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ТЕХНІКА  
ЕНЕРГЕТИКА  
ТРАНСПОРТ АПК



*Всеукраїнський науково-технічний журнал*

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ТРАНСПОРТ АПК**

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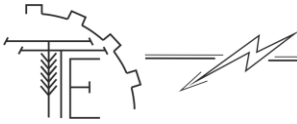
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## ЗМІСТ

**I. ПРИКЛАДНА МЕХАНІКА. МАТЕРІАЛОЗНАВСТВО. ГАЛУЗЕВЕ МАШИНОБУДУВАННЯ***Калетнік Г.М., Полєвода Ю.А., Токарчук О.А.***ДОСЛІДЖЕННЯ ТЕХНОЛОГІЧНОГО ПРОЦЕСУ МЕХАНІЧНОГО ЗНЕВОДНЕННЯ ВІДХОДІВ ХАРЧОВИХ ВИРОБНИЦТВ ШЛЯХОМ МАТЕМАТИЧНОГО МОДЕЛЮВАННЯ ..... 5***Макаренко Д.О., Деркач О.Д., Говоруха В.Б., Веселовська Н.Р.***МОДЕРНІЗАЦІЯ РУХОМИХ З'ЄДНАНЬ СЕКЦІЙ ПОСІВНОГО КОМПЛЕКСУ ..... 12***Nataliia Veselovska, Artem Kosakivskyi, Vitaliy Romanov***INNOVATIVE METHODS OF EXPANDING THE FUNCTIONAL CAPABILITIES OF THE SINGLE-SPINDLE LATHE ..... 21***Паладійчук Ю.Б., Телятник І.А.***АЛГОРИТМ ЕКСПЕРИМЕНТАЛЬНОГО ДОСЛІДЖЕННЯ ГІДРОІМПУЛЬСНОГО ПРИСТРОЮ ДЛЯ ЗМІЦНЕННЯ ДЕТАЛЕЙ ДЕФОРМАЦІЄЮ ..... 31***Солона О.В., Скоромна О.І., Огороднічук Г.М.***ЗАСТОСУВАННЯ ЦИФРОВИХ ТЕХНОЛОГІЙ У ГАЛУЗІ ТВАРИННИЦТВА ..... 43***Serhiy Shargorodskiy, Dmutro Kondratuk***STUDY OF THE KINEMATICS OF THE POSITIONING MECHANISMS OF WIDE-GRIP MACHINE-TRACTOR UNITS ..... 51****II. АГРОІНЖЕНЕРІЯ***Гриценко О.П., Степаненко С.П.***ЗАСТОСУВАННЯ ТЕОРІЇ РОЗМІРНОСТЕЙ І ПОДІБНОСТІ ДЛЯ ВИЗНАЧЕННЯ ПАРАМЕТРІВ І РЕЖИМІВ РОБОТИ АСИМЕТРИЧНОЇ ДИСКОВОЇ БОРОНИ ДЛЯ ОБРОБІТКУ ҐРУНТУ ..... 62***Дудін В.Ю., Білоус І.М.***ЕКСПЕРИМЕНТАЛЬНІ ДОСЛІДЖЕННЯ ДИСКОВОГО ПОДРІБНЮВАЧА ЗЕРНА ..... 71***Єленич А.П.***ОГЛЯД КОНСТРУКЦІЙ ЗЕРНОЗБИРАЛЬНИХ КОМБАЙНІВ КОМПАНІЇ NEW HOLLAND ..... 78***Павленко С.І.***ОБҐРУНТУВАННЯ РАЦІОНАЛЬНИХ ВАРІАНТІВ ЗАСТОСУВАННЯ ТЕХНІЧНИХ ЗАСОБІВ ПРИГОТУВАННЯ КОМПОСТНОЇ СУМІШІ ..... 89***Рябошанка В.Б.***СУЧАСНИЙ СТАН І ПЕРСПЕКТИВИ НАУКОВИХ ДОСЛІДЖЕНЬ ПЕРЕХОДУ ДИЗЕЛЬНИХ ДВИГУНІВ НА БІОДИЗЕЛЬНЕ ПАЛИВО ..... 97***Холодюк О.В., Твердохліб І.В., Кузьменко В.Ф.***ОСОБЛИВОСТІ КОНСТРУКЦІЙ СУЧАСНИХ ВІЗКІВ-ПІДБИРАЧІВ ТА ЕФЕКТИВНІСТЬ ЇХ РОБОТИ ПРИ ЗАГОТІВЛІ СТЕБЛОВИХ КОРМІВ ДЛЯ ВИРОБНИЦТВА ВИСОКОПОЖИВНОЇ БІЛКОВО-ВІТАМІННОЇ ПАСТИ ТА ЖОМУ ..... 106****III. ЕЛЕКТРОЕНЕРГЕТИКА, ЕЛЕКТРОТЕХНІКА ТА ЕЛЕКТРОМЕХАНІКА***Возняк О.М., Штуць А.А., Булига А.І., Харченко Р.Є.***ДОСЛІДЖЕННЯ ТА УДОСКОНАЛЕННЯ ПРОЦЕСУ ОБРОБКИ ЗОБРАЖЕНЬ НАВИГАЦІЙНОЇ СИСТЕМИ СІЛЬСЬКО-ГОСПОДАРСЬКИХ МАШИН З УРАХУВАННЯМ УМОВ ОБМЕЖЕНОЇ ВИДИМОСТІ ..... 120***Leonid Sereda, Ludmila Shvets, Olena Trukhanska, Volodymyr Shkuta***WOOD WASTE PROCESSING AS AN ALTERNATIVE FUEL ECONOMY ..... 132***Svetlana Kravets***OPTIMIZATION OF ENERGY-EFFICIENT PROCESSES IN THE PRODUCTION AND PROCESSING OF AGRICULTURAL PRODUCTS ..... 141**



## CONTENTS

**I. APPLIED MECHANICS. MATERIALS SCIENCE. INDUSTRY MACHINERY BUILDING***Grygorii Kaletnik, Yurii Polievoda, Oleksii Tokarchuk***STUDY OF THE TECHNOLOGICAL PROCESS OF MECHANICAL DEHYDRATION OF FOOD PRODUCTION WASTE THROUGH MATHEMATICAL MODELING..... 5***Dmytro Makarenko, Oleksii Derkach, Volodymyr Govorukha, Nataliia Veselovska***MODERNIZATION OF MOVEABLE CONNECTIONS OF THE SECTION OF THE SOWING COMPLEX..... 12***Nataliia Veselovska, Artem Kosakivskiy, Vitaliy Romanov***INNOVATIVE METHODS OF EXPANDING THE FUNCTIONAL CAPABILITIES OF THE SINGLE-SPINDLE LATHE..... 21***Yuri Paladiychuk, Inna Telyatnik***ALGORITHM FOR EXPERIMENTAL INVESTIGATION OF HYDROIMPULSE DEVICE FOR STRENGTHENING PARTS BY DEFORMATION..... 31***Olena Solona, Oksana Skoromna, Haluna Ohorodnichuk***APPLICATION OF DIGITAL TECHNOLOGIES IN THE FIELD OF ANIMAL HUSBANDRY.. 43***Serhiy Shargorodskiy, Dmutro Kondratuk***STUDY OF THE KINEMATICS OF THE POSITIONING MECHANISMS OF WIDE-GRIP MACHINE-TRACTOR UNITS..... 51****II. AGROENGINEERING***Oleksandr Gritsenko, Serhii Stepanenko***APPLICATION OF THE THEORY OF DIMENSIONS AND SIMILARITY TO DETERMINE THE PARAMETERS AND OPERATION MODES OF AN ASYMMETRICAL DISK HROW FOR SOIL PROCESSING..... 62***Volodymyr Dudin, Illia Bilous***EXPERIMENTAL DEVELOPMENT OF DISC GRAIN MILL..... 71***Anatoliy Yelenych***GRAIN HARVESTER COMBINED BY NEW HOLLAND..... 78***Sergii Pavlenko***JUSTIFICATION OF RATIONAL OPTIONS FOR APPLICATION OF TECHNICAL MEANS FOR THE PREPARATION OF COMPOST MIXTURE..... 89***Vadim Ryaboshapka***CURRENT STATUS AND PROSPECTS OF SCIENTIFIC RESEARCH ON THE TRANSITION OF DIESEL ENGINES TO BIODIESEL FUEL..... 97***Oleksandr Kholodiuk, Igor Tverdokhlib, Volodymyr Kuzmenko***CHARACTERISTICS OF THE DESIGNS OF MODERN PICK-UP TRUCKS AND EFFICIENCY OF THEIR WORK IN THE PROCUREMENT OF STEM FORAGE FOR THE PRODUCTION OF HIGHLY NUTRITIONAL PROTEIN-VITAMIN PASTE AND PULLEY..... 106****III. ELECTRICAL ENERGY, ELECTRICAL ENGINEERING AND ELECTROMECHANICS***Oleksandr Vozniak, Andrii Shtuts, Andrii Bulyha, Roman Kharchenko***RESEARCH AND IMPROVEMENT OF THE IMAGE PROCESSING PROCESS OF THE NAVIGATION SYSTEM OF AGRICULTURAL MACHINERY TAKING INTO ACCOUNT CONDITIONS OF LIMITED VISIBILITY..... 120***Leonid Sereda, Ludmila Shvets, Olena Trukhanska, Volodymyr Shkuta***WOOD WASTE PROCESSING AS AN ALTERNATIVE FUEL ECONOMY..... 132***Svetlana Kravets***OPTIMIZATION OF ENERGY-EFFICIENT PROCESSES IN THE PRODUCTION AND PROCESSING OF AGRICULTURAL PRODUCTS..... 141**



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## OPTIMIZATION OF ENERGY-EFFICIENT PROCESSES IN THE PRODUCTION AND PROCESSING OF AGRICULTURAL PRODUCTS

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*The article presents materials for the analysis of energy efficiency of foreign and domestic agricultural production and summarizes the factors affecting the reduction of their energy efficiency. The results of the analysis of energy resource consumption in the field of dairy farming and materials on the results of the application of energy-saving measures are given.*

*This article is devoted to the problem of optimizing energy-efficient processes in the production and processing of agricultural products, which is important for increasing productivity and reducing the impact on the environment in the agricultural sector. The activity of agricultural enterprises is accompanied by significant energy costs, and the optimization of these processes can lead to saving resources and reducing emissions of harmful substances.*

*The article considers current approaches to improving energy efficiency in agro-industrial production and food processing, including the use of modern technologies, process automation, use of renewable energy sources, and effective methods of resource management. The authors of the article consider practical examples of innovative solutions that help reduce energy consumption and improve productivity in the agro-industrial sector.*

*By conducting analysis and research in the chosen topic, the authors provide readers with important conclusions about how optimization of energy-efficient processes can contribute to the sustainable development of the agricultural sector and consumers in general. This article may be useful for agricultural professionals, researchers, government officials, and anyone interested in a balanced approach to agricultural production and processing to conserve resources and reduce environmental impact.*

**Key words:** energy efficiency, agriculture, production, processing of agricultural products, sustainable development, energy saving.

**Fig. 1. Table. 1. Ref. 10.**

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### 1. Problem formulation

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Optimizing energy-efficient processes in production consists in studying and substantiating the need to optimize energy-efficient processes in the production and processing of agricultural products. The problem lies in the following aspects:

The growth of the world population and the increase in demand for agricultural products creates pressure to increase production volumes in agriculture and food processing. This leads to an increase in energy costs in these industries.

Energy dependence of production and processing of agricultural products increases the risk of energy price fluctuations and can affect the economic stability of the industry.

Modern standards of sustainable development and environmental restrictions require the reduction of greenhouse gas emissions and other negative impacts on the environment. A high level of energy consumption can lead to environmental problems and undesirable consequences for nature.

Optimizing energy-efficient processes in agriculture and processing can help increase productivity, reduce costs, and improve product quality, which are important factors for increasing the competitiveness of the industry.

Thus, the problem of optimizing energy-efficient processes in the production and processing of agricultural products is an important challenge that requires research and development of effective strategies and practical solutions to improve the sustainability and efficiency of the agricultural sector.



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## 2. Analysis of recent research and publications

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Research in this area notes the growing attention to energy efficiency issues in the agro-industrial sector. This is due to the growing awareness of resource conservation and reduction of greenhouse gas emissions.

Researchers determine the use of innovative technologies, such as modern automation systems, the use of renewable energy sources, and the development of effective energy management methods to reduce energy consumption in agro-industrial production.

Governmental and international organizations actively stimulate research in the field of energy efficiency of agriculture by providing grants and support for the implementation of projects aimed at optimizing processes.

Research shows that optimizing energy-efficient processes can lead to reduced costs and increased productivity in the agribusiness sector.

Most studies emphasize the importance of an integrated approach that takes into account technical, economic and environmental aspects of energy efficiency in agriculture.

Research also emphasizes the importance of educating and informing farmers and operators about the opportunities and benefits of optimizing energy-efficient processes.

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## 3. Purpose of research

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Consider modern technologies and approaches to achieving energy efficiency in the agro-industrial sector and food processing, as well as analyze practical examples of successful solutions in this field.

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## 4. Results of the researches

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Agriculture is an integral part of the world economy and society. Production and processing of agricultural products require significant energy costs, and this aspect becomes especially relevant in the context of population growth and increased demand for food products. Therefore, optimization of energy-efficient processes in agriculture and processing of agricultural products is critically important for sustainable development and ensuring food security.

Currently, the specific energy intensity of the Ukrainian economy compared to the economies of the industrialized countries of the world, unfortunately, remains high. Taking into account purchasing power parity, this indicator is twice as high as the similar indicator in the USA, 2.3 times higher in the world community as a whole, and 3 times higher in the developed countries of Europe and Japan [1].

For the production of goods and services worth one thousand dollars in Ukraine, 0.89 tons of conventional fuel (t.u.p.) are spent, and in Norway and Sweden, which have similar climatic conditions, only 0.36 ton . and 0.26 t.u.p. respectively [1].

Currently, a number of normative acts have been adopted in Ukraine, which contribute to the implementation of measures to reduce the energy intensity of production.

The purpose of the development of the concept is to substantiate ways of increasing the energy efficiency of the country's agricultural production, taking into account the real conditions of the functioning of agricultural enterprises.

When developing the concept of energy saving and increasing the energy efficiency of production in the agricultural industry, a program-target method of solving the problem of energy saving was used with the definition of goals and objectives, the selection of a list of coordinated energy-saving measures, and their connection with technical, technological and financial possibilities [2,3].

The high energy intensity of production in domestic agriculture is due to the following characteristics [3.4]:

- very low level of labor productivity (for example, currently it is 10% of the US level);
- a low rate of utilization of power plants with a large set of technical and technological means (for example, the rate of utilization of electric substations, boiler houses , installed capacity of internal combustion engines does not reach 20%);
- a complex structure of the fuel and energy balance, the main components of which are the following types of fuel and energy resources (TER): diesel fuel and gasoline ( about 1/3), electricity (12%), solid fuel ( more than 1/3), gas, liquid oven fuel ;
- energy intensity in recent years production only increased ( consumption energy increased by 350%, growth crop and livestock products as specified period was, respectively, 25% and 35%) [5].



Rural household has evolve intensively, using innovative energy saving technologies , and this one process inseparable connected with increaіse consumption energy : an increase to date production by 1% entails an increase expenses energy resources by 2-3%.

In animal husbandry 18-22% of liquid is consumed fuel and 19-20% electric energy from everyone energy resources that are used for production goals in the countryside economy \_

Everything is higher the above has a negative effect on the state of the agro-industrial complex, as it is huge amount outdated equipment and communications (about 90% of them works beyond deadlines depreciation ), deterioration systems operation and service, as well as deficit able-bodied personnel necessary qualifications [6].

In Ukraine on 1 ha of arable land up to 250-280 kg of conventional is spent of fuel, while, for example, the USA - 140 kg.

So, rural household at night lags behind in the industry energy resource conservation from foreign countries.

The main causes of irrational use in agriculture is:

- underestimation roles energy in the development of the agricultural sector;
- morally and physically outdated technological agricultural equipment \_ production and processing industries ; significant costs thermal and electrical energy in animal husbandry to support production premises necessary parameters microclimate (especially for young animals ) ;
- low efficiency departmental boiler room from long heat networks;
- availability big quantity electric motors for technological installations that are operated with minimal loading ;
- uneconomical systems electric lighting

Modern agricultural production , in the first place queue animal husbandry is a big consumer energy resources and is a priority state policies in the industry agricultural production . According to the results of the analysis of the state and development prospects branch of dairy farming it was established that one of risks decrease profitability production in dairy farming and non-compliance programs him development is growth prices for energy carriers , primarily for electricity [7].

In the field of production, in particular in the agro-industrial complex (APC), there are two main types of resources - economic and natural, and their role can be determined by the level of technological development. The higher the level of technology, the less agricultural production depends on natural factors.

Economic resources of agricultural enterprises can be classified according to their value into the following types:

- basic resources, without which the functioning of agricultural enterprises is impossible;
- production resources that are necessary for the technological process of agricultural production;
- auxiliary or specific resources that take part in the production process.

Of natural resources, the most prominent role is played by resources of man-made origin, known as energy resources - these are reserves of energy that can be used to supply energy. It is important to note that some energy resources can be used as fuel or as raw materials for further processing.

Since the beginning of the 19th century, the main sources of energy have been fossil fuels such as coal, oil and natural gas, which have been widely used in agriculture. However, modern society uses different sources of energy, such as different types of fuel, combustible gases, combustible shale, peat, firewood, as well as the energy of falling water, wind, sun and atoms.

In the field of agriculture, the use of energy resources depends on the level of economic development of a particular country. Usually, the higher the level of development, the more diverse energy sources are used in the agricultural sector.

Modern agriculture in developed countries makes extensive use of alternative energy sources such as wind and solar energy. Previously, energy from falling water and wind was used to grind grain in water and wind mills.

Extraction and use of various types of fuel and energy resources in agriculture belong to the field of energy. Energy includes the fuel industry, power generation, and fuel and energy supply systems. It is important to note that energy is the basis of modern agriculture, and no agricultural enterprise can function without it.

The level of energy supply of agricultural enterprises is characterized by the following indicators:

- Energy security - the amount of energy capacity in horse-power or kilowatt-hours per hectare or per 100 hectares of agricultural land or arable land.





- Energy availability - energy capacity in horsepower or kilowatts per 1 average annual worker employed in agriculture.
- Electricity supply - the amount of electricity consumed for production needs, per 100 hectares of agricultural land, arable land or sown area.
- Electricity availability - the amount of electricity consumed for production needs, per 1 average annual worker employed in agriculture.
- Electricity capacity of production - the amount of electricity consumed for production needs, per 100 hryvnias of money circulation. This indicator can be expressed both in kilowatt-hours and in rubles. To calculate the electricity capacity of production in rubles, production costs for electricity per 100 rubles of money circulation are taken.
- The specific weight of electricity costs in the amount of production costs (%) - determines how many percent of production costs are paid for electricity.

The reasons for the irrational use of natural energy resources (NER) in agriculture can be reformulated as follows:

- Underestimation of the importance of energy in the development of the agricultural sector.
- Obsolete technical equipment in agriculture and processing industries.
- Large energy costs in rural animal husbandry to maintain the necessary parameters of the microclimate.
- Low efficiency of departmental boiler rooms and heating networks.
- A large number of little-used electric motors in technological installations.
- Uneconomical electric lighting systems.

Increasing energy efficiency in the agricultural sector should include the following strategic measures:

- Rational use of fuel and energy.
- Replacing expensive types of fuel with more affordable ones.
- Maximum use of local energy resources.
- Decentralization of heat supply sources.
- Application of energy-efficient technologies and use of non-traditional and renewable energy sources.

Some promising energy-efficient technologies for the agricultural sector include:

- Systems of cogeneration and trigeneration of energy for autonomous agricultural consumers, which allow to save energy resources.
- Energy-saving technologies and machines for the production of agricultural products.
- Natural heat and waste utilization systems (solar systems, heat pumps, etc.).
- Energy-saving systems for maintaining the microclimate in livestock facilities with utilization and recirculation of air heat.
- Energy-saving technologies for rural water supply systems.

In addition, the development of power management of heating, ventilation and air conditioning systems can help reduce energy costs. It is also important to develop electrical technology methods and equipment for the production of quality food, seed material and animal feed, as well as to use microwave energy in technological processes to improve energy efficiency in agriculture.

The peculiarities of the functioning of the agricultural industry are connected with the fact that biological objects are most often the object of influence of machine technologies: soil, plant, animal.

This has an impact on the consumption and distribution of energy and resources. In the process of economic activity, the company's resources occupy one of the central places, therefore the issue of energy saving for the company is very relevant today.

Energy conservation is the basic technology for creating efficient agriculture. The process of implementing the energy conservation policy, which is gradually coming into force in Russia, is extremely necessary as part of a complex of measures to overcome the crisis of the national economy. [7]

The goal of energy saving is to achieve maximum efficiency in the use of fuel and energy resources (PER). The efficiency of the use of PER is the volume of useful production of products obtained for a unit of PER, used by the equipment or technological process in the production process. Rational use of PER is the achievement of the maximum possible efficiency of the use of PER with the existing level of equipment and technologies.



Currently, the energy supply system, as well as agriculture in general, is in a state of deep systemic crisis.

The current state of agriculture in our country can be described as follows:

- Low level of labor productivity compared to western developed countries.
- High energy intensity of manufactured products, which is 4-6 times higher than in Western countries.
  - A large number of technological and energy resources used, with low useful use. The average annual utilization ratio of electrical substations, boiler houses and the installed capacity of internal combustion engines does not exceed 20%.
  - A complex structure of the fuel and energy balance (PEB) with a high dependence on diesel fuel, gasoline, electricity, solid fuel, gas and liquid fuel.
  - Obsolete equipment and communications, about 90% of which have already exceeded the limits of depreciation.
  - Destruction of the operation and service system, as well as reduction of the working fleet of machines.
  - Shortage of qualified workers.

In this regard, the previously cost-effective approach to rural energy, which assumed an increase in energy consumption with an increase in production, is no longer acceptable in the new economic conditions. Low level of energy efficiency, low quality and inefficient use of electrical energy are problems of many farms and territories in our country. In the conditions of the shortage of energy resources and the increase in their cost, the problem of energy saving becomes even more urgent.

Therefore, the main task for saving fuel and energy resources in agriculture is to reduce unnecessary energy consumption, which is about 30-40% of the total electricity consumption in agriculture. Many technological processes in the agro-industrial complex use an unregulated asynchronous electric drive, which consumes up to 60% of electricity. However, the choice of power of electric motors is usually carried out taking into account the maximum load, which occurs only 20-30% of the time of operation.

One of the promising directions for reducing electricity consumption is the wide implementation of a frequency-regulated electric drive. However, the success of its application in many cases depends on its reasonable use for specific technological processes and the choice of an appropriate management method, taking into account the peculiarities of agricultural production.

A reduction in electricity costs for lighting can be achieved by replacing incandescent lamps, which use only 5-8% of the consumed energy to produce light, with more efficient fluorescent lamps, which have a useful return of 20-30%.

About half of the total electricity savings can be achieved through the introduction of energy-saving machines, technological processes and equipment, including new industrial and technologies that require development. Approximately one-tenth can be saved by increasing the use of secondary energy resources.

Reduction of electricity consumption and reduction of lighting costs can be achieved through optimization of lighting systems, use of efficient light sources, correct selection and rational placement of lamps, use of new lighting devices, effective lighting management and its automation, rational construction of lighting networks, planned and high-quality operation of lighting systems

*Table 1*

*Indicators energy consumption different industries agricultural production*

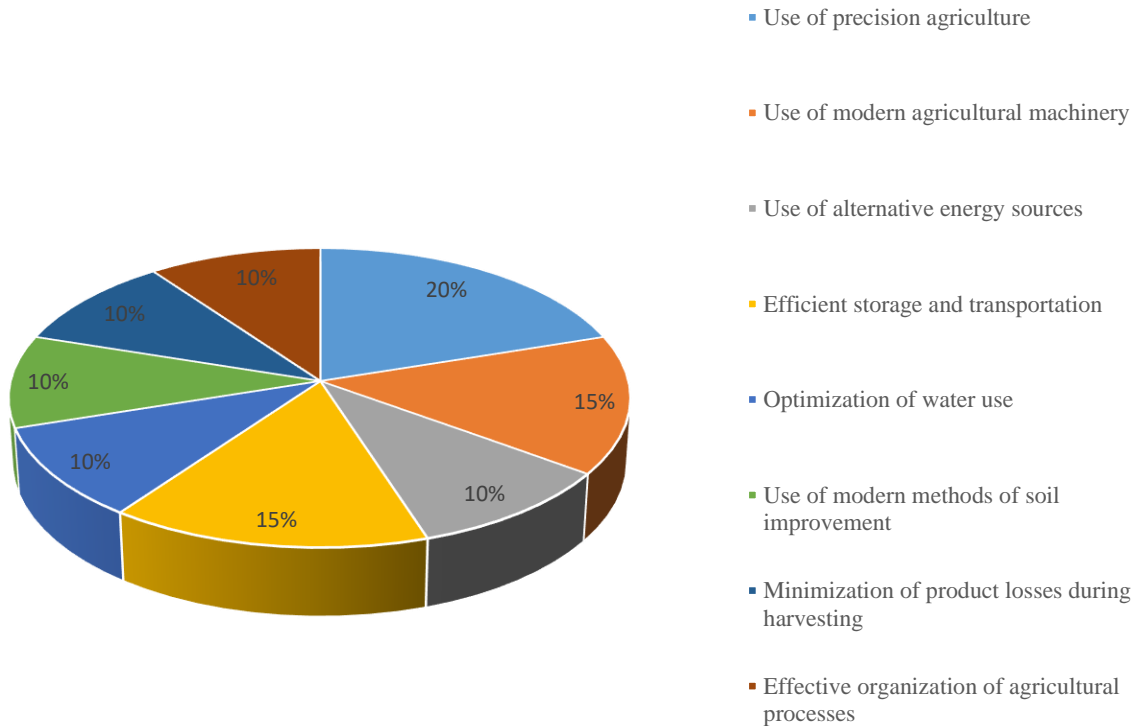
<b>Classification of energy efficient process</b>	<b>Contribution to reducing energy consumption</b>
Use of precision agriculture	20%
Use of modern agricultural machinery	15%
Use of alternative energy sources	10%
Efficient storage and transportation	15%
Optimization of water use	10%
Use of modern methods of soil improvement	10%
Minimization of product losses during harvesting	10%
Effective organization of agricultural processes	10%

The following energy-efficient technologies are very promising for agriculture:

- Systems of combined production of electricity and heat for autonomous agricultural consumers, which allow to save a significant amount of energy.



- Energy-saving machines, technological processes and equipment for the production of agricultural products.
- Natural heat and waste disposal systems.
- Energy-saving systems for maintaining the microclimate in livestock premises with the use and recirculation of air heat.
- Energy-saving technologies for rural water supply systems.



**Fig. 1. Classification of energy-efficient processes in the production and processing of agricultural products**

#### 1. The importance of energy efficiency in the agro-industrial complex

The agro-industrial complex is a large consumer of energy. From fields and agricultural machinery to processing and storage of products - every stage of production requires energy resources. However, a high level of energy consumption does not always mean high performance. Optimizing energy-efficient processes can help reduce energy consumption and costs while increasing yields and product quality.

#### 2. Use of modern technologies

Achieving energy efficiency in agriculture requires the use of modern technologies and innovative solutions. One of the key technologies is the introduction of precision agriculture, which allows for the optimization of the use of resources, including fuel, manure and water. With the help of sensors and geospatial technologies, farmers can precisely dose resources on each hectare of land, which allows to reduce losses and energy consumption.

#### 3. Solar and wind energy

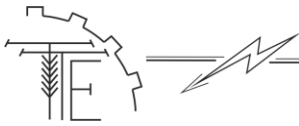
One way to reduce the impact of agriculture on the environment is to use alternative energy sources, such as solar and wind energy. Installing solar panels on agricultural buildings and using wind generators helps reduce dependence on traditional energy sources and reduce greenhouse gas emissions.

#### 4. Efficient storage and transportation

Energy consumption also occurs at the stage of storage and transportation of agricultural products. Efficient storage and transportation systems can help reduce product losses and reduce energy costs. With the use of modern technologies in the field of cold chain logistics, it is possible to store products under optimal conditions, reducing energy consumption.

#### 5. Education and informational support

An important element of optimizing energy-efficient processes is the education of agricultural workers and farmers. Awareness of modern technologies and practices is essential for their successful



implementation. Organizations and government agencies can provide support through training and information on energy efficient solutions.

## 5. Conclusions

Energy efficiency is a critical aspect of the sustainable development of agriculture and the agricultural processing industry. Reducing energy costs and increasing productivity can help reduce negative environmental impact and ensure economic efficiency.

Modern technologies and innovative solutions play an important role in achieving energy efficiency in the agro-industrial sector. The use of renewable energy sources, automation of processes and optimization of the use of resources can significantly improve production efficiency.

Stimulating energy efficiency research and initiatives is an important task for governmental and international organizations. Financing research and supporting projects aimed at optimizing energy-efficient processes can stimulate the development of this industry.

A comprehensive approach that takes into account technical, economic and environmental aspects is necessary to achieve success in optimizing energy-efficient processes. This means that the development of strategies and solutions should be thorough justified and take into account all aspects.

Educating and informing industry players, including farmers and professionals, about the benefits and opportunities of optimizing energy-efficient processes is critical. Conscious use and understanding of innovations can contribute to the implementation of these practices in practice.

The general purpose of the article is to promote the development and implementation of optimization of energy-efficient processes in agriculture and the field of processing of agricultural products in order to ensure sustainable development, preserve resources and reduce the negative impact on the environment.

Optimizing energy-efficient processes in the production and processing of agricultural products is critically important for the sustainable development of the industry and reducing the negative impact on the environment. The use of modern technologies, alternative energy sources and education can help ensure the efficiency and sustainability of agriculture in the face of growing demands for food security and environmental sustainability.

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### ОПТИМІЗАЦІЯ ЕНЕРГОЕФЕКТИВНИХ ПРОЦЕСІВ У ВИРОБНИЦТВІ ТА ПЕРЕРОБКИ СІЛЬСЬКОГОСПОДАРСЬКОЇ ПРОДУКЦІЇ

*Стаття присвячена проблемі оптимізації енергоефективних процесів у виробництві та переробці сільськогосподарської продукції, що важливо для підвищення продуктивності та зменшення впливу на довкілля в аграрному секторі. Діяльність сільськогосподарських підприємств супроводжується значними енергетичними затратами, і оптимізація цих процесів може призвести до економії ресурсів та зниження викидів шкідливих речовин.*

*У статті викладено матеріали аналізу енергоефективності зарубіжного та вітчизняного сільгоспвиробництва та узагальнено фактори, що впливають на зниження їхньої енергоефективності. Наведено результати аналізу споживання енергоресурсів у галузі молочного тваринництва та матеріали щодо результатів застосування енергозберігаючих заходів. Також розглянуті актуальні підходи до покращення енергоефективності в агропромисловому виробництві та продовольчій переробці, включаючи використання сучасних технологій, автоматизації процесів, використання відновлюваних джерел енергії та ефективні методи управління ресурсами. Досліджені практичні приклади інноваційних рішень, які сприяють зниженню споживання енергії та покращенню продуктивності в агропромисловому секторі.*

*Проводячи аналіз та дослідження в обраній темі, можна відзначити важливість оптимізації енергоефективних процесів, що може сприяти сталому розвитку сільськогосподарського сектора та споживачам в цілому. Стаття може бути корисною для фахівців у галузі сільського господарства, а також у виробництві та переробки сільськогосподарської продукції з метою збереження ресурсів і зниження впливу на довкілля.*

**Ключові слова:** енергоефективність, сільське господарство, виробництво, переробка сільськогосподарської продукції, стале розвиток, енергозбереження.

**Рис. 1. Табл. 1. Літ. 10.**

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