UDC 621.867

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IN-DEPTH EXAMINATION OF RECENT PROGRESS IN UTILIZING RENEWABLE ENERGY SOURCES

Abstract. *This study focuses on a thorough review and analysis of advanced renewable energy technologies. It considers a wide range of innovative solutions aimed at ensuring sustainable and efficient energy production from environmentally friendly sources. Among the researched technologies are solar panels, wind turbines, hydropower plants and biofuel systems, where their advantages, limitations and potential for future development are analyzed.*

In addition, it is examined important aspects related to the efficiency, cost-effectiveness and environmental impact of these technologies. It is highlighted issues of sustainable development and the role of renewable energy in reducing greenhouse gas emissions and ensuring energy security.

Keywords: *renewable energy sources, technological solutions, solar energy, wind power, hydropower, biofuels, sustainable growth, environmental aspects, energy security.*

Introduction. In the light of the growth of world demand for energy and increasing awareness of environmental problems associated with the consumption of traditional energy sources, there is a need to search for alternative, environmentally friendly energy sources. One of the powerful areas that are becoming increasingly important is the use of renewable energy sources (RES), such as the sun, wind, water and organic materials.

The research will consider a wide range of innovative solutions in the field of RES, including the development of solar panels, wind turbines, hydropower and biofuels. Attention will be paid to the efficiency, environmental friendliness and economic feasibility of using these technologies. [1-5].

Analysis of recent research and publications. In foreign and domestic literature, there are works devoted to various aspects of the state and development of renewable energy sources. The main emphasis in these works is on: technological innovations, efficiency and economy, reducing the negative impact on the environment and increasing the level of environmental awareness, research and development of the latest strategies, and proposals for development trends and forecasts, etc. [6-8].

The purpose and tasks of the research. The research aims to analyze and summarize the latest technological solutions in renewable energy, assessing their potential, benefits, and limitations. Tasks included reviewing scientific literature, categorizing renewable energy sources, examining their conversion technologies, analyzing advancements in solar, wind, hydro, and biofuels, comparing their effectiveness and cost to traditional sources, evaluating environmental impact and greenhouse gas reduction, and forecasting future development and implementation of renewable energy technologies.

Material and research results. In the light of the growth of world demand for energy and increasing awareness of environmental problems associated with the consumption of traditional energy sources, there is a need to search for alternative, environmentally friendly

energy sources. One of the powerful areas that are becoming increasingly important is the use of renewable energy sources (RES), such as the sun, wind, water and organic materials.

Modern technologies related to the use of RES are actively developing and becoming an object of great interest for scientific research and development of innovations. They not only open up new opportunities for obtaining energy, but also contribute to reducing dependence on traditional energy sources, which have their limitations and negative impact on the environment [9-10].

The analysis and review of the latest technologies in the field of RES is important for the further development of the energy industry and ensuring the sustainable development of society. The policy of decarbonization of the economy consists in increasing energy efficiency and the development of renewable energy sources. In order to implement the policy, it is necessary to determine the main factors of forming the energy efficiency of the production of electric energy of the enterprises included in the industrial parks.

Effective use of renewable energy sources (RES) in the energy balance system of Ukraine significantly depends on the use of renewable energy conversion technologies. The high cost of these technologies, and thus the energy obtained, is due to the low density of energy flows, their variability in time and the need for significant costs for equipment for energy collection, storage and conversion. Therefore, the use of advanced energy conversion technologies can significantly reduce the cost of energy obtained from RES and contribute to their introduction into the energy system of the region [5].

Based on the analysis of various sources of information, the most promising technologies for the transformation of the main types of renewable energy, such as solar, wind, biomass, tidal and wave, have been determined, which are presented in the table below [6-10].

Table 1 – Research of the latest prospective technologies of renewable energy conversion

Type of renewable energy source	**Disadvantages of the RES type and its conversion technology**	**Promising technologies of energy conversion**
Solar energy	- instability (impermanence) and unpredictability of the main source of energy, which depends on weather and climatic conditions - the need to use energy storage or additional sources - high costs for photovoltaic systems (PHS) due to the need for storage devices and reverse AC converters - low efficiency - the limited energy capacity of FES leads to the need for large areas for their installation.	• advanced inorganic thin film photovoltaic modules (PEM) • - Spherical FEMs based on copper-indium selenide (CIS) and thin-film polycrystalline silicon FEMs; • organic FEMs (including dye-sensitized FEMs based on organic polymers); • thermo-photoelectric (TPV) cells with a narrow gap band (lowgap-band).
Wind energy	Irregularity of wind conditions as a source of energy, loss of landscape aesthetics, difficulties in connecting to	• increase in generating potential (increase in the size of turbines, height of turbine towers, use of offshore winds and winds at high altitudes);

Type of renewable energy source	Disadvantages of the RES type and its conversion technology	Promising technologies of energy conversion
	existing networks (due to the remoteness of the most favorable places), and the cost of installing wind turbines.	• improving materials (reducing the dependence of tower structures on steel elements, reducing the weight of propellers (use of carbon fibers and high-intensity carbon plastic)); • improvement of the drive system (reducer, generator, electronics) (development of superconductor technology for lighter and more efficient generators; use of permanent electromagnets in generators); • use of new types of wind turbines: flying and vertical axis turbines; • generation in low-speed winds
Bioenergy	The need for land and water resources for cultivation (competing with food production); negative emissions, such as NO_x, soot, ash, CO, CO_2, during combustion; the seasonal nature of the growth of some crops; difficulties with scaling generating powers.	• co-combustion of biomass mixtures with traditional types of fuel; • use of new types of fuel from biomass, including various household and industrial wastes; • conversion of existing generating capacities on hydrocarbon fuel to the use of biomass; • increasing the heat output of biomass pellets due to drying; integrated biomass gasification with fuel cells.
Tidal and wave energy	- large capital costs for construction; - binding to the geographical position of the coastline and distance from existing electrical networks; - negative impact on the	• use of bridges as tidal power stations; • oscillating underwater wing (uses fins (wings) that are set in motion by the current instead of rotating elements);

Type of renewable energy source	Disadvantages of the RES type and its conversion technology	Promising technologies of energy conversion
	environment; - dependence on natural conditions; - high costs and complexity of maintenance; rapid wear and tear of generating equipment due to water exposure.	• systems using a venturi tube; • magnetohydrodynamic (MHD) systems (use a cryogenically cooled superconducting electromagnetic coil placed on the seabed where tidal waves pass); • use of wave attenuators - wave energy converters in the form of snake-like devices, half submerged in water; wave generators based on the reverse pendulum principle, generators with a liquid/gaseous working medium.
Geothermal energy	- Large capital costs and high energy intensity are explained by the need to manufacture expensive pumping wells and significant energy costs for pumping water.	• the use of the technology of geothermal circulation systems (GCS) makes it possible to intensify the extraction process, increase the level of extraction of thermal resources from the subsurface, and solve the problem of environmentally safe spent coolants.

As a result of the analysis, it was established that the main research in the field of RES development is aimed at reducing the costs of the production of converters by increasing their efficiency, saving materials, increasing energy intensity and using organic materials instead of scarce raw materials.

Conclusions. The study highlights the considerable potential for enhancing solar energy, as modern technologies offer greater utilization of this eco-friendly power source. It also stresses the importance of deeper exploration into wind energy due to its proven efficiency in generating electricity. Additionally, it underscores the promising contributions of hydropower and biofuels as supplementary renewable energy sources, emphasizing their significance for sustainable energy development.

In summary, the research indicates a bright outlook for renewable energy sources, including solar, wind, hydropower, and biofuels, in fostering sustainable energy development.

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UDC 621.867

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ПОГЛИБЛЕНИЙ АНАЛІЗ ОСТАННІХ ДОСЯГНЕНЬ У СФЕРІ ВИКОРИСТАННІ ВІДНОВЛЮВАЛЬНИХ ДЖЕРЕЛ ЕНЕРГІЇ

Анотація. *Дане дослідження зосереджується на ретельному огляді та аналізі передових технологій на основі відновлювальних джерел енергії. Розглядається широкий спектр інноваційних рішень, спрямованих на забезпечення сталого та ефективного виробництва енергії з екологічно чистих джерел. Серед досліджуваних технологій – сонячні батареї, вітрові турбіни, гідроенергетичні установки та біопаливні системи, де проаналізовано їх переваги, обмеження та потенціал для майбутнього розвитку.*

Крім того, розглядаються важливі аспекти, пов'язані з ефективністю, економічністю та впливом на довкілля цих технологій. Висвітлено питання сталого розвитку та роль відновлювальної енергетики у зменшенні викидів парникових газів та забезпеченні енергетичної безпеки.

Ключові слова: *відновлювальні джерела енергії, технологічні рішення, сонячна енергія, вітроенергетика, гідроенергетика, біопаливо, стале зростання, екологічні аспекти, енергетична безпека.*

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