УДК 330(045
DOI 10.47049/2226-1893-2024-2-225-233

GREEN ENERGY: A MODERN VIEW IN CONDITIONS OF ENVIRONMENTAL SAFETY

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Abstract. *Expansion of the use of renewable energy sources (RES) became possible due to technical progress in this area, which allowed, first of all, to significantly reduce the cost of electricity production by wind and solar power plants of various types. Since 2000, wind power has developed with an average annual growth rate of more than 21%. In the early years of wind power deployment, Europe was the key region for global wind turbine installations. In 2010, the region accounted for 47 % of global onshore wind turbine deployments. After 2010, other regions, especially China, have seen rapid wind energy development. By 2018, China had overtaken Europe to become the largest onshore wind energy market with nearly one-third of the world's installed capacity. Some experts estimate that onshore wind power installations will need to have an average annual growth rate of more than 7 % over the next three decades. Offshore wind energy technologies allow countries to exploit generally higher and sometimes more stable wind resources, by implementing gigawatt projects near densely populated coastal areas common in many parts of the world. This makes wind power an important addition to the portfolio of low-carbon technologies available to the energy sector in many countries.* ***Green energy****, in terms of environmental impact, leads to a more environmentally friendly process.*

Energy obtained from naturally occurring sources such as wind, sun and water, i.e. renewable energy is better for the environment because energy production does not produce greenhouse gases – gases that enter the atmosphere, trap heat and cause global warming.

The main goal of our work is to analyze the experience of large-scale development of renewable energy sources in a number of countries, its impact, including negative ones, on traditional generation and the electricity market, with the development of relevant specific recommendations for overcoming specific challenges and ensuring environmental safety in each country

***Keywords**: green energy, solar installations, wind turbines, traditional energy resources, renewable energy sources, maritime fleet.*

УДК 330(045
DOI 10.47049/2226-1893-2024-2-225-233

ЗЕЛЕНА ЕНЕРГЕТИКА: СУЧАСНИЙ ПОГЛЯД В УМОВАХ ЕКОЛОГІЧНОЇ БЕЗПЕКИ

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***Анотація.** Розширення використання відновлюваних джерел (ВДЕ) енергії стало можливим завдяки технічному прогресу в цій галузі, що дозволило, перш за все, значно знизити собівартість виробництва електроенергії вітровими та сонячними електростанціями різних типів. З 2000 року вітроенергетика розвивалася із середньорічним темпом зростання більш ніж на 21 %. У перші роки розгортання вітроенергетики Європа була ключовим регіоном глобального введення вітроустановок. У 2010 році на регіон припадало 47 % світових введень наземних вітроустановок.*

Після 2010 року швидкий розвиток вітроенергетики спостерігається в інших регіонах, особливо у Китаї. До 2018 року Китай випередив Європу і став найбільшим наземним вітроенергетичним ринком із майже однією третиною встановленої потужності у світі. За оцінкою деяких експертів, протягом наступних трьох десятиліть наземні вітроенергетичні установки повинні мати середньорічний показник зростання понад 7 %. Технології морської вітроенерге-тики дозволяють країнам експлуатувати загалом вищі, інколи ж і більш стабільні вітрові ресурси, реалізуючи гігаватні проєкти поблизу густонаселених прибереж-них районів, поширених у багатьох частинах світу. Це робить вітроенергетику важливим доповненням до портфелю низьковуглецевих технологій, доступних для енергетичного сектору багатьох країн.

Зелена енергетика, з точки зору впливу на навколишнє середовище, призводить до більш екологічно чистого процесу. Енергія, отримана з природних джерел, таких як вітер, сонце і вода, тобто відновлювана енергія, є кращою для навколишнього середовища, оскільки при її виробництві не утворюються парникові гази – гази, які потрапляють в атмосферу, затримують тепло і спричиняють глобальне потепління. Основною метою роботи є аналіз досвіду масштабного розвитку відновлюваних джерел енергії в ряді країн, його впливу, в тому числі негативного, на традиційну генерацію та ринок електроенергії, з розробкою відповідних конкретних рекомендацій щодо подолання специфічних викликів і бар'єрів та забезпечення екологічної безпеки в кожній країні.

Ключові слова: *зелена енергетика, сонячні установки, вітрові турбіни, традиційні енергоресурси, відновлювані джерела енергії, морський флот.*

Introduction. Climate changes are becoming an increasingly important issue as the effects of violent forest fires and coastal flooding are being observed.There is not much time left to combat global warming before its effects become irreversible. Some experts believe that renewable energy is the way of the future. However, it is clear that as the world population grows and traditional fuel sources such as coal, oil and natural gas may become limited or insufficient, serious research into alternative energy sources is needed.One of the challenges that many countries currently face in their pursuit of large-scale renewable energy is the lack of skilled technical personnel to manufacture, install, operate, and maintain renewable energy technologies.At the same time, it is known about a very small number of initiatives for the development of training programs for the training of mechanics or technicians in the field of technologies for the use of renewable energy sources for work in workshops in the processing industries, as well as for work on the installation, operation and maintenance of devices and systemsrenewable energy sources

Formulation of the problem. As you know, today climate change is becoming an increasingly urgent problem, for example, there are serious consequences of severe forest fires, coastal floods, there is evidence of global warming, etc. Some experts believe that due to the growth of the global population and the limitation of traditional fuel sources such as coal, oil and gas, serious research into alternative energy sources is necessary.

It is clear that the issue of the use of renewable energy sources insea transport is also a very relevant problem of our time [1P. 768-794; 2; 3; 5-8; 14; 15]. In research the authors used methods of comparison and synthesis of information, theoretical analysis and expert assessments.

Main material discussion. The author's research is based on the analysis of the thematic literature and monitoring of Internet *resource* materials using statistical and graphic data, comparison of the experience of different countries in the development of alternative energy sources**.** Currently, about 90 % of the world's goods are transported by sea, and although ocean freight transportation can be made more environmentally friendly, cargo ships are still powered by fossil fuels. Emissions from burning cheap fossil fuels in maritime transportation account for about 2 % of the world's total CO_2 emissions.Modern ship power plants, operating on various types of fuel, do not always meet the requirements of environmental standards. The United Nations Environment Program (UNEP) is the main body of the United Nations for environmental protection and one of the largest environmental organizations in the world.Renewable energy is energy obtained from natural sources such as wind, sun, and water, which is much better for the environment because no greenhouse gases are released during energy production. Greenhouse gases are gases that enter the atmosphere, trap heat, and cause global warming. Green energy leads to a more ecological ratio of environmental components. Renewable energy sources – wind, hydroelectric, biomass, solar and geothermal – account for only 11 % of total consumption, according to statistics. It is necessary to take advantage of the many opportunities in the renewable energy segment to make the supply chain more diversified. It is crucial, experts emphasize, to start making more investments in clean energy today in order to be prepared for the future locally and globally. As the results of our monitoring of statistical data from Internet resources have shown, lithium-ion batteries are the future. The world's military fleet (submarines, bathyscaphes and other marine vehicles) will increasingly use batteries based on rare-earth metals to reduce mass and dimensional characteristics and increase operating time. This is all related to the development of robotics and underwater vehicles. Thus, the technology of creating high-capacity lithium-ion batteries is the basic technology necessary for the creation of promising marine vehicles. However, it is necessary to note the problems: the issue of utilization of lithium-ion batteries in the fleet has not been finally solved yet, which requires large capital investments for the system development and its implementation. When using lithium-ion batteries on marine vessels, additional financial expenditures will be required to create new chemical compounds based on lithium and other elements, which can be used in energy accumulators, etc., as well as to create new chemical compounds that can be used in energy accumulators [4; 9-10; 12; 13; 16].

Let us emphasize that today the energy problem is one of the most urgent for all mankind. Traditional sources such as oil, gas and other fossils are gradually becoming more expensive and of course cause enormous damage to the environment. That is why solar panels, wind and hydropower plants, as well as bioreactors are becoming so popular today.

All of them refer to alternative or green energy sources, which will be discussed below.Since 2018, more than half of the increase in global generating capacity has come from renewable energy facilities – as of 2022, their share in global power generation capacity growth has reached more than 65 %. This means that for every additional megawatt of fossil fuel-fired generating capacity, RES power responded with two.

By creating market and regulatory conditions, all countries can attract investment and accelerate innovation through smart grids, efficient, reliable and sustainable technologies. However, they need to prepare tomitigate potential challenges when trying to integrate renewable energy. The future of energy looks different under different development scenarios. Fossil fuel industries will suffer the most, but at the same time they are essential for economic prosperity in transition.

Wind energy is a type of renewable energy that has reached maturity in recent times, as rapid technology improvements, supply chain efficiencies, and material and technical interactions in closely related markets have driven rapid cost reductions and the beginning of significant adoption in new markets.Renewable energy development has accelerated since 2012, reaching record levels and outpacing annual additions of conventional capacity in many regions. Among all renewable energy technologies, wind power after hydropower has dominated the renewable energy industry for many decades. Solar PV remains the second largest installed capacity renewable energy sector after wind power. By 2023, solar PV systems again dominated total renewable energy capacity and were twice as large as wind and larger than all fossil fuels and nuclear combined. The current, traditional economic model is sometimes referred to as the «*brown economy*». The main advantage of this model is its focus on economic efficiency and economic growth. The main disadvantage is that it pays little attention to and does not take into account the high negative impact that the production of goods has on the environment. It turns out that the «brown» economy is quite (albeit conditionally) capable of providing humanity with everything it needs. But then how will future generations meet their needs?

The alternative to the «*brown*» economy is the «*green*» economy. UNEP defines this economic model as follows: «*A green economy is an economy that provides long-term improvements in human well-being and reduces inequality, while allowing future generations to avoid significant environmental risks and impoverishment*». A green economy involves green energy. Through green energy, countries can significantly reduce or eliminate carbon emissions. The world needs to move towards green energy and carbon neutrality to preserve our planet, but it is also important not to go to extremes. You cannot make clean energy a reality without sufficient, reliable and viable baseload generating capacity. Suffice it to remember that it took oil almost a century to overtake coal in the energy mix. There is a perception that there are «bad» non-renewable and «good» renewable energy sources, but this division is reckless. Full decarbonization will take decades, and fossil fuels will be part of the energy system for a long time to come. And they have a chance to go from being a problem to being part of the solution through innovation. On this point, we can agree with experts who believe the world is capable of achieving zero emissions, but the effort to accomplish this task is «*perhaps the greatest challenge humanity has ever faced*».

The RE 100 group, which unites companies that advocate for meeting their energy needs entirely from renewable energy sources, includes such well-known global brands as IKEA, Facebook, General Motors, Google, Goldman Sachs, H&M, HP, HSBC, Microsoft, Sony, Unilever, Vestas, Walmart and others. In total, the group currently includes 229 companies.

Let us briefly consider and emphasize the role of Hydrogen energy.Hydrogen can be used in the «large» electric power industry, while it CAN replace natural gas and petroleum products, in transport (substitution of petroleum products); in the buildings sector (for heating and power supply, including autonomous, with the replacement of natural gas or petroleum products); in industry – as a raw material and substitute for traditional hydrocarbons.

Research results and discussion. According to leading experts, Asia will remain the leading region for solar PV installations by 2030, with 65 % of the total installed capacity. Significant development will be seen in China, where, according to forecasts, by 2030, 65 % of the total installed capacity will be installed. Projected to reach about 1,412 GW of installed capacity by 2030. North America will have the second largest installed solar PV capacity, reaching 437 GW by 2030, with more than 90 % of these installations in the United States. Europe will represent the third largest region with 291 GW of installed solar PV capacity by 2030. A similar picture is expected on the 2050 horizon, with Asia continuing to dominate with nearlyhalf of the total cumulative installed global capacity.Taking into account the existing trends in the development of «green» energy in the world, it will be possible to expect the formation of a new structure in the energy sector, according to experts, in the near future [20; 21]. In the American forecast «U.S Energy Information Administration» the share of renewable energy sources ranges from 5 % to 6,4 % in 2040. Hydrogen is also relatively convenient for long-term storage and transportation over any distance, including using existing natural gas infrastructure – and this opens up new opportunities for a fairly large number of regions of the world rich in renewable energy, but remote from the centers of energy consumptionaccumulators[17-19; 22]. For example, the Japanese program «Strategic Roadmap for Hydrogen and Fuel Cells» was launched back in 2014, The goal of the program is to build a «hydrogen society». The roadmap has specific key points. Thus, the target for the volume of hydrogen use in Japan was from the current 200 tons per year to 10 million tons in 2050 (an increase of 50 thousand times!). Japan's leadership is recognized internationally.

However, it must be emphasized that there are negative consequences of green energy.Renewable energy production often destroys habitats and harms wildlife. Even if there are rules against it, these areas can still cause harm to animals. Solar panels, for example, take up a lot of space and drive animals out of their habitat. A huge number of wind turbines will be dismantled in Europe in the near future. First generation wind turbines are becoming obsolete and need to be replaced with more modern and efficient ones.

This process, called capacity renewal, has begun at varying rates.For example, just three 50-meter blades of a low-power (by today's standards) wind turbine contain about 20 tons of fiber-reinforced polymers (FRP). How can such a quantity of polymer materials be reused or recycled effectively? They cannot be burned or taken to a landfill like regular garbage. And if we don't come up with a somewhat acceptable method of recycling, then by 2050, 40 million tons of composites will be awaiting disposal.

This data is provided by the Re-Wind research project, which is actively engaged in finding solutions to recycling problems. Analysis of prospects for the development of hydrogen energy in Ukraine shows thatfrom the point of view of scientific and technical achievements in this field, there is sufficient improvement. At all levels of industry structuresthe research community has the opportunity to help Ukraine implement hydrogen potential and achieve tangible results for the economy and the environment both by 2030 and beyond.By combining scientific and industrial directions, supported financially, it is possible to reach the world level of practical application of hydrogen technologies in our country.

Conclusions. The energy sector is undergoing transition and significant structural changes to ensure universal access to affordable, reliable, sustainable and modern energy for all.The energy sector is in transition and undergoing significant structural changes to ensure universal access to affordable, reliable, sustainable and modern energy for all. The key is to transform energy systems by integrating diverse conventional and renewable energy sources across a wide range of capacities. The ongoing technological changes are accompanied by the creation of an institutional framework that defines the regulatory, technological and economic rules for the reliable and efficient development and operation of energy systems in the new environment....Despite the above, the discussion on alternative energy sources, practical research and technological developments is still of great interest worldwide, so research in this direction needs to continue.

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Стаття надійшла до редакції 25.04.2024

Посилання на статтю:: Кошарська Л.В., Бредньова В.П., Нікіфоров Ю.О. Зелена енергетика: сучасний погляд в умовах екологічної безпеки // *Вісник Одеського національного морського університету:* Зб. наук. праць, 2024. № 2 (73). С. 225-233. DOI 10.47049/2226-1893-2024-2-225-233.

Article received 25.04.2024

Reference a journal artic: Kosharska L., Brednyova V., Nikiforov Yu. Green energy: a modern view in conditions of environmental safety // *Herald of the Odesa national maritime university:* Coll. scient. works, 2024. № 2 (73). P. 225-233. DOI 10.47049/2226-1893-2024-2-225-233.