closely linked, as evidenced by European researches. Thus, in December 2015, the EU Commission paved the way for a resource-saving society and a sustainable economy in Europe. In addition to developing an Action plan, it was suggested that key waste legislation be reviewed in order to reduce the generation and reuse and recycling of more waste in the future. Sustainable rural development is based on efficient agriculture and the introduction of energy efficient technologies.

In the context European integration and orientation to European standards of Ukraine, a comprehensive approach to rural development based on the latest concept of environmentally friendly and energy efficient development requires further research.

The scientific work is focused on achieving a comprehensive effect in ensuring sustainable agro-industrial production while ensuring the necessary levels of food and bioenergy security of the state.

The monograp touches on several related fields of science, including economic, agricultural, social, environmental protection, environmental management and will further contribute to the development of relevant fields of knowledge. The tasks of the work are aimed at solving acute problems of today, in particular economic, environmental and energy efficient.

The monograph was made in the framework of the state scientific work “Development of the concept of ensuring energy security and energy efficiency as priority areas for sustainable development of rural areas” (2021-2022).

1. ENERGY AND ENVIRONMENTAL ASPECTS OF BIOFUEL PRODUCTION FROM WASTE IN THE CONTEXT OF RURAL DEVELOPMENT

1.1. Energy efficiency and energy security of the state, rural areas and enterprises and the importance of bioenergy in energy supply[1]

Energy is a special sphere of the economy due to its technological specifics, which is determined by the physical complexity of the production processes, distribution and consumption of energy resources, the specifics of building the industry (high capital and material consumption of energy facilities, long construction and operation periods), close relationships with other industries, and also a high degree of dependence of mining, processing, production and transport processes on the level of their energy supply.

At the beginning of the XXI century, a modern vision of the energy mission was formed in the world, which is to make the most efficient use of natural fuel and energy resources and the potential of the energy sector to grow the world economy and improve the quality of life. As a result, a new energy strategy was formed in the leading countries, the main criteria of which are energy efficiency; sustainability, intelligent energy systems built according to the concept of Smart Grid; decentralization of energy; renewable energy sources.

The problem of guaranteeing Ukraine's energy security has become relevant due to the gradual depletion of basic fuel and energy resources, which, in turn, has led to escalating geopolitical conflicts in attempts to strengthen control over the extraction, distribution and transportation of fuel and energy resources. Therefore, the development of bioenergy is an important component for strengthening Ukraine's energy independence, which will contribute to the effective use of the country's potential to achieve economic, social and environmental effects.

The level of the energy sector development of any country has a decisive influence on the state of its economy, the rate of economic growth, the state of the environment, the solution of social problems and the standard of living of people. Therefore, the foundations of energy security and independence are always associated with the national

[1] Pryshliak N.V.

security of the state. Hence, the definition of energy security is important.

Energy security is a component of economic security. This is the purposeful influence of the management entity on threats and dangers, the creation of state and non-state institutions necessary and sufficient conditions to prevent deficits in providing consumers with economically available fuel and energy resources of acceptable quality in normal and emergency conditions, consistent and active energy conservation and diversification. Interpretation of the term "energy security" is given in Table 1.1.

Table 1.1

Interpretation of the definition "energy security"

Source	Definition
1	**2**
Kavalko M.P.	"Energy security" is one of the most important components of economic security, manifested, firstly, as the state of providing the state with fuel and energy resources, which guarantee its full life, and, secondly, as the state of security of the energy complex and the ability of the energy sector to ensure normal functioning of the economy, energy independence of the country.
Shidlovsky A.K., Vipanasenko S.I., Vorokhov L.P.	"Energy security" is the process of providing the state with fuel and energy resources, which guarantee its full life; the state of security of the energy complex and the ability of the energy sector to ensure the normal functioning of the economy, energy independence of the countries.
Mikitenko V.V.	"Energy security system of the country" is a combination of economic, political, technical-technological, resource and, in fact, energy, as well as scientific, geographical, organizational, managerial factors, etc., without which the analysis of any security is impossible.
Denchev K.	Economic security for importing countries is, first of all, ensuring the reliability of their energy supply, diversification of energy supply sources, ensuring the security of energy infrastructure, introduction of new technologies to reduce dependence on energy imports. For exporting countries, it is consolidating in strategic markets at cost-effective prices, providing capital and financing infrastructure investments and resource development.
Pryshliak N.	"Energy security" – the provision of energy in the energy sector in the required quantities at an affordable price, which allows to meet the needs of fuel and energy resources to ensure the livelihood of the population and the national economy.

continuation of table 1.1

1	2
World Energy Council	Energy security is the confidence that energy will be available and in the quantity and quality required by economic conditions.
International Energy Agency	Energy security – continuous physical availability at a price that is acceptable in terms of environmental compliance.
United Nations	"Energy security" is the continuous availability of energy in various forms, in sufficient quantities and at affordable prices.
Energy Strategy of Ukraine for the period up to 2030	Energy security is an integral part of economic and national security, a necessary condition for the existence and development of the state. In the modern sense, guaranteeing energy security is achieving a state of technically reliable, stable, cost-effective and environmentally friendly provision of energy resources of the economy and social sphere of the country, as well as creating conditions for the formation and implementation of policies to protect national interests in energy.
Methods for calculating the level of economic security of Ukraine	Energy security is a state of the economy that protects national interests in the energy sector from existing and potential threats of internal and external nature, allows to meet the real needs of energy resources to ensure the livelihood and reliable functioning of the national economy in normal, emergency and martial law.

Source: formed by the authors on the basis of the studied literature (Pryshliak et al, 2020; Kovalko et al, 2009; Shidlovsky et al, 2001; United Nations Organization; International Energy Agency)

Thus, energy security is a complex concept and can be considered as the provision of energy in the energy sector in the required quantities at an affordable price, which allows to meet the needs of fuel and energy resources to ensure the livelihood of the population and the national economy. Energy security affects not only on the energy system, but on the entire national economy.

Until recently, in the context of state economic policy in Ukraine, special attention was focused on the concept of "energy saving". At the same time, the world's leading countries are focusing on a more global approach, namely "energy efficiency", which includes the components of environmental friendliness and competitiveness. Interpretation of the concept of "energy efficiency" and its derivatives are given in Table 1.2.

Table 1.2

Generalization of approaches to the definition of the term "energy efficiency" and its derivatives in official documents

Official document	Interpretation
1	**2**
Law of Ukraine "On Energy Conservation" (№ 74/94-VR of July 1, 1994)	Energy saving – activities (organizational, scientific, practical, informational), which are aimed at the rational use and economical use of primary and transformed energy and natural energy resources in the national economy and which is implemented using technical, economic and legal methods.
Law of Ukraine "On Energy Conservation" (№ 74/94-VR of July 1, 1994)	Energy efficient products, technology, equipment – products or methods, means of its production, which ensure the rational use of fuel and energy resources compared to other options for the use or production of products of the same consumer level or with similar technical and economic indicators.
Law of Ukraine "On Energy Conservation" (№ 74/94-VR of July 1, 1994)	Energy saving (energy efficient) measures – measures aimed at the introduction and production of energy efficient products, technologies and equipment.
Strategy on energy efficiency and energy saving at enterprises, institutions and organizations belonging to the sphere of management of the State Agency of Ukraine for Exclusion Zone Management for 2018-2020	Energy efficiency is a stable energy supply of facilities, efficient (rational) use of energy resources, the use of less energy to ensure the same level of energy supply of buildings and structures or technological processes in production. Energy efficiency is a criterion for the quality of functioning of the economic model of the state.
European Commission (Communication on an Energy Efficiency Action Plan)	Energy efficiency – reduction of energy consumption without reducing the use of energy by production and equipment, i.e. it means the rational use of energy resources and alternative energy sources and reducing the overall energy demand in certain areas.
Federal Ministry of the Environment, Nature Conservation, Construction and Safety of Germany's Nuclear Reactors	Energy efficiency is a means of measuring the energy expenditure required to achieve a certain benefit. The lower the energy loss to achieve a specific goal, the higher the degree of energy efficiency.
Institute of Environmental and Energy Research	Energy efficiency means using less energy to perform the same task – that is, eliminating excess energy use.

continuation of table 1.2

1	2
United States (Department of Energy)	Energy efficiency cannot be expressed as a single indicator, so there are many approaches to its definition or interpretation as a concept: energy efficiency – the required level of energy consumption to achieve a certain level of well-being (eg, economic, social, living standards, environment and etc.); energy efficiency is an indicator that is inverse to energy intensity, it is a complex system of indicators, the interpretation of which depends on the system for which it is calculated, it is important to monitor the dynamics of these indicators and ensure their dynamic improvement through cost-effective mechanisms (technological renewal and use of resource-saving technologies).

Source: formed by the authors on the basis of the studied legislation

Energy needs are determined by three main factors: population growth, economic development of society and the scientific and technical level of production of technological processes. Of course, these needs in the world are growing from year to year and in 2020 they exceeded 10 billion tons of oil equivalent.

Along with coal, oil and natural gas are the main energy resources of the world economy. Stable functioning of hydrocarbon markets, ensuring their uninterrupted supply to consumers is a matter of national security.

The relationship between consumers and energy producers is such an important factor in the modern world that fluctuations in oil prices are quite capable of causing political unrest in a country.

Along with the increase in the world's population, energy production and, consequently, energy production are constantly growing. In the last 100 years alone, the Earth's population has almost quadrupled, and annual energy production has increased 21 times. Today, on average, one inhabitant of the planet Earth has 2.5 tons of conventional fuel energy resources. According to preliminary forecasts, by 2100 the population will grow to 10 billion, and the average specific energy per capita – up to 10 tons of conventional fuel in total energy production will reach 100 billion tons of conventional fuel (almost all fossil fuels, especially oil and gas, can be exhausted).

Current challenges, such as the threat of global warming, the depletion of fossil fuels and others, are forcing countries around the world to significantly change the structure of the energy sector. Currently, there are two main trends – the replacement of traditional energy sources with renewable energy sources and the reduction of overall energy consumption through the introduction of energy efficient technologies and measures. More and more countries are developing and implementing plans and strategies for significant, within 50-100%, coverage of their energy needs through renewable energy sources.

Solar radiation annually brings to our planet $0.7 \cdot 10^{18}$ kWh of energy, which is equivalent to 84 trillion tons of conventional fuel, or $3 \cdot 10^{24}$ J. Incoming solar energy is transformed into thermal energy of land and ocean, energy of currents, waves, wind, chemical, geothermal and biological energy, and after all kinds of transformations it is radiated back into space mainly in the form of low-temperature infrared radiation.

Considering estimates and projections of human impact on global climate processes, the researchers were able to persuade the governments of the 186 countries that participated in the 1992 Congress in Rio de Janeiro to take urgent coordinated action to reduce emissions. Further targeted research and ongoing processes in the world have led to an even greater understanding of the need for consistent implementation of both domestic and interstate measures to reduce the anthropogenic impact on the atmosphere.

With the growth of industrial production in the world, the amount of greenhouse gas emissions into the atmosphere has increased, which, in turn, has led to global climate change. To prevent this, the Kyoto Protocol was adopted in 1997, which was joined (as of November 2009) by 192 countries responsible for 64% of the world's greenhouse gas emissions.

Undeniable conclusions have been obtained that the global power generation sector is responsible for a third of the emitted gases. Earlier it was predicted that by 2010 the OECD countries set the level of emissions by the Kyoto Protocol, the annual contribution of developing countries could reach 3.5 – 4.1%, and by 2020 almost 30% of the level of global CO_2 emissions.

Today, renewable energy sources provide about 19% of final energy

consumption in the world, including traditional biomass – 9%, modern renewable energy sources – more than 10% (heat and electricity production, transport sector). In general, biomass (traditional and modern) covers about 14% of final energy consumption.

The term “traditional biomass” means the direct use of biomass for cooking and heating in developing countries. The term “modern renewable energy sources / biomass” refers to the use of renewable energy sources and biomass in modern energy production technologies.

Oil, natural gas and coal are the main energy resources of the world economy. Stable functioning of the markets for these fuels, ensuring their uninterrupted supply to consumers is a matter of national security.

The relationship between consumers and producers of oil and its derivatives is such an important factor in the modern world that fluctuations in oil prices are quite capable of causing political unrest in a country (Britchenko, Momot, 2012).

In 2020, the contribution of renewable energy sources to total electricity production in the world was almost 24%, with a significant share accounted for by hydropower – 16.6%. Of other RES, the largest share in wind energy is 3.1%, followed by biomass – 1.8%.

The largest producers of “green” electricity are 7 countries, whose total capacity is 71.5% of the world (470 GW, excluding hydropower): China, USA, Germany, Italy, Spain, Japan, India.

Prospects for the development of energy on a global scale are summarized by the International Institute for Applied Systems Analysis in conjunction with the World Energy Council. Based on the research results, the trends that will be inherent in energy in the XXI century are identified (Fig. 1.1).

Ukraine annually consumes about 200 million tons of conventional fuel and energy resources and is one of the energy-deficient countries, as it covers its energy needs by about 53% and imports 75% of the required volume of natural gas and 85% of crude oil and petroleum products. Such a structure of fuel and energy resources is economically impractical, creates the dependence of Ukraine’s economy on oil and gas exporting countries and is a threat to its energy and national security (Lysiuk et al, 2020).

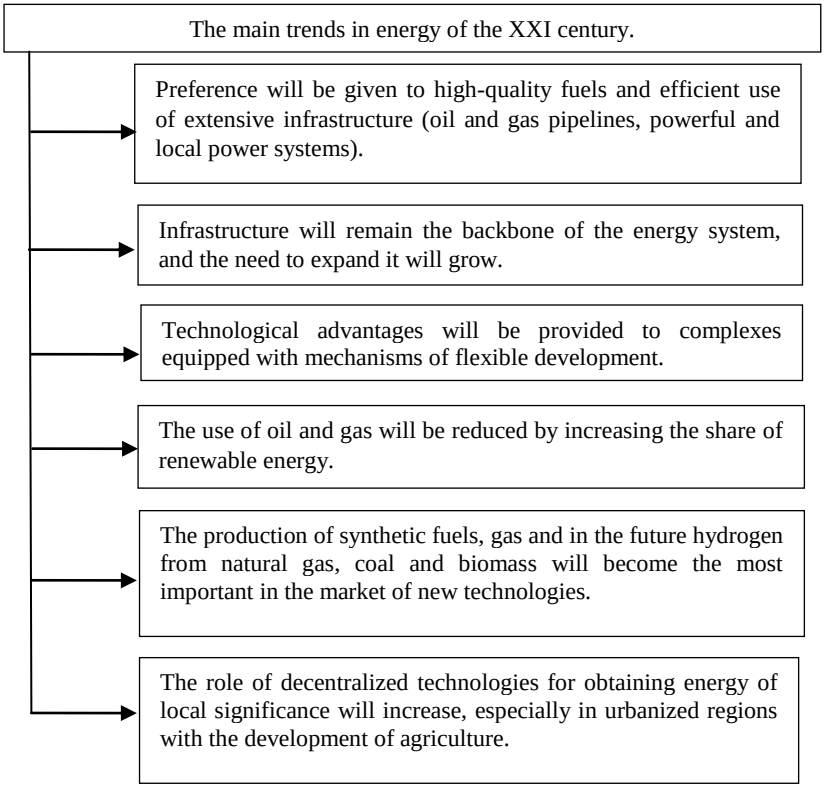

Fig. 1.1. **The main trends in energy of the XXI century**
Source: formed by the authors on the basis of the studied literature

The advantage of using bioenergy potential is that there is an opportunity to increase the gross production of environmentally friendly products while reducing energy costs, as bioenergy potential is renewable. Renewable energy sources account for about 14% of world primary energy consumption, of which incineration and biomass waste account for 11%, hydropower – 2.3%, wind energy – l0.026%, solar energy – 0.039%, geothermal energy – 0.442%. Coal (36%), natural gas (30%), nuclear energy (21%) and oil fuels (10%) account for the largest share in the structure of Ukraine's energy supply.

Limited own energy resources, dependence on importers of fossil fuels and constantly rising prices necessitate an immediate transition to the use of alternative fuels, the raw material potential for the

production of which is available in our country. If earlier Ukraine had to solve only the problem of high cost of imported natural gas, now the possibility and conditions of its import are in question. Difficulties also began with the supply of coal.

In the context of the global economic crisis, the issue of finding alternative energy sources, especially those that can be constantly renewed, becomes especially relevant. Ukraine has a great potential of alternative and renewable energy, currently one of the main directions of effective functioning of the agricultural sector, increasing the competitiveness of rural enterprises is the greening of agricultural production through the introduction of new agri-environmental technologies, compliance with technological and environmental requirements and management standards.

At the same time, the main sign of a strong economy of the world is the optimal provision of its needs with fuel and energy resources. Analysis of statistical data of the State Committee of Ukraine for Energy Conservation has shown that our country annually consumes about 200 million tons of fuel and belongs to the energy-deficient countries. In turn, Ukraine covers almost half of its energy consumption needs through imports, while its value increases annually in price.

Therefore, the most appropriate way to solve this problem is the use of renewable energy sources, biomass as an energy source, as well as the production of biofuels, which are alternatives to oil and natural gas, which include bioethanol, biogas and biodiesel.

In turn, energy security is an important component of national security of any country, as it affects the phenomena and processes not only of the energy system but also of the national economy as a whole, including for Ukraine, the issue of energy security remains the focus of many economists and researchers.

The problem of ensuring Ukraine's energy security has become very relevant due to the gradual depletion of basic fuel and energy resources, which, in turn, has exacerbated geopolitical conflicts in attempts to seize, control the extraction, distribution and transportation of fuel and energy resources. Therefore, to ensure Ukraine's energy independence, a necessary task is the development of bioenergy, which will allow using the country's potential to achieve economic, social and environmental effects.

The concept of economic security reflects the level of protection

of the interests of enterprises, the state and society due to the availability of sufficient resources to meet basic and additional needs. At the same time, the components of economic security are: investment, innovation, financial, energy, foreign trade, demographic, etc. Since the driving force of progress is energy resources, energy security is given an important place in the system of economic security (Pchelyanska and Pryshliak, 2019).

In turn, energy security is a complex concept that covers several levels, namely political, which characterizes the energy independence of a state or region; technogenic, which reflects the damage to human health and life, the environment, the ability to work, property, etc; economic – pricing policy and strategic reserves of energy resources, as well as the social level, which is the availability of energy consumption for the population.

In particular, energy security is defined as the protection of citizens and the state as a whole from the threat of shortages of all types of energy and energy resources arising from the impact of negative natural, managerial, socio-economic, domestic and foreign policy factors. It should be noted that energy security is one of the most important and main components of national security, because it affects the processes not only of the energy system, but the entire national economy. It is defined as the state of providing the state with fuel and energy resources that guarantee its full viability, as well as the ability to ensure the efficient functioning of the economy and energy independence of the country. It is the lack of fossil energy resources that determines the production and use of bioenergy, the modernization of which is a vector of development of the agricultural sector.

The problem of energy efficiency in agriculture is considered from two positions: technological re-equipment, which will reduce fuel consumption, and own production of fuel resources in agriculture, which will reduce the dependence of agricultural enterprises on external sources of fuel and energy resources and rising prices for them. to allow deterioration of an ecological situation. Therefore, the use of renewable energy sources will reduce the negative impact of burning new fuels on the environment, as evidenced by the policies of many countries that have focused on increasing the share of renewable energy and creating a highly

efficient, reliable, diversified energy system (Solod, 2013).

It should be noted that the basic strategic guideline of greening of agricultural natural production capital is the transition of enterprises and organizations to the mode of economic development based on modernization of production potential, introduction of advanced industrial technologies of agricultural production, creating conditions for increasing profitability of agricultural industries environment and dynamic social development of rural areas. After all, agriculture itself is the source and transformer of environmentally friendly energy of photosynthesis in forms available for use in the national economy.

In terms of coordination of diverse interests, it is necessary to take into account a number of strategic elements:

- increase in energy production for the purpose of import substitution;
- creation of strategic reserves of coal, nuclear fuel, oil and gas;
- diversification of energy supply sources;
- development of alternative energy;
- ensuring the autonomous operation of the integrated power system of Ukraine.

The analysis showed that Ukraine expects rapid development of energy crops. In 2015-2020, the volume of production may reach the volume of straw harvesting and exceed it after 2020. It is planned to cultivate energy crops on non-agricultural lands, such as river valleys, reclaimed areas of solid waste landfills, quarries, etc. It is expected that the cultivation of the most available plant resources for energy biomass production will be commercialized by 2020. The processing of organic waste into biogas, from which heat and electricity are produced, is projected to increase (Prospects for the development of renewable energy in Ukraine until 2030. REMAP – 2030).

In turn, experts say that in a political crisis, the most sensitive for Ukraine is the energy sector, where in the most severe scenarios such actions of the Russian Federation are possible, namely the refusal to supply natural gas due to gas debts or non-fulfillment of contractual obligations; refusal to supply oil and oil products by the countries of the Customs Union; refusal to supply and store spent nuclear fuel for nuclear power plants and the parallel operation of the Unified Energy System. Since the location of Ukraine's power grids was designed in the system of cooperation of the Soviet Union, it does not allow to efficiently distribute the generated electricity.

Consider the system of threats to energy security, which is shown

in Fig. 1.2.

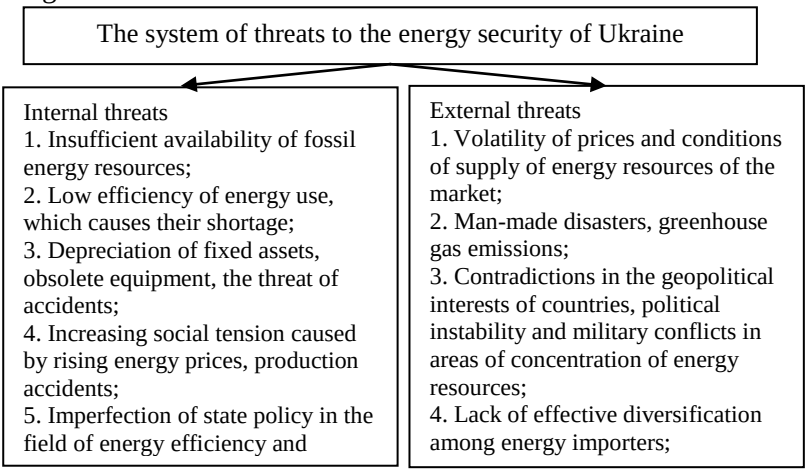

Fig. 1.2. **Scheme of threats to Ukraine's energy security**
Source: systematized by authors based on Kirieieva et al, 2019

This set of threats to Ukraine's energy security makes it possible to study the real state of development of the country's energy sector and at the same time to structure the concept of energy security. These problems are the limiting factors for the effective development of bioenergy and require modern scientific intervention and their solution to achieve a positive result.

At present, it should be taken into account that the state policy of Ukraine in the field of energy is characterized by inconsistency of economic and political interests at different levels of government. Only a balanced approach to solving problematic aspects of domestic energy development can produce the effectiveness of reforms aimed at the development of alternative energy sources in Ukraine.

At the same time, the development of bioenergy is a promising and important factor for strengthening energy security and reducing the negative man-made impact on the environment for Ukraine. At the same time, the concept of bioenergy development and the use of alternative and renewable energy sources (wind and solar energy, biofuels) concerns the rational use of our natural renewable and non-renewable resources.

Effective development of bioenergy will promote rural development and sustainable development, in order to ensure long-term competitiveness of agriculture and forestry, food and chemical

industries (Vazov, 2019). The development of bioenergy and its use can solve such global problems as food shortages associated with mineral depletion, environmental pollution, etc.

A necessary stage of our study is the analysis of the influence of driving forces on the development of bioenergy, which is shown in Fig. 1.3.

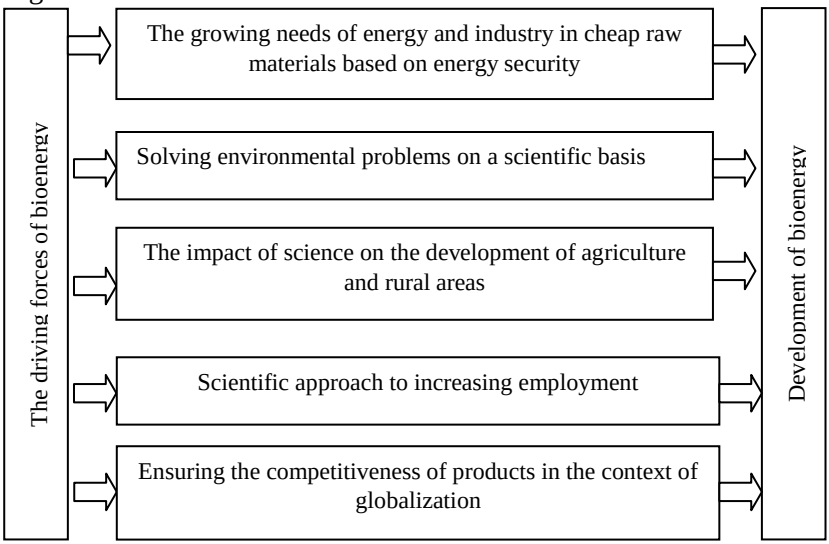

Fig. 1.3. **Scheme for ensuring the development of bioenergy**
Source: systematized by the authors

Along with the transition to the use of biofuels, it is necessary to ensure the economic interest of refineries in the production of blended gasolines. The next steps will be:

- introduce mandatory use of biofuels and blended gasoline by certain categories of consumers (by developing appropriate standards and technical regulations);
- establish a mandatory indicative quota for the consumption of bioethanol by gasoline producers (following the example of EU Directives);
- provide appropriate budget funding for research;
- to introduce a set of measures to increase yields, the introduction of resource-saving technologies for growing raw materials and their sale to domestic processors, rather than export.

Therefore, the organization and adjustment of biofuel production

will significantly improve the energy balance, reduce the country's dependence on imported energy, optimize the structure of energy resources, which will positively affect the energy security of the state.

It should be noted that the country's development goals should correlate with the sustainable development goals for 2016-2030, adopted at the end of 2015 in the framework of the 70th session of the UN General Assembly at the Summit. According to the results of the Summit, according to the official press release, it was stated that the society in Ukraine is ready to participate in the development of a long-term strategic document that would define the new goals of sustainable development. The goals of sustainable development, in turn, in Ukraine will be a new system of mutually agreed management measures in economic, social and ecological (environmental) dimensions, aimed at the formation of social relations on the basis of principles.

For the practical spread of the concept of transition to the use of renewable energy sources in the agricultural sector of the economy, it is necessary to justify the need to take measures at the state level to support the development of bioenergy in agricultural enterprises. At the same time, in order to prevent damage to the environment before the construction of plants producing alternative energy, it is necessary to establish at the legislative level a mechanism for mandatory state examination to analyze the interaction of renewable energy sources with the environment.

In particular, among the tools of targeted stimulation of bioenergy development at the level of agricultural enterprises are the following: introduction of preferential lending for the purchase of equipment for enterprises that implement technologies for the use of biomass for energy purposes; allocation of funds from state funding for scientific and technical development and research in the field of bioenergy, stimulating the processing of biomass into biogas and biofuels; harmonization of tariff policy; surcharges from the local budget for the use of biomass waste from crop and livestock products for energy needs.

Agriculture has a huge potential for alternative energy sources: grain, oilseeds, straw, sugar beets, manure and more. At the expense of these reserves it is possible not only to satisfy own needs, but also to diversify vectors of formation of energy security of the state.

Therefore, the next step in the study will be the consideration of the main criteria for the efficient use of biological resources for energy supply of agricultural enterprises. In turn, if we take into account that agricultural facilities will be energy independent, then in total the result will be achieved, which will ensure the energy security of the country. Given the efficiency criteria, which are considered as a comprehensive system of interconnected elements – economic, environmental, energy, innovation, information, social, political – generalized methods for assessing the energy potential of bioresources, biomass, agricultural waste, which provides a basis for justifying their use for energy production, which will provide a significant replacement of energy obtained from traditional sources (Fig. 1.4).

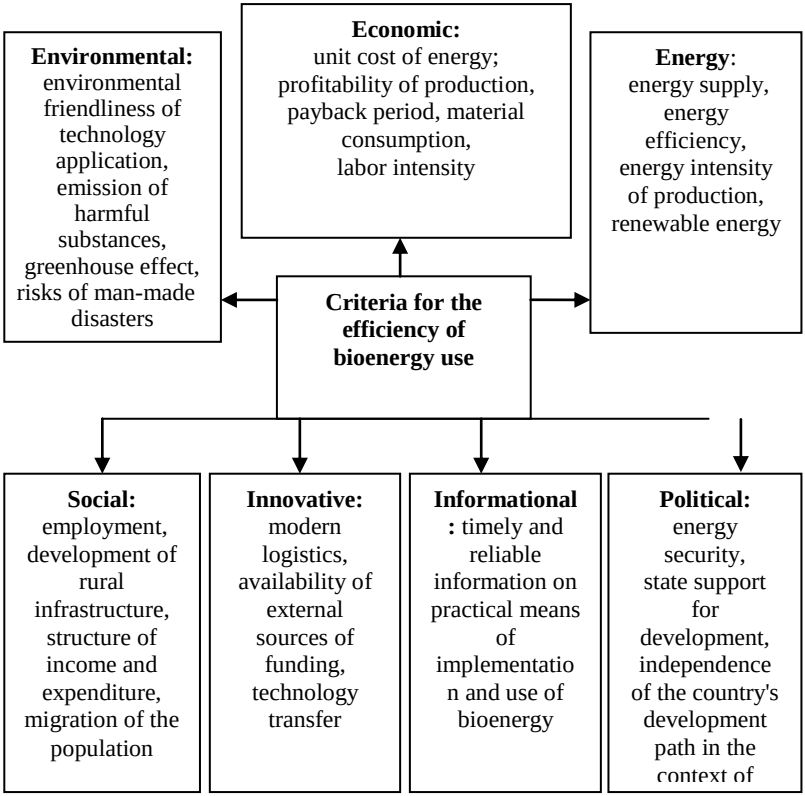

Fig. 1.4. **Criteria for the effectiveness of the use of bioenergy to achieve energy security of Ukraine**

Source: developed by the authors

The use of renewable energy sources in Ukraine tends to grow, which is a positive development, because the country will be able to provide itself with energy and not depend on the importing countries. The analysis showed that the production of electrical and thermal energy due to solar radiation can increase from 0.04% in 2001 to 7.7% in 2030, according to wind energy will be 0.2% and 25.4%, biomass energy – 17.87% and 26.3%. If this trend continues in the future, experts predict that bioresources will be able to provide 50% of the world's primary energy consumption by 2040. Unlike other energy sources, biomass is a versatile source that can be used to generate electricity and heat, as well as to obtain biofuels for transportation.

Having studied this issue, we can say that the development of bioenergy at the present stage of the maturing energy crisis is a very relevant, innovative and strategic benchmark for achieving energy, food and environmental security of Ukraine. An important task today is to take into account significant threats to the development of Ukraine's energy security, namely, the lack of effective structural reforms in the energy sector, a high-quality and efficient energy management system; lack of effective control over the activities of natural monopolies; high level of negative impact of energy facilities on the environment; ineffective system of subsidies for housing and communal services does not stimulate the population to carry out energy-saving and energy-efficient measures; high prices for energy resources and low incomes of the population etc. (Matviychuk, 2018).

Given that the current state of domestic energy security is unsatisfactory, it is the development of energy-saving technologies and non-traditional energy sources will have a positive effect, which will be expressed in improving environmental performance, reducing destructive impact on the environment, reducing emissions, supporting agricultural production by creating new jobs.

Therefore, it is necessary to pursue an appropriate energy policy, improve the regulatory framework and attract investment. In particular, the world community improves and develops bioenergy based on the development and implementation of innovative, science-intensive technologies of liquid and gaseous biofuels. In order to reduce Ukraine's dependence on science-intensive technologies of foreign countries, it is advisable to conduct its own fundamental, comprehensive research to create the latest resource- and energy-saving technologies for processing biomass into bioenergy.

1.2. Modern energy efficient technologies in agriculture[2]

Sustainable development of the energy sector has always been and remains a guarantee of prosperity of Ukraine's economy and one of the main components of its economic growth. The most important guarantees of constant, sustainable, proportional development of the state are the solution of such problems as energy intensity of production and energy supply of the economy. The effectiveness and success of the state's energy efficiency policy depends on scientifically convincing economic analysis, optimization and forecasting of the energy balance.

The total processes of integration of the country's economy and energy into world and European structures greatly increase the requirements for ensuring its energy security and energy independence. Thus, the factor of energy independence as the country's ability to independently form and implement policies independent of external and internal interference and pressure, acquires extraordinary importance as one of the main elements of energy, economic and national security, economic and political independence. The problem of achieving energy independence is one of the main tasks of energy policy for Ukraine and for many countries around the world. The development and optimal functioning of the fuel and energy complex of the state is one of the main factors in ensuring the efficient functioning of the economy and meeting the social needs of the population.

The solution of national problems in agriculture of Ukraine is possible on the basis of wide introduction of the newest economic mechanisms and models of energy saving. The importance of economic mechanisms and models of energy saving, as well as models of their adaptation as a means of accelerating the innovative development of world agriculture and agro-industrial complex of Ukraine, is enhanced by the fact that energy and resource-saving technologies cover virtually all sectors and subsectors of agricultural sectors (Talavyria, Holub, 2018).

At the present stage in the agricultural production of Ukraine more and more attention is paid to the development and

[2] Tokarchuk D.M.

implementation of independent economic mechanisms, models, energy saving structures, as well as energy saving technologies (Serskykh, Britchenko, 2019).

An extremely important direction is to motivate new models of adaptation of the world experience of energy saving in the agricultural sector of Ukraine's economy, in particular, through international technology transfer. Acceleration of the development of innovation processes in the agro-industrial complex of Ukraine is hindered by such factors as focus on outdated mechanisms (models) of energy saving, imperfect infrastructure of the agricultural market, small scale and low efficiency of world practice of high technology.

The main disadvantage of the existing economic mechanisms of energy saving in world and domestic agricultural production is the lack of a comprehensive approach to energy saving. These problems need to be addressed through the operation of interconnected energy saving methods and models for key sectors of agriculture. In fact, as a rule, these problems are solved separately from each other by specialists from different departments, and therefore do not agree with each other either in time or in economic space, which leads not only to large-scale overspending of energy, electricity and heat, but also intensifies crises.

The unresolved issues do not only worsen the quantitative and qualitative indicators of agricultural products, the main indicators of energy saving, but also pose a threat to the economic, environmental and energy security of the world and Ukraine. Therefore, it is extremely important to form the latest economic mechanism of energy saving, which is based on a comprehensive analysis of current trends in world agriculture, comparison of economic efficiency of existing agricultural technologies, optimization of energy saving in agricultural production, transfer of new methods of energy saving (Britchenko, Bezpartochnyi, 2020).

Agricultural production can be efficient only with the best (optimal) consumption of all existing types of energy. Any excess in energy consumption leads to an increase in the cost of agricultural products and reduce the profits of its producers. At the same time, too much energy restriction is also economically unprofitable, as it causes a deterioration in the quality of agricultural products or a decrease in its production.

Since the object of service in the agricultural sector are living organisms, the development and functioning of which are governed by biological laws, it is necessary to take into account these features of agricultural technology (compared to industrial technology) – and, above all, the presence of technological and biological optimums in crop production do not match. This situation makes us seek and find compromise economic and technological solutions. Therefore, the practical implementation of the economic mechanism for energy conservation in the agricultural sector is also associated with compromise solutions. On the one hand, it is desirable to maximize the savings of all types of energy, and on the other hand, ensuring normal conditions for the functioning of the photosynthetic apparatus of plants (in particular, in protected ground structures) requires considerable energy consumption.

Ukraine is ahead of the United States, China, and all developed European countries in terms of energy intensity of GDP (State Statistic Service of Ukraine, 2021). This situation is a consequence of the fact that the structure of the economy is dominated by energy-intensive industries; the technologies used are outdated and contribute to the economical use of resources, including and energy. As our country depends on gas and oil imports, the high level of energy intensity becomes a factor limiting the competitiveness of domestic products in international markets. In addition to economic and environmental benefits, increasing energy efficiency is a lever for strengthening national energy security, which is important for Ukraine's accession to the energy markets of Europe and the world.

Considering the importance of energy efficiency, Ukraine has adopted a number of regulations governing this area. In particular, the main one is the Law of Ukraine "On Energy Conservation", which defines the legal, economic, social and environmental bases of energy saving for all enterprises, associations and organizations located in Ukraine, as well as for citizens.

By the Resolution of the Cabinet of Ministers of Ukraine of November 26, 2014 it was decided to establish the State Agency for Energy Efficiency and Energy Saving of Ukraine, whose main objectives are: implementation of state policy in the field of efficient use of fuel and energy resources, energy saving, renewable energy sources and alternative fuels; ensuring an increase in the share of renewable

energy sources and alternative fuels in the energy balance of Ukraine; provision of administrative services in the relevant field, etc.

On August 18, 2017, the Cabinet of Ministers of Ukraine approved the Energy Strategy of Ukraine for the period up to 2035 "Security, Energy Efficiency, Competitiveness", which replaced the "Energy Strategy of Ukraine until 2030" due to imperfections and insufficient justification of the latter. The new Energy Strategy of Ukraine contains updated forecast indicators that determine the direction of energy development in our country, as well as other related industries. The strategy states that "the availability of resources in Ukraine, the creation of a competitive market environment and conditions for the systematic development of the resource base for nuclear energy, modernization of generating capacity and replacement of raw materials with alternative fuels, further exploration and production of hydrocarbons, including unconventional, as well as more efficient use of potential in the field of renewable energy will contribute to the gradual strengthening of Ukraine's position in the rational production of energy and its economical consumption".

By joining the Treaty on the Establishment of the Energy Community and becoming its member, our state has undertaken to comply with certain benchmarks in the energy sector, develop an appropriate regulatory framework, promote the liberalization of the energy market, the development of energy efficient technologies and energy conservation.

Energy saving is the newest direction in technological development, as well as an absolute necessity at the current energy prices and environmental requirements, is constantly increasing. In the structure of operating costs of a typical commercial building, energy costs are about 30%, and in some agricultural enterprises the share of energy in the cost of the product can reach 60%. So, an unmistakably developed set of energy saving measures can significantly reduce costs and optimize the budget.

At the same time, the effective and operative development of the agro-industrial complex of Ukraine requires constant introduction and re-equipment of new technologies to increase the production of value-added products. Today, the world is implementing the practice of acquiring modern science in digital technologies, breeding, agricultural machinery, smart farming – something that should become the basis of

technological tools of Ukraine as one of the leaders in the world agricultural market.

Only on the basis of wide introduction of the newest economic mechanisms and models of energy saving it is possible to solve national problems in agriculture of Ukraine.

In our opinion, it is rational to widely use and implement with a detailed analysis of the relevant economic and energy chains of economic modeling and forecasting of macroeconomic indicators of energy saving in world agriculture and agro-industrial complex of Ukraine, as well as development and introduction of new modern energy balances.

Significant savings of electricity, heat and energy are influenced by such factors as: ensuring a high level of automation and robotization of technological processes; multipurpose use of agricultural machines and mechanisms; unification of the corresponding technological equipment; clear interaction of a significant number of technologies, systems and equipment; Ensuring for each agricultural sector, for each technological process the optimal combination of energy constraints, energy consumption and energy efficiency are the main requirements for modern economic mechanisms of energy saving. Also extremely important for economic theory and practice is the problem of forming a new structure of the economic mechanism of energy saving in world agriculture – taking into account modern requirements for adaptation of world experience of energy saving in the agricultural sector of the world and Ukraine.

According to Korol, 2012 the method of systematic analysis of economic mechanisms of energy saving (EME) for the world and domestic agricultural spheres is based on three interrelated factors, namely:

1) factor limiting energy consumption (OE factor);

2) energy efficiency factor (EE factor);

3) energy saving factor (final E-factor).

In general, improving the energy efficiency of agricultural production involves the following:

- analysis of the results of patent search in the field of energy saving for key sectors of agriculture (especially for the crop sector);

- analysis and generalization of requirements to the current technological processes of the agricultural sector;

- separation of common and distinctive features (for industrial and agricultural energy-saving technologies);

- analysis of integrated energy saving indicators;

- analysis of the results of rapid diagnostics of world agricultural technologies and energy-saving structures;

- comprehensive analysis of the main energy factors and determining on their basis the effectiveness of the new economic mechanism of energy saving;

- substantiation of key elements of the economic mechanism of energy saving.

Today's energy-efficient technology in crop production is a set of agricultural techniques and methods of growing crops, technological means and operations, which are aimed at maximizing the biological potential of crop productivity based on the optimal use of appropriate and profitable resources (Miklovda et al, 2013).

One of the most important and most difficult strategic landmarks of the agricultural sector of Ukraine is the production of competitive environmentally friendly agricultural products. When growing crops, it is important to use such advanced agro-technological methods of energy-saving and resource-saving technologies that would reduce labor and material resources, high-quality soil fertility, increase crop yields and reduce production costs.

The main areas of implementation of these technologies are the biologization of technological processes in crop production, which involves: compliance with scientifically sound crop rotations using the best predecessors and high-yielding varieties and hybrids of crops; use of an effective fertilizer system with an emphasis on organic fertilizers, advanced tillage technologies, crop care, plant protection.

Despite the real achievements in the development of the agricultural sector of the economy, many issues in Ukraine are still to be resolved. Agriculture tries to integrate highly ideological and progressive scientific and technical developments and acclimatize them into its own production. The development and introduction into production of modern technologies for the production of crop products and energy-efficient farming systems is evidence of this.

Table 1.3 outlines the analysis of problems and prospects for the use of the above technologies in the field of crop production.

Thus, as can be seen from Table 1.3, in the field of crop

production, energy-efficient solutions are associated with space information technology, the use of modern technology and renewable energy sources.

Table 1.3

The latest technical and technological solutions in crop production that contribute to energy conservation

Perspectives	Problems
Energy saving equipment	
- technical performance of several operations in one pass, which significantly reduces the use of fuel resources; - reduction of terms of carrying out spring and autumn field works.	- the lack of the necessary amount of own funds to equip with modern machines and tools; - lack of highly qualified machine operators who can work on modern equipment.
Drip irrigation	
- saving of irrigation water, electricity, fertilizers; - reduction of soil erosion; - the possibility of developing unsuitable lands for cultivation; - reduction of operating costs; - carrying out agro-technical works together with watering, which reduces energy consumption.	- spontaneous nature of land reclamation; - low level of government support; - lack of a targeted scientific and technical program for micro-irrigation; - significant cost of irrigation construction; - lack and ineffective renewal of the irrigation equipment park.
Satellite technologies in agriculture	
- determination of accurate sown areas; - forecasting crop productivity; - the possibility of identifying land hidden from accounting, and the number of hidden products.	- significant need for financial investment; - requires a large amount of research and development; - the need for intellectual potential; - the need for highly qualified personnel, scientists.
Use of renewable energy sources	
- refusal to purchase energy resources and fuel on the basis of traditional energy sources, which increase annually in price; - energy efficient use of crop waste (straw, stems, baskets, tops, garden pruning etc)	- unstable demand for bioenergy products; - high investments; - low level of “green” tariff for electricity from biomass; -lack of an effective state program for the development of this area.

Source: formed by the authors on the basis of (Amons, 2017, Petrov, 2013) and own research

The experience of progressive agricultural enterprises argues that the introduction of resource and energy-saving technologies in the

agro-industrial complex of Ukraine guarantees the emergence of qualitative and quantitative changes in the economic activity of economic entities, increase their economic efficiency and significantly reduce competitiveness. It is also necessary to understand that the application of these agricultural technologies is impossible without scientifically sound systems of measures that provide for the maximum amount of agricultural products at minimum cost per quintal. Mechanical tillage is the most energy-intensive and labor-intensive in agriculture. According to scientists, it accounts for an average of 40% of energy and 25% of labor costs of the total field work. Minimizing the cost of energy and other resources in the cultivation of crops is currently a rather pressing and urgent problem.

Energy-efficient technologies for growing crop products require a clear sequence of agro-technological measures, taking into account the characteristics of crops, as well as a certain set of appropriate machines and tools. Zero and minimum technologies are 1.8-1.5 times higher than the efficiency of intensive technologies and 1.6-1.3 times higher than energy-saving ones (Table 1.4).

Table 1.4

Features of innovative energy and resource-saving technologies of agriculture

Technology	Advantages of introduction	Difficulties and caveats of implementation
1	**2**	**3**
"Mini-till" ("Low-till")	- Resource and energy saving efficiency of technology; - Reduces the dependence of yield on rainfall and air temperature; - Reduces the need for herbicides; - Reduces production costs; - Allows to reduce the number of agricultural techniques; - Increases soil fertility over time to 45% over 5-7 years; - Increase in productivity.	- Requires financial costs for the renewal of the machine-tractor fleet; - Insufficiently effective for counteracting soil erosion processes; - The need for consideration features and properties soil (density, humus content, mobile forms of nutrients); - There is resistance of weeds to herbicides; - There is compaction and acidification of the soil.
"No-till" ("Zero-till")	- The number of technological operations and terms of performance of mechanized works decreases;	- There is a need to purchase modern high-performance equipment;

continuation of table 1.4

1	2	3
	- There is a decrease in anthropogenic pressure on the soil; - Requires fewer units of machinery and equipment; - Promotes the accumulation of organic matter in the soil; - Resource savings (reduced costs for fuels and lubricants, seeds, fertilizers and plant protection products, reduced labor costs, depreciation); - Improves agrophysical properties of soil, provides high efficiency in the fight against water and wind erosion and other factors of its degradation; - Increases productivity at observance of all requirements of technology; - Ensures the preservation of soil fauna, accumulation of moisture in the soil; - Dependence on the influence of climatic conditions decreases.	- Decreased soil heating, which forces to change the timing of crops; - In the first years, yields may decrease; - Deteriorating phytosanitary condition of crops; - Possible reduction of field germination, which requires increasing the seeding rate by 15-25%; - The need for nitrogen increases; - Requires constant use of herbicides in higher doses; - Possible development of weed resistance to herbicides; - Deterioration of phosphorus nutrition of plants; - Inefficiency of organic fertilizer; - Requires highly qualified agronomic and technical staff.
"Strip-till"	- Accelerates the process of heating the soil in the treated strips; - It is possible to carry out root feeding; - Application of both mineral and liquid forms of fertilizers at different depths in two layers; - Resists wind and water erosion; - Reducing the number of agricultural techniques; - Reduces the need for herbicides and fertilizers; - Contributes to the retention of moisture in the soil and increase infiltration during precipitation; - Ensures the development of a strong root system of plants; - Increasing soil fertility and yield; - Reduction of production costs.	- Requires the purchase of specialized equipment; - Inefficiency in fields with difficult landscape conditions; - Possible deviations in the width of the rows, which causes the need to install an automatic or parallel control system; - Requires the use of modern based technologies satellite communications; - Requires highly qualified agronomic and technical staff.

Source: (Goncharenko, 2017)

In the field of crop production, the technology based on the integrated use of the latest research in agricultural science should be based on the following components: the use of energy-saving tillage techniques; use of high-performance equipment; introduction of advanced forms of production organization, replacement of traditional expensive energy resources with renewable own production.

Advanced technologies in the field of animal husbandry, which contribute to energy saving, are the introduction of biotechnology, modern technical and technological support, energy and resource-saving technologies. The general characteristic of problems and advantages of these technologies is given in Table 1.5.

Table 1.5

The latest technical and technological solutions in animal husbandry that contribute to energy saving

Perspectives	Problems
1	2
Modern technical and technological support of the industry	
- organization of convenient conditions for keeping and servicing animals; - facilitation of working conditions; - reducing the cost of production per unit of output; - creating a proper microclimate of farms; - increase animal productivity and improve the quality of animal products; - significant resource savings.	- significant cost of equipment and facilities; - the need to import new technological means of keeping, feeding and caring for animals; - low quality of domestic equipment and the need to improve the characteristics of metals and polymers used for the production of equipment.
Energy and resource saving technologies	
- reduction of costs and costs; - specialization of operations of growing and keeping animals: - creating a proper microclimate; - increasing the reproductive capacity of livestock; - effective organization of recreation and exercise of animals; - rational planning of the system of cleaning, transportation and utilization of manure (manure).	- the need for state support; - the need for organizational and economic support of intensive technologies; - a significant amount of investment in the re-equipment of livestock complexes and poultry farms; - introduction of automation and computerization of production processes; - use of robotics and electronic technologies: - training and retraining of personnel employed in the field of animal husbandry.

continuation of table 1.5

1	2
Biofuel (biogas) production	
- the possibility of converting animal manure and bird droppings from a source of environmental problems into highly efficient bioenergy products; - complete or partial refusal to purchase natural gas, electricity and heat, mineral fertilizers by replacing them with products based on bioconversion technology.	- high cost of bioenergy equipment; - lack of experience in organizing biogas production; - the need for skilled workers in the field of organic production; - difficulty in obtaining permits for tax benefits; - low level of "green" tariff for electricity from biogas.

Source: formed by the authors according to (Krachok, 2013, Pryshliak et al, 2020, Skoruk, 2012)

The experience of the world leading shows that in today's conditions the introduction of modern scientific and technological developments related to solar energy, bioenergy, wind energy, development of world agricultural technologies and their technical support, etc. is of special importance for energy saving and energy efficiency. At the present stage, the share of renewable sources in the structure of energy production in the world is 14.0% (with the largest share continuing to remain for biofuels). At the same time, solar energy shows an average increase of 37.3% annually, wind energy (23.6%), and biogas (12.3%). The undisputed leaders in the use of such energy are the Scandinavian countries, where the share of alternative energy reaches 70%.

Ukraine has significant renewable energy resources potential and significant potential for energy efficiency (Kaletnik, Klymchuk, 2013). Unfortunately, this potential is currently used to a very limited extent (4.6% of the total primary energy supply).

Energy-efficient technology in the agro-industrial complex is the production of fuel of biological origin for tractors and cars: biodiesel and bioethanol. Biodiesel is made from oilseeds, mainly rape (Tokarchuk, 2015), and bioethanol – from cereals, sugar crops (first generation) and cellulosic materials (second generation). If we compare the cost of their production by agricultural enterprises from their own raw materials with the price of traditional diesel fuel and oil-based gasoline, we can see the obvious economic benefits of biofuels.

Of particular note are the technologies associated with the disposal of waste from the production of agricultural products (biomass) (Pryshliak, Tokarchuk, 2020). The total energy potential of wood processing waste (sawdust, wood chips, etc.) and agriculture (straw, stalks and cobs of corn, stalks, baskets and husks of sunflower, tops, animal manure and bird droppings, etc.) is about 27 million tons. use for growing energy crops such as willow, acacia, poplar, as well as rapeseed and corn half of the 5 million hectares of unused agricultural land in Ukraine, you can get another 15 million conventional fuel.

The use of wood biomass and other crop wastes is possible by direct incineration to obtain electricity and heat, for the production of solid biofuels (pellets and briquettes), as well as to obtain other energy products through pyrolysis technologies.

Livestock waste is processed into bioenergy products due to anaerobic fermentation technologies. This produces biogas, which due to the cogeneration unit can be converted into heat and electricity, meeting the needs of the enterprise in these types of energy resources (Tokarchuk et al, 2020).

A successful solution to the problem of energy efficiency in the agricultural sector is impossible without compromise solutions that take into account a number of unique requirements for global agricultural technologies and agricultural production in general. As these factors have a very significant impact on the energy efficiency of the agricultural sector, it is necessary (along with the usual macroeconomic indicators) to identify the following:

a) compromise indicators of energy saving;

b) compromise economic zones of energy saving;

c) the impact of energy constraints and energy efficiency on the final macroeconomic indicators of energy efficiency in the leading agricultural sectors of the world and Ukraine.

In Ukraine, there are a number of problems of energy saving in the agricultural sector (Britchenko, Britchenko, 2001).

First, the effectiveness of the implementation of scientific advances is not high enough, especially at the borders of agricultural, environmental, technical and other sciences. It is worth noting that even where the energy supply of agriculture has increased several times, the yield of grain and industrial crops has increased by only 5-10%.

Secondly, the latest world-class machinery and energy-saving technologies are designed for a high level of agricultural and livestock culture, which has not yet been achieved by all farms. Thus, it is obvious that the introduction of modern equipment and the latest technologies should be classified, taking into account local conditions, climatic zones and the specifics of agricultural production.

Third, energy-efficient technologies for the construction of livestock facilities, modern technologies for keeping animals based on the use of the latest equipment, modern energy-efficient agricultural machinery are expensive. Today, not every company can afford to implement them at their own expense, and lending to farmers is used quite limited due to lack of available cheap long-term loans.

The existing practice of simplification of technologies to the most necessary operations in many agricultural farms of Ukraine, abandonment of resource- and energy-saving technologies – all this has a very negative impact not only on energy saving and macroeconomic indicators of plant growing efficiency, reduction of their yield, but also depletion and degradation.

In the field of animal husbandry, a significant number of agricultural enterprises continue to use outdated technologies for keeping, servicing, feeding animals, which carry significant energy costs, which negatively affects the cost of production. To date, energy-efficient technologies for the conversion of manure and bird droppings into biofertilizers and biogas have been developed, from which it is possible to produce both electric and thermal energy, or both. Unfortunately, the use of bioconversion technology for livestock waste remains rare in Ukraine.

Measures to improve government regulation and encourage the transition to energy efficient technologies include:

- improving the image of Ukraine on the world stage to increase investment attractiveness, which will require accelerating reforms in various areas of the economy;
- development of an effective energy policy that will correlate with the European energy vector;
- liberalization of energy markets, diversification of energy sources;
- development of realistic programs in the field of energy

efficiency, taking into account the readiness of the state to achieve the planned indicators;

- conducting educational activities, raising awareness in the field of energy saving for both government officials and local authorities, the general public. At the state level, it is necessary to qualitatively and systematically inform agricultural producers about modern energy-saving technologies, implement pilot projects and continuously monitor the efficiency of energy resources.

In order to introduce modern energy efficient technologies in the production of crop products, among the technological developments should be mentioned the following:

- providing farms with a new generation of machine and tractor fleets;
- application of satellite systems of precision agriculture;
- energy and resource saving system of direct sowing;
- use of renewable energy sources (sun, wind, etc.);
- modern biotechnologies for fuel production;
- energy-saving technologies of plant irradiation and drip irrigation in protected soil structures;
- technologies related to the utilization of industrial and household waste and human health.

Modern energy efficient technologies in the production of livestock products include:

- the use of promising resource- and energy-saving technologies for construction of new and reconstruction of existing livestock complexes (farms, poultry farms, etc.);
- transition to the use of modern means of mechanization in keeping and feeding animals, optimal equipment;
- advanced technologies for maintaining the microclimate of livestock farms through the use of biological heat released by animals;
- complex processing of animal waste (by-products) – manure, bird droppings using bioconversion with biogas production.

Ukraine has a huge potential for the use of renewable energy sources, such as biofuels and waste, hydropower, wind and solar energy.

However, the lack of innovation and investment, the imperfection of the regulatory framework, the difficulties of establishing this type

of activity slow down their development.

The current stage of agro-industrial complex development requires assessment of resource efficiency, based on the use of various criteria and indicators that help characterize resource consumption in crop production, as well as outline practical steps to reduce energy consumption and rational use in a market economy.

Energy saving and energy efficiency are especially relevant for the overall increase in economic efficiency of the national economy, especially in the face of steady growth in world prices for major energy resources, as well as significant foreign economic energy dependence of our country on suppliers of these resources. Five features of the innovation process in the agricultural sector of the economy are identified on the basis of scientific research:

- a long process of innovation development;
- innovations are usually of an improving nature;
- research of living organisms;
- leading role of research institutions;
- dependence onnatural zone and climate (Yankovska, 2009).

Further development of energy, given the European choice of Ukraine, should be carried out on the basis of economical use of energy products in all sectors of the economy. The economically feasible energy saving potential of the country is determined at the level of 45% of the current consumption of fuel and energy resources.

Energy saving in the agro-industrial sector of the economy includes a set of measures aimed at: increasing soil fertility and crop yields; ensuring the rational use of energy resources by reducing their costs; improvement of organizational and economic mechanisms of energy consumption; application of energy-saving technologies and equipment, renewable and secondary energy resources (Domushchi, Ustuyanov, 2013).

Table 1.6 presents the current priorities of the economic mechanism of energy saving for the agricultural sector of Ukraine's economy.

At the state level, it is necessary to inform agricultural producers about modern energy-saving technologies, implement pilot projects and constantly monitor the efficiency of energy resources.

Table 1.6

Priorities of energy saving in the agricultural sector of Ukraine

№	International priorities (on the example of the European Union)	Proposed national priorities (in the context of adaptation of EU experience in the agricultural sector of Ukraine's economy)
1	Accelerated transformation of energy systems into new (more reliable and secure) systems.	Accelerated replacement of obsolete technological and electrical equipment and transformation of the energy system of the agro-industrial complex of Ukraine on the basis of energy-saving technologies of the 5th and 6th technological structure.
2	Formation of a highly efficient energy sphere focused on low-carbon energy.	Formation of a new economic mechanism of energy saving in the agro-industrial complex, focused on low-carbon energy.
3	Extension of the Energy Community Agreement for further integration of countries wishing to participate in EU energy market.	Formation of the newest agricultural markets focused on energy, resource and nature conservation.
4	Introduction of innovative financial instruments in the field of energy saving.	Formation of a new innovation and investment model to stimulate energy saving.
5	Introduction of energy efficiency certificates in the industry of EU countries.	Introduction of energy efficiency certificates in the agro-industrial complex of Ukraine.
6	Transition to energy consumption from renewable sources, construction of energy generating plants that run on renewable energy resources.	Wide introduction of energy-generating installations and systems working on renewable energy resources in the agro-industrial complex of Ukraine.
7	Increasing funding for energy saving, energy efficiency and renewable energy projects.	Ensuring financing of energy saving projects in the agro-industrial complex of Ukraine for the period up to 2030.
8	Further development of EU energy intensity limitation policy.	Ensuring scientifically sound levels of energy constraint and energy efficiency with the prospect of gradual transformation of agro-industrial complex from consumer to producer of energy resources.

Source: Amons, 2017.

The analysis of energy supply of the national economy showed that our state has all the prerequisites and necessary capabilities that allow it to be equal in the world movement in the use of renewable energy sources.

1.3. Use of agricultural waste and crop by-products for energy purposes[3]

Ukraine's agriculture accounts for about 17% of gross domestic product, so it can rightly be considered a strategically important industry. Prerequisites for its effective development are the presence of fertile soils (chernozems occupy 60% of the total land area) and favorable climatic conditions. However, the agricultural sector has not yet reached such a stage of development, when production is based on waste-free technologies.

Active development of agriculture, increasing the production of crop and livestock products to meet the needs of the population and industry lead to an increase in the generation of waste in the agricultural sector and an increase in the burden on the environment. Negative impact on land, air and water basins is exerted by such types of waste generated during the production of agricultural products as: crop waste of organic origin; livestock and poultry waste of organic origin; biological waste (animal and poultry carcasses); residual fertilizers, biological and chemical plant protection products, veterinary drugs.

The legal framework for waste management includes the following laws of Ukraine: "On Waste", "On Environmental Protection", "On Ensuring Sanitary and Epidemiological Welfare of the Population", "On Veterinary Medicine", "On Decommissioning, Processing, Disposal , Destruction or Further Use of Low-quality and Dangerous Products", etc.

The main legal document on waste management, including agricultural waste, is the Law of Ukraine "On Waste" (of 05.03.1998 №187 / 98-VR with changes in 2002, 2005, 2010, 2012 2014 and 2015). The general provisions of the law provide the main definitions and terms, outline the tasks of waste legislation and the scope of the law, list the main principles and directions of state policy in the field

[3] Kaletnik G.M., Tokarchuk D.M., Pryshliak N.V.

of waste management, some items on standardization and regulation.

The law regulates the relationship of ownership of waste, the activities of entities in the field of waste management, their rights and responsibilities; determines the competencies of executive authorities and local governments in the field of waste management; regulates the implementation of state monitoring, accounting and information in the field of waste management, measures and requirements for the prevention or reduction of their generation and economic support of measures for waste disposal and reduction of their generation; establishes liability for offenses in the field of waste management and outlines the framework of international cooperation in the field of waste management. The law covers issues related to the production, collection, sorting, transportation, processing (utilization), removal, disposal and disposal of industrial waste in Ukraine, including agricultural waste.

By ratifying the Association Agreement between Ukraine on the one hand, and the European Union, the European Atomic Energy Community and their Member States, on the other hand, our state undertook to gradually adapt Ukrainian legislation to European legislation in accordance with areas defined in the Agreement. Among them – cooperation in the field of environment, aimed at developing a green economy. Accordingly, the Ukrainian legislation was amended to the existing ones and new normative legal documents were adopted. In particular, on November 8, 2017, the Cabinet of Ministers of Ukraine approved "The National Strategy for Waste Management in Ukraine until 2030", which focuses on identifying problematic areas of waste management policy in Ukraine and defining the main European norms that should be implemented in Ukrainian legislation based on the experience of EU member states.

Also, in accordance with European norms, Ukraine introduces two important principles of waste management: "polluter pays" and extended responsibility of the product manufacturer to fully cover the costs for further treatment of waste generated during the production process. In the European Union, these principles underlie waste management, as they guarantee the protection of the environment from pollution by waste producers. Adherence to the principle of extended producer responsibility ensures an increase in

the life cycle of resources through their reuse and disposal without creating obstacles to the circulation of goods in the domestic market.

In order to create a single classification of waste, which will be used by 28 member states, the EU has created its own classifier – the European Waste Catalog. Agricultural waste in the EWC is included in section 2, subsection 02 01. Although Ukraine has partially adopted the EWC, the classification of agricultural waste in Ukraine is still not fully harmonized and needs to be clarified.

According to the state classification, wastes generated in the agricultural sector and related to industrial, belong to section A. "Wastes from raw materials, extractive and processing industries", group 01. "Wastes from agricultural production and hunting" This group includes the following categories:

- wastes from the production of cereals, vegetable and horticultural products;
- wastes from animal husbandry and livestock production;
- wastes of production of mixed management products;
- wastes from the provision of services in crop and livestock production;
- hunting waste, trapping, game breeding;
- services specialized in the management of hunting waste and agricultural production, which are provided at the place of waste generation.

Since 2015, the term "animal waste", which included such classification groups as dead animals, waste generated by the production of products from raw materials of animal origin, unfit for consumption by both humans and animals, and must be subject to disposal, except for metabolic products used for the production of biogas or organic fertilizers, ceased to be used. These categories received the status of animal by-products not suitable for human consumption, and management issues were formulated in a separate Law of Ukraine "On Animal By-products Not Intended for Human Consumption" (№ 287-VIII of 07.04.2015 as amended by 2016).

This Law defines the organizational and legal framework for individuals and legal entities that provide activities related to the production, transportation, collection, storage, utilization, processing and disposal of by-products of animal origin or processed by-products of animal origin which are not intended for human

consumption. The Law prescribes certain categories of products (based on the magnitude of risks to human and animal health), management methods for each of these categories, the rights and obligations of market operators, requirements for waste management facilities, as well as responsibilities, which will be borne by those guilty of violating these requirements.

The European and world trend today is the increase the energy use of waste. It involves the incineration of waste for energy purposes and may include both the incineration of biomass itself and the incineration of solid biofuels (briquettes and pellets). Another promising area is the use of waste for biogas production. The volume of crop waste calculated in natural quantities in Ukraine is a theoretical bioenergy potential, i.e. in theory it can be fully used for energy production. To bring the theoretical potential into conventional fuel, the heat of combustion of the waste of the respective crops is taken as a basis. The amount of heat obtained from the volume of waste from individual crops must be divided by 7000 kcal / kg (Table 1.7).

Table 1.7

Theoretical bioenergy potential of primary waste (by-products) of crop production in Ukraine, on average for 2018-2020, thousand tons of conventional fuel

Crop	Heat of combustion, kcal / kg	Theoretical bioenergy potential
Wheat	3 285	12332.8
Barley	3 190	3160.7
Rye	3 240	257.2
Rice (straw)	3 000	24.7
Millet	3 000	55.6
Oat	3 850	267.7
Buckwheat	3 000	131.4
Other legumes	3 000	330.5
Soy	3 800	1971.7
Rapeseed	3 660	1773.2
Corn for grain (stems)	3 270	15399.1
Sunflower (stems)	3 270	10959.7
Total	x	46664.4

Source: calculated by the authors

The factor that affects the value of the theoretical bioenergy

potential the most is the yield of agricultural crops and the area allocated for them. In theory, the most energy can be obtained by using waste crops such as wheat, corn and sunflower for energy purposes.

The value of the technical bioenergy potential is directly influenced by the technology of harvesting agricultural crops and the existing technologies for processing waste into energy. These factors are taken into account by the coefficient of technical availability, by which it is necessary to multiply the theoretical potential (Table 1.8).

Table 1.8

Technical bioenergy potential of primary waste (by-products) of crop production in Ukraine, on average for 2018-2020, thousand tons of conventional fuel

Crop	Coefficient of technical availability	Technical bioenergy potential
Wheat	0.5	6166.4
Barley	0.5	1580.4
Rye	0.5	128.6
Rice (straw)	0.5	12.4
Millet	0.5	27.8
Oat	0.5	133.9
Buckwheat	0.5	65.7
Other legumes	0.5	165.3
Soy	0.7	1380.2
Rapeseed	0.7	1241.2
Corn for grain (stems)	0.7	10779.4
Sunflower (stems)	0.67	7343.0
Total	x	29024.1

Source: calculated by the authors

Factors on which the economically feasible bioenergy potential depends: competition between energy use of waste and its use in animal husbandry; the possibility of soil depletion due to the refusal to leave straw in the fields for fertilization when using it as a fuel resource.

Research on the energy use of plant waste is actively conducted in EU countries (Monforti et al, 2013, Christou, 2007). In general, they boil down to the fact that 25-50% of straw and corn residues for grain and 30-50% of waste from sunflower production can be used

for energy / biofuel production, the rest should be left in the fields. Studies by scientists (USDANRCS, 2006) have shown that for US conditions, 30-60% of the amount of straw and waste from the production of corn for grain should be used for energy purposes.

Opinions of Ukrainian scientists differ: specialists in soil science and agriculture are convinced that almost the entire straw crop should be left in the fields to preserve soil fertility. Other experts believe that in Ukraine, on the contrary, there is a surplus of straw, which is more cost-effective to attract to the fuel and energy balance. The position of the Ukrainian Bioenergy Association (UBA) on this issue: it is advisable to use up to 30% of the theoretical potential of grain waste (straw) and up to 40% of the theoretical potential of waste from the production of sunflower and corn for grain (Heletukha et al, 2017). When calculating the economic potential, these issues are important and it is necessary to take into account the coefficient of energy use (Table 1.9).

Table 1.9

Economic bioenergy potential of primary waste (by-products) of crop production in Ukraine, on average for 2018-2020, thousand tons of conventional fuel

Crop	Energy utilization coefficient	Economic bioenergy potential
Wheat	0.25	1541.6
Barley	0.25	395.1
Rye	0.25	32.1
Rice (straw)	0.3	3.7
Millet	0.3	8.3
Oat	0.3	40.2
Buckwheat	0.3	19.7
Other legumes	0.3	49.6
Soy	0.8	1104.2
Rapeseed	0.8	993.0
Corn for grain (stems)	0.35	3772.8
Sunflower (stems)	0.4	2937.2
Total	x	10897.5

Source: calculated by the authors

Calculations have shown that Ukraine has a significant potential

for primary crop waste that can be used for biofuel / energy production. It is necessary to take into account what part of the technical potential of waste should be used as an energy resource, and what – to leave in the field to preserve soil fertility or use as litter for animals. Taking into account the recommended by UBA energy utilization coefficients on average for 2018-2020 in Ukraine, the economic bioenergy potential of the main primary crop waste exceeds 10 million tons of conventional fuel per year.

It is very important today to consider the possibility of using crop waste for use in biogas plants, because energy consumption is growing. We see great prospects in the use of plant waste as a raw material for biogas production.

The problem of efficient waste recycling and disposal is one of the most acute in the world. Attention to the issues of rational waste management in Ukraine by both the authorities and the scientific community has significantly increased in recent years. The solution to the problem is possible through the implementation of effective measures for fast, safe waste processing and obtaining a positive economic and environmental effect from the disposal and reuse of raw materials.

The rate of accumulation of waste produced in Ukraine is increasing every year. In turn, biomass allows you to get a seventh of the world's fuel, and the amount of energy produced ranks third along with natural gas. In this case, biogas from organic biomass, regardless of origin, is a significant competition to traditional fuels due to the low cost of biomass. Our country has great agricultural potential for the production of alternative energy sources. Given this, today the issue of production and consumption of biogas is extremely important, because the energy security of our country is almost entirely dependent on imports of traditional energy sources.

It is investigated that the most efficient and universal energy source of all biological fuels is biogas, which is obtained from renewable raw materials and organic waste. Biogas is a combustible gas mixture obtained in the process of natural decomposition by methane fermentation of raw materials.

Given the rapidly growing amount of organic waste, biogas production solves the problem of waste disposal, including crop production, thus preventing methane emissions into the environment,

reduces the use of chemical fertilizers and prevents groundwater pollution (Kaletnik et al, 2019).

Biogas production has a significant potential in the production of heat and electricity due to the existing crop residues in agriculture, favorable climatic conditions, the availability of agricultural recourses. In turn, increasing the efficiency of the biogas industry, as the main form of management in the current conditions of economic transformation, is associated with the improvement and intensification of innovation, technical, organizational and financial mechanism. The task of increasing the efficiency of capacity is, first of all, to improve the system of state regulation and the use and implementation of new technologies that will bring the biogas industry to a new stage of effective development. The system approach is characterized by a comprehensive assessment of the impact of various factors and a targeted approach to their study (Palamarenko, 2019).

Due to favorable natural conditions and high soil fertility, Ukraine has a great potential of biomass available for energy use. The largest amount of agricultural biomass is formed in areas located in the central, southeastern and southern regions of the country, ie in places most favorable for growing crops. In these areas, the density distribution of biomass resources is the highest, so they have the highest level of economic feasibility of processing waste from primary treatment of crops (Resuleva, 2015). At the same time, the main factors influencing the volume of annual crop waste are sown areas, gross harvests and crop yields.

Today there are more than 30 million biogas plants in 65 countries, including – more than 12 thousand in European countries. There are more than 10 large biogas plants in the United States, 18 – in Denmark, which process 1.2 million biomass. Germany is the leader in the number of operating biogas plants – more than 5 thousand. In Western Europe such alternative heat carriers cover about 20% of total fuel needs in industry. In Ukraine only the first steps in this direction are being taken, although the scale of waste accumulation makes it possible to consider them as a powerful source of alternative fuels. At the same time, Ukraine as a member of the Energy Community in accordance with the Association Agreement with the European Union in recent years has introduced a

number of initiatives that will further develop the use of renewable energy sources, biogas production in particular (Shkarivska et al, 2020).

The use of biogas plants in Ukraine is promising for solving waste disposal problems, including crop production, improving the environmental situation, increasing soil fertility, reducing energy dependence and developing the local economy.

Table 1.10 shows the data on the energy potential of crops and crop waste for biogas production.

Table 1.10

Energy potential of crops and crop waste for biogas production

№	Crop	Biogas yield of 1 ton, cubic meters	Power output, kWh	Thermal energy output, kWh
1	Ensiled Sudanese grass	9	8	11
2	Alfalfa (2nd slope)	141	12	16
3	Clover silage (1st slope, beginning of flowering)	185	16	21
4	Corn: stems, cobs (mixture), 2% crude fiber	451	38	49
5	Green rye, the end of flowering	150	13	16
6	Corn silage	185	15	20
7	Soilage	208	18	23
8	Millet wax maturity	163	14	18
9	Forage ensiled mixture (peas, oats, barley, flowering stage)	168	14	19
10	Oil rapeseed silage	75	7	9
11	Ensiled sugar beet leaves	88	8	10
12	Ensiled cereals (whole plant)	214	18	23
13	Silage wheat (whole plant)	188	16	20

Source: formed by the authors on the basis of (Biteko Biogas, 2020)

For example, many farmers abroad already occupy separate fields of corn to produce biogas for the production of electricity and heat, ensile it and use it efficiently in biogas generators during the year. Such a prospect cannot be ruled out in Ukraine, especially in remote households, which are expensive to supply natural gas and electricity.

The sown area of grain corn in Ukraine in 2020 amounted to more than 5 million hectares. Natural gas is mostly used to dry corn grain. However, due to the high cost of production, the profitability of growing this crop is significantly reduced. Also, the efficiency of growing corn is greatly influenced by weather conditions. Therefore, it is expedient to replace part of the area of grain corn crops (within 2 million hectares) with the cultivation of silage corn, which will be used for biogas production in the future. This will allow annually to obtain about 35.2 billion m^3 of biogas or 17.0 billion m^3 of biomethane.

Growing silage corn as a raw material for biogas production is more cost-effective than growing corn for grain. Thus, at today's price for corn grain of 2.4 thousand UAH per ton and the potential grain yield of 8 ton per hectare, sales revenue will be 19.2 thousand UAH. The output of biogas from 1 ha of silage corn with a yield of 80 ton per hectare will be about 16 thousand m^3 per hectare or 8.5 thousand m^3 per hectare of biomethane. At current natural gas prices of UAH 6.4 per 1 m^3, sales revenue will amount to UAH 54.4 thousand per hectare, i.e. 2.8 times higher. At the same time, the financial costs of growing silage and grain corn are about the same.

At the same time, the economic attractiveness of using corn for energy purposes may threaten the reduction of food and feed. Based on this, the EU has adopted a new Law on Renewable Energy Sources, according to which the mass fraction of corn in the nutrient substrate for biogas plants should not exceed 60% (Britchenko, Stopochkin, A.I., 2016). Therefore, today the EU countries consider sugar beets as an alternative to corn in terms of energy raw materials for biofuel production.

Sugar beet is a traditional and most effective crop for Ukraine. Up to 11 thousand m^3 per hectare of biogas with a methane content of 60% can be obtained from one hectare of sugar beets (with a yield of 70 ton per hectare). At the same costs for growing sugar proceeds from the sale of sugar beets at prices of 410 UAH per ton will be 28.7 thousand UAH per hectare, and with the production of biomethane – 38.4 thousand UAH per hectare.

It is economically feasible to use sugar sorghum as a raw material for biogas production, which can be grown in the southern arid regions of Ukraine. Up to 100 ton per hectare of sugar-containing

biomass with juice sugar content up to 18% can be harvested from one hectare of sugar sorghum crops, which provides a potential biogas yield of about 17.6 thousand m^3 per hectare. The estimated area of sowing of this crop in Ukraine may be about 500 thousand hectares, which will provide about 4.4 billion m^3 of biomethane.

In addition, there is a large group of potential raw materials for biogas production, which consists of fresh grass, beet leaves, grass silage, corn and cereals, the yield of methane from which is from 270 to 330 liters per kg. You can also use rapeseed oilseed rape, which is quite actively grown in Ukraine (Tokarchuk, 2015). Straw has the lowest gas yield below 200 liters per kg of organic substrate. Energy plants have small deviations in the yield of gas, which is calculated within 300 liters of methane per kg of organic substrate with a fluctuation of ± 30%.

Significantly large differences are shown by energy plants when calculating the yield per hectare. If the mass yield is multiplied by the specific methane yield, the methane productivity is obtained per unit area for a particular crop.

The highest yield of methane from the dry mass gives beets and high-yield silage varieties of corn – 6000 m^3 of methane per hectare. Miscanthus, as a perennial crop, although it gives a good biomass yield of 200 centner per hectare, but low methane yield reduces the productivity of areas to the level of grass and silage – 4000 m^3 of methane per hectare.

Although grain and tubers have a high personal gas yield, when these date are transferred to field productivity, it will be 3,000 m^3 of methane per hectare. Intermediate crops have the lowest productivity of areas below 2000 m^3 of methane per hectare due to the short growing season.

Energy crops used for biogas production must have a simple cultivation technology, as well as provide a high yield of dry substance and methane per unit area.

In particular, it is crucial for biogas producers which plant species and variety or hybrid provides the highest methane yield per 1 hectare, as this has a decisive impact on the economic performance of the biogas plant. It should be noted that as elements of cultivation technology, plant density and row spacing can increase biomass production of energy crops (Grabowski, 2019).

The magnitude of the energy potential of biomass in Ukraine varies over the years and depends not only on the yield of major crops, but also on the technology of collection of relevant waste. In addition, one of the factors influencing the use of vegetable waste to produce biofuels is the seasonality of their formation. To ensure their uniform use throughout the year, it is necessary to comply with special storage conditions, which entails certain costs.

Vegetable crops and their waste for biogas production also have significant energy potential (Table 1.11).

Table 1.11

Energy potential of vegetable crops and their waste for biogas production

№	Type of waste / vegetable crops	Biogas yield of 1 ton, cubic meters	Power output, kWh	Thermal energy output, kWh
1	Vegetable waste	57	5	7
2	Vegetables:			
2.1	onion	80	8	11
2.2	carrot	73	6	8
2.3	cauliflower	59	5	7
2.4	cauliflower	51	5	6

Source: formed by the authors on the basis of (Biteko Biogas, 2020)]

However, these types of raw materials are usually used as a supplement to the main raw materials in the biogas plant.

The cultivation and use of energy crops, one way or another, faces a dilemma of consumption, ambiguously perceived by the population, as it competes with food crops. At the same time, food waste also deserves attention, as it is an energy resource that helps reduce the cost of recycling, as well as protect the environment. Food waste is generated constantly, does not need to be specially cultivated and can be used efficiently because it is a high-energy raw material for energy production.

The energy potential of some types of waste from the food industry of plant origin for biogas production is shown in Table 1.12.

Biogas plant for food waste processing is the most appropriate, affordable and efficient way to dispose of it. And, in comparison, for example, with combustion technology, it is much more affordable and needs less investment.

Table 1.12

Energy potential of food industry waste of plant origin for biogas production

№	Type of waste	Biogas yield of 1 ton, cubic meters	Power output, kWh	Thermal energy output, kWh
1	Soybean waste	517	43	56
2	Potato bard	35	3	4
3	Oat waste	620	53	68
4	Beer pellets	122	12	15
5	Apple core	112	9	12
6	Soy flour	552	54	70
7	Rapeseed flour	496	47	61
8	Various food wastes	120	11	15

Source: formed by the authors on the basis of (Biteko Biogas, 2020)

However, with the full feasibility of implementation, the technical requirements for the fermentation of food waste are quite high. First of all, the increased requirements apply to plastic packaging, glass, bones and other non-fermentable materials that come with food waste. During fermentation, these substances are problematic only if they get in large quantities, because they interfere with the decomposition of organic matter. Therefore, each biogas plant running on food waste has a sorting line. Studies have shown that the most common crops used for biogas production are sugar sorghum, corn for silage and sugar and fodder beets.

Therefore, for countries that consider it appropriate to obtain a sufficient amount of biogas, it is necessary to expand the sown area of the studied crops (Tokarchuk, 2019). It should be noted that the advantage of biogas production from agricultural waste is that it is an affordable means of energy production. At the same time, waste from the biogas production process serves as a high-quality fertilizer, and the process itself helps maintain cleanliness in the environment (Pantsireva, 2019).

Establishing a functional system of agricultural waste management will affect other areas of economic entities (micro level), as well as rural areas and the country as a whole (macro level), which will include the following benefits at different levels (Table 1.13).

Table 1.13

Potential and actual benefits of agricultural waste processing

Benefits	Ways to achieve
Energy and resource independence	– use of by-products as raw materials for the production of alternative heat and energy carriers, and / or additional products / materials.
Creation of additional jobs	– maintenance of processing equipment, sorting and waste collection require the involvement of labor resources.
Low-waste / waste-free production	–minimization of waste generation and / or waste-free production allow to increase the environmental safety of production processes and develop environmentally responsible business.
Creating a positive image of the enterprise	– minimization of waste generation and / or waste-free production allow to increase the environmental safety of production processes and develop environmentally responsible business.
Improving the ecological condition on the territory of the enterprise and increasing the ecological safety of management	– cleaning areas from waste and their further processing; – refusal to use other methods of utilization, such as incineration of crop waste directly on sown areas.
A step towards the creation of a circular economy (waste-free production)	– this benefit is the result of the entity achieving waste-free production.

Source: formed by the authors

Benefits include:

- energy and resource independence;
- creation of additional jobs;
- low-waste / waste-free production;
- creating a positive image of the enterprise;
- improving the ecological condition on the territory of the enterprise and increasing the ecological safety of management;
- a step towards the creation of a circular economy (waste-free production).

At effective processing and utilization of own waste the agricultural enterprises should:

- use waste or products based on them in the production of the main products for the enterprise (e.g. partially straw – as litter in animal husbandry, plowing part of crop waste to increase soil

fertility to increase crop yields);

- make full use of own waste or products from it for the needs of the enterprise (provision of energy needs at the expense of biofuels from own waste;

- attribute partially or completely the costs of waste processing to the cost of basic products;

- evaluate the environmental effectiveness of these measures.

There is a need for a feasibility study to improve the mechanism for the use of waste and crop by-products for energy purposes at the state and rural levels, as this will ensure the effectiveness of their treatment. It should be noted that the mechanism is closely related to and depended on society economic, political, legal and cultural system, on specifics of state mechanism framing and functioning, as well as on ecological and legal culture of legal subjects

The economic mechanisms of waste and by-products of crop production management is shown in Fig. 1.5.

The proposed mechanism for waste and by-products management has two levels: national and the level of rural areas.

The mechanism is based on the principles of waste management, which must comply with European standards: priority protection of the environment and human health from the negative impact of waste, ensuring the economical use of raw materials and energy resources, scientifically sound harmonization of environmental, economic and social interests society on the generation and use of waste to ensure its sustainable development.

Actually, the mechanism includes subsystems:

- target,
- controlling,
- functional,
- controlled,
- providing.

The target subsystem at the state level includes ecology and energy safety which can be achieved if waste is used as energy. At the local level, the goals are less global – the utilization of waste and energy use.

To ensure an effective mechanism for waste management, it is important to involve in the controlled subsystem all potential producers of waste and by-products: both agricultural enterprises and the population (households in which waste is generated).

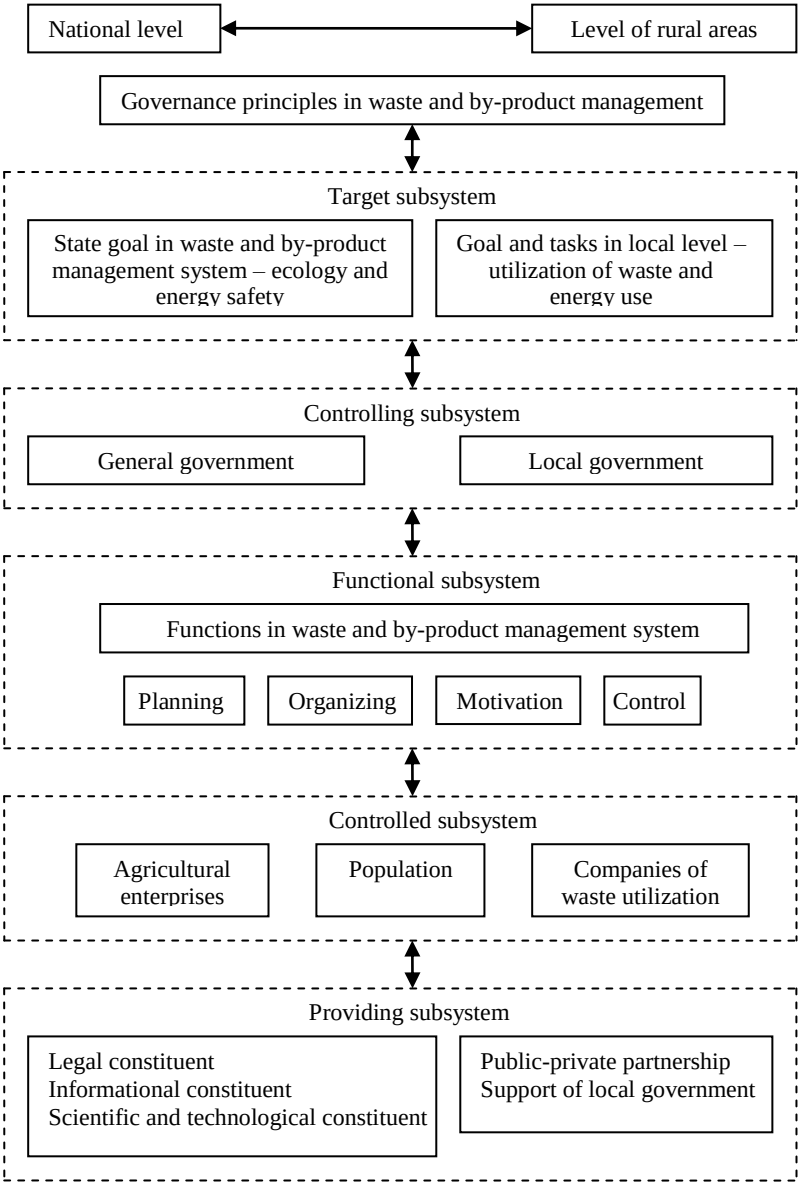

Fig. 1.5. **The economic mechanisms of waste and by-products of crop production management**

Source: developed by the authors

Providing subsystem at national level includes legal constituent (improvement of the legal framework for waste management and its harmonization with European legislation), information constituent (raising of environmental awareness level of the population, promotion of biofuel production from waste and by-products), scientific and technological constituent (support of researches in the field of bioenergy).

At the level of rural areas, public-private partnerships in the field of waste management and support of local government are important.

The legal framework in the field of environmental protection includes a large number of documents (Applications, Table A1, A2, A5).

The state stimulates the production of biofuels, including from waste, thanks to the "green tariff" (Applications, Table A3, A4).

Effective and purposeful development of waste management systems is certainly an important and necessary component of society's transition to clean technologies, one of the steps to the ideal goal of "zero Waste" (adopted in Europe, means completely waste-free technologies). It is necessary to significantly increase the efficiency of all institutions and organizations operating in the field of environmental protection, at the state, regional and local levels in such priority areas as:

- development of waste management systems and informing about their environmental pollution;
- development and adoption of regulations and guidelines to regulate activities related to waste at all levels of government in order to minimize and localize the negative impact of waste on any component of the environment;
- creation of favorable economic and legal conditions for coordination of improvement of waste management activities, in particular their processing, utilization, disposal, disposal;
- real involvement of competent public organizations and specialists in the ecological examination of pilot and other projects of utilization of various wastes: agrarian, industrial, solid household.

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2. INSTITUTIONAL ASPECTS OF THE FORMATION OF A "GREEN ECONOMY" IN THE AGRICULTURAL SECTOR

2.1. The concept of "green economy" in the development of social formations[4]

The realization of the vast majority of goals to meet the social and individual motives of mankind depends on the economy. The transformations and evolutionary changes that have taken place over the centuries have proved the crucial importance of building an effective economic system, and the given context of cognition gives grounds to emphasize that, by institutional status, the economy is: a comprehensive economic system governed by an institutional mechanism; organizational model of cost-mediated relations carried out to meet economic and social needs; the field of diffusion and application of innovations for the formation of competitiveness and ensuring scientific and technological progress. In turn, the development of the economy is an institutionally conditioned process with signs of constant transformation, change to find mechanisms as the most effective way of interaction of productive forces and the development of production relations. The noted interaction is the basis for understanding the foundations of the formation of the wealth of people, established by the classic of economic thought A. Smith (Smith, 2018). According to M. Tugan-Baranovsky (Tugan-Baranovsky, 1994), development of economy depending on the functional typing of innovations and institutions, the principles of their interaction on economic, market, social processes. This directly points to the interdisciplinary aspect of the problem, which should be considered in the institutional plane of assessing the "rules of the game", organizations and efficiency. Thus, the institutional mechanism of the economy is a structural model of the direction of economic interactions and support a certain trajectory of their development. For example, for the formation and development of a "green economy" a typical institutional mechanism is formed, which includes institutes and institutions to promote "greening" of the economic system and relations between economic agents in the

[1]Kaletnik G.M., Shpykuliak O.G., Bilokinna I.D.

process of market transactions.

At the present stage of development, Ukraine's economy is characterized by complex transformation processes, which are characterized by bringing the domestic legal framework in line with European standards, ie currently there is active economic integration and rapprochement with European Union policies. Compared to other countries of the Eastern Partnership, this process in our country is protracted. This was facilitated by factors that have developed historically in our country, as the latter has never had a developed institutional environment. One of the main aspects of the transformation of the domestic economy in the direction of European integration is the institutional one, which is based on market institutions that take into account the economic, political, historical, social and psychological characteristics of our country.

For each country individually and the world community as a whole, there is a priority task, which is to ensure sustainable and sustainable socio-economic development, the basis of which are institutional transformations aimed at achieving a specific goal. In Ukrainian society, this issue is important because the country is undergoing a very complex process of transformation of socio-economic relations, which is based on a defective institutional environment.

The institutional environment is a clear and ordered set of institutions that defines the constraints for economic entities that are formed within a particular system of coordination of economic activities. And the process of implementation and compliance with these institutions is called an institutional mechanism.

In order to explore the essence and significance of the institutional mechanism for the effective functioning of the national economy, it is necessary to learn about its basic element, in fact, about the "mechanism" from different points of view of science. Most scientists define the "mechanism" as a general scientific, multifaceted and comprehensive concept that characterizes material objects and their interaction at all levels of organization of matter, characterizes the processes of management and self-regulation in wildlife and society (Filippova, 2014). According to the dictionary of foreign words, the mechanism is a set of intermediate states or processes of any phenomena (Dictionary of foreign words, 1974). In

the scientific literature, the term “mechanism” translated from the Greek “mechane” means “weapon”, “machine”; in the first definition – is a sequence of states, processes that determine any actions, phenomena; in the second – a system, a device that determines the order of any activity. Under the “mechanism” means the internal system, the system, for example, the state mechanism of government. A mechanism is a set of states and processes from which there is any physical, chemical, physiological, mental or other phenomenon, such as a mechanism of thinking; it is a process of determining the dependence of management on the characteristics of the organization, which can be centralized and decentralized (Kovalenko, 2009). V. Bakumenko is of the opinion that the mechanism is everything that sets in motion, ie leads to practical implementation. For example, mechanisms for implementing strategies, government policies, projects etc. (Bakumenko, 2014).

Thus, first, the mechanism is a set of elements (components); secondly, the mechanism exceeds the sum of its elements in some of the qualitative properties; thirdly, the mechanism provides for a certain order of operation, ie has a purposeful nature; fourth, the mechanism has systemic properties that provide for the internal interconnection of the elements that are part of it. These definitions allow us to identify key parameters that belong to the term “mechanism” in general, on the basis of which it is possible to disclose the features and supplement the content of the mechanism (Mykhaylenko, 2006). Therefore, studying the institutional mechanism of the economy, it is necessary to take into account all the properties of the category “mechanism”, which is the basis for further economic knowledge.

Studies of institutional features of the economy focus on a wide range of issues, which are a kind of starting point for assessing the process interactions of socio-economic development. The range of institutional problems combines economic, social, political and legal issues, this is what distinguishes this trend of scientific research among others (Shpykuliak, 2009). Institutionalism is a relatively new direction in economics, but its system of studying economic phenomena has given the opposite, unlike any other methodological basis for resolving economic imbalances.

Institutionalism as a direction of modern economic thought

emerged at the turn of the XIX – XX centuries. Its main ideologue was the American economist and sociologist Thorsten Veblen. The very term "institutionalism" translated from Latin means custom, instruction, instruction. Representatives of institutionalism consider the basis of socio-economic development to be institutions, as well as no less important institutions. Rohach S.M. believes that institutionalism is a complex formation both in terms of research and achievements in the knowledge of economics and society. The peculiarities of institutional theory are that the subject of its knowledge are the institutions that exist in the economy, social sphere, law, morality, religion, etc. (Rogach, 2009). Another researcher Kucherenko V.M. holds the view that institutionalism is based mainly on non-economic interpretation of the essence of economic processes in a market society (Kucherenko, 2016). Although this is a debatable issue, because, in our opinion, institutionalism, along with economic factors also takes into account political, social, cultural and others, ie allows to study phenomena from different angles, and not only non-economic factors are taken into account in this study, occur comprehensively and comprehensively, which thus determines a clearer result.

The advantage of the institutional approach in the process of studying economic phenomena is that it is based on the analysis of all components of the category. This must be done in terms of unity and interconnectedness. The relationships that are identified through the institutional approach allow for a broader identification and deeper disclosure of the essence, taking into account the influence of external and internal factors, which together contribute to a clearer understanding of various social and economic aspects of a phenomenon.

An interesting opinion is expressed by Shapovalova T.V.: "Institutionalism is a direction of socio-economic research that considers the structuring, organization and functioning of society as a set of different institutions (family, party, trade union, public associations, etc.) taking into account time parameters" (Shapovalova, 2013).

In traditional institutionalism, the explanation of the interests and behavior of individuals occurs through the characteristics of institutions that determine their interaction. In neo-institutionalism,

on the other hand, the explanation of institutions is through the interests and behavior of individuals who use them to coordinate their actions.

A feature of neo-institutionalism is the unchanging “hard core” of neoclassicism. A new element of the subject of analysis of institutions is the correction of statements from the “protective shell” of neoclassical theory, which is why neo-institutional economics is considered an example of “economic imperialism”, which, as it developed, complemented “economics”. Neo-institutionalism used traditional microeconomic methods of analysis to investigate social relations from the point of view of a rational economic man, relying on other social sciences, such as law, psychology, sociology, politics, ideology and others.

Institutions are the main object of study in addressing socio-economic issues. Scientists make mistakes in identifying the concepts of “institution” and “institute” and this does not give clarity and effectiveness of research. This mistake was made by Russian researchers when translating these categories from a foreign language. Institutions are extremely important, but they can affect society both positively and negatively. At the same time, it depends on them whether certain economic and political operations will be carried out in good faith, or whether the achievement of the goal by market economy entities will not violate the rights and property of other representatives. Thus, for the application of certain institutions in market economies, it is necessary to take into account all the factors of influence in order to avoid a number of negative consequences. Institutions are not sustainable and they can change. This happens when organizations are dissatisfied with the institutional environment and believe that certain changes will help them achieve their goals. Institutions perform a number of important functions for the development of society and the introduction into the economy of the principles of rational use of resources. It is the state that plays a leading role in creating the right institutional environment for the development of the green economy.

At the present stage, sustainable development of the country's economy is based on the principles of “green economy” and is environmentally friendly. The means of realization of ecologically oriented strategic plans of economic development is the institutional

mechanism which is intended for maintenance of coordination of social, ecological, economic interests of a society and the state.

The main objectives of the institutional mechanism for the "green" development of the state economy are: stabilization and improvement of the environmental situation in general, greening of economic activity within the institutional and structural transformations adequate to market relations; creation of optimal conditions for effective use, preservation and reproduction of natural resource potential of territories; minimization of damage to natural ecosystems, compensation for losses and insurance of environmental risks; introduction of resource-saving technologies, biotechnologies, use economical methods of nature management; optimization of the structure of the country's economy as a whole and its regions, taking into account the peculiarities of the territories; stimulating economic interest in the rational and economical use of natural resources; restriction of inefficient competition in order to eliminate non-environmental technologies, equipment, products and services from the market (Burkinsky, Khumarova, 2013).

An important step in transforming the institutional mechanism of the state's economy was the approval of the Ukraine 2020 Sustainable Development Strategy. The purpose of the strategy was to introduce European living standards in Ukraine and the country's entry into leading positions in the world.

From the organizational point of view, we consider the institutional mechanism as an organizational and functional system of support, streamlining the relationship between economic and other actors in the market environment. That is, if we take into account the status and factors of economic development, the institutional mechanism acts as a moderator (creator) of a particular model of economy, such as "green".

The construction of the theoretical foundations of the institutional mechanism and the coordination of methodological provisions for its presentation in the practice of coordinating the interaction of components of the economic order is traced in science in the contours of characterization of organizational and functional system to ensure relations between economic and other actors in the market environment.

We believe that the characteristics of institutions and institutes

mean their quality. Also, in our opinion, in the system of the institutional mechanism it is expedient to allocate organizational and functional component. In the given theoretical concept we consider economic institutes and institutions which form structure of the institutional mechanism. They operate at the micro level (business entities), meso level (territorial units and industry) and at the macro level (economy, market). This is the organizational structure of the institutional mechanism, and the functional ones are the institute of labor, entrepreneurship, competition, and others. They are all divided into basic and derivative. This is the opinion of various researchers who are in favor of such a context of research evaluations, and we are in our work.

The institutional mechanism of the economy is represented in two general, macroeconomic dimensions: management and regulation. It is formed by basic and derivative institutions that regulate the interactions of participants in economic relations, directing in a certain direction. The same logic is inherent in "green" and other types of economic relations, which are practically embodied by humanity at a certain stage of its development. Thus, we note that the institutional mechanism is a set of functions, rules, norms, traditions, which: form a system of interaction of economic agents to achieve tactical and strategic development goals; regulate the procedure, methods of regulation and implementation of necessary measures; determine the nature, the trajectory of development, ie the model of interaction of productive forces and the development of industrial relations ("rules of the game"). The general purpose of the institutional mechanism is regulatory, but in the applied context the forms, methods, measures may change, for example, in the formation of the "green economy" the institutions of constructing the principles of sustainability, reproducibility, etc. are involved.

Categorically, according to the set of principles of construction, ideology of cognition, the institutional mechanism means the scheme, the order of interaction, the relationship of economic agents in the implementation of market transactions. The structural basis of the institutional mechanism is formed by the "rules of the game", restrictions and incentives that regulate the organizational and economic interaction of entities interested in achieving important goals for them. For example, in the system of building a "green

economy", the global context of goals is to achieve "green" growth as a process status of the implementation of the principles of sustainable development. Accordingly, in this context, an institutional mechanism is formed – it is about its specialization. The basis of ideologies is a construct of the economy based on the establishment of the institutions of the concept of sustainable development, which at the global level is formalized in the UN Sustainable Development Goals by 2030.

Existence of society at the present stage of development requires such a number of natural resources that exceeds the capabilities of our planet. World GDP has grown fourfold over the past 25 years, but this growth is mainly due to increased consumption of natural resources. Scientists have calculated that if the way of management will continue in this way in the future, then to support the life of society in 2030 will need the resource of our two planets, and in 2050 – 2.8 planets.

Given that the only materialized spiritual and creative force on the planet Earth is man and society as a whole, an important task of its development is to eliminate non-ecological and non-spiritual interaction of man with nature. The tools to achieve this goal are the ability to transform negative experiences, feelings and states, the implementation of nature appropriate, spiritually meaningful professional and social activities, the use of genetic, energy, spiritual, intellectual and mental capabilities of society in harmonizing interaction with nature, the implementation of value-oriented practical activities in accordance with the purpose of man in nature and society (Plotnikov, 2016).

T. Yemchyk (Honcharuk) notes that in order to improve the living standards of society, to reduce the burden on the environment, to solve social, climate, financial and fuel problems, it is necessary to find a radically new concept that would become the basis for further sustainable development. In the context of solving these problems, an important aspect of the development of modern socio-economic formations is recognized by science as the concept of "green economy" (Honcharuk, 2013).

The concept of "socio-economic formation" was first introduced by Karl Marx. His materialist understanding of the historical process had a sufficient influence on the further development of sociological science.

In general, the concept of "formation" is a socio-productive organism that develops, has special laws of origin, functioning, development and transformation into another, more complex social organism.

Socio-economic formation is a society that is at a certain stage of historical development. The formation is based on a known method of production, which is the unity of the basis (economy) and superstructure (politics, ideology, science, etc.). The history of mankind is a series of five successive formations: primitive communal, slave-owning, feudal, capitalist, and communist formations (Marx, 1959).

Avoiding an unambiguous interpretation of the concept of "socio-economic formation", Marx considers it as polysemantic and gives it the following meanings:

- economic structure of society throughout its historical existence;
- one of the three major stages of human history – primary (pre-class society), secondary (class society), tertiary (classless society);
- historical degree (type) of development of society;
- historically defined set of social relations;
- historically defined set of production relations.

Thus, the main terms are: "socio-economic formation" (in particular, when it comes to a set of production relations) and "social formation" (e.g., when it comes to a set of social relations in general) (Punko, Kosharska, 2013).

In particular, special attention was paid to this issue in Soviet literature. Soviet scholars believed that the entire history of mankind was a process of consistent, unbiased, obligatory for the whole society change of five socio-economic formations: primitive communal (primitive communist), slave-owning, feudal, capitalist and communist. They paid a lot of attention to the latter and had high hopes for it.

O.O. Vityuk divides social formations as follows: industrial, electronic and information society in his works (Vityuk, 2006).

According to A. Tofler's classification, the development of socio-economic formations is carried out within the agrarian-craft, industrial and information civilization. At the basic of each of them is a certain technological method of production (unity of productive

forces and technical and economic relations), based on manual, machine and automated labor, respectively (Mocherny, 1995).

Thus, the socio-economic formation is a historical division of society, which is based on the mode of production and production relations that developed in it. Returning to the global problems that have developed in our society, we can say that the further development of social formations requires a new paradigm that will improve the overall situation. Analyzing the situation for a long time, humanity has been trying to find the right way to solve problems. In the end, these searches did not go unnoticed and still yielded results.

The main direction of solving these problems by integrating environmental, economic and social components of sustainable development is set by the "Agenda for the XXI century", adopted by the historic Earth Summit in 1992 in Rio de Janeiro (Brazil), as well as the decisions of the World Summit on of Sustainable Development in Johannesburg (South Africa), 2002, by which UN member states are recommended to implement sustainable development strategies. The decisions of the UN Conference on Sustainable Development "Rio + 20", held in Rio de Janeiro, June 22-25, 2012, twenty years after the Earth Summit, recognized that progress towards the implementation of the principles of sustainable development in the national countries' development policies and strategies have been insufficient due to problems related, in particular, to weak institutional capacity, funding and integration. The initiatives of international organizations to develop and implement at the national level the concepts of "green" economy, "green" growth, "inclusive green" growth, which deepen the concept of sustainable development in the light of modern realities and aimed at its more pragmatic implementation were supported.

In 2008, the United Nations Environment Program (UNEP) announced the transition to a green economy in response to the financial and economic crisis, which should help the global economy to recover and increase employment, while accelerating the fight against climate change, environmental degradation and poverty. UNEP calls for maximum attention to be paid to the five most important areas, one of which is the development of sustainable agriculture, including organic production (Green Economy – the salvation of mankind, 2016).

O. Faichuk believes that society provides the "green economy" with technology and labor, while the feedback is observed in meeting consumer demand through previously created public goods in the process of material production and guaranteeing social equality. Instead, society receives not only natural landscapes, as a result of the interaction of ecology and society, but also extremely important elements for life (water, oxygen, solar energy, etc.). Finally, society returns to the natural environment the products of its own vital activity, such as carbon dioxide, etc. (Faychuk, 2016).

According to the UN, a "green economy" is an economy that leads to improved prosperity and social equality, while significantly reducing economic risks and shortages of natural resources.

The International Chamber of Commerce views the green economy as the one, where economic growth and environmental responsibility complement each other, supporting progress in social development (Chmyr, Zakharkevich, 2013).

Today, in addition to the concept of "green economy", there are also concepts of "green growth" and sustainable development. These three concepts have a common goal, namely the harmonious coexistence of three components – economy, environment, social sphere and optimal coordination between these components, which would be acceptable to all groups of countries: developed, developing countries and countries with economies in transition. However, there are some differences presented in Table 2.1.

The concept of "green growth" is to identify cleaner sources of growth, manage structural change for the transition to a green economy, create new industries, technologies and jobs (OECD). In turn, "sustainable development" means that the current generation has a duty to future generations to leave sufficient stocks of social, natural and economic resources (Sustainable development as a paradigm of social growth of the XXI century, 2001).

At the same time, UNEP emphasizes the relationship between the concepts of green economy and sustainable development: "The concept of green economy does not replace the concept of sustainable development, but it is now increasingly recognized that economy. For decades, when new wealth has been created using the brown economy model, society has not solved problems such as social marginalization and resource depletion, and we are still far

from achieving the Millennium Development Goals. Sustainability remains the most important long-term goal, but to achieve it we must make our economy green" (Organic Production, 2019).

Table 2.1.

Differences between the concepts of "green economy", "green growth" and sustainable development

	Component		
	Economic	Ecological	Social
1	2	3	4
"green economy"	Provides economic growth, increase income and employment, attract public and private investment, the formation of a flexible economy, the creation of new economic activities	Focuses on reducing environmental risks, deficits, carbon dioxide emissions and environmental pollution; increasing the efficiency of resource and energy use; prevention the loss of biodiversity and ecosystem services, within the ecology of the planet; requires all businesses to be environmentally responsible and to limit the burden on the ecosystem	Provides the achievement of well-being, social justice, better quality of life, social development, reduction of social inequality, equitable access to limited resources, meeting the needs of women and youth for human being
"green growth"	Provides economic growth and development; sustainable economic progress taking into account the state of the environment; more resilient, stable, manageable quality economic growth through new engines, green technologies, innovation, new jobs, rather than by increasing GDP	Focuses on the protection, maintenance and preservation of natural assets, the creation of low-carbon production, efficient use of fewer resources and energy, reducing emissions and minimizing pollution and environmental impact; ensuring climate and environmental sustainability; establishing harmony between economic interests and the state of the environment, its protection	Provides for the achievement of welfare, including social, ensuring access to the poorest sections of the population to basic goods; meeting demand in food production, transport services, housing construction and energy supply
	Emphasizes limiting the growth of production and consumption in economically developed countries, maintaining a sustainable economy,	Provides stability of biological and physical systems by support of use of secondary raw materials, minimization of quantity of waste, distribution of renewable energy sources, construction of treatment	Involves the preservation of human capital and the reduction of destructive conflicts, the fair distribution of resources among all members of

continuation of the table 2.1

1	2	3	4
sustainable development	developing and implementing new technologies, reducing investment in industries that exploit nature and increasing the share of science-intensive industries and technologies	facilities, plants on processing of household and industrial waste, reduction of the areas under dumps	society, the achievement of a dignified life and well-being, the guarantee of a minimum standard of living for all

Source: supplemented by the authors based on (Prushkivska, Shevchenko, 2013)

UNEP has identified the green economy as an economy that aims to increase the well-being of the population, make efficient use of natural resources and at the same time reduce environmental risks (United Nations Environment Programme, 2011).

UNEP and other international organizations that have supported the green economy initiative are proposing to invest up to 2% of world GDP (about $ 1.3 trillion per year) in greening the economy. Currently, about the same amount goes to subsidies, which often contribute to the "unsustainable" use of resources in sectors such as fuel production, agriculture.

The outcome document of the UN Conference on Sustainable Development "Rio + 20" (June 20 – 22, 2012, Rio de Janeiro, Brazil) entitled "The future we want" confirmed that the concept of "green economy" is designed to unite under a single flag a number of economic strategies and methods of economic analysis, relevant in terms of sustainable development (Kvasha, Musina, 2015).

It is the concept of "green economy" that has emerged as a new paradigm for the development of social formations. It contains radically new priorities of management and completely new directions of manifestation of economic factors in the environment.

Scientists such as V. Pidlisnyuk, M. Zagirnyak., Y. Irkova believe that the following interpretation can be most often found: "the economy is considered green, which leads to increased human well-being and strengthening social justice while reducing risks to the environment and the shortage of environmental resources" (Pidlisnyuk, Zagirnyak, Irkova, 2013).

The essence of the "green economy" is the possibility of effective use of existing natural resources on the basis of interregional and transnational cooperation and mutual compensation for losses (TUNZA, 2011).

J. Kvach, K. Firsova, and O. Borisov are more brief on this issue: "A green economy is an economy that increases people's well-being and ensures social justice, as well as significantly reduces risks to the environment" (Kvach, Firsova, Borisov, 2015). In turn, A. Chernykhivska believes that the "green economy" is economic development due to the wider introduction of energy efficient technologies, methods of "clean production", the use of renewable energy sources, etc. (Chirnykhivska, 2014).

In our opinion, B. Paton represents this term in very interesting way: "Green economy integrates human ecology and space into one system as a whole through economic, in particular effective market mechanisms, solving the corresponding long-term problem of sustainable development" (Paton, 2012).

Z. Lyulchak and D. Grechanyuk formulated this term as follows: "Green economy is the optimized use of irreplaceable, complementary both natural and human resources, taking into account the interests of society as a whole" (Lyulchak, Grechanyuk, 2013).

There is also a definition of "green economy" as a system of economic activities, related to the production, distribution and consumption of goods and services that lead to improved human well-being in the long run, without exposing future generations to significant environmental risks or environmental deficit (Zyabina, 2016).

In fact, the concept of a "green economy" is aimed at the long term, as it will not be possible to restart the economy quickly. It takes time to create the right institutional environment in which humanity will care for available natural resources. It is very important that the "green economy" is a tool to ensure the well-being not only for us but also to preserve it for our descendants.

The winner of the Nobel Prize P. Krugman (2009) spoke quite clear on the importance of the "green economy". He notes that when there are "negative externalities", i.e. costs borne by economic operators, while other economic entities do not pay an adequate price

for environmental pollution and the use of natural resources, the assumption that the market the economy will be self-regulating, is not working. The "green economy" provides answers to these questions (Krugman, 2010).

It is an economy that is a dependent component of the environment, within which it operates and ensures the growth of welfare in terms of reducing environmental pollution, increasing the efficiency of limited natural resources, their reuse, preventing biodiversity loss and providing ecosystem services (Stadnyk, 2013).

The category of "green economy" has a very broad interpretation in theoretical terms, in which it is understood as a tool for managing processes, related to ensuring harmonious relations (Bystryakov, 2011). This definition is rather superficial, does not take into account the peculiarities of the economy and does not provide a clear understanding of the term itself. However, it still explains what exactly the vector of action is aimed at. Creating a favorable environment to ensure harmonious relations is a rather difficult task at the present stage of development. Since market relations are far from ideal, there are many institutional barriers that need to be overcome in order to bring the environment, in which relations take place, closer to more or less harmonious.

The following important features of the "green economy" can be identified: efficient use of natural resources, conservation and increase of natural capital, reduction of pollution; low carbon emissions; prevention of loss of ecosystem services and biodiversity; income and employment growth (Novak, Datskiv, 2014).

It is noticeable from given above that the concept of "green economy" and its components have been studied by a large number of domestic and foreign scientists.

Thus, having analyzed all the above meanings of the "green economy", we can conclude that this concept is able to overcome the environmental, financial, psychological and social problems that are present today. The "green economy" is an economy that ensures the well-being of all segments of the population, with minimal risks to the environment. An economy in which people value all available natural resources is treated with care so, that our descendants can set a good example and be able to live safely in a resource-limited environment.

The very essence of the concept of "green economy", which humanity has chosen for the path of further development, is clear, but it is necessary to explore its principles, tasks for a deeper understanding and clarity of knowledge.

The main principles of the "green economy" are:

- equality and justice within one generation and between generations;
- compliance with the principles of sustainable development;
- the principle of caution regarding social consequences and impact on the environment;
- understanding the high value of natural and social capital, for example through the internalization of external environmental costs, "green" accounting, cost estimation for the entire life cycle and improved management;
- resource efficiency, sustainable production and consumption;
- the need to meet macroeconomic goals by creating "green" jobs, increasing competition and growth in key industries (Chyrnykhivska, 2014).

This concept allows to solve a number of acute problems of the domestic agricultural sphere, providing food protection of our state, social support of the rural population and minimizing environmental risks (Bilokinna, 2018).

Foreign scientists identify many market mechanisms and economic tools for the transition to the principles of "green economy", in particular:

1) public and private investment in "green production";
2) technology exchange between countries;
3) public procurement policy, which stimulates the production of environmentally friendly products;
4) targeted state support for research and development related to the creation of environmentally friendly technologies;
5) tax and budget reforms – development and implementation of appropriate environmental taxes on the principle of "pollution pays";
6) introduction of subsidies for environmentally friendly production and the corresponding abolition of resource-intensive production;
7) elimination of trade barriers for environmentally friendly products (Novak, Datskiv, 2014).

The transformation of the economy towards "green" means complex changes in sectors such as agriculture and forestry, industry, fisheries, renewable energy, water supply, tourism, transport, housing and communal services and waste management. Detailed measures to be taken during the "greening" of each of the sectors are given in Table 2.2.

Table 2.2.

Branches and directions of "greening" of the economy

Branches of the economy	Directions of "greening"
Housing and utilities	Reconstruction of residential buildings; flexible design and construction of new energy-efficient residential buildings with minimization of emissions of harmful substances; safe and clean shipment, removal, storage, utilization and processing of solid household and sewage waste
Energy industry	Investing in the infrastructure of renewable energy sources, reconstruction of existing energy and heat supply systems, smart energy systems
Transport	Investing in energy efficient modes of transport, electrification, rail transport, planning of "green" urban infrastructure for transport, use of low sulfur fuel
Industry	Reduction of harmful emissions and discharges; introduction of energy saving technologies; creation of ecological infrastructure; reduction of greenhouse gas emissions; reduction of negative impact on the vital systems of the population; waste collection, transportation, recycling and utilization, water saving; efficient use of natural resources
Construction economics	Application of environmentally friendly building materials and technologies; aesthetics of settlement creation, harmonization of coexistence of man, nature, technical solutions, business and state
Agriculture	Investing in improving of soil quality, organic production and increasing yields; clean technologies of storage and processing of raw materials; production of raw materials for non-traditional energy; efficient use of water resources, conservation of agricultural diversity; creation of agro-ecological infrastructure
Tourism	Development of green tourism; ecosystem services
Forestry and fishing	Biofuel production; creation of model forests; introduction of deforestation and fishing culture; development of forestry and landscape construction; "reasonable" consumption of natural resources

Source: formed by the authors based on (Liulchak, Grechanyuk, 2013)

Agriculture plays a very important role, as it produces not only

food for the population, but also raw materials for the secondary sector. Restructuring of agriculture is based on the production of organic products and organic farming. In this regard, some researchers put it this way: "greening of agriculture involves not only the production of organic products, but also the cultivation of energy crops and their use for energy purposes. In addition, the reorientation of the agro-industrial complex in the direction of "green economy" will reduce rising unemployment in rural areas, switch to environmentally friendly biofuels, achieve independence from traditional energy sources and reduce the cost of their consumption" (Kvach, Firsova, Borisov, 2015).

Previously, the expansion of production was only due to increased use of resources. However, in the "green economy" it is the opposite – reducing the use of natural resources, due to renewable resources, innovation and the introduction of new environmentally friendly "clean" technologies.

Ukraine, like all other countries, is trying to make changes in society and the economy on the principles of "green economy". The first serious step towards this goal, as noted earlier, was the adoption by the Verkhovna Rada of Ukraine in 2010 of the Law of Ukraine "On Basic Principles (Strategy) of State Environmental Policy until 2020". According to the draft Sustainable Development Strategy until 2030, the powers to coordinate actions, strategic planning, strategy implementation, monitoring and regular review of progress in the implementation of the strategy are assigned to the newly established National Agency for Sustainable Development under the Cabinet of Ministers of Ukraine with the authority to strategically plan the transition to sustainable development, coordinate intersectoral cooperation, integrate economic, social and environmental policies and monitor the implementation of the strategy (Draft Strategy for Sustainable Development of Ukraine until 2030, 2018).

Over the past few years, a number of crises have swept the world, from food and fuel to climate and financial. 60 percent of the world's ecosystems have degraded in the last few decades, carbon emissions have reached 40 percent, there is a significant shortage of water, a billion people are starving, another billion suffer from overeating and co-morbidities, one in four people in developing countries live

outside poverty line, two billion people live on less than $ 2 per day.

Humanity has increasingly begun to value the environment and gradually change its way of life in the direction of environmentally friendly consumption and energy efficiency in recent decades. Highly developed countries have long begun to apply the principles of the "green economy" to achieve sustainable development of their states.

At the same time, Ukraine is only taking the first steps towards a "green economy".

As a conclusion we can establish, that the "green economy" is an economy in which only energy-efficient technologies are used, ecologically clean food is consumed, production waste is disposed of, which ensures the welfare, ecological and food security of the population.

2.2. Formation of "green" efficiency of agricultural business[5]

The agricultural sector in Ukraine is one of the most promising for doing business. After all, we have a huge potential of land, material and labor resources, which is the basis for its development. However, agriculture and business need immediate institutional transformations. These changes should be carried out on the basis of a "green economy", by ensuring the welfare of the population, while reducing environmental pollution and ensuring food security of the state (Bilokinna, 2016).

I. Honcharuk notes that entrepreneurial activity in biofuel production is developing, and "green business" as a special sphere of entrepreneurial activity occupies a prominent place among the segments of interaction of productive forces and production relations on the basis of sustainability, energy efficiency, environmental protection and renewables. Promoting and putting into practice types of "green business" is the main task facing humanity today in the global dimension (Honcharuk, 2013).

To increase the volume of organic production is also important for the development of the "green economy". One of the components

[5] Kaletnik H.M., Shpykuliak O.G., Bilokinna I.D.

of organic farming is the application of organic fertilizers that are safe for the environment. The amount of applied organic fertilizers in Ukraine can be analyzed using the Table 2.3.

Table 2.3

Indicators of applied organic fertilizers in Ukraine

Indicator	2010	2015[1]	2016[1]	2017[1]	2018 [1,2]	2019 [1,2]	Deviation, +/-	
							2019 to 2010	2019 to 2015
Application of organic fertilizers, million tons	9.96	9.66	9.16	9.27	11.65	11.38	1.42	1.72
Application of organic fertilizers per unit of agricultural land area, kg per hectare	239.5	232.8	220.8	223.5	280.7	274.3	34.8	41.5
Areas treated with organic fertilizers, million hectares	0.4	0.4	0.5	0.5	0.8	0.8	0.4	0.4
Share of areas treated with organic fertilizers to the total area of agricultural land,%	1.0	1.0	1.2	1.2	1.9	1.9	0.9	0.9

[1] Excluding the temporarily occupied territory of the Autonomous Republic of Crimea, the city of Sevastopol and the temporarily occupied territories in the Donetsk and Luhansk regions (except for the area of agricultural land)

[2] Changing the methodology of state statistical observation.

Source: formed and calculated by the authors on the basis of (State Statistics Service of Ukraine, 2020)

The amount of applied organic fertilizers in Ukraine is increasing almost every year. In 2019, the amount of applied organic fertilizers increased by 1.42 million tons compared to 2010 and by 1.72 million tons compared to 2015.

The share of areas treated with organic fertilizers to the total area of agricultural land in 2019 was 1.9%, i.e. 0.8 million hectares. The application of organic fertilizers per unit area of agricultural land increased in 2019 compared to 2010 by 34.8 kg per hectare, and compared to 2015 by 41.5 kg per hectare.

Despite the fact that the level of awareness of domestic consumers about organic products and the peculiarities of their cultivation is still insufficient, however, the demand for certified

organic products in Ukraine is growing every year, amounting to 33.0 million euros in 2018, according to the Federation of Organic Movement of Ukraine (Milovanov, Konyashin, 2019) (Fig. 2.1).

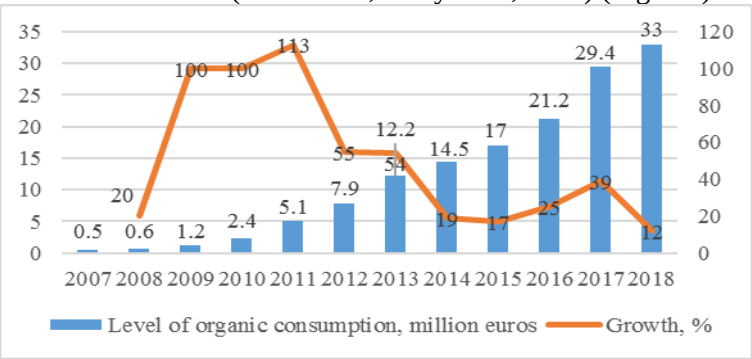

Fig. 2.1. **Dynamics of consumption of organic products in Ukraine and its annual growth**

Source: formed by the authors on the basis of (Milovanov, Konyashin, 2019)

During the period of 2007 – 2018 the largest increase in consumption of organic products in Ukraine was observed in 2011, namely 113%, then there was a sharp decline next year to 55%, there was a gradual increase in growth from 2015 to 2017, and in 2018 the increase in consumption of organic products was 12%. At the same time, in 2007 – 2018 the level of organic consumption was constantly increasing, so in 2007 this indicator reached 0.5 million euros, and in 2018 – 33 million euros.

UNEP notes that one of the main tasks of modern development is "greening" of agriculture, restoration of natural capital, provision population of drinking water and rational use of water resources, development of renewable energy and stimulating the spread of "green" tourism (UNEP, 2011). All these areas are related to some extent to the agricultural sector, the transformation of which is a key task of our state on the way to doing business on the principles of "green economy".

One of the preconditions for the development of a "green economy" is the high cost of traditional energy sources first of all, which are exhaustive and limited, which encourages a constant increase in their value.

Such Ukrainian scientists, representatives of the scientific school of Vinnytsia National Agrarian University as D. Tokarchuk, N. Pryshlyak, J. Palamarenko believe that in the conditions of practically monopolistic dependence of Ukraine on oil and natural gas imports and significant pollution of the environment by emissions, energy independence lies in the search for alternative sources of fuel and energy that would be environmentally friendly and independent of external supplies of raw materials (Pryshliak, Tokarchuk, Palamarenko, 2019).

Due to the above reasons, the use of renewable alternative energy sources in Ukraine is gaining momentum. Along with the use of solar and wind energy, bioethanol, biodiesel, biogas, solid biofuels, which are derivatives of agricultural production, are actively used. Therefore, it is appropriate to analyze the amount of agricultural products produced in Ukraine, which are raw materials for the production of the above mentioned alternative energy sources and fuels (Table 2.4).

Таблиця 2.4

Production of crops that can be raw materials for biofuel production in Ukraine, thousand tons[2]

Crops	2015	2016	2017	2018	2019	Deviation, +/- 2019 to 2015
cereals and legumes[1]	60126	66088	61917	70057	75143	15017
factory sugar beets	10331	14011	14882	13968	10205	-126
sunflower	11181	13627	12236	14165	15254	4073
beans	3931	4277	3899	4461	2751	-1180
rapeseed and colza	1738	1154	2195	2751	3280	1542

[1] In the mass after processing.

[2] Data excluding the temporarily occupied territory of the Autonomous Republic of Crimea, the city of Sevastopol and the temporarily occupied territories in the Donetsk and Luhansk regions.

Source: formed by the authors on the basis of (State Statistics Service of Ukraine, 2020)

We can conclude from the Table 2.4 that in 2018 the production of mostly all these crops increased, except for sugar beets, which production decreased by 914 thousand tons. A sharp increase in

production in 2018 was soybeans, rapeseed and colza, namely soybeans by 14.4% and rapeseed and colza by 25.3%. In addition, in 2018 the production of cereals and legumes, sunflower, soybeans, rapeseed and colza reached the highest levels for the period 2013 – 2019. In addition, it is necessary to analyze the area involved in the production of crops listed in Table 2.5.

Table 2.5

Harvesting area of agricultural crops, which can be raw materials for biofuel production, thousand hectares

Crops	2015	2016	2017	2018	2019	Deviation, +/-	
						2019 to 2015	2019 to 2018
cereals and legumes	14641	14337	14560	14794	15279	638	485
factory sugar beets	237	291	314	275	221	-16	-54
sunflower	5166	6087	6061	6167	5849	683	-318
soybeans	2136	1859	1982	1729	1580	-556	-149
rapeseed and colza	671	449	786	1039	1285	614	246

Source: formed by the authors on the basis of (State Statistics Service of Ukraine, 2018; State Statistics Service of Ukraine, 2020)

We see from Table 2.5 that in 2019 there was a rapid increase in harvesting areas of rape and colza by 23.4% (by 246 thousand hectares) compared to 2018, as well as increased harvesting areas of cereals and legumes by 3% (by 485 thousand hectares), but the area of soybeans decreased by 149 thousand hectares. Thus, the increase in the gross soybean harvest in 2018 was not due to the increase in sown areas, which is a positive factor.

Adaptation of the domestic agricultural sector to modern orientations of the global economy involves intensification of the whole set of factors aimed at effective support of the industry, significant changes in the policy of protection of domestic producers, adequate to WTO requirements and aimed at revealing the multifunctional role of agriculture (Furman, Pronko, 2019).

About 1.9 million tons of diesel fuel and 0.6 million tons of gasoline are used annually in the agricultural sector of Ukraine's economy for agricultural works. Almost 4.5 million tons of oil are used to produce this amount of fuel, which is mainly imported from

other countries. The constant increase in its value leads to an increase in the cost of petroleum products and, consequently, agricultural products. Therefore, the traditional option of meeting the energy needs of agriculture through only petroleum products is unpromising (Mosiy, Brevus, Ponomar, 2016). This proves once again that it is necessary to actively develop alternative energy and increase the share of non-traditional energy sources in the agricultural sector, which are renewable and much cheaper in the future.

The volume of biofuel production is increasing every year, so it is necessary to analyze the current state of bioenergy in Ukraine (Fig. 2.2).

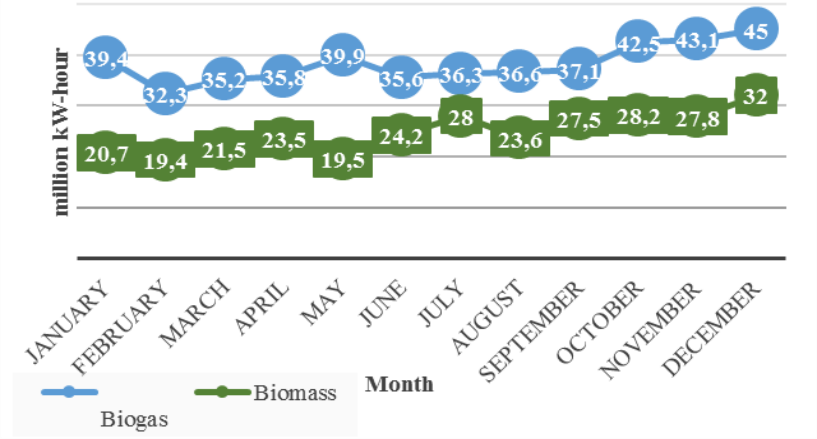

Fig. 2.2. **Production of electricity from biogas and biomass in Ukraine in 2020, million kW·hour**

Source: formed by the authors on the basis of (Bioenergy Association of Ukraine, 2021)

Fig. 2.2 shows that the production of electricity from biogas and biomass has been steadily increasing during 2020. In December compared to January 2020, electricity production from biogas increased by 5.6 million kW·h, and from biomass – by 11.3 million kW·h. Thus, electricity production from biomass in 2020 was 5.7 million kW·h higher than the corresponding production from biogas. We consider positive the increase in electricity production from these types of renewable energy sources.

Biogas production from plant waste is an efficient and

investment-attractive technology due to the presence of significant raw material potential in Ukraine, favorable climatic conditions and low cost of this type of energy (Tokarchuk, Pryshlyak, Palamarenko, 2020).

Agriculture is a source of raw materials for the production of alternative fuels and energy. This is its "green" efficiency, as not only the development of organic production and agriculture is a sign of "green" efficiency of agriculture, as well as the cultivation of crops, which later become raw materials for alternative energy and fuel.

A significant amount of energy is in by-products (straw, glycerin, pulp, etc.), which can also be successfully used for energy needs, in particular in direct combustion with appropriate preparation (grinding, granulation, pressing, briquetting, etc.) or after conversion to biogas or liquid biofuels using appropriate technologies (Kaletnik, Tokarchuk, Skoruk, 2020).

Presenting the content of the concept of "green economy" as a system of structuring socio-economic life and economic process on the basis of sustainable development, gives us reason to emphasize that biofuel production should be considered a component, subsystem, which is gaining ground and approval in Ukraine. The reason for this state is the objective conditions of development and prerequisites for sustainability, among which the motivation for the use of renewable energy sources becomes crucial (Honcharuk, 2013).

We agree with the opinion of I. Honcharuk, who notes that "green" agricultural entrepreneurship, i.e. carried out with the widespread use of renewable energy sources, indirectly acts as a self-regulatory incentive to achieve "green" energy independence. Interpreting the concept of "green" economy, it is advisable to introduce into the system of scientific research the category of "green" energy independence. Comments on the meaning of this concept as a set of evaluative characteristics of the "green", in particular renewable energy in the overall balance. Greening energy independence is also an effective way to develop businesses as part of achieving sustainability priorities (Honcharuk, 2020).

Energy cooperatives are part of a global trend towards decentralization of production and production of energy from renewable energy sources (RES). Energy cooperatives are most

actively developing in the EU. Such communities are engaged in generating electricity and providing heat to members of cooperatives. At the same time, the surplus of electricity is sold at a "green" tariff to the general grid. Global experience in the field of energy cooperatives can be used by individuals, communities, small and medium-sized businesses in Ukraine as an effective way to achieve independence from large energy suppliers (Ecodevelop supports the global trend of creating energy cooperatives, 2019).

This is an ecological business that will allow rational use of the roof area of utilities, reduce CO_2 emissions, and given the trend of increasing energy costs, use cheap clean energy and earn.

According to the Bioenergy Association of Ukraine, the total production of "green" electricity in 2020 amounted to 10,180 million kW·h, of which in percentage: solar power stations – 58%; wind power stations – 32%; small hydroelectric power plants – 2%; bio thermal power plants – 3%; biogas – 5% (Bioenergy Association of Ukraine, 2021).

According to the State Agency for Energy Efficiency and Energy Saving of Ukraine, the number of households that install solar electrical installations is increasing every year. Accordingly, the installed capacity of solar power plants is increasing rapidly (Figs. 2.3, 2.4).

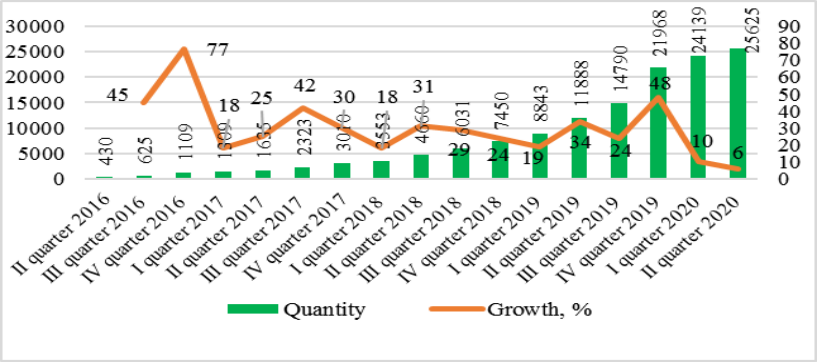

Fig. 2.3. **Number of households that have installed solar electrical installations**

*information for the second quarter of 2020 LLC Poltavaenergozbut did not provide

Source: formed by the authors on the basis of (State Agency for Energy Efficiency and Energy Saving of Ukraine, 2020)

As we see from Fig. 2.3, more than 25,000 households have installed solar installations. Their number in the second quarter of 2020 compared to the corresponding quarter of 2016 increased by 25,195.

The installed capacity of household solar installations in the second quarter of 2020 was more than 658 MW. Only for the first half of 2020 105 MW of solar installations were installed, and compared to the corresponding period in 2016, the capacity increased by 652.9 MW.

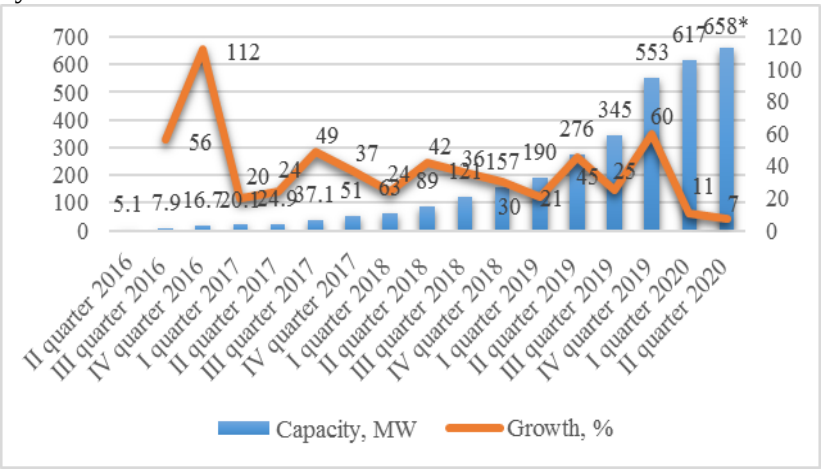

Fig. 2.4. **Installed capacity of solar electrical installations, MW**

*information for the second quarter of 2020 LLC Poltavaenergozbut did not provide

Source: formed by the authors on the basis of (State Agency for Energy Efficiency and Energy Saving of Ukraine)

Thus, the population increasingly understands the importance of production and consumption, as well as the benefits of solar energy every year. Therefore, solar installations are being installed by more and more households, not just large companies, because it brings economic benefits.

We propose to analyze the number of functioning cooperatives in Ukraine over the past five years. Which will allow us to judge the state of institutional support for the development of entrepreneurship and social benefits for the population (Table 2.6).

Table 2.6

Number of functioning cooperatives in Ukraine as of the end of the respective year

Type of cooperatives	2016	2017	2018	2019	2020	Deviation, +/- 2020 to 2016
production	2306	2248	2222	2206	2195	-111
Service	18169	18654	19055	19547	20046	1877
consumer	748	749	753	762	776	28
agricultural production	997	996	1005	1009	1000	3
agricultural service	1017	1073	1207	1270	1279	262
Total	26460	26975	27524	28071	28596	2136

Source: formed and calculated by the authors on the basis of (State Statistics Service of Ukraine, 2020)

We see from Table 2.6 an increase in cooperatives in Ukraine in 2016 – 2020 by 2136 and at the end of 2020 their number was 28596.

There is a decrease in production cooperatives for the study period by 111 and the end of 2020 their number was 2195. In 2016-2020 there was an increase in service cooperatives by 1877 and at the end of 2020 their number was 20046. There is also an increase in consumer cooperatives by 28 during the study period. Agricultural production and service cooperatives for 2016-2020 increased by 3 and 262 respectively. Thus, over the last five years, the institutional environment has had a positive impact on the creation of cooperatives, and businesses are beginning to understand the economic benefits of cooperatives.

I. Honcharuk's opinion is correct, noting that institutional energy independence and energy security in their formation include such interdependent factors as: infrastructure, technologies, progressive social capital, investment in the future of sustainable development, environmental standards, the availability of the necessary technical and technological tools for realizing the existing potential of energy efficiency, including in the production of alternative energy sources (Honcharuk, 2020). Thus, the creation of "green" energy cooperatives can be considered one of the components of energy independence and energy security in Ukraine, including in the

agricultural sector.

In Ukraine, in accordance with the Concept of the "green" energy transition of Ukraine, by 2050 the share of renewable energy sources should increase to 70%, but at the same time its cost should be balanced and economically justified (Ministry of Energy and Environmental Protection of Ukraine, 2020). In the conditions of a monopoly on the market for the production and supply of electricity, it will be very difficult to achieve a balanced price, since the monopolist always dictates "his own rules of the game". Therefore, in our opinion, prosumers (consumer + producer) can change the situation. That is, these are market entities that simultaneously produce and consume electricity.

The ideal of prosumer in this case is an energy cooperative. Such cooperatives become active participants in the electricity market because they use it for their own purposes and sell the surplus. And since according to the Concept of "green" energy transition of Ukraine until 2050, we seek to significantly increase the share of renewable energy sources, it is necessary to increase the number of "green" energy cooperatives that can generate, store and use environmentally friendly electricity.

The creation of "green" energy cooperatives will increase the share of renewable energy sources in the agricultural sector, significantly reduce the costs of the rural population and make them energy independent (Shpykuliak, Bilokinna, 2020).

The role of decentralized electricity supply is expected to increase significantly, requiring the use of modern technologies related to demand management, distributed storage and distributed generation (Honcharuk, 2020).

The development of cooperation should become one of the important areas of agricultural policy in the field of institutional transformation (Malik, Shpykuliak, Luzan, 2013).

This practice is being tested in Ukraine. So far in Ukraine there are only a few examples of such communities. Thus, in 2016 in the Kharkiv region, 12 agricultural entrepreneurs joined an energy cooperative for the production of biofuels for refueling their own vehicles. The equipment was purchased with a UN grant. As a result, due to the use of biofuels for sowing and harvesting, these farms have reduced the cost of their agricultural products by a third

(Ecodevelop, 2019).

Also two more energy cooperatives were established in 2018, namely the municipal energy cooperative "Sunny City" in Slavutych and LLC "Berezdovsky Energy Cooperative".

There are also communities in Ukraine that have already started using the green energy cooperative model, but not yet legally. For example, residents of the village of Losyatyn (Kremenets district, Ternopil region) on the basis of the existing agricultural service cooperative "Yahidnyi krai" organized the processing of production waste into fuel briquettes. Cooperative production waste – raspberry stalks, which need to be cut every autumn after the end of the season, is used as a cheap energy resource (Zinchenko, Sklyarov, Bondarchuk, 2017).

"Yahidnyi krai" can be taken as an example by any community in Ukraine, since those agricultural wastes that used to be simply destroyed can now bring significant economic and energy benefits. Residents of Ukrainian villages need to unite to get rid of a number of problems, first of all to have cheap electricity and heating of their buildings.

The establishment of energy cooperatives is important to combat the problem of waste disposal in Ukraine. Thanks to modern technology, this problem can be a new source of profit, rather than costs, as before. The fact is that the waste of agricultural enterprises, food industry enterprises are raw materials for the operation of biogas plants. Therefore, biogas can be produced as a result of utilization of waste of organic origin in biogas complexes.

However, in this case, it is very important to properly analyze the raw materials and final products, as well as to ensure a systematic supply of raw materials in the required volumes. Due to the fact that the waste of different enterprises in turn have different composition and acidity, it is necessary to correctly calculate the combination of waste for the substrate. Because it is necessary to maintain an appropriate pH level, the ratio between carbon and nitrogen, the presence of inhibitory methanogenesis compounds (Utilization of waste by means of biogas complexes, 2019).

The fact is that the reaction with the formation of methane can occur only under certain conditions. Too high or too low pH prevents oxidation of the substrate. As a result, biogas contains too little

methane or has too many impurities.

A universal solution to this problem is the creation of energy cooperatives consisting of enterprises in various industries. For each of the participants the problem of waste disposal is solved, and the produced biogas is spent on heating or electricity generation (Utilization of waste by means of biogas complexes, 2019).

Consider the possible structure of a "green" energy cooperative on the example of the energy cooperative "Sunny City", which it is located in the city of Slavutych.

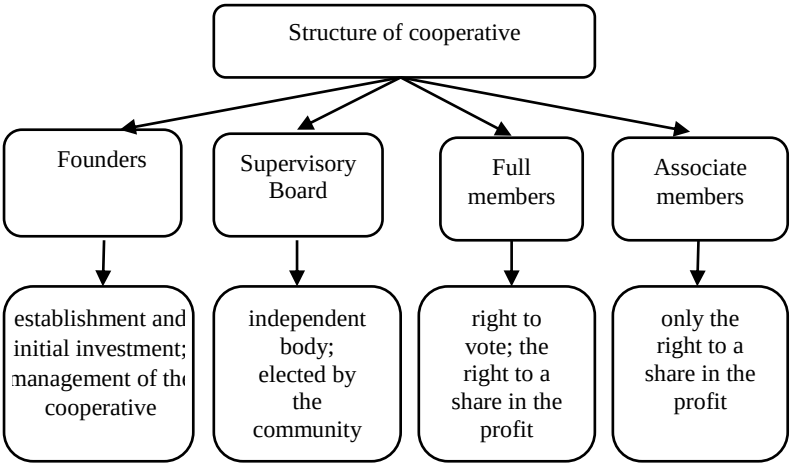

Fig 2.5. **The structure of the energy cooperative "Sunny City"**

Source: formed by the authors on the basis of ("Solar Cooperative": Slavutych - a city for investment, 2019)

As we see from Fig. 2.5, there are founders, supervisory board, full and associate members in the energy cooperative "Sunny City". Each of them plays a role in the activities of the cooperative. The Supervisory Board plays the role of the supervisory body. There is a significant difference between full and associate members, namely in the right to vote, the former have it and the latter do not.

In addition, the model of the submitted cooperative differs from the usual us, for example, a limited liability company. The fact is that one share in this cooperative costs UAH 15,000, but if the investor has 5 shares – he will have one vote, like the one who has one share. That is, each member of the cooperative has one vote, regardless of

the number of shares. In this way, the energy cooperative is free from discrimination from within and thus ensures social justice in the management process.

Germany and Austria are among the leading countries in the establishment of energy cooperatives. For example, 14 energy cooperatives were established in Germany in 2019. These include six local heating cooperatives and two energy cooperatives, each specializing in photovoltaic and wind energy. The business models of other new energy cooperatives are very different.

The Energy Cooperative will promote e-mobility in its region. Most cooperatives were founded in Bavaria, namely six energy cooperatives. These are mainly local heating cooperatives (Neugründungen von Energiegenossenschaften in 2019, 2020).

Germany began its path in the development of energy cooperatives a long time ago and their number in this country is increasing every year (Fig. 2.6).

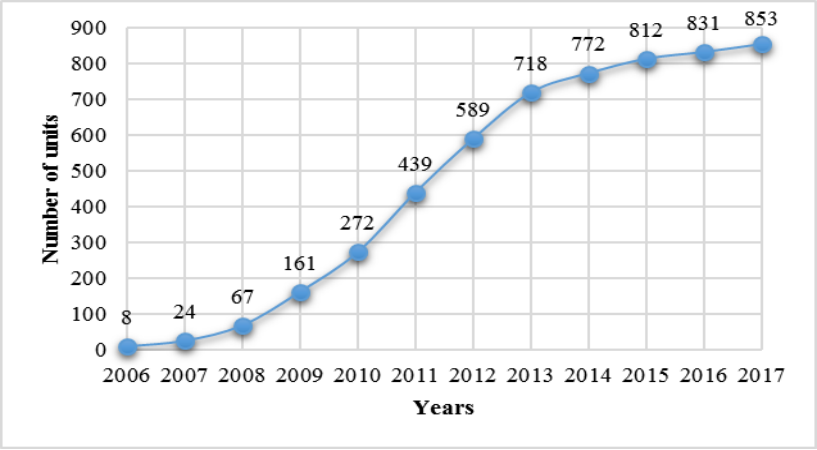

*Fig. 2.6.***The number of formed energy cooperatives in Germany during 2006-2017 years**

Source: formed by authors based on (Shpikulyak, Ivanchenko, 2018)

In 2006, the number of energy cooperatives in Germany was 8, and in 2017 – 853. Thus, in 2006-2017, the number of energy cooperatives increased 106 times. Recently, the institutional environment for the development of green energy cooperatives in Germany has deteriorated slightly, which has contributed to a

decrease in the growth of their number. The fact is that a very small number of energy cooperatives win tenders in the country, thus restrictions are implemented, negatively affecting the activities of this type of cooperatives.

Every cooperative in Germany must be a member of one of the legally recognized cooperative (audit) unions, which verifies the establishment of the cooperative in the interests of its members and creditors. Verification at the establishment stage is a necessary precondition for entering a cooperative in the register of cooperatives. During the inspection, the cooperative union must provide an opinion on the economic viability of the cooperative, the legal basis (statute) of its activities, the effectiveness of assistance to members of the cooperative and in general the absence of threat to the property of cooperative members and creditors. The cooperative has the right to choose the union independently (Baiko, 2016).

According to the Federal Office for Energy Cooperatives, there are a total of 843 energy cooperatives in Germany by the end of 2020, bringing together 200,000 people. They invested a total of 2.9 billion euros in renewable energy and generated about 8.31 TWh of clean electricity in 2019. This avoided 3.39 million tons of CO_2 emissions (Bundesgeschäftsstelle Energiegenossenschaften, 2020).

In 2019, Germany installed 29,456 wind turbines with a total capacity of 53,912 MW, which means that wind power is the dominant renewable energy source in the electricity sector. The share of wind energy in the total electricity consumption in Germany at the present stage is 24.5%. By generating wind power onshore in Germany, over 76,000,000 tons of CO_2 emissions were avoided in 2018 alone. The federal government's goal is for the share of renewables in electricity supply to rise to 40-45% by 2025, and then steadily increase thereafter. Wind energy will play an important role in this (Feldheim wind farm, 2020).

In Feldheim, Germany, 55 wind turbines with an electrical capacity of 122.6 MW supply energy to 65,403 households. 284 motors with 9844 PV modules produce 2.25 MW of power. Thus, the annual output is 2,748 MW. This covers the annual electricity needs of about 600 households.

The village of Feldheim has a biogas plant with an installed electrical capacity of 526 kW since 2008, which is run by a local

agricultural cooperative. 8600 m^3 of liquid manure, as well as 8700 tons of corn and 190 tons of grain flour are used as raw materials. These raw materials are produced and supplied by an agricultural cooperative. The plant annually produces 4 million kWh of electricity supplied to the public grid. The heat generated from power generation is fed into a purpose-built district heating network that supplies residents, livestock farms and commercial facilities. By providing their villages with autonomous heating, the residents of Feldheim save 259,000 liters of fuel oil annually (Feldheim wind farm, 2020).

Another successful German example of the creation of an energy cooperative is located in the village of Herbraum-Wald. The number of inhabitants of this village is 138 people. Previously, the heat supply in this village was carried out with the help of fuel oil. Then the residents decided to create an energy cooperative. Now they receive the heat from a boiler house that uses wood chips. Chips are supplied by local forestry, which also has a positive effect on the economic situation of this village, as it makes it easier to plan the price of the specified raw materials.

Table 2.7

Features of energy cooperatives in Germany and Austria

Energy cooperatives	Germany	Austria
1	2	3
Establishment	1. Constituent meeting: approval of statutory documents, election of members of the board and supervisory board; 2. Mandatory participation in the cooperative / audit union; 3. Conclusion of the cooperative union based on the results of the inspection of the cooperative; 4. Submission of documents required for registration to the relevant court.	1. Constituent meeting: approval of statutory documents, election of members of the board and supervisory board; 2. Mandatory participation in the cooperative / audit union; 3. Conclusion of the cooperative union based on the results of the inspection of the cooperative; 4. Submission of documents required for registration to the relevant court.

continuation of the table 2.7

1	2	3
Membership	At least three individuals or legal entities; the maximum number of members is unlimited. Each member of the cooperative has only one vote at the general meeting, regardless of the amount of invested capital.	At least three individuals or legal entities; the maximum number of members is unlimited. Each member of the cooperative has only one vote at the general meeting, regardless of the amount of invested capital.
Capital	Minimum capital is not required for establishment.	Minimum capital is not required for establishment.
Responsibility	Limited liability: personal liability of members is limited to their contribution. Liability to creditors for the obligations of the cooperative is repaid only from the property of the cooperative. It is possible (provided for in the charter) to make additional (cash) contributions in the case of bankruptcy of the cooperative, if the property of the cooperative is not enough to meet the requirements of creditors.	Liability can be: unlimited (members of the cooperative are jointly and severally liable for the obligations of the cooperative with all their property in case of liquidation or bankruptcy of the cooperative, if the property of the cooperative is insufficient to repay these obligations) or limited (in case of bankruptcy or liquidation) of cooperative, its members are liable for its obligations within their shares and the amount equivalent to the size of membership shares or only within the share contributions).
Licensing	On a general basis.	On a general basis.
State support	In general, support for the renewable energy sector (fixed green tariffs and the right of priority access to public energy networks).	In general, support for the renewable energy sector (fixed green tariffs and the right of priority access to public energy networks).

Source: formed by the authors on the basis of (Baiko, 2016)

In total, the residents of Herbraum-Wald have invested more than 750,000 euros in their energy infrastructure (Zinchenko, Sklyarov, Bondarchuk, 2017).

Trisdorf, Germany, became the first city in Europe where a biogas plant in combination with a heating system provides heat to

about 50 educational buildings, as well as a dairy complex. The electric power of the station is 290 kW, which covers the basic electrical load of the cooperative's facilities throughout the year. And two wood-fired boilers with a total heat output of 2150 kW meet the additional need during the heating period. At the same time, a large buffer reservoir with a volume of 120 cubic meters can compensate for the daily consumption peaks. In addition, the biogas plant supplies electricity to the public grid sufficient to supply 700 households (Ecodevelop, 2019).

Energy cooperatives are also common in Australia, with Hepburn Wind being an example. It is a wind farm located in Leonards Hill, Victoria, which consists of two 2.05 MW turbines. This cooperative was founded in 2007 by the Hepburn Renewable Energy Association, now known as Sheiro (Share) (Hepburn Wind, 2012). The purpose of creating this project was the idea of the population that the authorities are not fighting enough to combat climate change, so you need to show your own example. The said cooperative has more than 2000 members, most of them are local people. The cooperative provides electricity to 2,300 households in Hepburn, as well as the neighboring two Daylesford and Hepburn Springs, which have about the same number of residents.

The UK can be considered another successful country in the creation of energy cooperatives. There are currently a large number of energy cooperatives in this country specializing in renewable energy sources. There are cooperatives that produce and use solar, wind, hydropower and biomass energy. There is a community of green energy cooperatives called Energy4All. It was created in 2002. Energy4All offers a very successful combination of industry expertise, community engagement, ethical investment and business acumen by providing a package of administrative and financial services for cooperatives in return for an annual fee. That is, cooperatives, paying a certain amount, have comprehensive support from the community, it is very important not only for newly cooperatives.

As we can see, the UK has long started producing energy from renewable sources and already has significant experience in this area.

Green energy cooperatives are quite common in this country. Actually, thanks to them, renewable energy is rapidly developing. 27 cooperatives are part of the Energy4All communities. Most of them use wind energy, namely 13 solar energy – 9, hydropower – 4 and biomass energy – 1. Historically, the UK is located on islands where there are constant winds, therefore, this type of alternative energy is more common here.

At the end of 2007, with the support of Scottish Cooperative Development, the Edinburgh Public Energy Cooperative was established to enable Edinburgh residents to promote and develop renewable and low-carbon energy production in the city. After five years of studying the various options with little success, it was decided to move on and create a new cooperative, which will primarily focus on the implementation of a large-scale photovoltaic project for Edinburgh. This new cooperative was the Edinburgh Public Solar Cooperative (ECSC), which was established in 2013. This cooperative has solar panels, which are installed on the roofs of 24 buildings in the city. The cooperative has more than 540 members, 12 directors (of which 7 are members and 5 are appointed). The total capacity is 1.38 MW, which produces 1.1 GWh per year.

In the 2018/19 fiscal year, the ECSC Edinburgh Public Solar Cooperative earned a gross profit of £ 6,432 with a turnover of £ 210,448, and in the 2017/18 fiscal year the profit was £ 5,076 with a turnover of £ 215,474 (Edinburgh Community Solar Cooperative, 2020).

In the United Kingdom, including Scotland, the population is actively creating "green" energy cooperatives, which indicates the existence of an appropriate institutional environment that contributes to this. People understand the benefits of renewable energy and are willing to invest in green projects by joining cooperatives.

In the United States, a fairly large part of the electricity market is occupied by energy cooperatives formed by communities.

In total, there are 903 cooperatives in this country that deal with the distribution (delivery to the final consumer) of electricity. They provide power to 42 million people in 47 states. The service areas of these cooperatives cover 75% of the US territory. All these networks, together with all the equipment belonging to them, are directly

owned by the members of the respective energy cooperatives (Zinchenko, Sklyarov, Bondarchuk, 2017).

2.3. Strategic priorities for the development of the "green economy" in the agricultural sector[6]

Economic dynamics, efficiency and prospects of development of the agricultural sector, globally depend on the institutional capacity to implement aspects of sustainable development, the principles of management on the basis of sustainability, preserving the potential for future generations. In terms of production, assessing the priority principles of sustainable development, one of its preferred models is the "green" economy, especially in the context of understanding that agricultural functions are directly related to nature. In general, the meaning of this question is that the conceptualization and implementation of the model of agricultural sector development on the basis of "green" economy is a priority of foreign practice and should become so for the domestic. The discussion on determining the organizational and economic aspects of the development of the agricultural sector on the basis of the "green economy" is actualized in practice in the application of the scientific concept of the same name as a system of priorities for sustainable management.

Greening of agriculture involves not only the production of organic products, but also the cultivation of energy crops and their use for energy purposes (Chaika, 2011). Characterizing the production of biofuels as a subsystem of the green economy, we note that one of the sources of biofuel production is the use of the huge potential of domestic agriculture in the following aspects: processing of agricultural waste (straw, manure, pieces of wood); use of crops on biofuels, but under conditions of guaranteeing food security and adequacy of raw material potential for the processing industry, as well as meeting export opportunities (Organic Production, 2014). In addition, the reorientation of the agro-industrial complex in the direction of "green economy" will: reduce unemployment in rural areas; switch to environmentally friendly biofuels; achieve

[6] Kaletnik H.M., Shpykuliak O.G., Bilokinna I.D.

independence from traditional energy sources and reduce the cost of their supply (Chaika, 2011).

In order for the "green" economy to be effectively implemented in all sectors, including the agro-industrial complex, a well-organized work of relevant institutions and state support is needed. The process of forming the state policy of sustainable development is extremely complex at the level of interaction of institutions and the relationship of their functional responsibilities (Honcharuk, 2013) (Table 2.8).

Table 2.8

Institutional and functional scheme of sustainable development policy

Institutions	Functions
UN	Formation of principles of sustainable development, introduction of mechanisms of "green economy"
European Union	Legal regulation through norms and standards
The president	Political decision-making
Verkhovna Rada	Legislative support
Cabinet of Ministers	Regulatory support
Court	Practical implementation of legal support, protection of rights
Media	Formation of public opinion, informing the public
Business	Implementation of "green economy" projects
NGOs	Formulation of public initiatives, implementation of projects

Source: formed by the authors on the basis of (Potapenko, 2014)

At the present stage of development, the basis for the transformation of the agricultural sector on the basis of the "green economy" are: National Economic Strategy for the period up to 2030; Energy Strategy of Ukraine for the period up to 2035; Basic principles (strategy) of the state ecological policy of Ukraine for the period up to 2030.

There are also other formal institutions that help increase resource efficiency, reduce emissions of harmful substances into the environment, improve the quality of agricultural products and their compliance with European standards, through the introduction of eco-technologies in the production process, namely: National Waste Management Strategy in Ukraine until 2030 year; National Transport

Strategy of Ukraine for the period up to 2030; Strategy for the development of exports of agricultural products, food and processing industries of Ukraine until 2026, etc.

This allows to develop agribusiness in Ukraine in accordance with the principles of "green economy", thus not just to make a profit from business, but to improve and create decent competition in the markets of leading countries Institutional changes in agribusiness will overcome one of the main problems of the state – unemployment. After all, the restructuring of the existing economic system on the basis of a "green economy" will create new jobs. Agriculture and business will need qualified personnel in new areas, so a certain percentage of the population will be able to realize their potential, while receiving a decent salary.

Along with formal institutions, informal institutional factors, such as culture, traditions, habits, and value systems, play an important role in influencing the behavior of economic entities. It can be stated that most of these factors do not contribute to the achievement of strategic goals of agricultural production. In particular, as noted by Academician V. Geets, the basic condition for the development of society and economy is trust. In reality, the level of trust of agricultural producers in the intentions and actions of the state, even if they are positive, is quite low. Many years of experience in their interaction with the state have led to the idea that the state often does not fulfill its obligations, acts opaquely, creates additional bureaucratic obstacles, violates the terms of subsidy payments and more. Therefore, even the positive steps of the state to form formal institutional mechanisms to support the agricultural sector of the economy do not find a proper response from producers (Kucherenko, 2016). The change of informal institutions to new ones, built on the principles of "green economy", will strengthen the position of the state "in the eyes" of agricultural businesses and it will motivate the development of economic relations aimed at welfare and reducing the environmental impact.

Organic movement in Ukraine is developed by: Federation of Organic Movement of Ukraine, Association "Pure Flora", Association "Poltava-Organic", International Public Association of Bioproduction Participants "Biolan Ukraine", Club of Organic Agriculture, Union of Organic Farmers "Naturproduct" and many

other organizations. An important step in the state regulation of agro-industrial production was the adoption on 03.09.2013 of the Law "On production and circulation of organic agricultural products and raw materials" (Law of Ukraine "On production and circulation of organic agricultural products and feedstock", 2013).

The green economy is the salvation of humanity, a chance to start all over again, by stabilizing the economy, rational use of natural resources and social justice. Agriculture is the most important branch of the economy, as it provides the basic needs of the population in food. Therefore, first of all, it needs "green" transformations, namely investment in improving soil quality, organic production and increasing yields; clean technologies for storage and processing of raw materials; production of raw materials for non-traditional energy; efficient use of water resources, conservation of agricultural diversity; creation of agro-ecological infrastructure.

One of the priority programs of Ukraine's development in the field of "green economy" is the "EaPGREEN" program. The goal of the program is the transition of the Eastern Partnership (EaP) countries to a "green" model of business development and business by distinguishing between economic growth and environmental degradation and depletion of resources (Kvach, Firsova, Borisov, 2015).

The participation of our state in this program is a very positive moment, as we need additional financial support for the "green" transformation of the economy. That is, this institution has made it possible to develop by reducing material intensity, reducing the use of energy resources, reducing the dispersion of toxic substances, intensifying the use of renewable energy sources, increasing the intensity of services.

We agree that green business is first and foremost a profit-making business. In the short run, value-added will always have a higher priority than the prerogatives to reduce environmental impact and optimize resource use, other things being equal. However, the desire to maintain and strengthen competitive positions in the markets encourages companies to choose long-term strategies that take into account the prospects of expanding markets for environmental goods and services, the possibility of introducing and reducing the cost of new eco-efficient technologies, reducing energy prices from

renewable and alternative sources. National governments play an important role in stimulating these processes through the implementation of relevant standards and regulations, increased financial resources for research, development and demonstration of new technologies, reduced subsidies for the supply and use of fossil fuels – the main source of pollution (Ministry of Economy, 2016).

Theoretical principles of sustainable development policy, consolidation of society, improving the welfare of the population may include the development of environmental and social imperatives, which provide justification for the introduction of a new way of management, as close as possible to the laws of nature, rational use, prevention and reproduction of environment and natural resources. To radically reform the national economy, it is necessary to pay special attention to the environmental and social components of the state's development. The practical implementation of the relevant imperatives in all parts of the economic mechanism should contribute to the achievement of sustainable development goals, stimulate the formation of a "green" economy (FAO and WHO, 2019).

We agree with the opinion of I.G. Britchenko, who notes that in many European countries, small businesses generate up to 60% of cash flows to the budget. In Ukraine, small enterprises almost do not participate in the formation of the revenue side of the budget of both regions and the state as a whole, but the development of entrepreneurial activity is taking place (Britchenko, 2010).

In the light of the achievements of the International Year of Family Farms (IFRS) and the previous December 20, 2017 campaign of IFRS + 10, the UN General Assembly declared 2019 – 2028 the Decade of Family Farms of the United Nations (UNFPA) at its 72nd session. The UN SFG serves as a basis for countries to develop public policies and investments to support family farms and help achieve the UN Goals. During this decade, the issue of family farms will be considered in terms of a holistic approach to rural poverty in all its forms and dimensions, with CSWs playing a leading role in the transition to more sustainable food systems and societies. To ensure the success of the UN SFG, action must be supported by a coherent cross-sectoral policy that simultaneously addresses the environmental, economic and social aspects of agricultural and rural development (Malik and Fedienko, 1999).

Producers of agricultural products due to rising resource prices, ie rising inflation, are unable to provide the production process with sufficient water for irrigation, fertilizers, plant protection products and more. In addition, in the process of managing the principles of "green economy", each of the stages should be carried out in such a way as not to violate the environmental safety of the population and the environment. Due to the positive economic balance, Ukrainian farmers have increased the sown areas of sunflower, corn and rapeseed in recent years. These crops yield a significant amount of nutrients, moisture and reduce soil fertility. In addition, the bulk of these crops grown in our area are exported as raw materials for the production of environmentally friendly fuels. Thus, we create environmental risks for our economy and thus protect the economies of other countries.

The development of market relations in modern conditions is associated with increased competition between economic systems from the state to the individual entrepreneur at different levels of business contacts. This necessitates strengthening the capacity of economic entities and strengthening their competitiveness, which is expressed through a set of competitive advantages, thus such qualities that provide advanced socio-economic development (Britchenko, Gavrilko, Zavadiak, 2012).

Thus, the strategic imperative for the development of a "green economy" in the agricultural sector of Ukraine is to increase family farms of all agricultural areas (crop, livestock, fisheries and forestry). That is, the institutional transformation of personal peasant farms into family farms is necessary. Let's analyze the number of private farms in our country using Table 2.9, in order to understand the scale of transformation.

Table 2.9

Number of private farms in Ukraine[1]

	On January 1, 2019	On January 1, 2020	Deviation, 2020/2019, +/-
1	2	3	4
Number of farms, thousand	3 996.5	3 975.1	-21.4
Area of land plots, thousand hectares	6 132.2	6 133.6	1.4
including with the intended purpose			

continuation of the table 2.9

1	2	3	4
for construction and service of a house, economic buildings and constructions	791.0	788.3	-2.7
for personal farming	2513.4	2512.6	-0.8
for conducting commodity agricultural production	2 777.1	2 781.8	4.7
of which are rented	345.0	348.2	3.2

[1]Data are given without taking into account the temporarily occupied territory of the Autonomous Republic of Crimea, the city of Sevastopol and part of the temporarily occupied territories in Donetsk and Luhansk regions.

Source: calculated by the authors based on data from the State Statistics Service of Ukraine

The number of private farms as of January 1, 2020 is 3975.1 thousand, which is 21.4 thousand less than last year. However, the area of land increased by 1.4 thousand hectares and amounted to 6133.6 thousand hectares. That is, it indicates the expansion of land area of personal farms. The increase in this area is due to rent.

Family farming solves a number of economic, environmental and social problems. With the expansion of family farms, the economic situation in the country will improve, as the number of jobs will increase, which will reduce the unemployment rate among the working population of our country. The quality of agricultural products on the market will improve, as representatives of family farms sell products that they consume themselves, so they use a minimum amount of harmful substances in the management process. Problems of a social nature, first of all, gender equality, are solved, because in a family farm both men and women have equal rights to decent work and equal remuneration for work on their own farm. In addition, family farming will lead to the development of rural areas.

In our opinion, the state should promote the development of family farming in Ukraine in the following areas:

- providing positive institutional support for sustainable development of family farms;

- assistance to family farms in the development of organic production and certification of their lands;

-promoting the return of young people to rural areas for

permanent residence and the creation of family farms;

- encouraging family farms to unite and create rural cooperatives;
- strengthening family farms due to their insensitivity to external negative factors, including global warming, limited water resources, etc.;
- introduction of insurance of family farms against agricultural risks, weather conditions, etc.;
- encouraging the use of alternative energy sources in the management process;
- financial support for family farms.

The activities of the state are aimed at transforming the national economy in the direction of a "green economy" primarily concern the replacement of conventional energy sources with energy-efficient renewable energy sources (Bilokinna, 2017).

Ukraine is an energy-dependent country, energy needs are growing every year, so they must be renewed and rationally used. Hence the next strategic imperative is to increase energy efficiency in our country and achieve energy independence. This in turn will reduce energy intensity of GDP and ensure energy security of our country. Therefore, according to the Concept of "green" energy transition of Ukraine until 2050, energy efficiency and RES are becoming the determining areas of energy transition in Ukraine (Ilyina, Shpylyova, 2017). Improving energy efficiency will allow to achieve GDP growth without increasing the use of energy resources, which in turn will facilitate the management process. However, the introduction of new technologies, including in the agricultural sector, and the problems of climate change will require the active production of renewable energy sources. At the same time, Ukraine has a significant natural potential to increase renewable energy sources in the total amount of energy production, so to some extent it is ready for a "green" energy transition, which will achieve such national goals (Fig. 2.7).

Thus, it is necessary to actively develop the production of renewable energy sources, which should completely replace thermal and nuclear energy in the long run. In order to significantly increase the share of alternative energy sources in total energy production, it is necessary for enterprises and industry and agriculture, as well as the population built solar panels, including on the roofs of houses,

wind farms and biogas plants. This will increase the environmental friendliness of production, reduce the negative impact on the environment, reduce air emissions and, as a result, bring us closer to virtually zero greenhouse gas emissions and build a climate-neutral economy. Accordingly, such a “green” energy transition requires significant investment in large-scale start-up of renewable energy production, which will increase their price. Therefore, the state will need to control energy pricing and reimburse the costs of building alternative power plants to mitigate the energy transition in Ukraine.

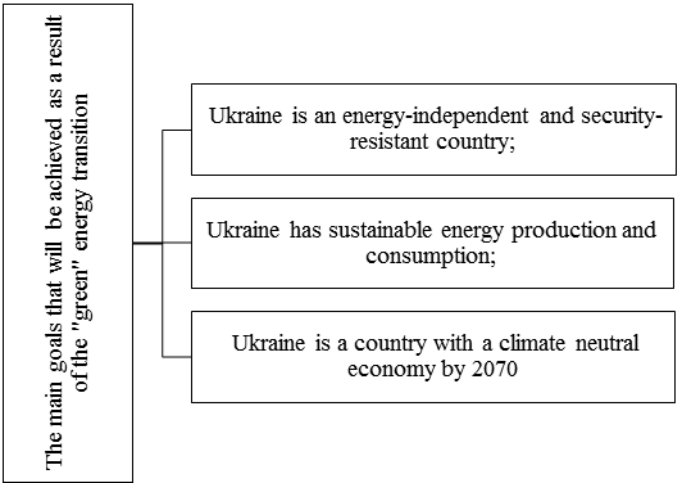

Fig. 2.7. **The main goals of the “green” energy transition in Ukraine**

Source: formed by the authors on the basis of (Ilyina, Shpilova, 2017)

The creation of energy cooperatives among producers is important for a “green” energy transition. In our opinion, “green” energy cooperatives are associations of citizens and other economic entities for the purpose of production, consumption and sale of environmentally friendly energy from renewable sources. For Ukraine, the creation of “green” energy cooperatives in the agricultural sector of the economy is a very promising idea, as a significant part of the Ukrainian economy is occupied by the agricultural sector, which needs cheap environmentally friendly energy resources (Shpykuliak, Bilokinna, 2019). Thanks to the

creation of “green” energy cooperatives, a larger share of agricultural producers will be able to use environmentally friendly energy in the production process. In this way, it is easier to make the transition to alternative energy in the agricultural sector.

One of the main roles of “green” energy cooperatives can be noted in the institutional mechanism of development of alternative energy in rural areas. The Ukrainian peasant is experiencing a significant shortage of energy resources, which are quite expensive. It is possible to reduce energy dependence and energy and fuel costs by using renewable energy sources, as well as by producing them yourself. However, the cost of technology and equipment to install a solar power plant on the roof of a house or to install a biogas plant based on agricultural waste is high and the individual farmer is unable to afford it. Therefore, it is profitable for Ukrainian peasants to join “green” energy cooperatives and personally produce energy and fuel from alternative sources for lighting warehouses, for the operation of their cars, tractors, combines, for personal consumption and more.

In Ukraine, the first “green” energy cooperative was established only in 2016. The Ukrainian economy, including the agricultural sector, is energy-intensive and energy-dependent. Therefore, increasing the share of alternative energy sources in total consumption is the only key to solving these problems. The institutional mechanism for the development of alternative energy in the agricultural sector has been formed in a relatively short time and is still imperfect. “Green” energy cooperatives have become a new effective element of this institutional mechanism, which is quite promising. The first steps in creating such cooperatives have already been made, there are several “green” energy cooperatives in Ukraine. However, the further development of this type of cooperation in the agricultural sector needs support at the state level, through the creation of appropriate formal institutions.

To better understand the state of the “green economy” in the agricultural sector and its assessment in our country, we propose to introduce the following indicators:

- the number of “green projects” related to the development of the agricultural sector;
- the number of family farms – representatives of “green” tourism;
- net profit of agricultural enterprises from “green” transactions;

- the number of recycled landfills in the country, which are located in rural areas;

- the share of enterprises that use “green” technologies in production;

- the percentage of family farms engaged in organic farming, of the total;

- part of advisory services that advise and help small businesses to move to environmentally friendly production;

- the share of family farms that use renewable energy sources in the management process;

- the number of “green” jobs in the agricultural sector for people with disabilities;

- the share of agricultural enterprises that use low-waste or non-waste production.

Rural development is one of the priorities for the development of a “green economy” in our country. Therefore, it is necessary to actively implement the latest technology and modern technologies in agriculture with the simultaneous development of organic farming, the use of renewable energy sources, the development of “green” tourism.

Certain negative factors motivate in the future to new decisions and opportunities. This also applies to the coronavirus pandemic, as during the quarantine a large number of workers began to work remotely and move from cities to villages. Because companies have invested in equipment to be able to work remotely, they will not require their employees to return to offices. Now a large number of people will understand the benefits of living in the countryside and will remain there for permanent residence, still working. However, this will lead to an increase in the rural population, which in turn will lead to the development of rural areas. The infrastructure will be improved due to the needs of the population in comfortable living conditions. In addition, some of those who remain will begin to develop agricultural business, having their own land on the principles of “green economy”. Thus, the coronavirus pandemic contributed to the further development of organic production and the development of rural areas in general.

In accordance with the resolution of the Cabinet of Ministers of Ukraine dated 29.07.2020 № 671 “On approval of the Forecast of economic and social development of Ukraine for 2021 – 2023” the main indicators of economic and social development are projected,

which are listed in Table 2.10.

Table 2.10

Main forecast macro indicators for 2021-2023 (according to the baseline scenario)

Indicator	2021	2022	2023
GDP,%	4.6	4.3	4.7
Consumer price index (December to December of the previous year),%	107.3	106.2	105.3
Increase in real average monthly wages of employees,%	12.1	6.0	5.1
Unemployment rate,%	9.2	8.5	8.0
Growth of exports of goods and services,%	2.9	6.4	8.2

Source: formed by the authors on the basis of (Resolution of the Cabinet of Ministers of Ukraine, 2020)

Therefore, according to Table 2.10 in the baseline scenario, the forecast indicators have a positive trend. It is expected that GDP growth in 2023 will be 4.7%, and in 2021 4.6%. The unemployment rate will gradually decline and in 2023 will reach 8%. Wages are expected to increase in 1221 by 12.1%, in 2022 – 6% and in 2023 the increase will be 5.1%. With such an increase in wages, the consumer price index will gradually decrease.

Also, considering the significant uncertainty in the forecasts of development, first of all, of the world economy and the duration and recurrence of the COVID-19 pandemic, the Forecast summarizes two alternative scenarios, which provide a more successful way for most economically developed countries to overcome the effects of the pandemic. , with a corresponding impact on the development of the Ukrainian economy (Resolution of the Cabinet of Ministers of Ukraine "On approval of the Forecast of economic and social development of Ukraine for 2021-2023", 2020).

Over the past few years, Ukraine has begun to take some steps to create institutional support that would promote the development of the agricultural sector. The following laws of Ukraine were adopted: "On Investment Activity", "On State Regulation of the Securities Market in Ukraine", "On the Foreign Investment Regime", "On Entrepreneurship", "On the Basic Principles of the State Agrarian Policy of Ukraine for the period up to 2015", "On State Support of Agriculture of Ukraine", signing of the Association Agreement between Ukraine and EU countries, as well as the establishment of a

Free Trade Area with the European Union, approval of the Strategy for the development of the agricultural sector until 2020, approval of the National Economic Strategy 2030.

The National Economic Strategy of Ukraine for the period up to 2030, approved by the resolution of the Cabinet of Ministers of Ukraine "On approval of the National Economic Strategy for the period up to 2030" dated March 3, 2021 № 179, defines the values of target indicators to be achieved by 2030 :

- real GDP growth at least twice;
- GDP growth per capita of not less than 10 thousand US dollars;
- growth of labor productivity not less than 1.7 times;
- increase the net inflow of foreign direct investment to at least 15 billion US dollars per year, starting in 2025;
- growth of exports to 150 billion US dollars;
- reduction of unemployment (according to the ILO methodology) to 6 percent;
- reduction of the gender pay gap to 10 percent.

Another powerful tool for state regulation of the national economy on the principles of "green economy" is "green procurement" of eco-efficient products. Green public procurement has a significant impact because public authorities are large consumers.

The institutional mechanism of formation of "green economy" in the agrarian sphere is formed according to strategic imperatives, ie according to the basic purposes which achievement is necessary for development of elements of "green economy" in agrarian sphere of Ukraine.

The institutional mechanism for the formation of a "green economy" must function in accordance with economic, environmental and social goals. The main institution that plays a significant role in the transformation of management in the agricultural sector in accordance with these goals is the institution of the state. To intensify the development of production and use of alternative energy sources, it is necessary to create an institution of "green" cooperation, by promoting the creation of "green" energy cooperatives.

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3. ENERGY AUDITING AS A FORM OF IMPLEMENTING THE STATE POLICY ON ENERGY SAVING AND ENERGY EFFICIENCY

3.1. State audit in ensuring economical and efficient use of public resources[7]

The functioning of the public procurement system (hereinafter – PPS) is indirectly related to the use of public resources, which include public funds (budgetary funds and own funds of state/municipal enterprises, institutions, organizations) and purchased items. Thus, the receipt and use of public resources by contractors is subject to inspections by control authorities for their efficient and economical use, but the results of the state audit in the field of public procurement indicate the existence of violations and corruptive practices that lead to a loss of financial resources. Improving the efficiency and effectiveness of the public procurement auditing system requires not only improved arrangement and methodology of its implementation, but also clear legal regulations and standardization in line with ISSAI international standards.

Particularly urgent and, at the same time, problematic remains the implementation of analysis in the field of public procurement, because, despite the principles of transparency, publicity and openness, information about the same indicators is unavailable and unstable. It is important to study theoretical and practical aspects of analysis and state audit of public procurement in Ukraine.

The impact and importance of public procurement in the enhancement of state economic capacity has been discussed in works by national researchers of economic theory M. Zveryakov, V. Bazylevych, O. Vasylyk, L. Alekseenko, V. Oseetskiy, O. Rozhko and others. The scientific achievements in the field of analysis and state audit of such scientists as S. Bardash, I. Basantsov, M. Bondar, I. Drozd, V. Zhuk, G. Kaletnik, S. Levitska, A. Lyubenko, V. Maxymovoi, V. Minyaila, I. Lazaryshynoi, K. Nazarovoi, M. Pysmenoi, Y. Slobodianyk, V. Shevchuk allowed the

[7] Kaletnik G.M, Zdyrko N.G.

development of theoretical, methodological and organizational aspects of the analysis and state audit of public procurement. However, the current studies with general approaches and already established positions appear to be of little use to the state procurement system, which is subject to constant change and restructuring. Analysis of existing problems in this field reveals a range of inconsistencies and contradictions, which requires the creation of a unified information-analytical and control support for public procurement management at the micro, meso and macro levels, as well as the use of analysis tools and public audit in the information electronic space.

Weakness of the methodology of public procurement analysis makes it impossible for interested users (state, society, business) to obtain a real assessment of the effects and losses from their implementation at the national and sectoral levels, as well as at the level of customers and participants in the procurement process, which in turn hinders the achievement of PPS maximum efficiency to ensure economic growth. Asymmetry of information bases, fragmentation of information support, duplication of functions and lack of communication between regulatory bodies, superficial analysis, imperfect reporting in the field of public procurement necessitate rethinking a number of fundamental theoretical and practical issues and developing on this basis conceptual framework for the establishment of the system of analysis and state audit of public procurement in Ukraine.

One of the forms of cooperation between the state and business entities is relations in the field of public procurement, which meets the needs of state enterprises, institutions and organizations in goods, works and services. Frequent changes in legislation on the arrangement and conducting of public procurement indicate the need for continuous improvement of the public procurement management mechanism for the development of all spheres in Ukraine.

Enactment of the Law of Ukraine “On Public Procurement” entails a number of significant differences from the Law of Ukraine “On Implementation of State Procurement” due to the need to ensure transparency of the procurement process at all stages of its implementation. In particular, there are only three procurement procedures in place of five; the right to use electronic systems and to

submit information has been replaced by the obligation to use such systems; only electronic documents are required for decision approvals; competitive selection in terms of framework agreements is carried out only through the use of an electronic auction. In addition, the Law of Ukraine "On Public Procurement" introduced and defined new concepts: the terms "authorized electronic platform", "electronic procurement system", "centralized procurement organization", "cloud computing system".

The main differences in the legal regulation of procurement are reflected in Table. 3.1.

Table 3.1

Changes in the legal regulation of procurement as an object of state audit

№	Feature	The Law of Ukraine "On Implementation of State Procurement"	The Law of Ukraine "On Public Procurement"
1	2	3	4
1	Basic terms	"state procurement", "competition", "competitive bidding documentation", "competitive bidding proposal", "competitive bidding committee".	"public procurement", "tender", "tender documentation", "tender application", "tender committee".
2	Procurement procedures	1) open bidding; 2) two-stage bidding; 3) request for quotations; 4) preliminary qualification of participants; 5) negotiated procurement procedure.	1) open bidding; 2) competitive dialogue; 3) negotiated procurement procedure.
3	Application of electronic systems	*Right* The customer has the right to carry out procurement procedures using electronic means.	*Duty* The customer carries out procurement procedures using an electronic procurement system.
4	Submission of information	*Right* Submission of information during the procurement procedure is carried out in written, and in the case provided for in paragraph 2, part. 2 of Article 12 of the Law – in the form of an electronic document.	*Duty* Submission of information during the procurement procedure is carried out electronically through the electronic procurement system.

continuation of table 3.1

5	Appeals against decisions	The complaint to the appellate body is submitted by the subject of the appeal in written form and must be signed by the person who submits it.	The complaint to the appellate body is submitted by the subject of the appeal in the form of an electronic document through the electronic procurement system.
6	Requirements for framework agreements	*Right* Competitive selection may be carried out by the contracting authority by means of an auction using electronic means.	*Duty* The selection and competitive bidding shall be carried out by the contracting authority using an electronic auction.

Source: generated by the authors (Law of Ukraine "On public procurement", 2014, Law of Ukraine "On public procurement", 2015)

The dynamic and sometimes unpredictable development of public procurement, driven by the need to fulfil Ukraine's obligations under he Association Agreement (The Association Agreement, 2014), necessitates an effective management of public entities and state-owned enterprises. The efficiency of public procurement management, on the one hand, affects the welfare of state and public needs (interests), the well-being of the population, and, on the other hand, the economic development of the entity.

The output basis for successful management is information support, since it is the quality of the information that determines the immediate detection of problems and the prevention of negative consequences.

Continuing the opinion of Kaletnik G. information not received in time, or its absence can be the basis for the collapse of not only the planned activities, but also the company, the consequences of which can be catastrophic. In the process of analysis, planning and management, control, information is constantly needed (Kaletnik et al, 2011).

Management in the field of public procurement has its own characteristics, however, we believe that its functions should be defined on the basis of generally accepted classical approaches.

The management functions describe the specific nature of the managerial activity for both the manager and apparatus, and characterize the type of this activity (Shorobura et al, 2015).

Based on the specifics of public procurement, we consider it appropriate to distinguish the following functions of procurement management: 1) planning; 2) organization; 3) motivation; 4) accounting, analysis, control; 5) regulation.

The approach of considering combination of procurement management functions depending on the scale and subjects of it may introduce some uncertainty and needs to be clarified. First, macro-management can be called state because it is the state bodies that carry out the planning functions (established Municipal Plan), arrangement (unified electronic procurement system), evaluation and control (by the Authority and control bodies), and regulation (coordination of the efficiency of implementation of all the functions). Secondly, when defining the nature of micromanagement in the public procurement sector, it is necessary to speak about its subject-matter relevance and to consider it as economic – management of production activity of subjects purchases (customers and participants).

The efficiency of any activity depends on the quality of administrative decisions formed by the management system. These decisions are made by the leadership on the basis of the information obtained through the accounting, analytical methods, control procedures and the use of feedback as one of the main technologies of strategic management. The functions of accounting, analysis and control are extremely important in the management system, because thanks to their implementation it is possible to form a system of accounting and analytical support and maintenance of management decisions.

Despite the importance of accounting, analysis and control as management functions, without their close interconnection with other its functions, such as planning, organization, motivation, regulation, they are not able to perform their tasks, because only due to the integration of all functions into a single system, a measure of synergistic effect is ensured, which enables both the customers and the participants to work with maximum efficiency.

Control is one of the important functions of management and,

together with the accounting and analysis functions, forms the information basis for its decisions.

In accordance with Lima Declaration of Guidelines on Auditing Precepts, the arrangement of controls is a mandatory element of public funds, as such management entails responsibility to society. According to the above document, control is not an end in itself, but an integral part of the regulatory system, which aims to identify deviations from accepted standards and violations of the principles, legality, efficiency and economy of material resources at the earliest stage to be able to apply corrective measures, in some cases, to bring the perpetrators to justice, to obtain compensation for the damage caused or to take measures to prevent and reduce such violations in the future (Lima Declaration, 1977).

In international practice, the scope of the concept of "audit" is considerably broader. For example, the European Commission Budget Directorate General's book "Welcome to the world of PIFC" states that "audit – in its broadest general sense – can mean any ex-post examination of an agreement, procedure or report in order to review/revise any aspect of it – its accuracy and effectiveness" (Government Audition Standarts, 2011).

Let's define the main differences between the concepts of "audit" and "control" used in INTOSAI standards. According to ISSAI 9100 "Glossary of Terms", audit – audit / control – analysis of the activities and actions of the body to ensure that they are performed in accordance with the objectives, budget, rules and standards. The purpose of this analysis is to identify deviations on a regular basis that may require corrective action.

The main and comprehensive term that defines the procedure for inspections (control, audit) in accordance with INTOSAI Standards is "audit". The term "control" is used in the sense of "internal control" and "quality control".

Control and auditing should contribute to the improvement of national systems of state activity. For this purpose, international organizations are established which set its standards in the field of control and audit (Table 3.2).

Thus, ISSAI international standards define state sector audit through financial audit, performance audit and compliance audit (Table 3.3).

Table 3.2

International standards in the field of control and auditing

№	Types of standards	The content of the standards
1	**International Standards on Auditing** *(ISA – ISA)*	International Auditing and Assurance Standards Board (IAASB) of the International Federation of Accountants (IFAC).
2	**INTOSAI international standards** *(ISSAI and INTOSAI GOV)*	International Organization of Supreme Audit Institutions (IAS), of which the Accounting Chamber of Ukraine (ACU) is a member.
3	**International standards of the Institute of Internal Auditors** *(International Standards)*	The Institute of Internal Auditors (IIA).
4	**Common internal control standards**	COSO Committee (Committee on Sponsoring Organizations of the Treadway Commission).

Source: generated by the authors

The control function of the governance entities in the field of public procurement is manifested through external and internal state audit.

Table 3.3

Forms of state sector audit in accordance with ISSAI

№	Types of standards	The content of the standards
1	Financial audit	identification of compliance of the submitted financial information with the adopted financial reporting system and legal framework.
2	Performance audit	identification of compliance of actions, programs and institutions with the principles of economy, efficiency and effectiveness, as well as opportunities for improvement.
3	Compliance audit	identification of compliance of a specific subject of consideration with the current authority defined as criteria.

Source: generated by the authors

In accordance with the Law of Ukraine "On the Basic Principles of Performing Public Financial Control in Ukraine" of June 26, 1993, 2939-XII (Law of Ukraine, 1993), external public audits may take

the form of:

1) financial audit (entity – the Accounting Chamber of Ukraine and the State Audit Office of Ukraine);

2) performance audit (entity – the Accounting Chamber of Ukraine).

Thus, the control function of management in the field of public procurement is implemented through state audit (performance audit and financial audit) by the Accounting Chamber and the State Audit Office (audit and monitoring). Comparative characteristics of audit and control in the field of state finance are presented in Table. 3.4.

Table 3.4

Comparative characteristics of audit and control in the field of state finance

Parameters	Auditing	Control
1	2	3
The purpose of performing	– ensuring the stability and economic security of the state; – providing all interested parties with independent information on how public administration is carried out.	– implementation of measures to ensure full revenue collection into the budget system; – preservation and efficient use of state property; – prevention of financial irregularities in the state sector of the economy.
Tasks	– comprehensive review of the state budget; – assessment of alternative options for budgetary decisions; – analysis of the long term effects of government programmes; – assessment of the technology providing authorities with information on the long term effects of legislative decisions in various sectors.	– informing to the competent authorities on deviations from accepted standards, violation of the principles of legality, efficiency and economy of material resources, in order to take corrective measures, compensate for damages and bring the perpetrators to justice.
Object	– financial resources and property of the state, their accounting; – draft laws and regulations; – assessment of financial results of budget execution; – assessment of forecasts and directions of development of separate branches of economy.	Targeted and legal use of budget funds.

continuation of table 3.4

1	2	3
Resource provision	Financing from the state budget.	Financing from the state budget.
Management of performing	Independently determined by the state auditor, who is exclusively guided by standards.	Specific planned tasks, as agreed with the supervisor.
Responsibility	Before the public in accordance with the standards.	Before administration for the fulfilling of duties.
Form of performing	– financial audit; – performance audit (activity audit, operational audit, etc.); – compliance audit; – audit of legality.	– audit; – revision; – inspection.
Outputs of performing	Free access of the public to information: the reports are given to the President, the Parliament, the state bodies whose budgets are considered. Open publication of reports and audit results in mass media.	There are restrictions on access to the results of monitoring.

Source: (Maksimova, 2013)

According to Nikiforova I. (Nikiforova, 2016), state financial audit has a number of differences from performance audit. Thus, the last one is to assess the effectiveness and efficiency of government decisions or indicators, as well as compliance with the principles of economy, efficiency and effectiveness in the organizations being audited. Instead, the purpose of financial audit is to assess compliance with the law when performing financial transactions – the truthfulness, clarity and reliability of accounts and reporting. The performance audit focuses on policies, programs, organizations, activities and management systems, and the financial audit focuses on the audit of financial transactions, accounts and financial statements (Nikiforova, 2016).

State audit can be defined as an independent form of state independent financial control, which is carried out by special entities (the Accounting Chamber of Ukraine and the State Audit Office of Ukraine) using appropriate methods (means) of control to obtain objective information about the real financial and economic condition of the controlled subject (Krestyannikova, 2016).

According to Pysmenna M., audit in the field of state

procurement involves a set of audit procedures and evaluation activities aimed at confirming data on procurement, assessing the effectiveness of procurement operations and spending budget funds, the validity and legality of the parties' actions related to the conclusion and execution of the state procurement contract (Pysmenna, 2016).

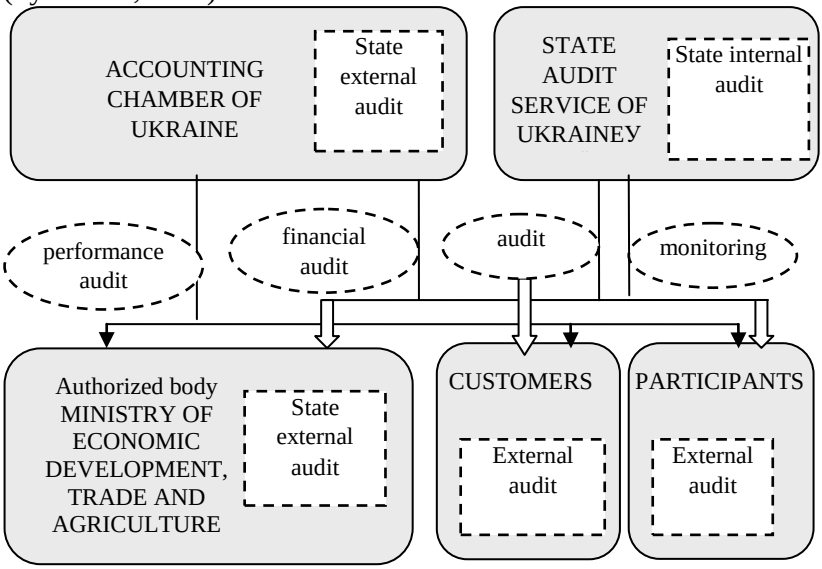

Fig. 3.1. **Implementation of the control function by the subjects of control in the field of public procurement**

Source: summarized by the authors

Therefore, control support of public procurement management involves implementation of state financial control in the form of state financial audit, performance audit, verification and monitoring of procurement by special regulatory authorities to assess the legality and correctness of public procurement, its efficiency process, as well as the level of satisfaction of state and public needs.

The analytical function is implemented through a preliminary analysis by the Accounting Chamber and monitoring of procurement by the State Audit Office to prevent violations in the field of public procurement. We propose to strengthen the analytical function of public entities through the generalization of information on indicators of public procurement, as well as systematization of the

results of legality control, correctness and efficiency of budget funds and other public resources (tangible, intangible, natural) by state bodies microlevels, mesolevels and macrolevels – by the State Statistics Service of Ukraine and the Ministry of Economic Development, Trade and Agriculture.

The coherence, interconnection and interaction of accounting-analytical and control functions with the functions of planning, organization, motivation and regulation in the field of public procurement provide the degree of synergistic effect that allows both customers and participants to work with maximum efficiency, savings and efficiency, and at the meso and macro levels – to increase the efficiency of the public procurement system as a whole.

Therefore, the efficiency of public procurement management depends on the quality of accounting and analytical support, which is formed due to the interaction of the functions of accounting, analysis and control with other components of the management system.

Thus, despite the importance of each management functions, without their close relationship they are unable to perform tasks, because only by combining all functions into a single system, provides a measure of synergy that allows both customers and participants to work with maximum efficiency, economy and efficiency.

We believe it is necessary to consider the arrangements for public procurement depending on its type and procedures. By types, public procurement, as defined in the previous section, is divided into pre-threshold and above-threshold.

Let's consider the essence and features of organization of pre-threshold procurements. The procedure for such procurement is regulated by the Prozoro Charter of 19.03. 2019 № 10 "On approval of the Instruction on the procedure for the use of the electronic system of procurement, the value of which is less than the value set out in paragraphs two and three of paragraph one of Article 2 of the Law of Ukraine "On Public Procurement"" (Instruction on the procedure for using the electronic procurement system, 2019).

While the Law of Ukraine on Public Procurement defines procedures for above-threshold procurement, then there are no clearly defined procedures for pre-threshold procurement in a single piece of legislation (Law of Ukraine "On public procurement",

2015).

The pre-threshold value of the procurement subject (hereinafter – "threshold") is:

– for ordinary customers, the value of the subject of goods and services purchase is equal to or exceeds UAH 200 thousand, and works - UAH 1.5 million;

– for monopoly customers – the value of the subject of goods and services purchase is equal to or exceeds UAH 1 million, and works – UAH 5 million. We consider it expedient to give the types of procedures in terms of purchasing the subject of procurement for pre-threshold amounts (Fig. 3.2).

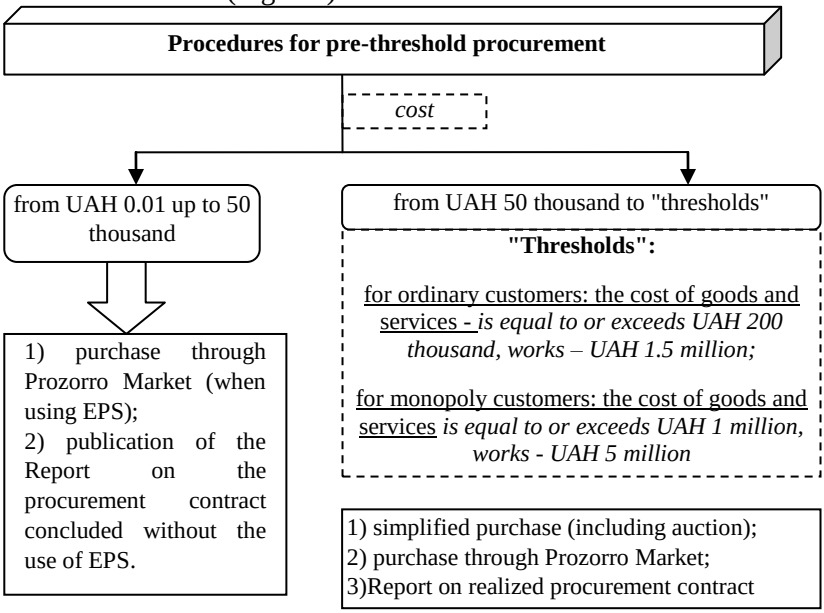

Fig. 3.2. **List of procedures used in pre-threshold procurement**
Source: summarized by the authors

Before discussing the specifics of the arrangements for public pre-threshold procurement through the use of these procedures, we consider it necessary to outline the main steps of their organization as a whole. The law does not define the obligation to use the Electronic Procurement System (hereinafter – EPS) for pre-threshold procurement, but only the right. In particular, it is established that

when purchasing goods, works and services, the cost of which is less than UAH 200 thousand for goods and services and UAH 1.5 million for works, customers must adhere to the principles of public procurement, and can (that is not obliged) to use EPS for the selection purpose of the goods supplier, the service provider and the executor of works for the conclusion of the contract. However, if the customer has made at least one purchase worth UAH 50,000 or more, he must register with the EPS in order to publish the Report on the concluded contracts.

The Electronic Procurement System (EPS) is an informational-telecommunicational system that provides for the conduct of procurement procedures, creation, posting, publication and exchange of information and documents electronically, which includes the Authority's web portal, authorized electronic terminals, between which automatic exchange of information and documents is ensured.

The EPS doesn't allow for procurements with an estimated value less than 3 thousand UAH, that if the annual amount of the procurement subject is less than 3 thousand UAH, the contract shall be concluded without the use of Prozorro.

Instruction №10 (Instruction on the procedure for using the electronic procurement system, 2019) defines the following stages of pre-threshold simplified procurement (Table 3.5):

1) procurement announcement;

2) the period of information clarification that specified in the announcement;

3) submission of proposals by participants;

4) electronic auction;

5) consideration of participants's proposals;

6) determination of the winner and completion of the procurement.

Therefore, Order №10 doesn't provide for such a stage as the qualification of the participant, which was determined by the already invalid Procedure for sub-threshold procurement (The procedure for organizing pre-threshold procurement, 2017).

Therefore, at stage I, the customer places and publishes the purchase announcement from the personal account on the electronic platform. When announcing a purchase, information about the customer is posted in the EPS; subject of purchase; the expected

purchase price (cannot be less than UAH 3,000) and the inclusion / exclusion of value added tax (yes / no); purchase currency; the size of the minimum step of lowering the price (0.5-3%); non-price criteria (specific weight – no more than 30%); the date and time of beginning and end of clarification period of information in the announcement (by the customer); date and time of the beginning and end of receipt of participants offers.

Table 3.5

Control and assessment of the legality of pre-threshold simplified procurement and features of their implementation by stages

Stages	Names of stages	Features of procurement as areas of analysis and audit
Stage I	Procurement announcement.	Needed information in the announcement: the customer; subject of purchase; expected cost and VAT inclusion / exclusion; purchase currency; step size of the price reduction; dates and times of the beginning and end of the clarification period, as well as receipt of proposals from participants.
Stage II	The period of information clarification that specified in the announcement.	Change of information about the purchase during: not less than 1 working day, if the purchase price is from UAH 3 thousand up to UAH 50 thousand and not less than 3 working days, if the purchase price exceeds UAH 50 thousand.
Stage III	Submission of proposals by participants.	Filling in the appropriate electronic forms and downloading the necessary electronic documents.
Stage IV	Electronic auction.	The EPS pauses for 5 minutes before announcing the round. Price reduction in three rounds (with a break of 2 minutes) by at least one step (from 0.5 to 3% of the cost) from its previous price.
Stage V	Consideration of participants' proposals.	Automatic disclosure of all offer information. Formation of a rating (from the lowest to the highest offered price). Download documents about the winner and / or rejection of the best offer.
Stage VI	Determination of the winner and completion of the procurement.	Publication of information about the intention to enter into an agreement with the winner of the procurement. Signing the contract within 30 days.

Source: formed by the authors on the basis (Instruction on the procedure for using the electronic procurement system, 2019)

At the stage of information clarification (stage II) the customer has the opportunity to change the information about the purchase, adding or changing documents during: at least 1 working day, if the purchase price is from UAH 3 thousand up to UAH 50 thousand and not less than 3 working days, if the purchase price exceeds UAH 50 thousand. The history of changes made by the customer is saved and available for viewing by users. It is important that any person has the right and opportunity to contact the customer through the EPS for clarification on the information of the announcement and to demand the elimination of violations. Clarification requests and / or demands are made only in text form without the possibility of attaching files. All questions / answers are stored in the EPS and are available to all users for viewing. Information regarding the author of the request for clarification and / or demands in the EPS is anonymous and is not disclosed.

At the third stage, participants submit their proposals on the subject of procurement, filling out the appropriate electronic forms and downloading the necessary electronic documents. Each participant has the right to submit only one proposal. The participant has the right to make changes and clarifications to the submitted application until the deadline for stage completion of the applications submission, as specified by the contracting authority. The history of changes made to the proposal is stored in the EPS and can be viewed by the users after the end of the stage of the electronic auction. Participants have the right to withdraw their offer before the end of the deadline set by the contracting authority. If no participant submits a proposal at this stage, the procurement is automatically considered not to have taken place.

Determination of the date and time at the IV stage (electronic auction) is automatic and is determined by the EPS. Before the start of the e-auction stage, the EPS automatically discloses information only on prices of participants' proposals, while the information on the participants themselves is closed until the end of the stage.

Before the start of the e-auction, the EPS pauses for 5 minutes and then automatically announces the round. In each round, participants in the order determined by proposal from the highest to the lowest price, and for proposals with the same prices – the first one, within 2 minutes have the opportunity to reduce the price of

their offer by at least one step from their previous price (Instruction on the procedure for using the electronic procurement system, 2019).

The customer independently sets the step (in UAH), which is calculated as a percentage of the expected purchase price and should be in the range from 0.5 to 3% of the expected purchase price converted into monetary units.

During the round until the end of the bid submission time, the participant has the opportunity to change the price. If the participant does not take action to change the price of his/her bid, the EPS retains the previous bid price and gives the next participant the opportunity to submit the price. The auction is held in three stages (rounds), the pause between rounds is 2 minutes (Instruction on the procedure for using the electronic procurement system, 2019).

At the V stage (consideration of proposals) all the information specified in the proposals of the participants is automatically disclosed and their rating is formed in the order from the lowest to the highest price offered by them. The customer uploads documents containing information about the winner and / or rejection of the most cost-effective offer in the EPS in separate files.

In stage VI, the winner is determined and the procurement is completed, after which the EPS publishes information about the intention to conclude a contract with the winner of the procurement by downloading information about the winner (name of the procurement winner, price of its final proposal, proposal documents). Within 30 days after the deadline for submission of proposals, the customer completes the procurement in the ETS by signing a procurement contract or its cancellation. The procurement contract must be placed in the ETS within two working days from the date of its conclusion and available for viewing by users.

We consider it appropriate to detail each stage in order to identify the specifics of open tendering.

Stage I is the placement by the customer on the web portal of the Authorized Body (the Ministry of Economic Development) of the announcement of the open bidding procedure with simultaneous publication of the announcement and tender documentation.

The announcement must state all the essential conditions of the planned purchase, in particular, the quantity and place of delivery of goods (volume and place of work or services), the expected cost

(including VAT, excise tax, etc., if paid by tax law), deliveries. In addition, information related to procurement is indicated – the deadline for submission of tender proposals; size, type and conditions of providing security for them; date and time of opening of tender offers (for purchase of goods and services in the amount of more than 133 thousand euros or works more than 5150 thousand euros, in other cases they are determined by the electronic bidding system automatically), as well as the size of the minimum price reduction the time of the electronic auction in percent or monetary units and the mathematical formula that will be used in the electronic auction to determine the indicators of other evaluation criteria (Klimenko, 2019).

Table 3.6

Information environment for open bidding by main stages

Stages	Features of procurement at each stage
Stage I	Placement by the customer on the Authorized Body's web portal of the announcement for open bidding procedure with simultaneous publication.
Stage II	Submission of the tender offer in electronic form via the e-procurement system by filling in e-forms (after publication of the announcement and tender documentation of all interested persons).
Stage III	Disclosure of only information about the prices offered by participants and evaluation of tender offers.
Stage IV	Determining the final price of the offer during the electronic auction. Decision on the intention to enter into an agreement and post a notice on the web portal of the Ministry of Economic Development.
Stage V	Concluding a procurement contract with the winner of the tender during the term of his proposal (not later than 20 days from the date of the decision to enter into the contract, but not earlier than 10 days from the date of notice publication of intent to enter into a procurement contract).

Source: generalized and formed by the authors

Furthermore, the customer has the right to make changes to the tender documents. In this case, the deadline for submission of tenders will be automatically extended so that at least seven days are remaining between the time of making the amendments and the end of the deadline for tenders submission.

Stage II – submission of the tender offer in electronic form via the electronic procurement system by filling in electronic forms (after

publishing the announcement and tender documentation for all interested persons).

Filling in electronic forms with separate fields, which indicate information about the price, other evaluation criteria (if established by the customer), information from the participant about its compliance with the qualification criteria, the requirements of Art. 17 of the Law and the tender papers, and loading of the necessary documents required by the customer in the tender documentation. Documents confirming the participant's compliance with the qualification criteria, and documents containing a technical description of the procurement subject are submitted in a separate file.

The tender offer must contain confirmation of the provision of the it by the bidder, if such security is provided by the announcement of the procurement procedure (Klimenko, 2019).

The bidder has the right to make changes or withdraw its bid before the deadline for its submission without losing its security for the bid. Such changes or the statement of withdrawal of the tender offer shall be taken into account if they are received by the electronic procurement system before the deadline for submission of tender offers.

Stage III – disclosure of only information about the prices offered by participants and evaluation of tender offers. After the deadline for submission of tender offers and before the start of the electronic auction, only information about the prices offered by the participants is disclosed. The evaluation of tender proposals is carried out automatically by the electronic procurement system on the basis of the criteria and methods specified by the customer in the tender documentation and by using an electronic auction.

Stage IV – Determining the final price of the offer during the electronic auction. The final price of the bid is determined during the electronic auction, which is held in three rounds, during each of which the bidder has the right to reduce the price once at least one step set in the tender documentation. After the auction, the bids of the participants are arranged in ascending order of price, tender bids are opened, and the customer begins the bidding process (Klimenko, 2019).

The offer with the lowest price is considered first. The deadline

for review of the tender offer should not exceed five working days from the date of the auction, but may be extended to 20 working days. In case of rejection of the tender offer with the lowest price, the customer considers the next one from the list of participants, which is determined to be the most economically advantageous.

Stage V – concluding a procurement contract with the winner of the tender during the term of his offer. The Customer enters into a procurement contract with the winner of the tender during the term of proposal, not later than 20 days from the date of the decision to intend to enter into a procurement contract in accordance with the tender documents. In order to ensure the right to appeal against the decisions of the customer, the procurement contract may not be concluded earlier than 10 days from the date of notice publication of intent to enter into a procurement contract (Klimenko, 2019).

The main shortcomings in the development of public financial control in Ukraine (including in the area of public procurement) include:

1) insufficient number of control units in the State Audit Service, as well as the lack of organizational and / or functional independence of such units;

2) imperfection of internal and external methodological base on issues of state financial control;

3) shortcomings in terms of completeness of audit activities, quality of documentation of audits carried out and validity of conclusions based on their results;

4) the lack of a proper regulatory framework regarding the implementation of the SCC.

Most of the control measures in the field of public procurement today fall precisely on audits and audits conducted by the bodies of the State Audit Service, the Accounting Chamber of Ukraine and departmental auditors. At the same time, there is no single legislative act which would clearly state the tasks, functions, status and areas of competence of the above-mentioned bodies; the exercise of relevant powers is governed by a variety of regulatory documents, the provisions of which are often contradictory and do not provide for systematic state control of public procurement. This leads to unnecessary duplication of audits of the same entities on the same issues and does not facilitate the rapid elimination of deficiencies established by their results.

3.2. Organizational and methodological approaches to the state audit of public resources[8]

Our state's financial control system, which dates back to the Soviet period, could not readily accept such a new control institution as state audit. However, as a result of market transformations, it becomes necessary to reform the system of financial control by separating independent external financial control – state audit (Slobodyanyk, 2009).

In our opinion, state audit is one of the forms of state financial control, which is carried out by the control body – the Accounting Chamber of Ukraine and the State Audit Office and is considered a form of external follow-up control.

The audit of compliance is an integral and inseparable part of the state audit, including public procurement.

Arrangement and official implementation of compliance audit as one of the state audit components according to ISSAI (International Standards of Supreme Audit Institutions) – International Standards of Supreme Audit Institutions (INTOCAI) should be accompanied by the adoption of an appropriate legislative and regulatory framework and the preparation of organizational and methodological support.

From 2018, International standards have a different name and structure (The INTOSAI Framework of Professional Pronouncements – Conceptual basis of professional standards INTOSAI). Therefore, in order to bring national legislation in line with International Standards, we believe that compliance audit should be approved as a kind of state audit at the legislative level.

In order to provide recommendations on the directions for modernization of the state audit system in Ukraine, we consider it appropriate to outline the main components of the state audit system in the field of public procurement (essence, purpose, objectives, subjects, objects, principles, functions, methods, classification).

It is important for the theory and practice of public procurement auditing to define the subject and object.

The subject of state audit in the field of public procurement, which is, in fact, the activity of customers for transparent planning,

[8] Kaletnik G.M, Zdyrko N.G.

implementation of pre-contractual and contractual procedures, as well as the use of purchased items using electronic system in the manner prescribed by law to meet the needs of state, business and society. Such the subject definition of the state audit of public procurement corresponds to the philosophical understanding of subject cognition, as it reflects the summation of the studied properties, criteria (expediency, legality, reliability, efficiency), expressed in certain logical forms (procurement process, activity).

We believe that it is necessary to expand the concept of the object of state audit, going beyond the use of only budget funds. Thus, guided by the definition of "customer" according to the Law of Ukraine "On Public Procurement" (Law of Ukraine "On public procurement", 2015), it should be noted that customers – public authorities, local governments and social insurance bodies established in accordance with the law, as well as legal entities (enterprises, institutions, organizations) and their associations that meet the needs of the state or territorial community, if such activities are not carried out on an industrial or commercial basis.

Based on this, it is necessary to define the object of state audit as budget funds that are sent to managers at different levels to meet their needs, as well as own funds received by state (municipal) enterprises as a result of their activities, which should be used by them on the principles of economy, efficiency , expediency and legality. Therefore, to ensure the clarity of further research, we assume that one of the objects of state audit is financial public resources (budget expenditures and own funds of state / municipal enterprises).

This is important to determine the object of state audit as the purchase of goods, works and services for loans and borrowings provided in accordance with international agreements of Ukraine by international monetary and credit organizations (International Bank for Reconstruction and Development, International Finance Corporation, Multilateral Investment Guarantee Agency, International Development Association, the European Bank for Reconstruction and Development, the European Investment Bank, the Nordic Investment Bank), carried out in accordance with Art. 6 of the Law of Ukraine "On Public Procurement" (Law of Ukraine "On public procurement", 2015).

However, we believe that today is no an assessment of the use effectiveness of procurement items in accordance with their stated characteristics. Thus, to determine the most advantageous offer, the price or reduced price is set by law (Law of Ukraine "On public procurement", 2015), but we believe that this prevents the purchase of the highest quality item (goods, works, services), and leads to additional costs in the future (reconstruction, additional maintenance, replacement), which cannot be evidence of budget savings. Therefore, we consider it appropriate to specify another object of state audit – goods purchased by customers (non-current (tangible and intangible assets, as well as natural resources) and tangible current assets), works, services that should be subject to detailed assessment of their use for saving the state budget.

Thus, the object of the state audit of public procurement is public resources, which include budget funds (expenditures), own funds of state / municipal enterprises and funds of loans provided by international monetary and credit organizations, aimed at procurement, as well as purchased items of procurement (goods (non-current and current assets), works and services) used by the customer to meet the needs of his/her activities.

State audit in its current sense goes beyond the control of state finances and covers not only them, but also other economic resources of public value, and in some cases is extended to the finances of economic entities (Slobodyanyk, 2015).

Slobodianyk Y. adheres to a similar idea, describing the state audit as a type of control aimed at determining the compliance of public resource management with the established criteria. Public resources include not only the state budget and resources created at the expense of its funds, but also other types of national resources (material, natural, labor, information, intellectual, etc.), which are of public importance (Slobodyanyk, 2015).

However, we believe that in terms of the procurement process it is still more appropriate to define resources more broadly than public, because in addition to the affiliation of resources, which is embedded in the concept of "public", the basic principle of procurement is publicity, transparency and accessibility of information on their implementation. Also, in our opinion, the subject of a state audit could be natural resources for their

sustainable and efficient use. For example, if the customer purchased forestry products at an abnormally low price, the State Audit Office should question the efficiency, economy and cost-effectiveness of the use of such natural resources by the participant (state-owned enterprise). Based on the above, the purpose of the public procurement audit is to inform interested stakeholders (the public and the state, represented by the state authorities) about lawful, correct and efficient use of public resources by verifying compliance with legal requirements (compliance audit), accuracy and validity of accounting and financial accounting data (financial audit), as well as assessment of compliance of achieved indicators with the specified criteria of procurement process efficiency (performance audit) at micro- and macrolevels in compliance with the principles of independence, transparency and clarity.

We believe that, in order to establish compliance with INTOSAI standards, it is necessary to supplement the Law of Ukraine "On the Accounting Chamber" (Law of Ukraine "On the Accounting Chamber", 2015) with another component of public audit (including in the field of public procurement) – compliance audit. In addition, a detailed analysis of the Reports of the Accounting Chamber (Accounting Chamber of Ukraine, 2018) gives grounds to argue about the application of methods, tools and procedures for compliance audit (assessment of compliance with legislation, rules, regulations). Therefore, the initial (main) tasks of the state audit of public procurement are:

1) verification and assessment of the legality of the procurement process by customers and participants, as well as the organization of the system (including electronic) procurement by the Authorized Body and its subordinate enterprises, institutions, organizations – compliance audit;

2) verification and assessment of compliance with financial parameters in terms of determining procurement procedures, as well as the correctness of the financial reflection of their implementation in accounting and financial reporting;

3) verification and evaluation of the effectiveness of the procurement process through the analysis of economy, productivity and effectiveness of procurement.

The related objectives of the state audit of public procurement,

after identifying the facts of illegality, impropriety and inefficiency of operations with public resources are:

− establishing the causes of deviations, errors and violations, as well as providing recommendations to avoid them in the future;

− ensuring transparency and accessibility to the public of information on public resource management;

− checking the status of violations elimination and correction of errors.

Therefore, implementation of public procurement is also subject to checks by the state financial control authorities for legality and efficiency. The subjects of state audit are directly its initiator – the highest body of state audit and executors – state auditors, independent auditors and experts (specialists in matters subject to state audit). In this case, the initiator of the state audit will always be the highest body. Only the initiator of the state audit determines the conditions and procedure for involving certain performers depending on the tasks, form and significant circumstances of a particular one (Slobodyanyk, 2015).

The subjects that exercise control in the field of public procurement within their powers include the Antimonopoly Committee of Ukraine and the Accounting Chamber, as defined in paragraph 3 of Art. 7 of the Law of Ukraine "On Public Procurement" (Law of Ukraine "On public procurement", 2015). Empowerment in the field of control over the receipt of funds in the State Budget of Ukraine and their use by the Accounting Chamber is also established by Art. 98 of the Constitution of Ukraine (Constitution of Ukraine, 1996).

The Law of Ukraine "On the Accounting Chamber" of July 2, 2015 №576-VIII (paragraph 1 of Article 7) defines its responsibilities and establishes that the Accounting Chamber carries out financial audit and performance it on procurement at the expense of the state budget , and also carries out preliminary analysis, before consideration at sittings of committees of the Verkhovna Rada of Ukraine and at plenary sittings of the Verkhovna Rada of Ukraine, of the annual report containing the analysis of functioning of public procurement system and the generalized information on results of control in the sphere of purchases promulgation (Law of Ukraine "On the Accounting Chamber", 2015).

The Law of Ukraine "On Public Procurement" stipulates that one of the main functions of the Authorized Body is to prepare and submit no later than April 1 of the year following the reporting budget year to the Verkhovna Rada of Ukraine, the Cabinet of Ministers of Ukraine, the Accounting Chamber, the Report, which contains an analysis of the functioning of the public procurement system and generalized information on the results of control in the field of procurement. Apart from the definition in the same Law of the Authorized Body as the central body of executive power that implements the state policy in the field of public procurement, no specific subject is defined. The answer is found in the Regulation on the Ministry of Economy, Trade and Agriculture of Ukraine (hereinafter – the Ministry of Economy) (Regulations on the Ministry of Economic Development, Trade and Agriculture of Ukraine, 2014), which defines that this Ministry is the central executive body, whose activities are directed and coordinated by the Cabinet of Ministers of Ukraine. However, paragraph 96 in defining the tasks of the Ministry of Economy does not say a word about the generalization of information on the results of procurement control in the preparation and submission of the Report, only provides an analysis of the functioning of the public procurement system.

The Regulation stipulates that the Ministry of Economy implements the state policy in the field of state and public procurement. Indirectly, the control powers of the Ministry of Economy are defined in paragraph 4 of Art. 5 (Regulations on the Ministry of Economic Development, Trade and Agriculture of Ukraine, 2014), which provides for control over the use of financial and material resources, which means monitoring of the efficiency and effectiveness of customer funds in public procurement. Therefore, the subjects of the state audit of public procurement are:

1) the highest body of external financial control in Ukraine – the Accounting Chamber in terms of compliance audit, financial audit and performance audit;

2) body of internal state control – the State Audit Office in terms of compliance and financial audit with the use of monitoring as a preventive measure.

Based on the above, we believe that the state audit in the field of public procurement is a form of state financial control, which is used

by the relevant entities (the Accounting Chamber, State Audit Office) to monitor and verify (correctness, legality, efficiency and economy) usage of public resources to ensure proper information and efficient management at the macro- and microlevels.

The application of such a definition of the state audit will enable to narrow the terminological apparatus and remove the perceived overlaps and broaden the subject-objective area.

Therefore, on the basis of the conducted research we will formulate theoretical components of the public procurement audit system, which include the purpose, objectives, subject, objects, entities (Table 3.7).

Table 3.7

The components of the public procurement auditing system

Components	The essence of the state audit system
The purpose of the state audit	Informing stakeholders (the public and the state, particularly the public authorities) about the legitimate, proper and effective use of public resources at the macro and micro levels in compliance with the principles of independence, transparency and comprehensibility.
Objectives of state audit	***Initial*** – verification and evaluation: 1) legality of carrying out activities by customers and participants in the field of procurement, as well as the organization of the procurement system; 2) the correctness of compliance with financial parameters and the reflection of procurement in accounting and financial reporting; 3) efficiency of the procurement process (economy, productivity, efficiency).
	Related – − establishing the causes of deviations, errors and violations, as well as providing recommendations to avoid them in the future; − ensuring transparency and accessibility to the public of information on public resource management; − checking the status of violations elimination and correction of errors.
Subject of state audit	Public procurement.
Object of state audit	Activities of customers regarding the legal, correct and effective implementation of public procurement.
	Activities of the Authorized Body and state enterprises / institutions in the field of public procurement.
	Public resources (procurement items and public funds).

Source: summarized and suggested by the authors

It is important for the efficiency and effectiveness of state audit to determine its functions. In foreign countries, control on behalf of society is exercised by a special constitutional body, which is represented by the state audit institute, whose functions include both regulatory and constructive (Pikhotsky, 2016).

Pikhotsky Y. specifies such functions of state audit as planning, organising, stimulating and controlling (Pikhotsky, 2016).

Having conducted research on the functions of state audit in general, we believe it appropriate, taking into account the specifics and features of public procurement, also considering it appropriate to adapt them and highlight the functions of state audit of public procurement (Table 3.8).

Table 3.8

The main functions of state audit of public procurement

№	Function name	The content of the function
1	2	3
1	Control	Verification of the legality and correct usage of public resources in accordance with legal requirements.
2	Analytical	Assessment and evaluation of the efficiency usage of public resources by contractors at different levels as well as the organization of the public procurement system.
3	Informational	Informing the public about the level of public resource management via the formation of analytical and summary reports based on the collection, processing and evaluation of regular analytical and survey information.
4	Social	Ensuring the efficient, equitable distribution and use of public resources, as well as supporting the development of society in accordance with the identified priorities and goals; identification of factors hindering the society, protection of public interests in the rational use of resources.
5	Preventive	Promoting the elimination of errors and violations identified by the control system, research of the causes of their occurrence, prevention of them in the future so that to preserve of public resources.
6	Prophylactic	Early detection and prevention of possible errors, violations and illegal actions by the subjects of the procurement process (customers, participants, top managers).
7	Synthetic	It relies on the development of specific proposals to improve the efficiency of the monitored entity.

continuation of table 3.8

1	2	3
8	Stimulating	Promoting the creation of conditions for state administration to comply with the requirements of legislation in the field of public resources, the formation of a conscious public attitude to the results of state audit.
9	Predictable	Strategic, operational planning and coordination of the development of the state administration system based on analysis and assessment of the actual results of the state audit.

Source: developed by the authors using (Slobodyanyk, 2015, Lyubenko, 2014, Pikhotsky, 2016, Budnyk, 2016)

There are currently no legally established functions for state audit, which in our opinion prevents it from being effective and efficient.

The state audit should perform not only the task of identifying errors and violations, that is the task of retrospective nature. Public auditors should be creators who identify inefficiencies and ways to address the problems and risks faced by this controlled entity. Therefore, apart from retrospective nature, the functions of state audit should be aimed at preventing pre-crisis phenomena, errors and violations, assessing the development strategy of the controlled institution, justifying the optimal or alternative strategy and long-term development program, assessing forecasts and directions of certain sectors of the economy, regions and the state as a whole (Budnyk, 2016).

A clear definition of the principles of the public procurement audit is essential for defining the organizational and methodological provisions of the state procurement audit.

In particular, according to the Code of Ethics of Supreme Audit Institutions (ISSAI 30 “Code of Ethics”), the fundamental principles include: Integrity; independence and objectivity; Competence; Professional Behavior; Confidentiality and Transparency (ISSAI 30 “Code of Ethics”, 2011).

Authors Dikan L., Golub Y., Synyugina N. outline the principles of state audit arrangement: specialization, cooperation, proportionality, parallels, directness, rhythmicity (Dikan et al, 2011).

The Law of Ukraine “On the Accounting Chamber” defines the following principles of state audit: independence, legality,

completeness, objectivity, reliability and validity. The activities of the Accounting Chamber are based on the principles of legality, independence, objectivity, neutrality, transparency and impartiality (Law of Ukraine "On the Accounting Chamber", 2015).

Important in determining the principles of the state audit of public procurement is the principles of the procurement itself in accordance with the Law of Ukraine "On Public Procurement": fair competition among participants; maximum economy and efficiency; transparency and oversight at all stages of procurement; non-discrimination of participants; objective and unprejudiced evaluation of tender offers; prevention of corrupt practices and fraud. Essential and complementary to the state audit is openness, transparency and impartiality (Law of Ukraine "On public procurement", 2015).

The Lima Declaration, the main purpose of which is to call for the independence of public finance audits, sets out the following principles: institutional, financial and personal independence, personal responsibility, the right to information and the right to take action (Dikan et al, 2011, Lima Declaration, 1977).

Therefore, based on the research, we can identify the following principles of state audit of public procurement:

1) fundamental principles – integrity, independence and objectivity; competence; professional behavior; confidentiality and transparency;

2) special principles – legality, completeness, reliability, validity, impartiality, transparency, openness, clarity, a unified approach.

To implement the functions of state audit of public procurement, general scientific and own methodological techniques are used:

– general science: analysis and synthesis, induction and deduction, abstraction and concretization, analogy, modeling, systems approach;

– own: assessment of the legal framework and indicators of statistical, financial and operational reporting; comparison, interviews, questionnaires (the process of interviewing customers, participants and other actors in the procurement process), testing (with the introduction of additional modules in electronic systems (platforms, maidans)).

Considering a number of unsolved problems in the state audit of public procurement, the task of arrangement and methodology of its

implementation at the stages of the procurement process in terms of investigation of legality, accuracy and efficiency is relevant, and which is devoted to the next stage of the research.

As established by previous research, state audits are carried out in three areas: performance and financial audits, the tasks of which are set out in legislation, and compliance audits, which are carried out but not legally defined. It is proposed to correct this shortcoming by making appropriate clarifications and adjustments to the legal framework for state audit (Laws, Regulations, Instructions) on the legal recognition of compliance audits.

The performance audit is conducted by the Accounting Chamber of Ukraine. According to the Law of Ukraine "On the Accounting Chamber", the performance audit involves establishing the actual state of affairs and assessing the timeliness and completeness of budgetary expenditures, productivity, efficiency, economical use of budget funds by their managers and recipients, legality, timeliness and accuracy of decision making by the budget process participants, status of internal control of budget funds managers (Law of Ukraine "On the Accounting Chamber", 2015).

Gorshenina D. characterises the performance audit as a tool for assessing and controlling the use of budgetary resources in terms of the goals and objectives set, their compliance with the government's development strategy (Gorshenina, 2015). However, this approach can be considered somewhat narrowed, as it does not take into account all types of resources (except budget funds, state property, labor resources), which are in the scope of performance audit interests, and misses the mechanism of their transformation into the final product (service), the optimization of which is a crucial task of this audit type. Focusing on the strategic goals of the state is the main characteristic of strategic audit (Vysochan, 2019).

O. Parkhomenko defines performance audit as an assessment of the appropriate balance between the price and the quality of the achievement of the set target due to economical, efficient and effective management decision-making on the use of public funds (Parkhomenko, 2016).

The concept of "performance audit" is not unambiguously interpreted by different translations of the Lima Declaration and other INTOSAI regulations and standards: "efficiency (control)

audit", "implementation audit", "activity audit", "action audit", "productivity audit", "administrative activity audit".

It is important to distinguish between efficiency as the difference between the results achieved and the inputs, where efficiency is defined as the ratio of these indicators.

Essentially, the auditor carrying out a cost-effectiveness analysis should answer three follow-up questions:

1) Did the planned objective of using budgetary funds succeed? <performance criteria>.

2) Is the used amount of public funds at least minimally possible to achieve the set objective? <economy criteria>.

3) Was the method of reaching the established objective reasonably optimal for the available volume of allocated budget funds? < efficiency criteria (in some sources – productivity)> (Vysochan, 2019).

Therefore, the purpose of the public procurement efficiency audit is to assess the economy, efficiency and effectiveness of public resources (budget funds, material and non-material resources purchased, as well as natural resources) in compliance with the principles of independence, transparency and publicity. Assessment of the achievement degree of the goal and implementation of performance audit objectives in public procurement is impossible without the development of a performance criteria system.

Summarizing the results of the research we can conclude that the audit of public procurement efficiency should include:

1) general issues – used to evaluate the effectiveness of the public procurement process at the level of the state, sectors, regions, customers and participants. These include:

– strategic (pragmatic) issues – economic evaluation of the achievement of the strategic goal, objectives and targets to be carried out after achieving the final financial results of the procurement sector in 3-5 years. For example, evaluation of the effectiveness of the Strategy in the field of public procurement (Strategy for reforming the public procurement system, 2016) after the completion of the term of its implementation (2016-2022);

– current issues is an economic assessment of the goal achievement, objectives and targets of the procurement sector for the current year. For example, an assessment of the implementation and

fulfilment of the objectives of the Strategy (Strategy for reforming the public procurement system, 2016), which are foreseen for each year;

– sectoral economic issues – assessment of the impact of the procurement process on the efficiency of any sector (agricultural production, industry, transport, medicine, education, etc.). For example, the purchase of school buses by schools has helped to increase the efficiency of the engineering plants;

– social issues – assessment of complaints from the population and public organizations about the procurement process (the information is received as a result of the previous or subsequent evaluation of public procurements via "Prozorro");

– environmental issues – assessment of the procurement process impact on the environmental indicators and the effectiveness of environmental measures.

2) individual questions – used to assess the effectiveness of a particular procurement at the level of any customer.

Thus, the basic criteria for assessing effectiveness in public procurement audits must be economy, efficiency and effectiveness.

The literal translation of "economy" is interpreted as "economical", and some authors (Gordeeva, 2015) mean this very way one of the components of the efficiency audit. However, our research shows that there is a significant and fundamental difference in the concepts of "economical" and "economic", since the former indicates the diligence, and the latter the adherence to economics. Therefore, having translated ISSAI 300 "Basic Principles of Performance Auditing", we consider it appropriate to describe "economy" as economical, diligent and efficient. According to the Law of Ukraine "On the Accounting Chamber of Ukraine" (Law of Ukraine "On the Accounting Chamber", 2015), the assessment of the cost-effectiveness of budget funds establishes the state of achievement by the manager and recipient of such funds planned results through the use of minimum budget funds or achieving maximum results when using budget funds.

We believe that the assessment of overall efficiency is not possible without the existence of additional criteria and their combined use with the basic ones. For example, too long period of procurement procedures is problematic for public procurement,

which generally leads to the risk of losing the need for a particular procurement item. That is why the criterion of timeliness is important. For example, when a certain category of patients is at risk of death or illness without the availability of medical equipment or medicines, and such purchases are made for several months, the government must regulate these aspects to ensure both the timeliness and efficiency of the procurement process. At the same time, ignoring the quality criterion and not taking it into account leads to the customer incurring additional costs in the future, which in no way can confirm the criterion of economy.

In order to evaluate the criterion of saving public funds and resources, we propose evaluating the criterion of efficiency, which is carried out on the basis of analysis of compliance of the declared requirement in the procurement plan with the real need of the contracting authority. Thus, we consider it appropriate to define basic and additional criteria of public procurement efficiency audit:

– basic – economical, productivity and effectiveness;

– additional criteria – timeliness, quality, expediency.

The International Standard for Supreme Audit Institutions ISSAI 100 "Fundamental Principles of Public Sector Auditing" defines that financial audit is one of the three main types of audit. It examines whether the entity's financial information is presented in accordance with the applicable conceptual framework of the financial statements and the regulatory framework. This is achieved by obtaining sufficient and appropriate audit evidence to enable the auditor to conclude that the financial statements do not contain material errors or omissions.

According to Art. 4 of the Law "On the Accounting Chamber", financial audit is to verify, analyze and assess the correctness, completeness of accounting and reliability of reporting on budget revenues and expenditures, establishing the actual state of affairs on the intended use of budget funds and compliance with legislation on transactions with them (Law of Ukraine "On the Accounting Chamber", 2015). In 2015, the Accounting Chamber approved the Guidelines for conducting the Financial Audit by the Accounting Chamber (Methodical recommendations, 2015) (hereinafter – the Guidelines), which determine the procedure and its powers to conduct financial audits.

Regardless of the objects and objectives of the financial audit, budget and financial statements, primary documents, accounting documents are subject to review during the audit, other documents and data on the use of normative-legal acts, regulatory and other documents regulating the procedure for the receipt and use of public resources. The main criteria established by the financial audit are: probity, adequacy, completeness, value for money and legality.

Therefore, the financial audit is inseparable from the compliance audit by the Accounting Chamber and the State Audit Office.

In continuation of previous research, we detail information on the features and main violations identified during the Financial Audit of the Accounting Chamber of public procurement.

Table 3.9

The main directions of financial audit carried out by the Accounting Chamber

№	Directions	Detailing of directions
1	Status analysis of public procurement	1.1. Analysis of legal and regulatory support for public procurement in Ukraine.
		1.2. Analytical assessment of public procurement.
		1.3. Analysis of technical and operational work of information and telecommunication system "PROZORRO".
2	Activity analysis of the Authorized Body (Ministry of Economic Development, Trade and Agriculture) in the field of public procurement	2.1. Analysis of the Ministry's performance of public procurement functions.
		2.2. Analysis of the Ministry's Annual Report on the Functioning of the Public Procurement System.
		2.3. Assessment of the state of the recommendations implementation of the Accounting Chamber based on the results of previous control measures in the field of public procurement.
3	Activity analysis of other bodies in the field of public procurement	4.1. Work analysis of the Antimonopoly Committee of Ukraine as an oversight body.
		4.2. Activity analysis of control and law enforcement agencies in the field of public procurement.
4	Analysis of the Strategic Action Plan implementation	5.1. Implementation of the Action Plan for the Strategy implementation of reforming the public procurement system ("road map").

Source: summarized by the authors

In order to increase the efficiency of public procurement, it is important to adopt the best experience of foreign countries in organizing the work of supervisory authorities in the procurement process.

The control and appeal bodies in foreign countries include: in Denmark, the Complaints Commission; in Hungary, the Public Procurement Arbitration Commission; in Cyprus – Tender Authority, Supreme Court; in Austria – Administrative Court, in Slovenia – National Control Commission.

In order to ensure an adequate level of public financial control, its efficiency and effectiveness, it would be necessary to: constantly increase the level of professional qualities of the state internal auditors in planning, conducting and documenting the results of audits; increase the number of internal audit units and complete them. Functions and tasks of state auditors need to be avoided in order to avoid conflicts of interest in exercising clear distribution control.

Therefore, public procurement is one of the instruments of state regulation and realization of public welfare. The role of public procurement should be considered not only in terms of meeting public needs, but also the needs of society. Based on the implementation of public procurement tactical and strategic tasks and in order to implement the concept of sustainable development, we propose to determine the role of public procurement as part of the economic, social and environmental policies of the state. According to legal requirements, public procurement is classified as a threshold and a threshold. Procedures for the implementation of sub-threshold procurement include open bidding, competitive dialogue; negotiated procurement procedure. Analytical assessment of the current state of public procurement in Ukraine, it is worth noting that both the number of public procurement and their value increases every year, thus ensuring budget savings and meeting the needs of both customers and participants. Public procurement control tendencies indicate an increase in control results, however, typical violations and abuses also occur.

3.3. Conceptual framework for the development of energy audits in Ukraine[9]

The world is undergoing changes in approaches to the formulation of the energy policy of states: the transition is underway from the outdated model of functioning of the energy sector, which was dominated by large producers, unprofitable fuel, inefficient networks, lack of competition in the natural gas and electricity markets, coal – to a new model, which creates a more competitive environment, provides opportunities for development and minimizes the domination of one type of energy production or sources and/or ways of supplying fuel (Energy Strategy of Ukraine, 2017).

At the same time, the priority is given to increasing energy efficiency and the use of energy from renewable and alternative sources. The implementation of prevention and adaptation measures to climate change is also one of the priorities of global energy development.

This is posing new economic and technological challenges for Ukraine and at the same time opens up new opportunities for the search for and implementation of innovative developments in the extractive industry, production and processing of secondary fuels, production, transformation, supply and consumption of energy necessitates the formation of a new energy policy for the state (Energy Strategy of Ukraine, 2017).

Ukraine is one of the energy deficient countries that satisfy its needs in fuel and energy resources (FER) at the expense of their own production by less than 50% (Resolution of the Cabinet of Ministers "On the Comprehensive State Energy Saving Program of Ukraine", 1997). Proprietary FER is produced in such mining and geological conditions that make them non-competitive with imported FER. This is above all true for oil and gas production. The current situation is not good in the coal industry, where most mines have low economic performance.

Although Ukraine has large reserves of coal that could last for hundreds of years, their development requires large capital investments which the state is unable to provide in the current

[9] Kaletnik G.M, Zdyrko N.G.

economic crisis. Therefore, the efficiency of FER in the Ukrainian economy and in the social sphere is very low. The energy intensity of the gross domestic product in Ukraine is now more than twice as high as the energy intensity of the industrially developed countries of Western Europe and continues to grow (Resolution of the Cabinet of Ministers "On the Comprehensive State Energy Saving Program of Ukraine", 1997).

According to the Ukrainian State Statistics Service, fuel stocks are decreasing every year (Table 3.10). It should be noted that among all types of fuel there are no data on crude oil (including gas condensate), as this information is not made public in order to ensure compliance with the requirements of the Law of Ukraine "On State Statistics" on the confidentiality of statistical information.

Table 3.10

Fuel reserves in Ukraine as of August 1, 2021*

Types of fuel	On August 1, 2021, thousand tons	Increase, decrease (-) on August 1, 2021, in% to	
		July 1, 2021	August 1, 2020
Coal	2287.6	-18.1	-44.2
Motor gasoline	120.9	-2.8	-18.3
Gas oil (diesel fuel)	309.8	-5.7	-26.4
Heavy fuel oils	82.5	-4.6	-18.0
Liquefied propane and butane	18.7	-2.6	-13.8

Source: built according to the State Statistics Service (The official website of the State Statistics Service of Ukraine, 2021)

**without taking into account the temporarily occupied territory of the Autonomous Republic of Crimea and the city of Sevastopol and part of the temporarily occupied territories in Donetsk and Luhansk*

We can see that, for example, reserves of black coal decreased by 44.2% (or 1812.0 thousand tons).

The same negative downward is also observed for other types of fuel, which will further aggravate crises in Ukraine's energy sector.

According to the State Statistics Service, despite the increase in the installed capacity of power plants in 2020 compared to the previous one by 3694.0 thousand kW, electricity supply decreased by

4016.0 million kWh (Table 3.11).

Table 3.11

Installed capacity and supply of electricity by type of power plant

Types of generating enterprises	Installed capacity of power plants at the end of the year, thousand kW		Deviation 2020+/-2019	Electricity supply, million kWh		Deviation 2020+/-2019
	2019	2020		2019	2020	
Total	**51444**	**55138**	**3694**	**141213**	**137197**	**-4016**
Including						
thermal power plants	22265	22311	**+46**	40910	36300	**-4610**
thermoelectric power station	5855	5890	**+35**	10738	12837	**+2099**
nuclear power plants	13835	13835	**0**	77948	71249	**-6699**
hydroelectric power plants*	6326	6335	**+9**	7712	7415	**-297**
other power plants	3163	6767	**+3604**	3906	9396	**+5490**
From them						
wind power plants	795	1110	**+315**	1760	3271	**+1511**
solar power plants	1953	5194	**+3241**	1883	5684	**+3801**

Source: summarized according to the State Statistics Service (The official website of the State Statistics Service of Ukraine, 2021)

**Including hydroelectric power plants*

In terms of types of generating enterprises, it should be noted a positive trend in the operation of wind and solar power plants, because simultaneously with the increase in their capacity by 315 and 3241 thousand kW, there is an increase in electricity supply by 1511 and 3801 million kWh, respectively, which is another argument and confirmation of the need for Ukraine's transition to the use of alternative energy sources.

Therefore, in order to simplify graphical understanding of analytical data, we consider it necessary to present them in graphical form. As a percentage comparison, we can see that, for instance, electricity supply from nuclear power plants amounts to 51%,

although they account for 25.1% of the total structure. And on the other hand, with 40.5% of the capacity provided by thermal power plants, electricity supply is 26.5%.

We believe it is necessary to assess changes in the capacity and supply of heat by types of generating companies (plants). In comparison with last year, there is a tendency to reduce the installed capacity of power plants (by 15.661 Gcal/year), as well as the supply of heat (by 2055 thousand Gcal). All types of generating companies (apart from waste heat treatment plants) also show considerable reductions. The installed capacity of waste heat recovery units increased by 220 Gcal/year in 2020, and heat supply increased by 432 thousand Gcal/year (Table 3.12).

Table 3.12

Established capacity and supply of heat by type of generating plant(s)

Type of generating plant(s)	Installed capacity of power plants at the end of the year, Gcal / year		Deviation 2020+/- 2019, Gcal / year	Thermal energy supply, thousand Gcal		Deviation 2020+/- 2019, thousand Gcal
	2019	2020		2019	2020	
Total	**129045**	**113384**	**-15661**	**91009**	**88954**	**-2055**
Including						
thermal power plants	4240	4207	**-33**	1241	1125	**-116**
thermoelectric power station	31959	29896	**-2063**	26733	25517	**-1216**
nuclear power plants	2596	2596	**0**	1443	1387	**-56**
thermal power centres (boiler house)	83974	70485	**-13489**	53954	52954	**-1000**
disposal installations	4138	4358	**+220**	6656	7088	**+432**
other installations	2138	1843	**-295**	983	883	**-100**

Source: summarized according to the State Statistics Service (The official website of the State Statistics Service of Ukraine, 2021)

The state of thermal energy in Ukraine is unsatisfactory. According to the information materials of the Ministry of Energy and Coal Industry, about 80% of TPP and CHP units exceeded the limit

of physical wear and tear by 200.000 hours. Therefore, its radical modernization and construction of new facilities is extremely important. The vision of the future thermal energy should be based on the total volume and structure of energy in the country as a whole, which in turn should be based on the volume and structure of social production, take into account the resource base, environmental standards and energy security (Draft concept of modernization of thermal energy of Ukraine, 2016).

Ukraine has signed and ratified international agreements, according to which Ukraine is obliged to reduce the energy intensity of its own economy, encouraging energy consumers to save energy and energy efficiency:

– UN Framework Convention on Climate Change, which establishes a framework for tackling climate change;

– The Paris Agreement, under which Ukraine is obliged to make its nationally contribution to achieve the goals of sustainable low-carbon development of all sectors of the economy and increase the ability to adapt to the adverse effects of climate change, in particular by reducing greenhouse gas emissions.

To implement national action plans on energy efficiency and energy policy, state authorities (the Verkhovna Rada of Ukraine, the Cabinet of Ministers of Ukraine, the President of Ukraine, the State Agency for Energy Efficiency and Energy Saving of Ukraine) and the National Commission for State Regulation of Energy (hereinafter – the National Commission)) exercise their powers (Table 3.13).

In addition to the listed state bodies that regulate the energy sector, there are Ministries. The Ministry of Energy and Water Resources Protection of Ukraine is the main body in the system of central executive authorities that ensures the formation and implementation of state policy in the field of environmental protection and environmental safety. In accordance with the assigned tasks, the Ministry of Energy, within the limits of its competence, is able to influence the energy efficiency of the regulatory process in the field of air protection and climate change, particularly, in terms of the creation and organization of the functioning of the national greenhouse gas emission trading system (Green Paper, 2019).

Since September 2019, the Ministry of Energy has also been the main body in the system of central executive bodies, which ensures

the formation and implementation of state policy in the fuel and energy sector. In accordance with the assigned tasks, the Ministry of Energy has the opportunity to influence energy efficiency in industry in the process of forming the regulatory framework in the relevant fuel and energy markets and ensuring the implementation of the Energy Strategy of Ukraine for the period up to 2035 (Green Paper, 2019).

Table 3.13

Responsibilities of state regulators in the field of energy efficiency

Subjects	Functions and responsibilities
the Verkhovna Rada of Ukraine	– determines the principles of domestic and foreign policy; – considers and adopts the Laws of Ukraine (including the settlement of certain issues in the field of energy efficiency); – approves the State Budget of Ukraine (including approval of expenditures aimed at financing energy efficiency and energy saving).
the Cabinet of Ministers of Ukraine	– the highest executive body that carries out public administration in the field of energy saving (Article 9 of the Law of Ukraine "On Energy Saving"); – implements means of influencing energy efficiency (economic and pricing policy, regulation of the national economy, development and implementation of national programs).
the President of Ukraine	– issues decrees and orders that are binding on the territory of Ukraine (Decree of 26.07.1995 № 666/95 "On the establishment of the State Committee of Ukraine for Energy Conservation" and of 13.04.2011 № 462/2011 "On the State Agency for Energy Efficiency and energy saving of Ukraine), and also has the right of legislative initiative.
the State Agency for Energy Efficiency and Energy Saving of Ukraine	– carries out the state examination on energy saving; – develops state norms, rules, technical regulations, as well as monitors the implementation of programs in the field of energy efficiency and energy saving; – defines and implements mechanisms of energy efficiency and energy saving, as well as organizes training in this area; – promotes energy efficiency and energy saving, as well as participates in the creation of funds in this area.
the National Commission for State Regulation of Energy	– forms the price and tariff policy in the fields of energy; – promotes competition in energy markets.

Source: summarized by the authors

In accordance with European Parliament and Council Directive 2012/27/EC of 25 June 2012 on energy efficiency (hereinafter the Directive), an "energy audit" means a systematic procedure to obtain proper knowledge of the current energy performance of a building or a group of buildings, industrial or commercial activities, installations, private or public services by identifying and quantifying the cost-effective possibilities for energy conservation and providing a report on the results obtained (Directive 2012/27/EU, 2012).

Energy audits should be able to make detailed and verified calculations of the implemented measures to provide clear information on the potential costs, which can be carried out by in-house experts or energy auditors. The data used in energy audits should be kept for statistical analysis and performance monitoring.

The Directive stipulates that the National Energy Efficiency Action Plans should include the number of energy audits carried out for the previous period; the number of energy audits carried out by large enterprises in the previous period; the number of large companies in their territory, noting the number of those covered by Article 8 (that have carried out energy audits) (Directive 2012/27/EU, 2012). However, we believe that the National Plan should not include quantitative indicators of audits or companies, but a set of interconnected, systematic and mutually reinforcing measures that would contribute to the improvement of energy efficiency and saving in Ukraine.

The International Organization for Standardization (ISO) has approved the international standard ISO: 50002 "Energy audit. Requirements and guidelines for use" (Energy audit, 2016). In order to ensure unification and harmonization with international standards, on the basis of ISO 50002 at the national level adopted National Standards of Ukraine (NSU) ISO 50002: 2016 "Energy audits. Requirements and guidelines for implementation" (Energy audits, 2016).

According to the international and national standards, energy audit is a systematic analysis of energy use and consumption within the specified area of energy auditing application for the purpose of identification, quantification and reporting of opportunities for energy results improvement (Energy audit, 2016).

According to the Directive, the energy audit must be accessible to all end-users and meet certain criteria:

1) must be based on current, measured, tested operational data on energy consumption and load profile (for electricity);

2) must include a detailed review of the energy use profile of the buildings or groups of buildings, industrial activity or installation, including transport;

3) they should be based, if possible, on life cycle cost analysis (LCCA) rather than simple payback periods (SPP) to take into account long term costs, the remaining balances of long term investments and discount rates;

4) must be proportionate and sufficiently representative to enable a true picture of the overall energy efficiency and to reliably identify the most significant opportunities for improving it.

The scope of the energy audit is the area of energy use and related processes to be included in it, as determined by the organization with involvement of the energy auditor, which may include several boundaries (Energy audit, 2016).

One of the regulatory documents governing the implementation of energy audits is the standard methodology "General requirements for organizing and conducting energy audits", approved by the National Agency of Ukraine for the efficient use of energy resources (Order №56 of 20.05.2010), (hereinafter – the Methodology) (Standard Methodology, 2010).

According to the approved methodology, energy auditing is one of the forms of implementation of the state energy saving policy, which is to provide assistance in improving the usage efficiency of fuel and energy resources (FER) (Standard Methodology, 2010).

The methodology defines the main purpose, tasks, objects and subjects of the energy audit (Table 3.14).

We believe that the purpose, objects and objectives should be expanded and modernised to meet today's challenges and will be presented in the next section of this study.

In our opinion, the notion of the subjects of the energy audit: "customer" and "executor" should be specified. The methodology does not specify the meaning of these terms, but it is obvious that the customer is the enterprise, institution, organization that requires an assessment and orders the energy audit services, and the executor is

the energy auditor (firm). The Law of Ukraine "On Auditing Financial Statements and Auditing Activities" № 2258-VIII of December 21, 2017 stipulates that the customer is a legal or physical person who is obliged by law or has the right to order audit services (Law of Ukraine "On Audit of Financial Statements and Audit Activities", 2017).

Table 3.14

Current definitions of the purpose, tasks, objects and subjects of the energy audit

Elements	The content of elements
1	2
The purpose of the energy audit	assisting the management of the facility that consumes FER in determining the status of FER consumption, energy saving potential, sources of wastage and the amount of wasteful use of FER by the production and supporting units, technological processes and individual consumers, in the development of energy-efficient measures, their technical and economic evaluation and assessment of their impact on the natural environment
The objectives of the energy audit	1) Identification of the general state of the facility that consumes FER, its main divisions and technological processes as consumers of FER; 2) Analysis of FER consumption balances separately for each type; 3) analysis of FER consumption balances in energy-intensive process units, technological processes, and sub-units; 4) analysis of FER losses at energy audit sites; 5) analysis of FER costs in the cost of products; 6) evaluation of energy conservation potential of energy audit objects; 7) evaluation of the efficiency level of utilization of FER; 8) analysis of energy efficiency of products; 9) analysis of FER consumption and its comparison with applicable standards, preparation of suggestions for its reduction; 10) evaluation of the efficiency of SEM functioning; 11) Development of recommendations on the implementation of energy-saving measures with their technical and economic assessment.
The subjects of the energy audit	Customer and Executor

continuation of table 3.14

1	2
The objects of the energy audit	1) objects that consume FER; 2) individual subdivisions of the object that consume FER; 3) technological processes of the main and additional productions; 4) energy-intensive users of FER; 5) pre-commissioning and re-commissioning facilities; 6) power supply systems; buildings and structures; 7) FER usage monitoring and accounting system; 8) energy management system; 9) investment and ownership proposals, programmes, projects, loan agreements.

Source: summarized by the authors (Standard Methodology, 2010)

Clarity in the definition of these concepts brings NSU ISO 50002: 2016 "Energy audits. Requirements and guidelines for implementation", which provides for two entities: the organization (customer) and energy auditor (executor). Thus, an "organization" is defined as a company, corporation, firm, enterprise, authority or institution, part or combination, officially registered or not, public or private, which has its own functions and administration, and which include the provision of control and management of energy use and consumption (Requirements and guidelines, 2016). The Notes indicate that the organization may be a person or a group of persons, which, in our opinion, causes conceptual contradictions, as we consider incompatible in the concept of "organization" of all the above entities, so hereinafter we mean them as "customers", especially that in legislative terms it is correct.

State Standard NSU ISO 50002: 2016 defines that an energy auditor is an individual or a group of persons who conduct an energy audit. The Notes indicate that the energy audit may be conducted by the organization using its own or borrowed resources (these may be energy consulting and energy service companies) (Requirements and guidelines, 2016).

From the legislative and theoretical point of view, this Standard and other legal acts on energy audit are in conceptual conflict with the Law of Ukraine "On Auditing Financial Statements and Auditing Activities" № 2258-VIII of December 21, 2017, as the latter provides that the auditor is a physical person who has confirmed his / her qualification for conducting auditing activities has relevant

practical experience and is included in the Register of Auditors and Auditing Entities (Law of Ukraine "On Audit of Financial Statements and Audit Activities", 2017). It is clear that energy auditors do not meet all these criteria, however, our previous research found that the cause of this conceptual conflict is the understanding of ISSAI International Standards of the concept of "audit" more comprehensive than "control", as well as "auditor" in relation to "controller". Thus, in order to eliminate these inconsistencies and harmonize them with International Standards, it would be worthwhile to make significant legislative adjustments in terms of auditing (including state audit).

The Energy Efficiency Directive requires that energy audits are carried out in an independent and economically efficient manner by certified and/or accredited experts hat they are carried out and monitored by independent bodies (USAID Project, 2016). In line with this, most European countries have introduced specific requirements for energy auditors regarding their professional knowledge gained through training or professional certification and practical work experience. In some countries certification programmes are being implemented whereby auditors are certified upon completion of training and examination (Bulgaria, Slovakia), or only after examination (Sweden, Czech Republic). Certificates may have a limited validity period of a few years (e.g. 5 years in Sweden, continuing professional development courses every 3 years in Slovakia) (USAID Project, 2016).

The experience of European countries suggests that auditors must be certified and/or accredited expert for effective and independent energy audits.

For the purpose of proper information support, we consider that a commonly available database should be created for the implementation of the proactive energy audit, including a Directory of certified auditors as well as a list of services to be provided by them. Since this amount of information must be clearly controlled and accurate, we believe that the state body (Ministry of Energy of Ukraine or the State Agency for Energy Efficiency and Energy Saving of Ukraine) should be responsible for its development.

Information tools serve to provide insights into the energy use of entities and to reveal the potential opportunities to improve their

energy efficiency. The information platforms must also provide the possibility to present the best applications of energy saving and energy efficiency as well as the exchange of experience. Thus, education, information and communication activities should be tools that can be used to implement efficient energy reforms while protecting the natural environment.

We believe it is necessary to review the principles and types of energy audits.

In order to conduct an effective energy audit, auditors must adhere to the following general principles as specified in NSU ISO 50002:2016 (Requirements and guidelines, 2016):

1) competence, which can be evidenced by: appropriate level of education, skills and experience; technical skills specific to energy use, nature of work, interfaces and energy audit objectives; knowledge of types of energy used and subject to inspection; knowledge of national and local standards for energy audits; availability of management skills;

2) confidentiality – guarantees proper handling of restricted information or confidential information (energy audit information cannot be used by the energy auditor inappropriately, for personal benefit or to the detriment of the legitimate interests of the organization);

3) objectivity – the energy auditor has to act independently and uninterruptedly. Conflicts of interest (personal, financial or other) must be promptly identified and reported to the management of the organization;

4) access to equipment, resources and information – ensuring that the auditor has access to the organization, technical facilities/premises, equipment, systems and processes; personnel (engineering, maintenance, service providers), suppliers and contractors; other sources of information such as chairs, manuals, results statements; surveys, data from past utility bills, monitoring and control data, electrical diagrams of electrical installations and test records (protocols).

The state standard also defines specific principles for conducting energy audits:

1) the audit should correspond to the defined nature and scope of the energy audit work, the scope and objectives of the audit;

2) measurements and observations used should take into account the specifics of energy use and consumption;

3) collected data on the level of achieved/received energy efficiency must be typical for the types of activities, processes, equipment and systems subject to energy audit;

4) the data used to quantify the level of attained/received energy efficiency and to identify opportunities for improvement must be consistent and clearly identifiable;

5) the process of data collection, verification and analysis should be transparent;

6) the energy audit report should highlight the possibilities for improving the achieved/the expected level of energy efficiency on the basis of the relevant technical and economic analysis (Requirements and guidelines, 2016).

The list of principles in the Methodology, which are not reflected in the State Standard and are, in our opinion, some of the key ones, is also supplemented:

1) scientific validity and legitimacy of the energy audit report;

2) validity and completeness of the energy audit information;

3) compliance with the achievements of scientific and technological progress, norms and rules of technical and ecological safety, regulations, standards and international requirements;

4) independence of energy auditors during their energy auditing activities;

5) responsibility of the energy auditors for the organization, conducting and quality of the audit (Standard Methodology, 2010).

Therefore, summarizing the above, the principles of energy auditing can be classified into two groups: general and specific (Table 3.15).

The timing of the energy audit depends on the type of facility that consumes FER, the size of the facility, and the amount of FER consumed. The timing of the energy audit may be adjusted to a timeframe to be agreed with the Customer by increasing the number of energy auditors or decreasing the amount of work to be done (Standard Methodology, 2010).

Particular attention should be paid to the classification of energy audits.

A specific feature of the energy audit is the classification into types (in NSU ISO 50002:2016) and kinds (in the Methodology), which, in our opinion, requires detailed consideration and improvement.

Table 3.15

General and specific principles of energy audit

Principles	The content of principles
General	Competence, confidentiality, objectivity, access to equipment, resources and information, logistics and legitimacy, reliability and integrity, taking into account the advances of science and technology, independence, accountability.
Special	The audit must be consistent with the intended nature and scope of the energy audit work, the scope and objectives of the audit; the measurements and observations used must take into account the specifics of energy use and consumption; collected data on the achieved/received energy efficiency level must be typical for the kinds of activities, processes, equipment and systems subjected to energy audits; the data used to quantify the achieved / estimated energy efficiency and to identify opportunities for improvement must be consistent and clearly identifiable; the process of collecting, verification and analysis of the data must be standardized; the report on the results of the energy audit should highlight the possibilities for improving the achieved/the expected level of energy efficiency on the basis of the relevant technical and economical analysis.

Source: summarized by the authors on the basis (Standard Methodology, 2010, Requirements and guidelines, 2016)

Therefore, according to NSU ISO 50002:2016, energy audits are divided into 3 types (Table 3.16), which can be carried out both individually, and from an expedited audit, for example, to a detailed or comprehensive audit.

Performing a class 3 audit requires a great deal of professional effort, time, skills and financial know-how from the auditor. Therefore, this type of audit is often used not for the entire company or the entire entity, but only for certain activities defined as a type 1 or 2 audit. A special feature of this type of audit is that the intensity of each step in the energy audit process is considerably increased.

The appropriate level of detail required for the audit depends on the subject of the audit, the type of energy use and energy consumption as well as the resources available for the audit (Requirements and guidelines, 2016).

Table 3.16

Types of energy audit according to NSU ISO 50002:2016

Type of audit	Name of audit	The content of audit types
Type 1	***Express Audit***	A quick overview of the energy situation at the enterprise without a quantitative assessment of the possible cost potential. Initial identification of energy efficiency measures for detailed analysis at audit level 2 and 3.
Type 2	***Detailed audit***	A detailed study of the main energy consumers at the company and the calculation of the energy saving potential. Mapping and evaluation of specific measures with cost and benefit calculations. Definition of measures for detailed evaluation at audit level 3.
Type 3	***Complex audit***	investment-grade audit (the most detailed audit level defined by the ISO 50002 standard). Detailed assessment of specific type 2 audit activities with early conceptualization of the project, selection of equipment and provision of commercial offers from equipment and service providers.

Source: summarized by the authors on the basis (Requirements and guidelines, 2016)

At the stage of preliminary preparation for the audit of the organization and the energy auditor, it is necessary to establish the availability of data for the energy audit and determine whether this data is sufficient for the audit of a more detailed type.

If additional measurements are required, the organization and the auditor should usually agree on the extent of the measurements required before proceeding with the audit. It is advisable to agree on the current or basic rate to be used for financial analysis, when conducting type 2 or higher audits (Requirements and guidelines, 2016).

Differences between detailed (2nd type) and complex (3rd type) energy audit are presented in table. 3.17.

After reviewing the types of energy audits, we consider it necessary to outline the types of energy audits in order to make their classification consistent and to make suggestions for their optimization.

Table 3.17

Differences between detailed and complex energy audit

№	Detailed energy audit	Complex energy audit
1	2	3
1	This is usually carried out for the entire company.	Conducted for a specific project with a clear objective of attracting investment. It can be applied to the whole enterprise, but is usually only economically efficient for organizations with high energy costs.
2	Knowledge of energy consumption processes is required. For example, to evaluate the efficiency of conventional refrigeration plants, boilers, etc.	Specific knowledge of specific processes and/or technologies is required. For example, for a type 3 audit of a cement plant, the auditor needs specific expertise in this area.
3	Measurements can be taken on demand. There is no need for continuous recording of measured data.	Measurement and sometimes long term data maintenance is necessary to understand the full performance of the equipment and the effects of changes.
4	A preliminary list of measures can be given to clients before a detailed analysis is carried out.	A preliminary list of activities will necessarily be given to clients to select the few most feasible implementation activities for which an investment project will be developed.
5	In terms of costs, can be used the prices available. For example, prices for engines on the Internet.	It is necessary to contact the suppliers to find out about new technologies and designs. Costs should be based on the preliminary design of the equipment and negotiation with the suppliers.
6	Non-energy benefits should be identified. They can be quantified, if possible.	Non-energy costs should be quantified, if possible, and taken into account in the financial analysis. For example, tax benefits, reduced costs of care, etc.
7	The use of express-analysis techniques.	To determine the relationship between energy consumption and relevant changes, appropriate analysis methods should be used. The existing energy consumption accounting system should be analyzed and ways to improve it should be suggested. Business strategies should be taken into account.

Source: (Project USAID, 2016)

It should be noted that paragraph 5.4 of the Methodology (Standard Methodology, 2010) specifies the following types of

energy audit:

1) initial – conducted at pre-start and reoperation phases of functioning of the facility energy audit to verify the adequacy of installation and maintenance in accordance with the requirements of regulations on indicators of energy efficiency of equipment used by FER. This type of energy audit will result in a decision on whether the equipment used by FER should be commissioned or put into service.

2) periodic – conducted over a specified period of time to determine key performance indicators that characterize the efficiency of FER use in the conditions of the enterprise.

3) extraordinary – conducted in the interval between periodic energy audits in cases where the validity of the results of the previous energy audit raises doubts, as well as in cases of a decrease in the efficiency of FER usage.

4) local – conducted to evaluate the use efficiency of certain FER types, secondary energy resources or specific indicators of energy efficiency of the company. The local energy audit may include energy audits of the most energy-intensive users at the request of the customer.

5) express audit – conducted at the pre-contractual stage of the energy audit, also due to limitations on the scope and duration of the audit to determine indicators of energy efficiency of the facility using FER, individual units or individual groups of units.

6) specific – carried out when special tasks related to the energy audit are solved, in which the customer is involved (e.g. identification of technological and accidental armouring of the facility, identification of user-regulators of electric power) (Standard Methodology, 2010).

We believe that the disadvantage of this classification is the lack of classificatory features, which leads to a lack of a clear understanding of the types and capabilities of the energy conductor.

Furthermore, there is some confusion about the consistency of certain types (defined by the Directive) and kinds (defined by the Methodology) of energy audits, which have a different meaning. For example, according to the Directive, an express audit (as a type) is a quick review of the energy situation at the enterprise without a quantitative assessment of the possible potential of costs, which is

carried out already at the survey stage and the results of which are the first basis for detailed (2nd type) and comprehensive (3rd type) energy audit. However, an express audit, as a kind, according to the Methodology, is carried out at the pre-contract stage, which understandably prevents the planning of the energy audit, much less its implementation at the investigative stage. Therefore, the essence of an express audit under the same normative documents has significant differences in the scope, purpose and terms of implementation, however terminologically defined, which, we believe, cannot be accepted and requires a significant correlation and correction.

Unlike the Directive, the Methodology defines the kinds of energy audits. Thus, the form of the energy audit can be of two types:

1) voluntary – executed in respect of any energy audit objects at the request of the interested entity upon approval of the supervisor or owner of the audited entity;

2) mandatory – to be performed on a request and at the expense of the funds of the interested bodies of executive power or local self-government bodies for the objects of state ownership, the list of which are approved by the Cabinet of Ministers of Ukraine or a body authorized by it.

We believe that the essence of the mandatory audit is essentially narrowed and the scope of the mandatory energy audit should be broadened for the purpose of effective implementation of the energy audit and to ensure energy efficiency in general. The first reason for limitation of meaningful engagement is the lack of at least an approximate understanding of this type of audit according to the main Law "On Audit of Financial Statements and Auditing Activity" (Law of Ukraine "On Audit of Financial Statements and Audit Activities", 2017). Thus, mandatory audit is defined by the Law as an audit of business entities which, according to the legislation, are obliged to publish or provide financial statements to auditors together with the financial statements, that is carried out by audit entities on the grounds and in the manner prescribed by the Law. Therefore, in both initiative and mandatory audits the auditor or an audit firm is the subject of the audit, that we believe the Methodology should also be updated and brought in line with the

general legislation in terms of mandatory audits content.

Another reason for the limited scope of the value-added work is the list of bodies involved due to their affiliation to only the governing authorities or local self-governing bodies, since one of the important issues in the energy audit should be the use of public (budgetary) funds for procurement by state enterprises, institutions, organizations (contractors) of heating and energy resources. However, not only customers can be controlled entities, but also participants of the purchasing process (suppliers, distributors). Thus, considering the objects of the energy audit, it should be noted that the parties involved can be not only bodies of the executive power, but also legislative (the Accounting Chamber), presidential (the Antimonopoly Committee) and judicial branches of power. Therefore, according to the definition of mandatory audit given in the Methodology, we conclude that the audit is related to the state audit.

We believe that mandatory energy audits must be carried out by all state-owned enterprises operating in the energy sector, the list of which has been approved by the relevant legislation. Thus, according to the State Budget Code of Ukraine, the auditor's conclusions on the annual financial statements for the last three years are subject to mandatory disclosure by the state enterprises, if the audit was performed in accordance with the requirement of the law or at the decision of the supervisory board of the state enterprise (if established) or the management entity of the state-owned property, which exercises the functions of management of the enterprise.

Thus, the legal requirements stipulated by the Civil Code once again confirm the necessity of independent mandatory audits by individual entities; however, with Ukraine's approval of the Energy Strategy until 2035 and in order to ensure energy efficiency, such audit should also include mandatory audits of the efficiency of production and implementation of energy resources.

Therefore, we propose a fundamentally new approach to the classification of energy audits by introducing a new classification signifier "due to legislative requirements", according to which we distinguish between these types of energy audits (with a new scope of work):

1) independent – audit of efficiency usage of fuel and energy

resources conducted by auditors registered within the Register of Auditors, with a view to expressing the auditor's opinion independently and providing an audit report. Can be voluntary (initiative) and mandatory:

a) voluntary – energy audit carried out on initiative of economic entities or physical persons (households) to determine the level of energy efficiency and energy consumption, as well as to find ways of saving fuel and energy resources;

b) mandatory – audit of state-owned enterprises in the energy sector, which are required by law to disclose information on the efficiency of production and sale of fuel and energy resources;

2) state energy audit is an audit conducted by the state controlling authorities on the correct use of budgetary funds for the purchase of fuel and energy resources by customers, as well as their economical and efficient use.

In case of non-independent energy audits, payment for the audit is made by the customers, while in case of government audits, it is the government's cost of retaining its controlling authorities.

It should be noted that in foreign countries, in contrast to Ukraine, there are special regulatory requirements for energy auditors – the Regulation on Energy Auditors (Bulgaria), the Regulation on Energy Specialists (Czech Republic). Practices of implementation of the EU Directive on energy audit in some foreign countries in terms of requirements for energy auditors indicate high requirements for qualification of energy auditors.

In Bulgaria, energy auditors must have the necessary technical equipment and staff; there are special requirements for staff regarding completed higher education and work experience in the relevant position; there is a mandatory requirement for a qualification certificate after the exam; must be registered in the public register by the ASER Agency; annual reporting to ASER.

In Germany, there are special requirements for energy auditors regarding training experience or professional qualifications and practical experience; and there is a Register of Energy Auditors established by the BAFA Office.

In Slovakia, energy auditors must have the required level of education and experience; there is a certification scheme under the auspices of SIEA, including training and examination; Certified

auditors are registered by the Ministry of Economy and SIEA in the energy auditors database; mandatory training of auditors every 3 years has been introduced.

Swedish energy auditors are certified on the basis of their level of education and work experience only after passing a test that includes written and practical parts and is valid for up to 5 years.

In the Czech Republic, there is a qualification scheme for energy specialists – the license is granted to specialists after passing the exam (oral and written), there are special requirements for the minimum required level of education and relevant experience, and there is a database of energy specialists.

Analyzing foreign experience, we believe that to increase the level of energy efficiency of any entities (including households) at the legislative level it is necessary, first, to determine the general requirements for qualifications, education and experience of energy auditors; secondly, to introduce a mandatory public Register of energy auditors with information access to potential customers of energy audits; third, the introduction of mandatory certification and advanced training at least every 3 years.

Thus, the experience of European countries shows that the auditor must be a certified and / or accredited expert for the purposes of efficient and independent energy audit.

In order to provide adequate information, we believe that a publicly available database should be created to conduct an independent energy audit, which would include a Directory of Certified Auditors, as well as a list of services they would provide. Since this array of information must be clearly controlled and accurate, we believe that the state body (Ministry of Energy of Ukraine or the State Agency for Energy Efficiency and Energy Saving of Ukraine) should be responsible for its formation.

Information tools are used to provide information on energy consumption of entities and to reveal potential opportunities to improve their energy efficiency. Information platforms should also provide the opportunity to present the best examples of energy saving and energy efficiency, as well as to share experiences. Thus, educational, informational and communication activities should become tools that would be used to implement effective energy reforms while ensuring the protection of the environment.

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CONCLUSIONS

1. Energy independence, as one of the components of energy security, occupies a crucial place in the national security system of the state, which requires a comprehensive theoretical and methodological justification for assessing its level, taking into account interdependence and interaction with other signs and indicators of energy and economic security. Energy independence of the state as a component of energy security is a difficult socio-economic definition, characterized by a set of statistical indicators, the level of independence of the state in conducting energy policy capable of resisting external and internal calls through enhanced economic development, without harming society and national production in general.

Energy security remains one of the important elements of economic security, which guarantees the sustainable development of each country's economies. The priority tasks in the direction of strengthening Ukraine's energy security are to increase energy efficiency, introduce innovative energy-saving technologies, develop the production and use of renewable energy sources. Without the diversification of the domestic fuel and energy sector and the introduction of energy-saving technologies, Ukraine will continue to depend on oil and gas imports, losing significant foreign exchange reserves. An important state task should be to improve the management system of the fuel and energy sector and the energy saving process.

2. Introduction of the latest energy-saving, energy-saving and environmentally friendly technologies in the agricultural sector of the economy, based on the use of energy-intensive, wide-ranging, high-tech machinery and equipment, resource-saving tillage technologies, wider use of renewable energy sources in Ukraine, including bio-energy, in the near future will allow to ensure high-performance production.

3. Agricultural waste and by-products have significant bioenergy potential and can be incinerated directly, used to produce solid biofuels or biogas. Biogas production from plant waste is an efficient and investment-attractive technology due to the presence of significant raw material potential in our country, favorable climatic

conditions and low cost of this type of energy. However, Ukraine is at the initial stage of introducing renewable energy sources, scientific, technical and economic problems of biogas production and use are insufficiently studied, which encourages further research in this area.

4. The agricultural sphere, in terms of its impact on human life, goes far beyond simple production, its significance is global, in particular in terms of impact on human life and health, food and environmental security. It is known from practice that for several decades humanity has been trying to overcome a number of global problems that have developed in modern conditions, namely the problems of environmental pollution, the shortage of natural resources on our planet. The way out of such a difficult situation is possible only due to radical changes in the method of production, the transition to new environmentally friendly and resource-saving technologies.

The agricultural sector in Ukraine is one of the most promising for doing business. Ukraine has a huge potential of land, material and labor resources, which is the basis for its development. However, agriculture and business are in need of immediate institutional transformations. Such changes should be carried out on the basis of a "green economy", namely, ensuring the well-being of the population, while reducing environmental pollution and ensuring the food security of the state. Therefore, the agricultural business should focus on long-term strategies developed, and the costs incurred in the short term should be covered by the state. It is also necessary to carry out changes in informal institutions in order to increase business confidence in the state, which is no less important in transforming economic relations in the domestic market.

5. In modern conditions, that are characterized by variability and globalization processes, in the domestic economy there is a transplantation of institutions that have shown themselves positively in developed countries. That is, there is a borrowing of institutions, but there is a need to take into account national characteristics in this process. Because, the same institutions in different countries are manifested differently due to mental, economic, cultural and other characteristics.

Agricultural producers have begun to actively grow crops that can

be used as a feedstock for biofuel production, namely corn, rapeseed, soybeans, etc. However, these crops are mostly exported and not processed in Ukraine. The value added of raw materials is much lower than the value added of finished products, so Ukraine loses a significant amount of profit. In addition, if raw materials are processed into biofuels within the country, it is possible to meet domestic fuel and energy needs and reduce our country's energy dependence on imported fuels.

There is an active development of organic farming and production in Ukraine. The adoption of the Law of Ukraine "On Basic Principles and Requirements for Organic Production, Circulation and Labeling of Organic Products", which came into force on August 2, 2019, had a positive impact on their development in accordance with European standards.

6. The application of organic fertilizers during organic farming is very important, because such fertilizers are of natural origin and safe for human life and the environment. In Ukraine, the amount of applied organic fertilizers is growing every year, so in 2019 it was applied 1.42 million tons more than in 2010 and – 1.72 million tons more than in 2015.

For the development of a "green economy" in the agricultural sector, small business in the countryside is important, ie the transformation of personal farms into family farms is necessary. However, an important condition for such a transformation is government support in the form of grants, subsidies, cheap lending, and so on. As family farms have to switch to organic farming and production, such a transition is resource-intensive, so state support is a must in this case. The creation of family farms will develop entrepreneurship in rural areas, but on the basis of a "green economy".

The creation of the above institutions is strategically important for the formation of a "green economy" in the agricultural sector and will allow faster implementation of its elements in the management process.

Implementation of various organizational and economic aspects of agricultural development on the basis of "green economy" – an unconditional priority, adapted to national realities, its implementation is one of the ways to ensure sustainable development of Ukraine's

economy, which also relies heavily on agri-ecosystem priority.

7. The research is devoted to the development of scientifically proved proposals for the evolvement of theoretical foundations, expansion of methodological tools and establishment of organizational provisions for analysis and government audit of public procurement under the progress of information environment for the procurement process management at macro, meso and micro levels.

The scientific work validates the need to expand the subject area of government audit of public procurement through understanding them as the customer's activities regarding transparent planning, implementation of pre-contractual and contractual procedures, as well as the application of purchased procurement items via the electronic system in accordance with the procedure established by legislation in order to meet the needs of the state, business and society, which allows for a comprehensive assessment of public procurement in different analytical sections at all stages of the life cycle.

The limitation of information's analytical capabilities on public procurement has led to the expediency of improving their classification. Public procurement is suggested to be divided on the certain basis providing deepening of analyticity on CPV codes, on an origin, on a value limit; by sources of funding, which allows for a comprehensive analytical assessment and government audit of the developed analytical sections in accordance with the needs of interested users.

8. Following the close examination of the results of analysis and government audit, the lack of a comprehensive and complete vision of the of the public procurement system effectiveness is established. The system of public procurement is identified as an object of analysis and government audit through the interaction of subsystems: theoretical (essence, purpose, objectives, subject-matter and subjects of public procurement), organizational (independent or centralized organization of procurement), methodological (principles and procedures of public procurement, stages of the life cycle of procurement items) and classification (types of procurement on various bases), which allows obtaining a complete and integrated information base for management decisions, taking into account the intersystem interaction.

As proved, the coherence, interconnection and interaction of accounting-analytical and control functions with the functions of planning, organization, motivation and regulation in the field of public procurement provide the very level of synergistic effect that allows both customers and participants working with maximum effectiveness, economy and efficiency, while increasing the efficiency of the public procurement system as a whole at the meso and macro levels.

9. Energy audit – a systematic procedure to obtain proper knowledge of the current energy performance of a building or a group of buildings, industrial or commercial activities, installations, private or public services by identifying and quantifying the cost-effective possibilities for energy conservation and providing a report on the results obtained.

Energy audits should be able to make detailed and verified calculations of the implemented measures to provide clear information on the potential costs, which can be carried out by in-house experts or energy auditors. The data used in energy audits should be kept for statistical analysis and performance monitoring.

The energy audit must be accessible to all end-users and meet certain criteria: must be based on current, measured, tested operational data on energy consumption and load profile (for electricity); must include a detailed review of the energy use profile of the buildings or groups of buildings, industrial activity or installation, including transport; they should be based, if possible, on life cycle cost analysis rather than simple payback periods to take into account long term costs, the remaining balances of long term investments and discount rates; must be proportionate and sufficiently representative to enable a true picture of the overall energy efficiency and to reliably identify the most significant opportunities for improving it.

To increase the level of energy efficiency of any entities (including households) at the legislative level it is necessary, first, to determine the general requirements for qualifications, education and experience of energy auditors; secondly, to introduce a mandatory public Register of energy auditors with information access to potential customers of energy audits; third, the introduction of mandatory certification and advanced training at least every 3 years.

APPLICATIONS

Table A1

The main legislative initiatives of the EU countries on climate change

№	Normative-legislative act and year of adoption	Substantive provisions
1	2	3
1.	A Community Strategy to limit Carbon Dioxide Emissions and to improve Energy Efficiency, 1991	Among the main directions of this strategy were identified: implementation of large-scale energy efficiency measures; gradual abandonment of solid fuels in favor of natural gas; increasing the share of renewable energy in the overall structure of consumption; setting the cost of CO_2 emissions through the introduction of a carbon tax in all EU countries; introduction of a monitoring mechanism to control CO_2 emissions. A number of proposals have also been made to reduce emissions in the main sectors that are the largest sources of greenhouse gas emissions: energy, industry, transport and household consumption. This strategy became one of the first official documents on the creation of a market mechanism for regulating CO_2 emissions, introduced under the scheme of trade in permits for greenhouse gas emissions.
2.	Signing and ratification of the Kyoto Protocol, 1997	EU countries have agreed on joint commitments to reduce greenhouse gas emissions by more than 11.7% from 1990 levels during the first implementation period of the Kyoto Protocol commitments in 2008-2012.
3.	EU Directive 2003/87 / EC, 2003	Member States have the right to determine the level of incentives for cogeneration, including through the issuance of additional permits for greenhouse gas emissions. Preference is given to power plants with a higher level of energy efficiency in the country.
4.	Road map, 2007	Defines the principles of achieving the goal set by the Kyoto Protocol. The document formulates requirements for national action plans of EU member states; detailed goals for certain types of renewable energy sources in electricity generation by 2020; the tasks to be performed by the European Commission within its competence to ensure the implementation of plans at the European level have been identified; priorities and priorities for EU member states have been identified.

continuation of table A1

1	2	3
5.	Directive 2009/28 / EC "On the promotion of the use of energy from renewable energy sources", 2009	The directive sets national targets for renewable energy for the 27 EU countries, which is 20% of the EU average for renewable energy by 2020. Each national target is about 13% higher than the country's renewable energy use in 2005. This Directive is one of the main EU documents in the field of renewable energy.
6.	Directive 2009/29 / EC ЄOn the improvement and extension of the emissions trading scheme of the (European) Community, 2009	This Directive amends Directive 2003/83 / EC and was adopted in order to improve and expand the EU's greenhouse gas emission allowance trading system. It provided for a more significant reduction in greenhouse gas emissions.
7.	Directive 2009/30 / EC on the requirements for petrol, diesel and gaseous fuels and the mechanisms for monitoring and reducing greenhouse gas emissions (Fuel Quality Directive), 2009	The directive amends a number of elements, including fuel specifications, and introduces a mechanism to monitor and reduce greenhouse gas emissions and ensure the sustainability of biofuels. The law requires fuel suppliers to report and reduce greenhouse gas emissions during the life cycle of energy supplied to road transport.
8.	Directive 2009/31 / EC on the geological disposal of carbon dioxide (CO2), 2009	This Directive establishes a legal basis for the environmentally sound geological storage of carbon dioxide (CO_2) to participate in the fight against climate change.
9.	Decision of the European Parliament and of the Council №406 / 2009 / EC, 2009	The document sets out the Community's overall emission reduction targets for 2020 and extends to non-trading economies, in particular the transport sector (excluding aviation and international shipping), buildings, agriculture, waste disposal and more.
10.	Regulation 443/2009 "On standards setting emission requirements for new passenger cars in the framework of the (European) strategy to reduce carbon dioxide emissions by low-capacity vehicles", 2009	Establishes emission standards for new passenger cars as part of a comprehensive community approach to reducing CO_2 emissions from passenger cars.
11.	Directive 2010/31 / EU, 2010	This Directive aims to increase the energy efficiency of buildings and building blocks. Public authorities that own or occupy a new building should set an example by building, buying or renting buildings with "almost zero energy consumption".

continuation of table A1

1	2	3
12.	"Energy 2020. Strategy of competitive, sustainable and secure energy", 2010	The Energy Strategy sets relevant goals in the field of energy and climate change for 2020 - to reduce greenhouse gas emissions by 20%, increase the share of renewable energy sources to 20% and increase energy efficiency by 20%. Priority for the decarbonisation of the energy sector is included in all scenarios for the long-term development of energy in the European Union. At the same time, the European Council, with the aim of further decarbonisation, has identified the possibility of reducing emissions from 85 to 95% for the period up to 2025 from the level of 1990. The strategy envisages large-scale implementation of renewable energy sources both at the set target level by 2020 and its further increase over the next decades with systematic and consistent introduction of necessary changes and additions to the relevant regulatory framework with further adoption and adjustment of National Development Action Plans. renewable energy sources.
13.	Regulation of the EU Commission № 601/2012	Based on monitoring and reporting of greenhouse gas emissions. At the national level, the preparation of carbon reporting is regulated by national legislation and regulations. Legislation includes criteria for determining which companies should report or recommendations for which companies should prepare carbon reporting (in the case of voluntary reporting systems); the content of carbon reporting; requirements / recommendations for calculations and reporting; verification requirements / recommendations; frequency of reporting; administrative regulation measures (in the case of mandatory reporting systems).

continuation of table A1

1	2	3
14.	"Energy Efficiency and its contribution to energy security and the 2030 Framework for climate and energy policy", 2014	Energy policy measures on energy efficiency and climate change for the period up to 2030 are envisaged, the goals of which for the EU member states are: reduction of greenhouse gas emissions by 40%, improvement of energy efficiency by 27% and increase of 27% use of renewable energy sources in energy structure of the European Union, which significantly exceeds the previously adopted relevant indicators in the EU Energy Strategy until 2020.
15.	COM Energy Package (2015) 80 "A Framework Strategy for a Strong Energy Union with a Progressive Climate Policy" (Energy Union Strategy), 2015	The Energy Union Package sets out a framework strategy for a sustainable energy union with a forward-looking climate policy.
16.	Directive 2012/27 / EU, 2012	It sets a 20% energy efficiency target for the EU by 2020. The directive sets a number of intermediate energy savings targets for consumers and industry. In particular, energy distribution companies must save 1.5% of energy annually through energy efficiency measures. EU countries are obliged to introduce energy efficiency indicators for buildings, products and services as public procurement criteria. In addition, EU countries must modernize at least 3% of state-owned buildings each year. Requires member states to define individual energy saving indicators and to develop national action plans in the field of energy saving and energy efficiency, including through the intensification of the development of combined heat and power (cogeneration) systems. According to this directive, EU member states must develop appropriate national programs.
17.	Energy Union Package (2015) 80 "A Framework Strategy for a Strong Energy Union with a Progressive Climate Policy" (Energy Union Strategy), 2015	The Energy Union Package sets out a framework strategy for a sustainable energy union with a forward-looking climate policy.

continuation of table A1

1	2	3
18.	Directive 2015/2193, 2015	Medium Combustion Plant (MCP) Directive on the limitation of emissions of certain pollutants into the atmosphere from medium combustion plants. The MCP Directive regulates emissions of pollutants from fuel combustion in installations with a rated thermal input of 1 MW or less and less than 50 MW (Єmedium combustion plantsЄ), regardless of the type of fuel they use.
19.	"Roadmap for the Energy Union to 2050", 2012	The roadmap identifies four main paths to a more sustainable, competitive and secure energy system by 2050: energy efficiency, renewable energy, nuclear energy, and carbon capture and storage.
20.	EU Strategy on heating and cooling, 2016 p.	Its main priorities are to increase energy efficiency and decarbonization of existing and constructed buildings in all sectors of the economy.

Source: formed by the authors according to EU regulation

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Table A2

Basic legislative, normative-legal acts and program documents in the field of environmental protection

№	Normative-legislative act and year of adoption	Substantive provisions
1	2	3
Decrees of the President of Ukraine:		
1.	On the strategy of sustainable development "Ukraine – 2020" from 12.01.2015 № 5/2015	This Decree provided: 1. To approve the Strategy of sustainable development "Ukraine – 2020" 2. The Cabinet of Ministers of Ukraine: 1) to approve by February 15 each year an action plan for the implementation of the provisions of the Sustainable Development Strategy "Ukraine – 2020"; 2) inform quarterly, by the 15th day of the month following the reporting quarter, on the status of implementation of the action plan for the implementation of the provisions of the Sustainable Development Strategy "Ukraine – 2020".
Laws of Ukraine		
2.	On the protection of the natural environment from 25.06.1991 № 1264-XII	The law regulates relations in the field of environmental protection in Ukraine. The law provides the basic principles of environmental protection. Ownership rights to natural resources, objects of legal protection of the natural environment, state target and other ecological programs are defined.
3.	About protection of atmospheric air from 16.10. 1992 № 2707-XII	The law is aimed at preserving and restoring the natural state of the air, creating favorable conditions for life, ensuring environmental safety and preventing the harmful effects of the air on human health and the environment. This Law defines the legal and organizational framework and environmental requirements in the field of air protection.
4.	On ensuring the sanitary and epidemic well-being of the population of February 24, 1994 № 4004-XII	The law regulates public relations that arise in the field of sanitary and epidemiological well-being, determines the relevant rights and responsibilities of state bodies, enterprises, institutions, organizations and citizens, establishes the procedure for organizing the state sanitary-epidemiological service and state sanitary-epidemiological supervision in Ukraine.

continuation of table A2

1	2	3
5.	On energy saving dated 01.07.1994 № 74/94-VR	The law defines the legal, economic, social and environmental bases of energy saving for all enterprises, associations and organizations located on the territory of Ukraine, as well as for citizens. The law provides the basic principles of state energy saving policy
6.	On the ratification of the United Nations Framework Convention on Climate Change of 29.10.1996 № 435/96-VR	This law ratifies the United Nations Framework Convention on Climate Change, signed on behalf of Ukraine on June 11, 1992 at the United Nations Conference on the Environment in Rio de Janeiro. The ultimate goal of this Convention and all related legal instruments that may be adopted by the Conference of the Parties is to achieve in the implementation of the relevant provisions of the Convention the stabilization of greenhouse gas concentrations in the atmosphere at a level that would not allow dangerous anthropogenic impacts on climate system. This level must be reached in the time needed for the natural adaptation of ecosystems to climate change, which will make it possible not to jeopardize food production and will contribute to further economic development on a sustainable basis.
7.	On alternative energy sources dated 20.02.2003 № 555-IV	The law defines the legal, economic, environmental and organizational principles for the use of alternative energy sources and promotes the expansion of their use in the fuel and energy sector. The law defines the features of public administration and state regulation in the field of alternative energy sources
8.	About the Basic principles (strategy) of the state ecological policy of Ukraine for the period till 2020 from 21.12.2010 № 2818-VI	This law approves the Basic Principles (Strategy) of the State Environmental Policy of Ukraine for the period up to 2020

continuation of table A2

1	2	3
9.	On the ratification of the Paris Agreement of 14.07.2016 № 1469-VIII	This law ratifies the Paris Agreement concluded in Paris on December 12, 2015 at the Twenty-first Conference of the Parties to the United Nations Framework Convention on Climate Change and signed on behalf of Ukraine on April 22, 2016 in New York, which enters into force on on the thirtieth day after at least 55 Parties to the United Nations Framework Convention on Climate Change, which are estimated to account for at least 55 per cent of total global greenhouse gas emissions, have deposited their instruments of ratification, acceptance instruments , approval or accession.
10.	On environmental impact assessment dated 23.05.2017 №2059-VIII	The law establishes the legal and organizational framework for environmental impact assessment aimed at preventing environmental damage, ensuring environmental safety, environmental protection, rational use and reproduction of natural resources, in the decision-making process of economic activities that may have a significant impact on the environment, taking into account public, public and private interests.
Administrative Government Documents		
11.	Resolution of the Cabinet of Ministers of Ukraine “On approval of the State target economic program of energy efficiency and development of energy production from renewable energy sources and alternative fuels for 2010-2021”	This Resolution approves the State Targeted Economic Program for Energy Efficiency and Development of Energy Production from Renewable Energy Sources and Alternative Fuels for 2010-2021. The purpose of the Program is: to create conditions for bringing the energy intensity of Ukraine's gross domestic product closer to the level of developed countries and European Union standards, to reduce the energy intensity of gross domestic product during the Program by 20 percent compared to 2008 (by 3.3 percent annually), to increase efficiency use of fuel and energy resources and strengthening the competitiveness of the national economy; optimization of the structure of the energy balance of the state, in which the share of

continuation of table A2

1	2	3
		energy obtained from renewable energy sources and alternative fuels will be at least 10 percent in 2015, by reducing the share of imported fossil fuels, including natural gas, and replacing them with alternative energy sources , including secondary, subject to adequate funding of the Program.
12.	Order of the Cabinet of Ministers of Ukraine dated 07.12.2016 № 932-r. The concept of implementation of state policy in the field of climate change for the period up to 2030	This order approves the Concept of implementation of the state policy in the field of climate change for the period till 2030. The purpose of the Concept is to improve state policy in the field of climate change to achieve sustainable development of the state, create legal and institutional prerequisites for a gradual transition to low-carbon development with economic, energy and environmental security and improve the welfare of citizens. The concept defines the grounds for the development of draft laws and other regulations, strategies and action plans for their implementation for various components of public policy in the field of climate change.

Source: formed by the authors according to the normative legal documents of Ukraine

Table A3

Green tariff coefficient for electricity produced using alternative energy sources

Categories of electricity facilities for which the "green" tariff is applied	"Green" tariff coefficient for facilities or its queues / start-up complexes put into operation							
	to 31.03.2013 inclusive	from 01.04.2013 to 31.12.2014	from 01.01.2015 to 30.06.2015	from 01.07.2015 to 31.12.2015	from 01.01.2016 to 31.12.2016	from 01.01.2017 to 31.12.2019	from 01.01.2020 to 31.12.2024	from 01.01.2025 to 31.12.2029
1	2	3	4	5	6	7	8	9
for electric energy produced from wind energy by electric power facilities, the value of the installed capacity of which does not exceed 600 kW	1.20	-	-	-			-	-
for electricity generated from wind energy by electricity facilities with an installed capacity of more than 600 kW but not exceeding 2000 kW	1.40	-	-	-			-	-
for electricity generated from wind energy by electricity facilities with an installed capacity of more than 2000 kW	2.10	-	-	-			-	-
for electricity generated from wind energy by wind power plants consisting of wind turbines with a unit installed capacity not exceeding 600 kW	-	1.20	1.08	1.08			0.96	0.84
for electricity generated from wind energy by wind power plants consisting of wind turbines with a single installed capacity of 600 kW but not more than 2000 kW	-	1.40	1.26	1.26			1.12	0.98
for electricity generated from wind energy by wind power plants consisting of wind turbines with a unit installed capacity of more than 2000 kW	-	2.10	1.89	1.89			1.68	1.47

continuation of table A3

1	2	3	4	5	6	7	8	9
for electricity generated from biomass	2.30	2.30	2.07	2.30			2.07	1.84
for electricity produced from biogas	-	2.30	2.07	2.30			2.07	1.84
for electric energy produced from solar radiation energy by terrestrial power facilities, the value of the installed capacity of which does not exceed 10 MW	8.64	6.30	5.67	3.15	2.97	2.79	2.51	2.23
for electric energy produced from solar radiation energy by terrestrial power facilities, the installed capacity of which exceeds 10 MW	4.80	3.50	3.15		2.97	2.79	2.51	2.23
for electricity generated from biomass	2.30	2.30	2.07	2.30			2.07	1.84
for electric energy produced from solar radiation energy by electric power objects, which are mounted on the roofs and / or facades of houses, buildings and structures, the value of the installed capacity of which exceeds 100 kW	8.28	6.48	5.83	-	-	-		
for electric energy produced from solar radiation by electric power objects, which are mounted (installed) on the roofs and / or facades of houses, buildings and structures, the value of the installed capacity of which does not exceed 100 kW	7.92	6.66	5.99	-			-	-
for electricity generated from solar radiation by electricity facilities that are installed on the roofs and / or facades of houses, buildings and structures	-	-	-	3.35	3.20	3.04	2.74	2.43

continuation of table A3

1	2	3	4	5	6	7	8	9
for electricity generated by microhydroelectric power plants	2.16	3.60	3.24	3.24			2.92	2.59
for electricity generated by mini-hydropower plants	2.16	2.88	2.59	2.59			2.33	2.07
for electricity generated by small hydropower plants	2.16	2.16	1.94	1.94			1.75	1.55
for electric energy produced from geothermal energy	-	-	-	2.79			2.51	2.23

Source: formed by the authors according to the normative legal documents of Ukraine

Table A4

"Green" tariff coefficient for electricity generated by generating installations of private households using alternative energy sources

Categories of generating installations of private households for which the "green" tariff is applied	"Green" tariff coefficient for private households, application-notification on installation of generating installations which is registered by the energy supplier							
	to 31.03.2013 inclusive	from 01.04.2013 to 31.12.2014	from 01.01.2015 to 30.06.2015	from 01.07.2015 to 31.12.2015	from 01.01.2016 to 31.12.2016	from 01.01.2017 to 31.12.2019	from 01.01.2020 to 31.12.2024	from 01.01.2025 to 31.12.2029
for electric energy produced from solar energy by generating installations of private households, the value of the installed capacity of which does not exceed 30 kW	-	6.66	5.99	3.72	3.53	3.36	3.02	2.69
for electricity generated from wind energy by generating installations of private households, the value of the installed capacity of which does not exceed 30 kW	-	-	-	2.16			1.94	1.73

Source: formed by the authors according to the normative legal documents of Ukraine

Table A5

Basic principles of the United Nations Conference on Environment and Development

Principle	Substantive provisions
1	2
Principle 1	Caring for people is central to sustainable development efforts. They have the right to a healthy and fruitful life in harmony with nature.
Principle 2	In accordance with the Charter of the United Nations and the principles of international law, States have the sovereign right to develop their own resources in accordance with their environmental and development policies and are responsible for ensuring that activities within their jurisdiction or control do not harm the environment. other states or districts outside the scope of national jurisdiction.
Principle 3	The right to development must be exercised to ensure that the needs of present and future generations in the areas of development and the environment are fairly met.
Principle 4	To achieve sustainable development, environmental protection must be an integral part of the development process and cannot be considered in isolation.
Principle 5	All nations and all peoples are working together to address the crucial task of eradicating poverty – a prerequisite for sustainable development – in order to reduce the gaps in living standards and better meet the needs of the majority of the world's population.
Principle 6	The special situation and needs of developing countries, especially the least developed and most environmentally vulnerable countries, are given special importance. International action in the field of environment and development must also be aimed at meeting the interests and needs of all countries.
Principle 7	States are cooperating in a spirit of global partnership to preserve, protect and restore the health and integrity of the Earth's ecosystem. Due to their different roles in the deterioration of the global environment, states have a common but different responsibilities. Developed countries recognize the responsibility they have in the context of international efforts to ensure sustainable development, given the stress that their societies create for the global environment and the technologies and financial resources they possess.
Principle 8	To achieve sustainable development and a higher quality of life for all people, states must limit and eliminate unviable patterns of production and consumption and encourage appropriate demographic policies.

continuation of table A5

1	2
Principle 9	States should work together to strengthen national capacity-building for sustainable development through the deepening of scientific understanding through the exchange of scientific and technical knowledge and the expansion of the development, adaptation, dissemination and transfer of technologies, including new and innovative technologies.
Principle 10	Environmental issues are addressed in the most effective way with the participation of all interested citizens at the appropriate level. At the national level, everyone should have appropriate access to environmental information available to public authorities, including information on hazardous materials and activities in their communities, and on the opportunity to participate in decision-making processes. States develop and encourage public awareness and participation through the wide provision of information. It provides an effective opportunity to use judicial and administrative procedures, including redress and remedies.
Principle 11	States adopt effective environmental legislation. Environmental standards, regulatory objectives and priorities should reflect the environmental and development conditions in which they apply. Standards applied by some countries may be inappropriate and involve unreasonable economic and social costs in other countries, including developing countries.
Principle 12	To address environmental degradation more effectively, States must work together to create a favorable and open international economic system that promotes economic growth and sustainable development in all countries. Trade policy measures taken to protect the environment must not constitute a means of arbitrary or unjustified discrimination or a disguised restriction on international trade. Unilateral action to address environmental concerns outside the jurisdiction of the importing country should be avoided. Environmental measures to address transboundary or global environmental issues should, as far as possible, be based on international consensus.
Principle 13	States should develop national laws on liability and compensation for victims of pollution and other environmental damage. States shall also cooperate expeditiously and more decisively with a view to further developing international law concerning liability and compensation for the adverse effects of environmental damage caused by activities carried out under their jurisdiction or control in areas outside their jurisdiction.
Principle 14	States must cooperate effectively to prevent or prevent the transfer to other States of any activities and substances which cause serious environmental damage or are considered harmful to human health.

continuation of table A3

1	2
Principle 15	In order to protect the environment, states, in accordance with their capabilities, widely apply the principle of precautionary measures. In cases where there is a risk of serious or irreversible losses, the lack of full scientific certainty is not used as a reason to delay the adoption of cost-effective measures to prevent environmental degradation.
Principle 16	National authorities should seek to promote the internalisation of environmental costs and the use of economic resources, taking into account the approach that the polluter should cover the costs associated with the pollution, with due regard for the public interest and without prejudice to international trade and investment.
Principle 17	The environmental impact assessment as a national instrument is introduced taking into account the envisaged activities that may have a significant negative impact on the environment and which are subject to approval by a decision of the competent national authority.
Principle 18	States shall immediately notify other States of any natural disasters or other emergencies which may have unexpected adverse effects on the environment in those States. The international community is doing its utmost to provide assistance to affected countries.
Principle 19	States shall send prior and timely notifications and relevant information on activities that may have significant adverse transboundary effects to States concerned and shall consult with those States at an early stage and in good faith
Principle 20	Women play a vital role in the rational use of the environment and development. Therefore, their full participation is necessary to achieve sustainable development.
Principle 21	The creative forces, ideals and courage of the world's youth must be mobilized in order to form a global partnership in order to achieve sustainable development and ensure a better future for all.
Principle 22	Indigenous peoples and their communities, as well as other local communities, have a vital role to play in the rational use and improvement of the environment through their knowledge and traditional practices. States must recognize and properly support their identity, culture and interests and ensure their effective participation in the achievement of sustainable development
Principle 23	The environment and natural resources of peoples living in conditions of oppression, domination and occupation must be protected.
Principle 24	War inevitably has a devastating effect on the process of sustainable development. Therefore, states must respect international law, which ensures the protection of the environment during armed conflicts, and must cooperate, if necessary, in its further development.

continuation of table A5

1	2
Principle 25	Peace, development and environmental protection are interdependent and indivisible.
Principle 26	The Party shall settle all its environmental disputes peacefully and by appropriate means in accordance with the Charter of the United Nations.
Principle 27	States and peoples shall cooperate in a spirit of goodwill and partnership in the implementation of the principles embodied in this Declaration and in the further development of international law in the field of sustainable development.

Source: formed by the authors according to the report of the United Nations Conference on Environment and Development

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Main scientific and educational publications: The author of over 350 scientific and educational works including 24 monographs, 20 study guides, 8 handbooks and over 150 scientific articles in popular journals, 29 articles in the Scopus and 12 articles in the Web of Science databases, and 61 patents for utility models and products.

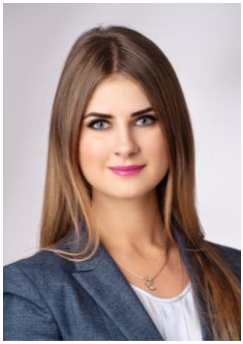
Author of the following products: "High-octane acid additive for petrol" (patent for the product № 29365, registered on 15.05.2003. State Department of Intellectual Property); "Methods of producing alcoholic liquid" (patent number 23578 for utility model Registered in the State Register of Ukraine patents for utility models 25. 05.05.2007); "Process for production of alcoholic liquid" (patent № 82624 for the model is registered in the State Register of patents of Ukraine for industrial property dated 25.04.2008).

As a People's Deputy of Ukraine and Chairman of the Verkhovna Rada Committee on Agrarian Policy and Land Relations, from 2010 to 2014 wrote more than 85 bills, 50 of which were adopted by the Verkhovna Rada of Ukraine and signed by the President of Ukraine and entered into force.

Teaches disciplines: "Agrarian policy and land relations", "Biofuels: efficiency of production and consumption in the agro-industrial complex of Ukraine".

Bilokinna Ilona
Ph.D., Assistant Professor of the Department of Administrative Management and Alternative Energy Sources
Vinnytsia National Agrarian University,
executor of the state theme "Development of the latest concept of the use of agricultural waste to ensure energy autonomy of agricultural enterprises"

Biographical data: In 2015 graduated from Vinnytsia National Agrarian University with a master's degree "Accounting and Auditing". In December 2019, graduated from the post-graduate school of Vinnytsia National Agrarian University. From 2021 is a Ph.D. in the specialty "Economics and Management of the National Economy".
Research area: Development of "green economy" in the agricultural sector.
Main educational-methodical and scientific publications: More than 25 publications, 20 of them – scientific and 5 – educational and methodical. Has 10 papers in professional journals, 1 article in a journal that is included in the databases databases Web of Science.
Teaches disciplines: "Biofuels: efficiency of production and consumption in the agro-industrial complex of Ukraine", "Agrarian policy and land relations".



Pryshliak Natalia
Ph.D., Associate Professor of the Department Administrative Management and Alternative Energy Sources
Vinnytsia National Agrarian University (VNAU)

Head of the state scientific work "Development of a new concept for the use of agricultural waste to ensure the energy autonomy of agricultural enterprises", 2019-2021.

Executor of the state scientific work "Development of the concept of ensuring energy security and energy efficiency as priority areas for sustainable development of rural areas", 2021-2022.

Biographical data: In 2012 graduated from Vinnytsia National Agrarian University with a master's degree in "Accounting and Auditing". In October 2015, graduated from the postgraduate school of VNAU. In 2016 got a Ph.D. degree in the specialty "Economics and Business Management". The academic title of associate professor of the Department of Administrative Management and Alternative Energy Sources of VNAU was awarded in March 2019.

Scientific direction: Efficiency of production and consumption of biofuels, use of wastes of agricultural enterprises for biofuel production.

Main scientific and educational publications: has more than 110 publications, of which 82 – scientific and 30 – educational and methodological. A co-author of three collective monographs. Has 50 articles in professional journals, 16 articles in journals included in the databases Scopus and Web of Science.

Completed an internship at the Institute of Biogas Technology (China, Sichuan, 2010), the University of Pennsylvania (USA, 2012), Ohio State University (USA, 2016), the Energy and Resource Institute (India, 2018). Participated in Erasmus + youth volunteer events in Scotland, Italy, Lithuania, Macedonia, France, Armenia and Georgia.

Teaches disciplines: "Agrarian policy and land relations", "Biofuels: efficiency of production and consumption in the agro-industrial complex of Ukraine".

Shpykuliak Olexander Grigorovich
Doctor of Economics, Professor, Corresponding Member of NAAS of Ukraine, Scientific Secretary of the National Research Center "Institute of Agrarian Economics", Professor of the Department of Administrative Management and Alternative Energy Sources
Vinnytsia National Agrarian University

Biographical data: Graduated from Vinnytsia National Agrarian University in 2000, majoring in "Economist-organizer of agricultural production". In 2013 got a Ph.D. degree in the specialty "Economics, organization and management of enterprises". Since 2010 Doctor of Economics in the specialty "Economics and management of the national economy". In 2008 awarded the academic title of Senior Researcher in specialty 08.00.04 – economics and enterprise management (by type of economic activity), and in 2015 – the academic title of Professor in specialty 08.00.03 – economics and management of the national economy.
Research area: Disclosure of the problems of the development of entrepreneurial activity in the countryside and the functioning of the agricultural market, institutional support for the development of the agricultural sector of the economy, the agricultural market and entrepreneurial and innovative activities in the agricultural sector.
Main educational-methodical and scientific publications: More than 280 publications, of which 269 are scientific and 11 are educational-methodical. Has 7 articles in journals included in the scientometric databases Scopus, Web of Science.
Teaches disciplines: "National economy in the conditions of global institutional transformations"

Tokarchuk Dina
Ph.D., Associate Professor of the Department of Administrative Management and Alternative Energy Sources
Vinnytsia National Agrarian University (VNAU)

Responsible executorof the state scientific work "Development of a new concept for the use of agricultural waste to ensure the energy autonomy of agricultural enterprises", 2019-2021.

Executor of the state scientific work "Development of the concept of ensuring energy security and energy efficiency as priority areas for sustainable development of rural areas", 2021-2022.

Biographical data: In 2008 graduated from Vinnytsia State Agrarian University with a master's degree in "Management of Organizations". In December 2011 graduated from the postgraduate school of VNAU. In 2013 got a Ph.D. degree in the specialty "Economics and management of the national economy". The academic title of associate professor of the Department of Administrative Management and Alternative Energy Sources of VNAU was awarded in December 2015.

Scientific direction: Socio-economic and environmental aspects of biofuel production and use, use of waste for biogas production.

Main scientific and educational publications: has more than 150 publications, of which 79 – scientific and 72 – educational and methodological. A co-author of 6 collective monographs, 2 textbooks, 3 patents. Has 36 articles in professional journals, 8 articles in journals included in the databases Scopus and Web of Science.

Teaches disciplines: "Management of efficiency of biofuels and biomass production and use", "Engineering management", "Biofuels: efficiency of production and consumption in the agro-industrial complex of Ukraine"

Zdyrko Nataliya
DSc., Professor, Dean of the Faculty of Accounting and Audit,
Vinnytsia National Agrarian University (VNAU)
Responsible executor of the state scientific work "Development of the concept of ensuring energy security and energy efficiency as priority areas for sustainable development of rural areas", 2021-2022.

Biographical data: In 2007 graduated from Vinnytsia State Agrarian University with a master's degree in "Accounting and Auditing".
In December 2013, graduated from the postgraduate school of National Research Center "Institute of Agrarian Economics" of the National Academy of Agrarian Science of Ukraine. In 2014 got a Ph.D. degree in the specialty "Accounting, analysis and audit" (by type of economic activity. The academic title of associate professor of the Department of Audit and State Control of VNAU was awarded in September 2017.
During 2016-2019 – degree seeker of Doctor of Economic Sciences, Vinnytsia National Agrarian University. In October 2020 – defense of a doctoral dissertation at the National Research Center "Institute of Agrarian Economics". In 2021 got a Doctor of Economic Sciences degree in the specialty "Accounting, analysis and audit" (by type of economic activity. The academic title of professor of the Department of Accounting and Taxation in the Economy of VNAU was awarded in August 2021.
Scientific direction: State financial control, energy audit in Ukraine.
Main scientific and educational publications: has more than 160 publications, of which 110 – scientific and 50 – educational and methodological. A co-author of three collective monographs. Has 60 articles in professional journals, 6 articles in journals included in the databases Scopus and Web of Science.
Teaches disciplines: "State financial control," "Audit".

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