UDC 330(045)
DOI 10.47049/2226-1893-2023-1-178-189

GREEN ENERGY: CURRENT STATE AND PROSPECTS

L. Kosharska
Candidate of Engineering Sciences
Professor of department of «Technical Service and Repair of Ships»
ORCID 0000-0001-5575-3745
kosharska@gmail.com

Odessa National Maritime University, Odesssa, Ukraine

V. Brednyova
Candidate of Engineering Sciences
Professor of department of «Descriptive Geometry and Engineer Graphics»
ORCID 0000-0002-3005-2384
vera2008@ukr.net

Odessa State Academy of Civil Engineering and Architecture, Ukraine, Odessa

V. Shahov
Senior Lecturer
of department of «Technical Service and Repair of Ships»

Odessa National Maritime University, Odesssa, Ukraine

Abstract. *The article is devoted to the study of the current state of green energy, characteristics of its various types and prospects for development. Green energy is a part of the energy production system that uses renewable energy sources. The most common types of green energy are photovoltaic conversion of solar energy and the use of wind energy. Less well known are technologies for using marine tidal energy and wave energy from the sea surf. There are such exotic green energy projects as reverse osmosis, one-way diffusion − using the interaction of fresh and salt water to generate electricity by raising wind turbines into the upper stratosphere in the form of airships (such projects are currently being developed in Alaska). It is obvious that renewable energy sources do not pollute the environment, help reduce greenhouse gas emissions and mitigate the effects of climate change. They are virtually inexhaustible, while fossil fuels will eventually run out. Today, the reality of green energy is as follows.*

Globally, about 1 % of electricity is generated by solar installations and just over 2 % by wind turbines. If we consider not only electricity, but all the energy produced, the share of green energy, despite its rapid development over the past decade, is now about 5 %. Globally, the growth of installed solar and wind power capacity is doubling every four years.

The main purpose of the article is to conduct a critical comparative analysis of published data on energy consumption in Europe and the world, based on the need to significantly reduce the gap in energy consumption per capita in developed countries.

A review of the effectiveness of the use of various energy sources in machine building, shipbuilding and ship repair in the world as a whole was also carried out in the direction of developing practical recommendations for creating an effective process of performing logistical tasks in transport using alternative energy sources.

It is known that traditional sources such as oil, gas and other minerals are gradually becoming more expensive. That is why solar panels, wind farms, and hydroelectric power plants are becoming so popular today as new sources of alternative or green energy. Let us emphasize the role of hydrogen energy. Hydrogen can be used in the large power industry, while it can replace natural gas and oil products, in transport; in the sector of buildings (for heat and power supply, including autonomous, with the replacement of natural gas or oil products); in industry − as a raw material and a substitute for traditional hydrocarbons.

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

УДК 330(045)
DOI 10.47049/2226-1893-2023-1-178-189

ЗЕЛЕНА ЕНЕРГЕТИКА: СТАН ТА ПЕРСПЕКТИВИ

Л.В. Кошарська
к.т.н., доцент кафедри «Технічне обслуговування і ремонт суден»
kosharska@gmail.com

Одеський національний морський університет, Україна, Одеса

В.П. Бредньова
к.т.н., професор кафедри «Нарисна геометрія та інженерна графіка»
vera2008@ukr.net

Одеська державна академія будівництва та архітектури, Україна, Одеса

В.І. Шахов
старший викладач кафедри «Технічне обслуговування і ремонт суден»

Одеський національний морський університет, Україна, Одеса

Анотація. *Стаття присвячена дослідженню сучасного стану зеленої енергетики, характеристиці різних її видів та перспективам розвитку. Зелена енергетика − це частина системи виробництва енергії, яка використовує відновлювані джерела енергії. Найпоширенішими видами «зеленої» енергетики є фотоелектричне перетворення сонячної енергії та використання енергії вітру. Менш відомі технології використання морської енергії припливів і хвильової енергії морського прибою. Існують такі екзотичні проекти зеленої енергетики, як зворотний осмос, одностороння дифузія − використання взаємодії прісної та солоної води для отримання електроенергії, піднімаючи вітряки у верхні шари стратосфери у вигляді дирижаблів (зараз такі проекти розробляються на Алясці). Очевидно, що відновлювані джерела енергії не забруднюють навколишнє середовище, сприяють зменшенню викидів парникових газів в атмосферу та зменшують наслідки зміни клімату. Вони практично невичерпні, тоді як викопні види палива рано чи пізно закінчаться. Наразі реальність зеленої енергетики виглядає наступним чином. У всьому світі близько 1 % електроенергії виробляється сонячними установками і трохи більше 2 % − вітрогенераторами. Якщо ж розглядати не лише електроенергію, а всю вироблену енергію, то частка зеленої енергетики, при всьому її бурхливому розвитку за останнє десятиліття, зараз становить близько 5 %. У світі зростання встановлених потужностей сонячної та вітрової енергетики подвоюється кожні чотири роки.*

Основна мета статті − провести критичний порівняльний аналіз опублікованих даних щодо енергоспоживання в Європі та світі, виходячи з необхідності суттєвого скорочення розриву в енергоспоживанні на душу населення розвинених країн.

Також був зроблений огляд ефективності використання різноманітних джерел енергії у машинобудуванні, суднобудуванні та судноремонті в цілому в світі у напрямку розробки практичних рекомендацій для створення ефективного процесу виконування логістичних задач на транспорті з використанням альтернативних джерел енергії .

Відомо, що традиційні джерела, такі як нафта, газ та інші корисні копалини, поступово дорожчають. Саме тому сонячні панелі, вітрові електростанції, гідроелектростанції стають сьогодні такими популярними як нові джерела альтернативної або зеленої енергії. Підкреслимо роль водневої енергетики. Водень може використовуватися у великій енергетиці, при цьому він може замінити природний газ і нафтопродукти, на транспорті; у секторі будівель (для тепло-і електропостачання, в тому числі автономного, із заміщенням природного газу або нафтопродуктів); у промисловості − як сировина і замінник традиційних вуглеводнів.

Ключові слова*: зелена енергетика, сонячні установки, вітрогенератори, традиційні енергоресурси, відновлювальні джерела енергії.*

Introduction. The «green transformation» became a buzz word in the energy sector and has been gaining enormous momentum and gathering support worldwide. Green energy is defined as produced in a process using alternative sources, inexhaustible or renewable, as compared to fossil fuels. Furthermore, green energy solutions produce significantly less greenhouse gases and other harmful substances whereas requiring much lower service costs after commissioning. The effectiveness of green energy is largely determined by geographical location allowing easier implementation of solar farms in regions with intense solar radiation.

But despite its growing popularity due to clean and inexhaustible sources, the green energy has been a subject to debates raising important economical and safety concerns and demanding further refinement of definitions. It is important to note that renewable and inexhaustible energy sources are not the same. Despite its seeming perpetuity on Earth, at least in the next several billion years, the energy of the sun is restricted by limited supply of the rare earth metals used for solar panels manufacturing. In addition, the problem of atmospheric pollution from the use of renewable energy sources (RES) is often omitted or shifted to the background in popular environmental publications. And from this point of view, not all of RES fully respect the principles of green energy. Such traditional renewable organic materials as wood, peat, etc. are not environmentally friendly when used as energy sources or in other words are not green due to production of carbon dioxide. Another good example of green energy technologies that releases carbon back into the atmosphere is processing of organic waste. Implementation of wind and solar solutions is impossible without significant subsidies at the expense of traditional energy, making transition to these types of energy in market economy hard to achieve. To disadvantages of much debated nuclear energy sources, belong high capital cost compared to other sources, long approval and commissions time due to technical difficulties and safety issues, creation of radioactive wastes, used reactor fuel, and large scale catastrophic impact in case of accident or leakage. Despite the fact that many countries followed Italy in abandoning nuclear energy and shutting down the power plants, more than thirty countries worldwide are still operating nuclear power plants. Belgium, Germany, Spain, Switzerland, Taiwan implement a long-term policy of abandoning nuclear energy, etc.

Formulation of the problem. Technically, climate change could be regarded as the result of an increase in concentration of greenhouse gases or an increase in emissions into the atmosphere. The task of reducing this concentration should include development of natural carbon depositing ecosystems to compensate for the negative consequences of anthropogenic emissions from the burning of fossil fuels. The purpose of this study is to analyze the global energy crisis and energy redistribution during the fourth industrial revolution, to identify the priority directions for the development of alternative green energy and renewable energy sources. The authors used the following research methods: the method of theoretical analysis, the method of comparison and generalization of information.

Main material discussion. It is generally acknowledged that production of efficient energy is one of the main factors of economic growth, labor productivity as well as individual quality of life. The energy consumers vary from private households to large industrial parks. As a result of population growth and industrial development, energy consumption in the world has increased more than fourteen times over the past hundred years [1; 2; 10-16; 4; 6; 5-14 etc.]. According to some demographic forecasts, the population of the Earth will reach 9 billion people by the middle of the 21st century. In this connection, it is only natural to expect an increase in energy consumption. The coronavirus pandemic intensified awareness about the need to replace fossil fuels with renewables as soon as possible, and the drop in demand for oil and gas clearly showed that the era»of hydrocarbons might be coming to its end. In its forecast, the French oil company «Total» stipulates that the oil consumption will begin to fall already at the end of the current decade [3; 5; 7-14; 10; 14 etc.]. However, it is still not clear how exactly humanity will deal with the transition to renewable source in the near future. Many green energy technologies are at the prototyping stages, and efficient and inexpensive energy storage devices are still in development. Research in this field is ongoing, but a working solution still remains to be found.

One of the notable phenomena of recent years has been the energy transformation, that combines technologies for increasing of energy efficiency and technologies for the use of energy produced by renewable energy sources which allows for simultaneous development in several directions [7; 11; 16 etc.]. The use of alternative energy accelerates the modernization of the economy, increases the level of economic security of national economies, which fundamentally changes the quality of economic growth. Development of alternative energy sources is a powerful driver for innovation and the basis for the formation of a low carbon green economy of the future, characterized by high-tech solutions, energy security and reduced impact on the environment. Alternative energy sources also reduce dependence of the national economies on fossil fuels.

Oil and gas sources will gradually disappear replaced by the RES. To the most explored sources of renewable energy belong solar, wind, water, including sewage, tides, natural water bodies waves, geothermal sources, land, air, water, biological mass, biological gas. The amount of energy obtainable from the above sources could easily cover all the current energy needs of the mankind. A number of researchers believe that rendering green energy cheaper than traditional energy is unrealistic in the next 15 years. One of the reasons is a high cost related to the localization of generating facilities, requiring creation of supporting industrial base driving the investments up. Another problem with implementing a green energy is related to potential significant losses to the providers of conventional utility services. In this connection, it is crucial to harmonize ecological and economic aspects of the green energy, as well as choose an optimal energy supply model.

Traditional energy sources keep playing a dominant role in the world energy balance as well as in individual countries. Fossil fuels have the advantage of the established transportation routes as well as offer significant benefits. However, as available resources begin to run out, the cost of their production increases. On the other

hand, the cost of alternative energy sources is falling due to large-scale investments in innovative technologies. According to the calculations of the US Energy Information Administration (EIA), in 2020, 40 % of energy in the country was obtained from non-fossil fuel sources. In Europe, the production of solar electricity in 2020 increased by 60% compared to 2019 [9; 13 etc.]. As a result of the wind farms use, the UK already has a 67-day coal-free period and plans to phase out fossil fuels by 2025, as well as ban the production of new petrol and diesel cars by 2030.

Economic benefits from implementing alternative energy sources include creation of new jobs, stabilizing energy cost by reducing dependance on currency fluctuations and supply chain disruptions through increasing localization, however due to the limited-service life of the equipment new challenges arise, mainly related to high cost of recycling as well as ecological impact at the expense of the future generations. On the other hand, to the main disadvantages of fossil fuels belong constantly depleting deposits, releasing of greenhouse gas emissions including carbon monoxide, soil and water pollution, oil spills, etc. The following trends have emerged as possible solutions: gradual transition to a post-industrial society based on the development and widespread of information technologies, improving standards of education and culture.

Below is the list of the most common and rapidly developing types of green energy.

- Hydropower is the most common type of a green energy, with approximately 54% of all generating capacity in the world and China as a world's leader of hydroelectric power production. The main source is the potential of a water flow. The development and construction of hydroelectric power plants is also at the top of the list not only in terms of the scale of the projects and investment cost but also in terms of shortest pay off time and lower than in solar and wind cost of generated energy. One of the main disadvantages of hydroelectric power stations is necessity to flood quite large areas of land. Tidal and wave stations produce energy using periodically changing levels of the seas and oceans.

- Wind energy ranks second in terms of production scale. Technological advances and the use of new composite materials have contributed to increasing the service life and reducing the cost of wind turbines. Onshore wind stations are not only the most economical option of the energy production in Great Britain but also cover about 10 % of all energy needs of the country, providing electricity to about 4.5 million households. One of the advantages of the wind energy is that it can be effectively used in sparsely populated areas by installing windmills parks. It is important to note that windmills require practically no ordinary fuel for their operations. It is estimated that one 1 MW generator saves about 92,000 barrels of oil or about 29,000 tons of hard coal over 20 years of operation [12 etc.].

- Solar energy is the fastest-growing type of green energy and the third largest in the world in terms of RES-based production in 2021. The solar energy is at its peak of efficiency in the equatorial countries. The largest solar power plant is located in the United Arab Emirates and produces enough electricity to reduce the carbon footprint equivalent to eliminating 200,000 cars. But the use of solar and wind energy sources is not without disadvantages. First of all, it is highly dependent on weather fluctuations. Although using satellites to forecast solar exposure could minimize this problem.

Secondly, unlike fossil fuel electricity generation, solar and wind energy flows are not constant. This means that photovoltaic (PV) and wind turbines cannot produce electricity on demand.

- Bioenergy is the fourth largest type of green energy. The production of electricity and heat is based on the innovative use of traditional biomass sources, such as agricultural by-products and household waste. In this case, energy, both electrical and thermal, is produced from organic fuel. The most affordable, although relatively ineffective biofuels of the first generation include products obtained as a result of waste processing. Biofuels of the second generation include products obtained by pyrolysis, i.e., rapid conversion of mass into liquid. The latter is much easier to transport and transform into fuel for cars or power plants. The raw materials here could be algae, corn, sugar cane, rapeseed etc. The disadvantage of bioenergy is the willingness of farms to grow fuel crops incited by increasing demand. China, Great Britain, and India are leaders in bioenergy production. Brazil, Germany, the USA, and Sweden are also actively developing these technologies.

- Geothermal energy is a rapidly developing type of renewable energy source. A geothermal plant produces electrical energy from the thermal energy of underground sources (for example, geysers). The main advantage of geothermal energy is its inexhaustibility and independence from environmental conditions, weather, and year season. To disadvantages of geothermal energy, belong high mineralization of thermal waters by toxic compounds and metals, which prevents discharging into natural reservoirs. The largest producer of geothermal electricity in the world is Iceland. Prominent positions in this area are occupied by Indonesia, Italy, Mexico, the Philippines, and the USA.

- Hydrogen energy. Hydrogen is one of the most abundant elements on the surface of the earth. The process of hydrogen combustion produces large amounts of heat and water. The global structure of hydrogen-based production is used in several industries. Coal processing accounts for 18 % of global hydrogen-based production, and 4.3% is provided by green hydrogen obtained from renewable water energy sources. However, 78 % of global hydrogen is still produced by processing of natural gas and oil. Green hydrogen is costly and energy-consuming, putting a colossal strain on the resources of the entire economy. An alternative to green hydrogen is the so-called blue hydrogen, which is obtained from natural gas. Carbon dioxide released during its processing is not released into the atmosphere but is captured for further use instead. «Gray» hydrogen production technologies benefit from the record low cost about $1.85. per kg [8; 15 etc.], but cause emissions of greenhouse gases into the atmosphere.

In our study, we emphasize the impact that several consecutive systemic worldwide crises have on the economy in general and the energy sector in particular. Modern energy sector is at a crossroads, urgently requiring serious qualitative shifts in approach to existing problems. The importance to study and understand these problems and their role in the global economy have been repeatedly discussed at various conferences, summits, and forums.

The transition to a fully sustainable global energy landscape could take more than 30 years. As new innovative RES solutions continue to appear on the market, the

technologies for their use will become more and more accessible in various spheres of society, ranging from consumer marketing to infrastructure. Some researchers believe that by 2030 it is possible to achieve at least 80 % of the world's energy production utilizing RES. The most promising types being photovoltaic solar panels and onshore wind power plants, as well as hydroelectric power units in China.

The main trends in the development of ecologically clean energy are summarized as follows:

1. Acceleration of developments in the field of green hydrogen. Transition to this type of fuel will allow to ensure the most ecologically clean chain of energy production, with two major drawbacks related to hydrogen production and storage technologies being still in development stage, and enormous consumption of a clean fresh water. Despite gradually improving competitiveness of ecologically pure hydrogen, its cost of production is still high. Australia, Chile, the European Union, Germany, Japan, Saudi Arabia, and the United States have committed to significant investments in ecologically pure hydrogen production. The growing interest in green hydrogen as opposed to traditional energy raises the question of the feasibility of further utilization of existing extensive gas infrastructure. Some market players consider installing hydrogen and ammonia production alongside wind farms.

2. Improvement of bioenergy technologies, using organic waste from landfills and reservoirs and waste from agricultural production, as energy source. Thermochemical or biochemical reactions of biomass processing, allow to obtain heat and biofuel (ethanol, biogas, biodiesel, etc.).

3. Increasing interest in geothermal energy, as one of the most reliable and efficient sources of energy. At a depth below the level of soil freezing (approximately 3 meters below the surface of the earth), the temperature remains constant throughout the year and is approximately equal to the average annual temperature of the outside air. This can be used as an energy source to generate electricity or heat, heating or cooling a building.

4. Companies that choose to transition to sustainable energy and commit to a more sustainable future are more likely to win the trust of consumers. Corporate giants that strive for success are developing and implementing business plans in the field of sustainable development. Google, for example, it their pledged to become «carbon-free» by 2030 has presented a detailed implementation roadmap.

CEE countries differ in their specialization in the structure of electricity generated from RES. Latvia, Slovenia, Slovakia, Romania and Bulgaria, the share of hydropower is 56 %-87 %. Wind energy dominates in Lithuania and Poland (64 % and 63 %, respectively). Hungary and the Czech Republic register a fairly high proportion of solar generation (59 % and 48 %, respectively). Romania (11,2 thousand MW), Poland and Bulgaria (approximately 4,5 thousand MW) are characterized by the highest potential for the development of green energy. The current circumstances force European countries to restore and expand coal based power generation despite heavily polluting emissions, which slows down the EU's transition to green energy.

Despite the fact that new large deposits of natural gas were discovered in the Eastern Mediterranean, those remain unexploited as European leaders are giving in to the

pressure of environmental activists. After the Fukushima NPP accident, followed by a wave of nuclear power plants closures across Europe, the share of this reliable and stable source of arguably clean energy in the EU energy balance has sharply decreased. The energy crisis of 2021 racked havoc in economies across the world and reiterated significance of the energy stability in all spheres of public life including economy, national security, environmental protection, and health care. The growth of national economies depends significantly on the dynamics of energy prices and their availability or shortage. Stable energy prices and supplies play a key role in global economic competitiveness, whereas volatility of the main energy sources creates challenges in energy storage and accumulation. In this respect wind and solar with the market share of more than 20 % in the total electricity generation in the EU, need more investments and development to offer more flexible energy supply solutions.

Current extensive international debates over the role of the existing liberal economic system, highlight depletion of resources, as well as intellectual and civilizational crisis, rapid deterioration of environment, distraction of biodiversity among other cataclysms that the humanity currently faces. The analysis of all these processes and phenomena allows us to conclude that the needed transformation in global energy supply heavily depends on the efficiency the energy transition towards clean energy sources to support sustainable development and prevent further climate degradation. This transformation includes increase in use of solar technologies, large-scale use of wind energy and the improvements in the field of energy storage together with parallel development of electric vehicles and the improvements in energy efficiency. In the next 30 years, the emphasis will be on energy accumulation, utilization and storage technologies, hydrogen energy technologies, the introduction of digital and intelligent systems in the electric power industry, carbon capture, etc.

Another problem is the possible shortage of various metals and materials necessary for the development of renewable energy. According to a World Bank report, demand for materials such as copper, lithium, cobalt and graphite, will increase by 500% by 2050 with copper market already showing signs of significant shortages.

Energy transition is aimed at solving the climate problem by abandoning coal, oil, natural gas and expanding the use of green energy sources. Analysis of forecasts supporting energy transition shows that the most important condition for achieving these goals is the preservation of energy inequality between the developed and the developing world. Thus, in their study «Energy Transition Outlook 2020», DNV GL predicts that in 2050 shower energy consumption in North America will be three times higher than in Latin America, in Europe − more than twice higher than in India, Pakistan and Bangladesh; in Australia, the Republic of Korea and Japan almost twice as high as in the countries of Southeast Asia. North American countries will be consuming more than 6 times more energy than African countries to the south of Sahara. The countries of Central and Eastern Europe (CEE), due to their substantial socio-economic differentiation, show significant differences in the scale and structure of energy supply. The development of green energy sector in the region is actively supported by state programs. The aim of this article was not to describe and consider all existing aspects and problems of the energy transition but to focus on the question if energy transition can be achieved at all and to

which extent. To answer this question, several factors should be considered. One of the most crucial factors is the current level of the world population and its forecasted growth in the next 30 years. The United Nations Department of Economic and Social Affairs made the most reasonable predictive assessments of this issue. By the middle of 2030, the total population is forecast to reach 8,548 million people, and in 2050 − more than 9,123 million people, with 1,315 million living in developed economies, and the rest in developing economies.

The prerequisites for the energy transition were formed by the Paris Agreement signed in 2015 and known as the Paris Climate Agreement. It is an agreement between the leaders of more than 180 countries to reduce carbon emissions to net zero and limit the rise in global temperatures.

Research results and discussion. In addition to complexities of design, manufacturing and operation of specialized equipment required for implementation of RES, additional problems arise, related to the disposal of equipment at the end of its life cycle. The 20-year service life of photovoltaic cells means that the disposal of solar panels installed since 2010 will begin in 2030. At the same time, according to the experts, letting current technological limitations dictate conditions of energy sources development will lead in the long term to social and economic upheavals. This is a challenge for the policy transition to RES adopted by the CEE countries. Another problem that forces countries and governments to show restraint in implementing RES is related to the protection of the interests and saving jobs at power engineering enterprises manufacturing equipment for traditional thermal power plants. There are currently wide debates dedicated to the future of thermonuclear energy. Despite significantly higher efficiency of nuclear power plants compared to conventional energy sources, numerous challenges arise from the differences in nuclear power generation strategies of different countries.

Conclusions. The transition to innovative, and sustainable energy means a transition to a fundamentally different energy system in order to address a number of various challenges and factors. The timing of the energy transition will have to be realistically assessed. Despite the significant progress in the field of new technologies and increasing energy efficiency, the full realization of the energy transition by 2050 is highly unlikely. The majority of the world's population is from the developing countries that undergo dynamic economic growth and major social changes that go hand in hand with increasing energy consumption. Achieving a large-scale goal of energy transition while stabilizing global greenhouse gas emissions, meeting future energy demand, and expanding access to reliable, clean electricity will require large additional investments in global energy industry. Significant socio-economic transformations of the entire society need to be introduced in parallel, since achieving necessary transition within the energy sector alone seems unrealistic.

The transition to green energy is being actively lobbied by the European Union and the United States. At the same time, 85 % of the world's energy balance and 75 % in EU countries are still accounted for by hydrocarbons. And for one billion people on earth, firewood remains the main source of heat and fuel for cooking. The current trend is still dominated by electricity produced from fossil fuels preventing the «green energy wave»

from completely replacing oil and gas producers with solar farm and windmills as a reliable base of a large-scale energy transformation in the coming years.

In conclusion, we note that as new capacities of renewable energy sources appear, an increasingly acute will become. storage requirement Without storage, when too much electricity enters the grid on sunny, windy or low-demand days, supply exceeds demand and negative pricing occurs. Forecasts show that the demand for energy storage, with the exception of pumped storage capacity will grow globally to almost 500 GWh in 2025. Lithiumion batteries will make up the majority of the market and are likely to become more economical as production volumes increase, as large quantities developed and distributed for use in many industries.

Despite the foregoing, the discussion of issues related to alternative energy sources, research and development, is still of great interest around the world. Therefore, research in this direction needs to be continued.

REFERENCES

1. *Bobylev S.N., Zakharov V.M. «Green» economy and modernisation. Ecological and economic foundations of sustainable development. 2012. № 60. P.4-83 (in Russian).*
2. *Degtyarev K.S., Zalikhanov A.M., Solovyov A.A., Solovyov D.A. On the question of the economics of renewable energy sources. Energy: economics, technology, ecology. 2016. № 10. P.10-20 (in Russian).*
3. *Kosharska L.V., Brednyova V.P., Nikiforov Yu.O. Development of green energy at the present stage as a policy of global energy // Вісник Одеського національного морського університету: Зб. наук. праць, 2022. № 1(67). С. 168-188.*
4. *Koval V., Kaminskyi O., Brednyova V., Kosharska L. Digital Ecosystem Model of Labour Resources Management in Economic Militarism Revista Gestion De Las Personas Y Technologia. 2022, November, 14(45). PP.123-143.*
5. *Kosharska L., Brednyova V., Nikiforov Yu. Research of the Regularities of «Green» Energy and the World Trends of its Development. Scientific Journal Transport Development. Odesa National Maritime University. 2022. is.4(45). P.7-14.*
6. *Mastepanov A.M. Energy transition: what to prepare for the global oil and gas. Problems of Economics and Management of the Oil and Gas Complex. 2019. № 10(178). P.5-14 (in Russian).*
7. *Safiullina A. Green energy may soon become cheaper than traditional energy // Vedomosti. 2020 (in Russian).*
8. *Solovieva O. Green hydrogen threatens Russian oil and gas // Nezavisimaya Gazeta. 2021 (in Russian).*

9. *A review of large-scale wind integration studies / Dowds J., Hines P., William R., Buchanan T., Kirby E., Apt J., Jaramillo P. // Renewable and Sustainable Energy Reviews. 2015. № 49. P. 768-794.*
10. *Eckhous B., Mathis W., Mutaugh D. Ten renewable energy trends to watch in 2021 // World Oil. 2021.*
11. *Fuks R. Green revolution. Economic growth without prejudice for ecology. (in German). 2016. P.221.*
12. *Huber M., Dimkova D., Yamasher T. Integration of wind and solar power in Europe: Assessment of flexibility requirements // Energy. 2014. Vol. 69. P. 236-246.*
13. *Pakulska T. Green energy in Central and Eastern European (CEE) countries: new challenges on the path to sustainable development // Energies. 2021. № 14(4).*
14. *Renewable energy statistics 2020 / International Renewable Energy Agency. 2020. P.391.*
15. *Why we need green hydrogen // Columbia Climate School. 2021.*
16. *Future of Energy. Global Issue. Co-curated with: Massachusetts Institute of Technology. 2020.*

Стаття надійшла до редакції 10.02.2023

Посилання на статтю: Кошарська Л.В., Бредньова В.П., Шахов В.І. Зелена енергетика: стан та перспективи // Вісник Одеського національного морського університету: Зб. наук. праць, 2023. № 1 (68). С 178-189. DOI 10.47049/ 2226-1893-2023-1-178-189.

Article received 10.02.2023

Reference a JournalArtic: Kosharska L., Brednyova V., Shahov V. Green energy: current state and prospects // Herald of the Odessa national maritime university. Coll. scient. works, 2023. № 1 (68). 178-189. DOI 10.47049/ 2226-1893-2023-1-178-189.