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ALGORITHMIC APPROACH TO THE DEVELOPMENT OF THE USE OF BIOENERGY RESOURCES

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Abstract
This study is devoted to the use of an algorithmic approach to the development of the use of bioenergy resources. The purpose of the article is to describe the application of an algorithmic approach in the process of improving the use of bioenergy resources in the national energy conservation system. The authors characterize the stages of research on the development of the use of bioenergy resources in Uzbekistan. The proposed algorithmic approach can be applied to improve the use of bioenergy resources in the national energy conservation system. The use of an algorithmic approach makes it possible to create an information base for making sound management and technical decisions in the field of bioenergy development, to make a reasonable choice of priority bioresources at the regional and local levels; provides complexity in considering the needs for bioresources and the possibilities of meeting them.

Keywords*: bioenergy, bioresources, renewable energy sources, sustainable development.*
JEL Codes*: B41, Q01, Q20, K32.*

Introduction

Currently, the transition to renewable energy sources is an urgent task of every state. The reasons for updating this process are related to the need:

- at the global level – mitigation of the negative effects of climate change in the world. High greenhouse gas emissions and deadly air pollution make the development of bioenergy especially relevant;

- at the regional and sub–regional level - solutions to regional problems. As an example, it can be noted the importance for many countries of creating a system of regional "energy security";

- at the national level – the development of state policy measures in the field of energy conservation, energy efficiency improvement.

The energy intensity of the gross domestic product in Uzbekistan is almost four times higher than in the countries of the European Union, and twice as high as the global average (Uzbekistan energy profile, 2022).

The relevance of the study is fully consistent with the goals and objectives of sustainable development until 2030. Among the main tasks at the Summit on Sustainable Development, ensuring universal access to affordable, reliable, sustainable and modern energy supply was noted. According to the World Bank, 2.6 billion people in developing countries use traditional types of biomass for cooking and heating (Saghir, 2005).

Literature review

At the preparatory stage of the study, the main scientific literature and the existing regulatory framework were analyzed on the example of a single country. An international team of scientists conducted research on the example of two countries (Uzbekistan, Ukraine), which differ in their level of development, the available potential of resources, existing problems and development prospects. This article attempts to reflect the results of the study, which were conducted on the basis of the analysis of the experience of the development of bioenergy resources in Uzbekistan.

It should be noted that the interest in various problems of bioenergy (technical, organizational, economic, legal and environmental, and others) in the world is huge. According to the research data, 124,285 articles were published on this topic only for the period 2000-2018 (Welfle A., Thornley P., Röder M., 2020). This made it possible to conclude that the importance of the issues under consideration was determined by the attention to this issue from both scientists and practitioners working in different areas of bioenergy. An overview of the global prospects for sustainable development of bioenergy production is contained in the article Duarah P, Haldar D, Patel AK, Dong CD, Singhania RR, Purkait MK, 2022). The authors of the article conclude that the use of biofuels will improve the social, economic and environmental conditions of human life. Among the modern articles on this topic, it should be noted the materials of the special issue of the journal “Resources” - “Special Issue” “Biomass Energy Resources: Feedstock Quality and Bioenergy Sustainability”, which published an article on the evaluation of biomass feedstock and effect on biofuel quality (Duca D., Toscana G., (2022); O. Awogbemi, D.V.V. Kallon, V.S. Aigbodion, 2021) presented the study Trends in the development and utilization of agricultural wastes as catalyst. In the article Bužinskienė, R., & Miceikienė, A., 2021 an assessment of the secondary use of agricultural waste for the production of bioenergy was carried out. This article emphasizes the need for support in conducting training and developing knowledge and skills in this area in order to develop these areas.

Due to the increased attention to the development of the theory and practice of bioenergy, articles have recently appeared in Uzbekistan that focus on the use of bioenergy resources. The articles (Ismailov A., Juraev Z., Ismoilojonov Y., Alijanov D, 2022; Pushkar V., Shcheklein S., Akifyeva N., 2019) and other authors characterize the potential of renewable energy sources in Uzbekistan, emphasize the importance of solving energy supply issues for rural areas of the country.

Among the studies conducted in Uzbekistan, an article should be highlighted (Avezova N., Khaitmukhamedov A., Vokhidov A., 2017), which notes the need to use renewable energy sources to ensure energy security and improve the standard of living of the country's population. The article (Saipov Z.U., Arifdzhanov G.A., 2020) is of interest, which describes the condition and prospects for the development of bioenergy in the agricultural regions of Uzbekistan. The authors determine the potential of organic waste from animal husbandry and poultry farming in agriculture.

Uzbekistan is developing a regulatory framework for the introduction of bioenergy and renewable resources. In 2019, a special Law on the use of renewable energy sources (Law, 2019) was adopted. In 2020, Uzbekistan approved a program of comprehensive measures for the development of biotechnologies and improvement of the country's biological security system in 2020-2024. (The program, 2020). Uzbekistan has approved a strategy for the transition of the Republic to a "green" economy for the period 2019-2030. Thus, according to this Strategy, Uzbekistan aims to increase the share of renewable energy sources in total electricity production to more than 25% by 2030 (Decre, 2019). The strategy also plans to: double the energy efficiency index; reduce the carbon intensity of the gross domestic product; ensure access to modern, inexpensive and

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reliable energy sources for the entire population and all sectors of the economy.

But the further development of bioenergetics requires the creation of a certain methodological basis. Research should be conducted on the basis of the proposed algorithm, which should provide an integrated approach and consistency in implementation. All this determined the purpose of the study, its subject and object.

Methodical approach

The provisions of this article are based on the hypothesis that energy conservation and energy efficiency should be improved by expanding the use of bioenergy. The development of bioenergy is the most important step towards the creation of systems of sustainable development and energy efficiency.

The object of the study is the use of bioenergy resources for the purposes of energy conservation and energy supply in the system of sustainable development of countries.

The subject of the study is the improvement of the use of bioenergy resources based on the use of an algorithmic approach.

The research was carried out by a creative team of scientists from Ukraine and Uzbekistan on the basis of a common methodological approach using the developed research algorithm. The main research methods used were a comparative analysis of the state of affairs in the fields of energy conservation, bioenergy development in Ukraine and Uzbekistan; methods of induction, deduction. The comparative analysis is based on quantitative and qualitative approaches, which allows us to highlight the prospects for the development of bioenergy.

Due to the increased attention to the use of bioenergy resources, a scientific problem arises, which consists in the lack of a methodological approach to solving new theoretical and practical problems in this process. The choice to solve this scientific problem is justified primarily by the extent to which the proposed approach will contribute to solving the practical problem of improving the use of bioenergy resources. The purpose of the article is to describe the application of an algorithmic approach in the process of improving the use of bioenergy resources in the national energy conservation system.

Research results and discussion

The algorithmic approach can be characterized by a sequence of steps in the process of improving the use of bio-energy resources in the energy saving system. The following algorithm of practical activity in this field is proposed, consisting of a number of stages. The algorithmic approach can be characterized by a sequence of steps in the process of improving the use of bio-energy resources in the energy saving system. This article characterizes the essence, features of the implementation of 4 stages of activity. For the successful implementation of each stage, in the future, it is necessary to develop specific methodological recommendations for regional and local authorities that will participate in this process. In this article, only the main characteristics of the activity at each stage are considered in detail.

At the first stage, the assessment of the existing potential of renewable energy sources at the national, regional and local levels is carried out; the place of bioresources among renewable energy sources is determined. The total potential of renewable energy sources in Uzbekistan is presented in table 1.

Table 1. Potential of renewable energy sources

Renewable energy source	Technical potential, Mtoe	Общий потенциал, Mtoe
Hydropower	2	9,2
Wind power	0,4	2,2
Solar power	177	50,973
Geothermal energy	0,3	67000
Total alternative energy sources	179,3	117984

**Source: (Uzbekistan energy profile, (2022)).*

The total capacity of renewable energy sources in Uzbekistan in 2018 amounted to 1,844 MW, which covers about 3% of total energy consumption. On average, 10-12% of all electricity in the country is generated from renewable energy sources. All this allows us to conclude that Uzbekistan has a great potential for renewable energy sources.

The most promising is the use of solar energy, the potential of which is 98.5% of the total potential of renewable energy sources. Currently, two industrial-scale solar photovoltaic power plants are operating in Uzbekistan, built with the help of funds from foreign investors. Only one solar power plant in the Samarkand region will generate 260 million kW.h of energy per year, which will be able to provide electricity to more than 80 thousand homes. The commissioning of the station, according to calculations, will save 78 million cubic meters of natural gas per year and prevent the release of 100 thousand tons of harmful emissions into the atmosphere (The second, 2022).

The presence of strong winds in Uzbekistan makes wind energy a promising direction. One of the goals of the document "The Concept of providing the Republic of Uzbekistan with electric energy for 2020-2030" (The concept, 2020) is to bring the wind power capacity to 3000 MW by 2030. When comparing power utilization coefficients, wind potential indicators in the territories of wind power plant construction, it was found that Uzbekistan's indicators are 1.5 times higher than the global average. Out of a total of 8,760 hours per year, wind farms in Uzbekistan can operate at full capacity for about 3,900 hours (Uzbekistan, 2022).

However, bioresources have not been adequately developed in the renewable energy system. This makes it necessary to develop a number of measures for the development of bioenergy at the national and regional levels.

The main advantages of the development of bioenergy in the republic are the following

1. For the national economy:

– development of the investment potential of the regions;

– development of energy in rural areas.

2. For the population:

– increasing the level of employment in rural areas;

- meeting the growing demand for electricity.

3. To achieve sustainable development:

- reduction of land, water and air pollution;

- reducing the number of waste, warehouses and landfills for their storage.

At the same time, the study analyzed the main problems that hinder the development of bioenergy in Uzbekistan.

1. The high cost of renewable energy production and its limited generating capacity compared to traditional energy sources.

2. There are no effective financial support mechanisms (tariffs and taxes) that will stimulate the use of bioenergy.

3. The regulatory framework for the development of bioenergy needs further improvement, taking into account the principles of sustainable development.

4. There are no effective technical capabilities for processing and using bioenergy. The costs of purchasing, installing and maintaining such installations are high.

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5. Insufficient awareness of the possibilities of bioenergy resources.

The second stage is to determine the needs of the country's regions for bioenergy resources. It should be noted that in the "Concept of providing the Republic of Uzbekistan with electric energy for 2020-2030" (The concept, 2020), the annual growth in electricity consumption in the republic will be about 6-7 percent. By 2030, the republican consumption is projected to amount to 120.8 billion kWh (an increase of 1.9 times by 2018), the consumption of electric energy per capita by 2030, according to forecast data, will increase to 2,665 kWh. The shortage of energy resources in Uzbekistan is associated with an increase in domestic consumption, economic growth, population growth and people's well-being and income, which is why the need and demand for energy resources is growing sharply. Under the existing conditions of energy consumption, accelerated industrialization and population growth in Uzbekistan (according to UN forecasts, the country's population will increase to 37 million people by 2030) can significantly increase the economy's demand for energy resources. For each region of the republic, it is necessary to make forecast calculations of energy demand, taking into account population growth, industrial and agricultural development, and the standard of living of the population. The country needs to take a course on energy conservation, energy efficiency improvement, expansion of the use of renewable energy sources in the economy and consumption of the population, transition to a "green economy" model and others. According to the concept (The concept, 2020), of energy development of Uzbekistan, it is supposed to be a comprehensive development of renewable energy sources.

At the third stage, the potential of bioresources is being determined at the national, regional and local levels (it will increase by 71.4 percent compared to 2018). This will allow you to choose priority sources of biological resources in each region of the republic.

It should be noted that various types of bioenergy resources are distributed unevenly across the country. And this makes it necessary to draw up a map of the distribution of bioenergy resources, taking into account their quantity and quality. As an example, the values of the minimum and maximum indicators of the amount of waste processing during the introduction of biogas plants in livestock and poultry farms of the republic are given (table 2).

Table 2. Forecast indicators of the amount of waste processing during the introduction of biogas plants in livestock and poultry farms of Uzbekistan (thousand tons)

Name of the region	2022 forecast data, thousand tons	2025 Forecast data, thousand tons
Total for Uzbekistan, including:	2397	11985
Republic of Karakalpakstan	106	477
By region:		
Minimum value		
- Syrdarya region	22	99
Maximum value		
- Tashkent region	252	1134

**Source: compiled by the authors based on (Shadimetov, 2022).*

In Uzbekistan, the use of the organization of the use of the II and III generation of biofuel production from plant stems and microalgae (aquatic plants) is promising. Currently, in the republic, stems and tops (root crops) of crops such as cotton,

cereals, rice and potatoes are used as livestock feed and as fuel.

The main bioenergy raw material in Uzbekistan is cotton. 2-4 tons of stems can be removed from one hectare of cotton, which can be processed into briquettes, can be subjected to thermochemical decomposition to obtain biogas. The annual gross energy potential of cotton stems is estimated at 2.3 million tons, the technical potential (using thermochemical biomass conversion technology) is 0.3 million tons. The second source of biological resources is reeds, both banks of canals and reservoirs in the amount of 10 to 12 million tons per year (Outlook, 2014).

Logging resources, however, are insignificant, since only a small part of Uzbekistan (3.2% of the total land area) is covered with forests: the largest area is occupied by saxaul, juniper. All forests of the country belong to the I classification group, economic logging and some types of non-economic logging are not allowed in them.

Preliminary studies have shown that the most common direct use of biomass in Uzbekistan is the processing of biomass and organic agricultural waste for the production of biogas. Since fertilizer can also be obtained in the process of biogas production, obtaining both high-quality organic fertilizer and an autonomous energy source simultaneously compensates for greenhouse gas emissions and environmental damage that come from organic waste collection systems, thereby creating an environmentally closed energy system. Thus, the economic effect of using bio-fertilizers is very similar to the effect of using biogas, which makes bio-fertilizers the second most important product of biogas technologies

It should be noted that further research should be carried out in the Karakalpak Autonomous Republic to search for promising biological resources. The Aral Sea is located on the territory of the Karakalpak Autonomous Republic, which is a very specific, extremely complex from a hydrological point of view and insufficiently studied natural object (Aral, 2011). An example is the use of algae as a raw material for biofuels of the third generation. This type of resource is suitable because of the high ability of algae to produce large amounts of lipids suitable for the production of biodiesel. In addition, this fast-growing biomass can be used directly for the production of a wide range of biofuels. All this indicates that research is being conducted to determine the potential of bioresources at the regional and local levels.

Conclusions

The study concluded that for the successful development of bioenergy, it is necessary to apply an algorithmic approach that determines the sequence of selection and improvement of the use of bio-energy resources in the national energy conservation system.

The use of an algorithmic approach makes it possible to create an information base for making sound management and technical decisions in the field of bioenergy development, to make a reasonable choice of priority bioresources at the regional and local levels; provides complexity in considering the needs for bioresources and the possibilities of meeting them.

The resource potential of biomass in Uzbekistan has huge opportunities.

To accelerate the country's transition to bioenergy resources, it is proposed to develop a number of draft laws that reflect the issues of creating:

- material and technical basis for the cultivation, collection and processing and use of bioenergy resources;
- regulatory requirements for the quality of biological resources.

An important issue is the development of national and regional programs aimed at the development of bioenergy; incentive systems for the development of bioenergy.

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