

L.Svystun
PhD in Economics, Associate Professor National University
“Yuri Kondratyuk Poltava Polytechnic”
svmila308@gmail.com

I.Samoilyk
Doctor of Economics, Professor, Poltava State Agrarian University
iuliia.samoilyk@gmail.com

M.Svystun
PhD student, Poltava State Agrarian University
niksv@gmail.com

PROSPECTS OF HYDROGEN ENERGY IN THE PROCESSES OF THE DE-OCCUPIED UKRAINIAN TERRITORIES RECONSTRUCTION

Abstract

It has been analyzed the state and prospects of the alternative energy development in Ukraine, in particular, in the post-war reconstruction context in the de-occupied territories. The world experience of using state support for the renewable energy development has been considered, obstacles to the use of renewable energy sources in Ukraine have been determined, and the direction of hydrogen energy investment in the context of the national economy development after the war has been determined.

Keywords: *national economy, energy security, alternative energy, hydrogen energy, de-occupied territories.*

The war in Ukraine is a catastrophe for humanity of the 21st century, it is accompanied by significant casualties among the population, the buildings, structures, and infrastructure facilities destruction. The hostilities, which began on February 24, 2022, dealt a powerful blow to the economy of Ukraine and huge damage to the infrastructure, leading to significant economic losses. According to the assessment of the Ministry of Economy of Ukraine, the total losses of our country due to the war, including both direct and indirect, range from 564 billion dollars USA to 600 billion dollars USA. In Ukraine, at least 411 educational institutions, 36 health care institutions, 1,600 residential buildings, 7 thermal and hydroelectric plants. Currently, it is extremely difficult to count the destroyed houses in the countryside. Ukraine’s economy loses 50-60 % of its “unproduced” gross domestic product. Revenues to the state budget decreased by 70 % from customs authorities and by 30 % from tax authorities [1].

This war went far beyond the territorial boundaries of Ukraine, the economy destruction caused crisis phenomena in many countries of the world, the imbalance of food chains became a real threat of famine. So the world’s leading countries support Ukraine on the way to the liberation of its entire territory. However, it will not be possible to remove the damage caused to the territories where hostilities were conducted and the occupied territories at the same time. The processes of restoration and reconstruction of the de-occupied territories will be long and large-scale and will require significant amounts of resources, both financial, human, and energy [2].

Consequently, the reconstruction of the national Ukrainian economy will require active development of the energy industry and the involvement of foreign companies for the restoration of social and economic infrastructure [3].

Ukraine’s problem is the centralization and integration into a single energy system of large-scale generation facilities, namely: nuclear power plants, thermal power plants, hydroelectric power plants, etc. The deployment of russia’s military aggression against Ukraine, constant missile attacks on energy

infrastructure facilities cause significant problems for the operation of the energy supply system of civilian facilities and the livelihood of the population, because all systems are related to energy supply. The enemy purposefully damages energy objects. For example, as of February 10, 2023, almost two dozen power units of thermal power plants remain damaged due to constant Russian attacks. Ukraine temporarily lost 44 % of nuclear generation, 75% of TPP capacity, and 33% of blocked CHP plants after the temporary occupation of Ukrainian energy facilities part. As for the energy infrastructure in the territories of hostilities, it is almost completely destroyed and needs to be restored on an already modern innovative basis. The solution may be the development of alternative energy and energy generation in liberated territories from the occupiers.

Under the conditions of Ukraine's energy dependence on energy supplies and the constant increase in energy prices, the issue of changing the energy strategy through the formation of an effective energy saving program and the development of alternative energy in Ukraine should be classified as strategically important, which requires an urgent solution. The energy strategy of Ukraine until 2030 determines that the development of alternative energy sources should be considered as an important factor in increasing the level of energy security, in particular, taking into account Ukraine's European integration intentions.

The need to ensure the country's energy security, the irreversible depletion of the world's hydrocarbon reserves, the rising price of energy carriers, the problems of environmental pollution force most developed countries to form their energy strategies aimed at the development of alternative energy. According to the International Energy Agency, by 2030, the share of electricity generated using alternative sources will double from the current figure of about 16 % of total production. The energy strategies of most developed countries, in particular, in the USA, Germany, Spain, Sweden, Denmark, and Japan, in the long term indicate an increase in the share of renewable energy sources in the total energy balance to 20-50 % [4].

China and the USA invest in the development of alternative energy 42 % of the total volume of such investments in the world. Investment in solar energy occupies a leading position and prevails in the USA, Germany, Japan, and Italy. One of the world leaders in the use of alternative energy is Germany, in which 7 % of the total amount of energy consumed has been produced using renewable energy sources. One of the reasons for this is the purposeful policy of the state on the development of alternative energy. In Sweden, the geothermal system as a means of heating residential premises is an integral part of newly built houses, so, at the current stage, more than 300,000 geothermal systems are in operation. In Finland, 12,000 houses are equipped with geothermal systems. Significant amounts of investment in the development of alternative energy from 2012 to the beginning of the full-scale invasion of Russia have been also observed in Ukraine.

According to experts of the Institute of Renewable Energy of the National Academy of Sciences of Ukraine, the total annual technically achievable energy potential of renewable energy sources of Ukraine in terms of conventional fuel is about 98 million tons. p., which is more than 50 % of total energy consumption in Ukraine at the moment and 30 % of energy consumption in 2030 [5]. Today, the share of energy obtained from alternative sources is about 3 %. According to the Ukrainian energy strategy, the share of alternative energy in the country's total energy balance was planned to reach 20 % by 2030 [6]. The main and most effective areas of renewable energy in Ukraine are wind energy, solar energy, bioenergy, hydropower, and geothermal energy. The indicated indicators testify to the significant potential for the development of alternative energy in Ukraine.

However, little attention is paid to this direction of alternative energy as a generation technology through the use of solar energy, and accumulation and storage in a gaseous state (hydrogen).

Similar installations are already used in Australia and some European countries. They are located in the private sector and provide an opportunity to meet the energy needs of the household, and to direct the surplus to the sale or refueling of cars with hydrogen engines. Such cars began to be produced by Renault, Hyundai, Toyota, etc. Some municipalities in Australia have launched urban transport with

hydrogen engines manufactured by Hyundai. The installation includes a solar panel, an electrolyzer, a compressor and hydrogen storage tanks. Energy production occurs during daylight hours thanks to the operation of solar panels and is processed into hydrogen, accumulating in special containers. At night, the process is reversed: the house and residents use energy resources for heating and lighting, and the operation of appliances.

Some companies offer technology for the production of hydrogen with a capacity of 10 m³/h to 1000 m³/h, which is also suitable for the private sector. Alkaline electrolysis technology is used for hydrogen production. It is the most widely used and proven technology available today, it is safe and reliable. Pre-purified water is fed into a tank with alkali, which after preparation enters the electrolyzer. In the electrolyzer, water is split into hydrogen and oxygen with the help of electricity. Hydrogen gas is released on the cathode side and exits through the perforation of the separation plate from the cathode side in the direction of the hydrogen collector channels. And then it moves from the central part of the block. A reaction takes place at the cathode. At the same time, gaseous oxygen is released on the anode side, which moves from the central plates of the electrolyte cans. The hydrogen and oxygen gases then enter the hydrogen separator and oxygen separator, respectively, where the alkali is separated from the gases and returned to the electrolyser by an alkali pump. After that, hydrogen gas enters the adsorption unit under conditions of temperature change for further purification, while oxygen is released as a by-product. The electrolyzer uses a two-way injection technology using a special material to prevent leaks during operation. Thanks to this, a long service life, high system efficiency and limited maintenance costs are ensured. A special activation process takes place at the cathode of the electrolyzer, which ensures high efficiency of water electrolysis with relatively low energy consumption. This technology will make it possible to create a wide network of hydrogen filling stations [7].

Currently, a large part of the Ukrainian people lives in private houses in rural areas (more than 40 %). The same situation was observed in the currently occupied territories. Also, almost the entire population that became forced migrants lost their jobs and incomes. And thus, the installation of generation systems in private households in the de-occupied territories will make it possible to:

- to provide the basic needs of the population in terms of heating, lighting, cooking, etc.
- provide such households with a stable income thanks to the possibility of selling hydrogen for the needs of other individuals and municipalities, refueling vehicles. This is an important aspect, because in the absence of jobs, people cannot count on endless social payments from the state and international organizations.
- to strengthen the autonomy of communities and Ukraine's energy independence, to implement the fourth energy transition.
- to develop modern environmental technologies in energy and transport.
- to strengthen the health of Ukrainians, as it has been proven that a significant spread of respiratory and viral diseases occurs, including and due to significant air pollution and hydrocarbon emissions in the energy sector.

The main restraining factors for the alternative energy development in Ukraine, in addition to the state of war, are limited financial resources, in particular due to the high price of extracted energy, which is caused by expensive high-tech equipment and a sufficiently long payback period. Most European countries are successfully developing the field of alternative energy due to strong support from the state and attracting investment resources. After all, alternative energy is a high-tech industry, so the question of financing scientific and technical support for the development of new technologies for obtaining energy from renewable sources is acute. The strategic direction is the technical and economic evaluation of the use of high-tech equipment in Ukrainian natural conditions, the determination of prospects and the necessary financial resources for the modernization of this equipment in accordance with the existing technical and achievable energy potential.

Diversification into small-scale generation is also a way to minimize the effect of the oligarchy on the state's economy, since most energy systems are owned by large corporations. Therefore, the development of hydrogen energy in the de-occupied territories will allow modern ecological technologies expansion in energy and transport, and also, strengthen the health of Ukrainians, and provide the sustainable development of the state in the future.

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L.Svistun

i.ü.f.d., dosent, "Yuri Kondratyuk adına Poltava Politexnikası" Milli Universiteti

I.Samoylik

i.e.d., professor, "Yuri Kondratyuk adına Poltava Politexnikası" Milli Universiteti

M.Sviştun

doktorant, "Yuri Kondratyuk adına Poltava Politexnikası" Milli Universiteti

İşğal edilmiş Ukrayna ərazilərinin yenidən qurulması prosesində hidrogen enerjisi perspektivləri

Xülasə

Məqalədə Ukraynada alternativ enerjinin inkişafının vəziyyəti və perspektivləri, xüsusən də işğaldan azad edilmiş ərazilərin müharibədən sonrakı bərpa kontekstində təhlil edilir. Bərpa olunan enerjinin inkişafına dövlət dəstəyindən istifadənin dünya təcrübəsi öyrənilmiş, Ukraynada bərpa olunan enerji mənbələrindən istifadəyə maneələr müəyyən edilmiş, müharibədən sonra milli iqtisadiyyatın inkişafı kontekstində hidrogen enerjisi sərmayəsinin istiqaməti müəyyən edilmişdir. müəyyən edilmişdir.

***Açar sözlər:** milli iqtisadiyyat, enerji təhlükəsizliyi, alternativ enerji, hidrogen enerjisi, işğaldan azad edilmiş ərazilər.*