ЕКОНОМІЧНІ НАУКИ

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RENEWABLE ENERGY IN THE CONTEXT OF ECONOMIC AND NATIONAL SECURITY THREATS UNDER RUSSIAN AGGRESSION

Abstract

Renewable energy is a priority in making the "green" transition from climate-damaging fossil fuels to "clean" renewable energy sources, as well as ensuring sustainable access to energy worldwide.

The article is aimed at analyzing the impact of the Russian-Ukrainian war on the development of renewable energy sources in Ukraine and its economic return.

The authors suggest several effective low-cost steps to minimize the impact of the current Ukrainian situation on the economy and the formation of the energy independence of Ukraine, as well as the further development of the industry focused on quitting Russian gas.

Key words: *renewable energy sources, solar energy, solar power plants, economic impact, Russian aggression.*

Introduction

Energy is the basis for the development of modern civilization. It is difficult to overestimate how much better life becomes in a society with the developed energy sector. Freeing a person from hard physical labor, the energy sector of the economy contributes to the increase of the greatest value for humanity – the increase of individual freedom.

The modern progress of the world economy is inextricably linked to the growth of energy production rates. This is due to many factors:

– a general increase in world production;
– development of transport and telecommunications;
– development of remote mineral deposits;
– waste disposal;
– the growth of energy consumption in everyday life (heating, lighting, powering household appliances, etc.);
– technical rearmament of armies, etc.

The energy industry currently faces many problems, and the most acute one is the problem of its sources. Today, 6 billion people on Earth consume more than 12 billion kilowatts of energy per year, that is, an average of 2 kilowatts per person.

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This energy comes from:
– coal – 26%;
– black oil – 42%;
– gas – 20%;
– hydropower – 4%;
– nuclear – 5%;
– other sources – 3%.

In other words, about 90% of our energy comes from organic fuels – oil, coal, and gas. These sources of energy are also called non-renewable because the speed of their accumulation in the bowels of the Earth is much lower than the speed of their consumption (approximately 106 times).

However, traditional energy, based on extractive technologies, has reached the level which caused dependence and almost colonial status of states that are engaged in the extraction and sale of raw materials. Today, democratic civilized states choose such a development path for their economy which relies on the production of renewable energy, that is, energy based on the use of renewable sources and resources. Thus, the use of wind, solar, biofuel, and small hydropower plants are gradually replacing old power plants using coal, oil, gas, and enriched uranium in these countries. And this is the only way to deal with perhaps the most key problem of the present – the deterioration of ecology, climate change, and all the ensuing harmful consequences for people and the planet.

The world community has repeatedly raised the issue of regulating the ecological situation and curbing the global climate change processes looming over us. Being aware of the problem's severity and effects it can trigger, countries at the international level are trying to make every effort to solve it for the sake of preserving normal human life, as well as any life or existence on earth.

An extremely important event last year was the climate summit in Paris within the framework of which 192 countries adopted a new global climate agreement, which replaced the Kyoto Protocol and aimed to restrain global warming processes. Participating countries agreed to prevent the average temperature from rising by more than 2 degrees.

The Paris climate summit was preceded by a September meeting of representatives of UN member states, which resulted in a project called "Transforming our world: Agenda for sustainable development until 2030". It defines 17 global goals of sustainable development, the achievement of which will make it possible to solve the most pressing problems faced by humanity at least partially. These include the eradication of poverty, hunger, improved health, quality education, gender equality, clean water and sanitation, renewable energy, decent work, economic growth, innovation, and infrastructure, reducing inequality, sustainable development of cities and communities, responsible consumption, climate control, life underwater and on land, peace, and justice, and partnership for purpose.

The primary task is the development of renewable energy, as it is a prerequisite for solving all other tasks.

Alternative energy sources are non-fossil energy sources that constantly exist or periodically appear in the surrounding natural environment, such as solar, wind, geothermal, aerothermal, hydrothermal, wave and tidal energy, hydropower, biomass energy, gas from organic waste, sewage gas – treatment plants, biogas.

Humanity needs more and more energy, which will be difficult or even impossible to obtain from non-renewable sources shortly. Indeed, according to various estimates, the explored organic fuel will be enough for 30–50 years. If we take into account the so-called geological reserves, which will be explored in time, and their exploitation is not delayed, then, organic fuel may be enough for another 100–150 years given the ever-increasing level of energy consumption. Moreover, only coal can keep its place in the energy balance for a long time. However, its use is accompanied by a high level of pollution of the Earth's atmosphere. Nuclear energy, which today has significantly more raw materials than organic fuel, has developed dynamically in the world during the last 20–30 years. But today, according to many experts, it can no longer be considered a promising type of energy due to the high risk of radioactive contamination of the environment, which was manifested in a series of man-made accidents and disasters, especially during the infamous Chornobyl disaster.

Therefore, the world is paying more and more attention to the use of so-called renewable energy sources – the Earth's heat, wind energy, tides, biogas, solar radiation, etc. In fact, all these sources of energy are completely determined by the direct action of the Sun.

Literature review

Some studies have attempted to link renewable energy consumption and economic growth. However, most of the studies concern EU countries and other factors. For example, Tutak and Brodnyi (2022) analyzed the impact of renewable energy sources on the economy, the environment, and traditional energy sources. In addition (Smolović et al., 2020), using pooled mean group (PMG) estimation in a dynamic panel (ARDL model) established the relationship between renewable energy consumption and economic growth in original and new EU member states. In addition, a panel vector autoregression (PVAR) model (Koengkan, Fuinhas, and Marques 2019) examined the relationship between financial openness, renewable and non-renewable energy consumption, CO2 emissions, and economic growth in 12 Latin American countries. A review of hybrid renewable energy systems (HRES) in developing countries was conducted by Zebra et al. (2021). However, there is a lack of domestic research analyzing the current state of the industry given the impact of the Russian invasion and destruction of solar energy companies. This issue needs to be studied thoroughly, and some problem solutions must be suggested.

Purpose. The paper aims to analyze the impact of the Russian-Ukrainian war on the renewable energy sources development in Ukraine and its economic output.

Methodology. A mixed approach was used to conduct a comprehensive study and obtain objective results. Systemic, synergistic, cultural, and axiological approaches to the comparative analysis of the economic phenomena are used. The application of the principles of dialectics, objectivity, and continuity made it possible to identify the characteristic features of the introduction of renewable energy in Ukraine, investigate this process in chronological order, and analyze the impact of Russian aggression on its current state.

Results. In 2019, Ukraine entered the TOP-10 countries in the world in terms of the pace of development of green energy, and in 2020 – in the TOP-5 European countries in terms of the pace of development of solar energy.

According to the State Energy Efficiency Agency, in 2021, almost 15.000 Ukrainian families installed solar panels. This is twice as much as in 2020. In total, by the end of 2021, there are about 45.000 households in Ukraine which use solar panels and save on electricity bills. The total capacity of such SPPs exceeded 1.2 GW.

At the beginning of 2022, the total capacity of green energy facilities reached 9.656 MW.

However, the invasion of Russia not only stopped the development of the industry but also caused devastating losses. Enterprises were on the verge of bankruptcy.

Solar energy is safe for the environment. It can be produced while the sun shines. The use of solar radiation is appropriate for the production of thermal and electrical energy and is feasible throughout the territory of Ukraine.

The average annual amount of total energy of solar radiation, which enters the territory of Ukraine every year, is 1.070 kWh/m. sq. in the northern part of Ukraine up to 1.400 kWh/m. sq.

Photoelectric equipment can be operated quite efficiently throughout the year, but it is maximally efficient during 7 months of the year (from April to October).

The conversion of solar energy into electrical energy in Ukraine's conditions should be focused primarily on the use of photovoltaic devices. The availability of significant reserves of raw materials, industrial and scientific, and technical bases for the manufacture of photovoltaic devices can ensure not only the full needs of domestic consumers but also the export of more than two-thirds of the manufactured products.

Taking into account the experience of implementing solar power plants (hereinafter referred to as SPP) in European countries with a similar level of solar radiation, as well as taking into account the global trends of a constant decrease in the cost of construction of SPP due to the advancement of technologies, SPP electricity production can be significantly increased in Ukraine because of the improvement of technology and the commissioning of new capacities.

Operating costs for the hot water supply system based on SC are minimal as electrical energy is used only for the performance of the circulation pump. For example, the annual production of thermal energy by flat solar collectors is 8.7 MW·h (7,5 Gcal) for the needs of a public facility of 650 l/day of hot water. At the same time, about 180 kWh of electrical energy is consumed for the operation of the circulation pump.

Solar photovoltaic (PV) cells convert sunlight directly into electricity. Currently, crystalline silicon (c-Si) and so-called thin film technologies (FT) dominate the world market. PV systems based on high-purity crystalline silicon use elements which are assembled in modules and electrically connected. The system of thin-film PV technology consists of a thin layer of semiconductor material deposited on glass, polymer, or metal. The PV system based on crystalline silicon is the oldest and currently dominant PV technology, accounting for approximately 85–90% of the PV market.

Concentrated Solar Energy (CSE) plants use mirrors to concentrate solar radiation onto a receiver that collects and transfers the solar energy to a heat-conducting fluid, which can be used either for end-use or to generate electricity using conventional steam turbines. Large CSE enterprises can be equipped with heat storage systems to supply heat energy to consumers and generate electricity also at night or in case the day is cloudy.

There are four types of CSE plants, namely: parabolic reflector, Fresnel reflector, solar tower, and parabolic tray, which differ from each other in the design, configuration of mirrors and receivers, working fluid, for energy transfer, and the presence or absence of thermal storage. The first three types are used in most power plants with centralized electricity production. The system using a parabolic reflector is the most technologically advanced. Solar parabolic troughs are more suitable for the distribution production of electricity.

CSE – enterprises require the availability of direct solar radiation for their operation and hence are an attractive option for installing in the region of the Sun Belt between 40 degrees north and south of the equator.

The choice to install solar PV technologies is often based on a trade-off between initial costs, module efficiency, and electricity tariffs. In countries with good solar resources and high electricity tariffs, electricity produced by photovoltaic systems for the population has already been compared to retail electricity prices.

For low-power stations, the place for installation can be the roofs of buildings, provided that their carrying capacity is increased. Photocells are also widely used for autonomous lighting. The demand for them grows every year due to the development of technology and the decrease in equipment cost.

The experience of EU countries and North America shows that solar energy can be used on an industrial scale even at night. In Spain and the USA, some enterprises generate electricity from the heat accumulated during the day in the dark.

Stations working using solar energy (heliostats) are generally silent. A significant disadvantage is that such stations occupy large areas. Every 1 MW of SPP capacity requires at least 1.5 hectares of land to be set aside. The downside

is that the energy output is not constant. SPP today accounts for about 4% of the electricity generated from renewable energy sources in the world. The conversion of solar energy into electrical energy occurs mainly through the use of photovoltaic cells.

With the help of solar energy, it is possible to partially provide electricity to residents of the private sector (in parallel with the operation of the electrical network). For this reason, photovoltaic elements are used, which are located on the roof of the house.

In private houses, solar collectors (SC) can be used to generate heat in the hot water supply system. Solar collectors can heat water up to 70 °C. During the day, the SC transforms the Sun's energy into thermal energy, which heats the water stored in heat-insulated containers (accumulator tanks). Water is supplied from storage tanks to the hot water supply system. SCs are installed on the roof of the building, and the storage tank and auxiliary equipment are mounted in the technical room (State Agency for Energy Efficiency and Energy Supply of Ukraine, 2022).

About 60% of industrial solar power plants are concentrated in the southern and southeastern regions of Ukraine, where active hostilities are taking place.

According to the statements of company managers, solar generation will suffer the greatest losses from the Russian occupiers.

The reason for this is the large area of industrial solar generation facilities. Thus, following various estimates (specified due to the location of generation facilities in the zone of active hostilities), 30–40% of power plants in the regions affected by the Russian invasion lost 1 120–1 500 MW of installed capacity.

Industrial solar power plants, which are located in the Mykolayiv energy hub, were the most affected. Thus, the solar park of the Solar Generation company (22 MW) was attacked by artillery weapons, and a week later by a helicopter; there was a projectile on the territory that detonated after the repeated fire.

In addition, it is impossible to turn on the objects to the generation due to the destruction of 5.5 km of the 150 kV power line that supplies the city of Mykolaiv.

It is also known about the destruction of 100% of the generating capacity of solar power plants in the Kharkiv region.

In such conditions, the profitability of these objects is equal to zero, given that in most cases they are loaned or refinanced by Ukrainian banks and international financial institutions.

By the beginning of 2022, 1.2 GW of private household solar power plants have been put into operation in Ukraine.

Statistics on the location of private SPPs and their superimposition on the sites of shelling of populated areas in Ukraine show that under estimates, about 280 MW (24%) of the installed capacity was destroyed.

According to NEC "Ukrenergo", Kyiv, Chernihiv, Sumy regions, and the city of Mariupol, there is significant damage to high-voltage electrical substations and networks.

The average number of damages on high-voltage lines on a 100-km section reaches 50 cases. Works are underway to restore 11 high-voltage lines and 7 substations.

The worst situation is observed in the regional networks managed by Oblenergo in the areas of hostilities. Currently, up to 600 km of 110 and 150 kV networks, more than 1 000 km of 35 kV networks, and more than 20 substations with a voltage of 110 and 35 kV were damaged.

Electricity consumption decreased by 1/3, which is due to a large amount of damaged equipment, the shutdown of industrial enterprises, and internal and external migration of the population.

Along with the impact of changing weather conditions, the deficit of electrical energy in Ukraine turned into a surplus. Consequently, almost every day, dispatch commands are sent to green generation facilities to unload (actually disconnect) throughout the daylight hours. And the synchronization of national power grids with the energy system of the EU and Moldova ensures the stability of Ukrainian networks through the possible support of capacity provision and frequency support.

Currently, export-import flows take place only on one line, and this is not enough to save the Ukrainian green generation.

However, the quick joining of ENTSO-E (even in the status of an observer member) in the future will have a positive impact on the development of Ukrainian industrial power plants of green energy.

Due to regulatory documents adopted at the level of the industry Ministry, RES producers risk becoming bankrupt, and the entire industry may cease to exist.

Thus, on 03/04/2022, the Ministry of Energy of Ukraine issued order № 103 "Regarding settlements on the electricity market", by which the state enterprise "Guaranteed Buyer" is obliged to direct all funds received from the sale of electric energy from renewable energy sources to the repayment of debts to the State Enterprise "NAEK "Energoatom"".

According to order No. 103, the Ministry of Energy decided to direct all the funds received by HarPok from the sale of "green" energy (at market prices) to the needs of another type of generation.

On March 28, 2022, the Ministry of Energy published order № 140 "On settlements on the electricity market", according to which, based on the results of the sale of electricity for the first 10 days of the settlement month, the distribution of funds from the "GarPok" account must be carried out with the following restrictions:

– 15% of the weighted average "green" tariff for 2021 for SES;

– 16% of the weighted average "green" tariff for 2021 for wind turbines;
– 35% of the weighted average "green" tariff for 2021 for HPP;
– 40% of the weighted average "green" tariff for 2021 for biogas stations;
– 60% of the weighted average "green" tariff for 2021 for biomass stations.

All other funds received from the sale of "green" generation are distributed between NAEC Energoatom and NEC Ukrenergo.

Therefore, producers of green energy (in particular, solar and wind) now receive payment for the electricity released to the grid, which does not even cover the current costs of operating generation facilities, paying taxes, and mandatory payments.

Regarding the repayment of loan payments, if available, the received funds will, of course, not be enough to fulfill financial obligations.

Conclusion

The following low-cost steps are effective to minimize the impact of the described situation on the economy and the formation of energy independence of Ukraine, as well as the further development of the industry, aimed at quitting Russian gas:

1. To give destroyed and damaged green energy facilities access to the new Fund for the restoration of war-ravaged energy infrastructure in Ukraine, which was created by the European Energy Community.
2. Support (in the form of tax holidays, zero rent and land tax for 5 years, and preferential connection to networks) for the construction of new solar and wind power plants. New construction should be concentrated in regions which are affected due to a severe shortage of electricity.
3. Provision of preferential conditions for access of green energy companies to the electricity market "a day ahead" to reduce the burden on SE "Guaranteed Buyer" from payments under the green tariff.
4. Increasing the level of flexibility and decarbonization of Ukraine's energy system, primarily through the construction of new energy storage and maneuvering capacities, in particular, using biomethane.
5. Creation of special stimulating conditions for the production of renewable gases by green energy facilities (green hydrogen and synthetic renewable methane).

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ВІДНОВЛЮВАНА ЕНЕРГЕТИКА В КОНТЕКСТІ ЗАГРОЗ ЕКОНОМІЧНІЙ ТА НАЦІОНАЛЬНІЙ БЕЗПЕЦІ В УМОВАХ РОСІЙСЬКОЇ АГРЕСІЇ

Анотація

Відновлювана енергетика є пріоритетом у здійсненні «зеленого» переходу від шкідливого для клімату викопного палива до «чистих» відновлюваних джерел енергії, а також забезпечення сталого доступу до енергії в усьому світі.

Для мінімізації впливу нинішньої української ситуації на економіку та формування енергетичної незалежності України, а також подальшого розвитку галузі, спрямованої на відмову від російського газу, у статті запропоновано кілька ефективних маловитратних кроків.

Мета. *У статті здійснено аналіз впливу російсько-української війни на розвиток відновлюваних джерел енергії в Україні в контексті загроз економічній і національній безпеці.*

Методи. *Для проведення комплексного дослідження й отримання об'єктивних результатів застосовувався змішаний підхід: системний, синергетичний, культурологічний і аксіологічний методи щодо порівняльного аналізу економічних явищ.*

Результати. *Вторгнення Росії не тільки призупинило розвиток енергетичної галузі, а й завдало руйнівних втрат. Підприємства, зокрема ті, що займаються відновлювальною енергетикою, опинилися на межі банкрутства або просто були знищені. Так, сумарна потужність об'єктів зеленої енергетики на початок 2022 року досягла 9 656 МВт. Виробники зеленої енергії (зокрема, сонячної та вітрової) отримують плату за відпущену в мережу електроенергію, яка не покриває навіть поточних витрат на експлуатацію об'єктів генерації, сплату податків і обов'язкових платежів. Перетворення сонячної енергії на електричну в умовах України має бути орієнтоване насамперед на використання фотоелектричних пристроїв. Наявність значних запасів сировини, виробничої та науково-технічної бази для виготовлення фотоелектричних пристроїв дозволяє забезпечити не тільки повні потреби вітчизняних споживачів, а й експортувати понад дві третини продукції, що випускається. Нині експортно-імпортні потоки здійснюються лише по одній лінії, і цього не досить для збереження української зеленої генерації.*

Висновки. *Для мінімізації впливу описуваної ситуації на економіку та формування енергетичної незалежності України, а також розвитку галузі, спрямованого на відмову від російського газу, пропонуються такі маловитратні кроки:*

1. Надання зруйнованим і пошкодженим об'єктам зеленої енергетики доступу до нового Фонду відновлення зруйнованої війною енергетичної інфраструктури України, створеного Європейською енергетичною спільнотою.

2. Підтримка (у вигляді: податкових канікул, відсутності орендної плати та земельного податку протягом 5 років, пільгового підключення до мереж) будівництва нових сонячних і вітряних електростанцій. Нове будівництво має бути зосереджено в регіонах, де відчувається реальна нестача електроенергії.

3. Надання пільгових умов доступу компаній зеленої енергетики ринку електроенергії «на добу вперед», зниження навантаження на ДП «Гарантований покупець» від платежів за зеленим тарифом.

4. Підвищення рівня гнучкості та декарбонізації енергосистеми України, насамперед завдяки будівництво нових енергоакумулюючих і маневрених потужностей, зокрема, з використанням біометану.

5. Створення особливих умов стимулювання для відновлюваних газів об'єктами зеленої енергетики (зелений водень і синтетичний відновлюваний метан).

Ключові слова: *відновлювані джерела енергії, сонячна енергія, сонячні електростанції, економічний ефект, російська агресія.*

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