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**HYDROGEN ENERGY AS A KEY ELEMENT OF UKRAINE'S ENERGY-EFFICIENT ECONOMY**

*This article analyzes the role of hydrogen energy as a strategic component in shaping Ukraine's energy-efficient economy. It highlights that hydrogen energy is a crucial direction capable of ensuring the country's transition to an energy-efficient economy based on the rational use of natural resources. The article notes that the development of hydrogen energy contributes to diversifying Ukraine's energy balance and implementing innovative technologies in various sectors of the economy, particularly in industry, transport, and the energy sector. It is emphasized that Ukraine has significant potential for integrating hydrogen technologies due to its natural resources and geopolitical position. The production of "green" hydrogen can enhance the country's energy independence and promote its integration into the European energy market. According to estimates from the International Renewable Energy Agency, Ukraine has a high potential for renewable energy development, particularly in wind and solar power, exceeding 400 GW. However, to effectively utilize this potential, it is necessary to address the issue of instantaneous energy distribution and consumption, which can be achieved through "green" hydrogen technology. The article states that hydrogen energy plays a crucial role in achieving carbon neutrality goals under the "Net Zero 2050" initiative, while the European Union considers Ukraine a strategic partner in developing hydrogen energy, contributing to the implementation of pan-European climate goals. The article also examines the importance of developing a comprehensive strategy for the implementation of hydrogen technologies in Ukraine, including state initiatives, financial and economic incentives, the development of research infrastructure, and the integration of hydrogen technologies into key economic sectors. Notably, projects such as the "Odesa Hydrogen Valley" and "Zakarpattia Hydrogen Valley" contribute to developing hydrogen infrastructure and integrating Ukraine into the international energy network. The article emphasizes the need for active cooperation between government agencies, research institutions, and businesses for the successful implementation of the hydrogen strategy, which will help Ukraine become a significant player in the international hydrogen energy market.*

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**1. STATEMENT OF THE PROBLEM IN A GENERAL APPEARANCE AND ITS CONNECTION WITH IMPORTANT SCIENTIFIC OR PRACTICAL TASKS**

Hydrogen energy is one of the most promising areas in renewable energy development, capable of ensuring a transition to environmentally friendly and sustainable energy systems. Using hydrogen as an energy carrier opens up broad opportunities for reducing greenhouse gas emissions, decreasing dependence on fossil fuels, and ensuring energy security. Due to its unique physicochemical

properties, hydrogen has high potential for integration into the energy, transport, and industrial sectors. Innovative "green" hydrogen production technologies based on renewable energy sources are particularly significant in the global fight against climate change. Global trends show increasing attention to the development of hydrogen strategies and programs aimed at achieving ambitious environmental goals. In Ukraine, hydrogen energy has significant potential, considering its geographical location, natural resources, and opportunities for integration into European energy networks.

Therefore, the development of hydrogen energy can become a crucial factor in ensuring a sustainable future and enhancing the competitiveness of Ukraine's energy sector and economy.

## 2. ANALYSIS OF LATEST RESEARCH AND PUBLICATIONS

A review of current research and publications indicates growing scientific interest in hydrogen energy development. Researchers such as Yu. Stelmaschenko and V. Filippova highlight that global interest in this field has surged in recent years, with hydrogen energy increasingly being called the energy of the future and a key element in combating climate change. Ukraine is regarded as one of the leading potential suppliers of "green" hydrogen to Europe. Hydrogen use facilitates both short- and long-term seasonal energy storage in systems powered by renewable energy sources. The application of wind and solar energy in various economic sectors is challenging without hydrogen, which will play a leading role in integrating significant volumes of renewable energy, particularly in transport, heating, and cooling. According to scientists, state support is critically important for developing Ukraine's hydrogen sector, including aligning legislation with European norms and introducing transparent permitting procedures. Hydrogen energy is an essential component of the country's post-war recovery, which should be based on the principles of a "green" economy, while Ukraine's integration into the global hydrogen economy must consider national interests.

At the same time, O. Shraiber, V. Dubrovskiy, and O. Teslenko emphasize that hydrogen is currently one of the key factors in the energy transition toward sustainable development, facilitating the widespread adoption of renewable energy sources. The hydrogen economy is expanding globally, and hydrogen produced via electrolysis using wind or solar energy will occupy a significant place in many economic sectors. From a scientific perspective, reducing greenhouse gas emissions, particularly CO<sub>2</sub>, requires increasing reliance on "green" hydrogen as a climate-neutral energy source, developing, and implementing national hydrogen strategies.

Similarly, O. Zelenko, T. Hutsan, and I. Osmirko highlight that scientists, experts, and

entrepreneurs consider hydrogen energy one of the most promising directions for modernizing energy systems and transitioning to a new global energy supply structure. The properties of hydrogen, the rapid development of scientific and technological progress, and the growing share of renewable energy sources drive large-scale investment in the global hydrogen economy. This necessitates further research into mechanisms for stimulating hydrogen energy development, prospects for its integration into national economies, infrastructure for hydrogen transportation and storage, and its effective combination with traditional energy technologies.

Meanwhile, Ya. Kryll emphasizes that Ukraine has significant potential for developing a hydrogen economy due to its natural resources and strategic geographical location. An analysis of implemented projects in the country confirms that hydrogen technologies can become a key factor in energy independence and Ukraine's integration into the European market. Therefore, according to the researcher, effectively realizing this potential requires the creation of appropriate infrastructure, standardizing hydrogen certification in line with EU requirements, and attracting investment through European support programs, particularly by participating in European Hydrogen Bank auctions.

Additionally, S. Kudria, O. Repkin, L. Yatsenko, and L. Shynkarenko have developed the Concept of Ukraine's Hydrogen Energy Roadmap until 2035, aimed at creating a new energy sub-sector in the country. This roadmap envisions implementing advanced technologies, building scientific and technical infrastructure, and partially meeting Ukraine's energy needs with environmentally clean energy sources. It will contribute to the development of renewable energy as a strategic state policy priority, reducing dependence on fossil fuels, and improving the environmental situation.

## 3. SELECTION OF PREVIOUSLY UNSOLVED PARTS OF THE GENERAL PROBLEM TO WHICH THIS ARTICLE IS DEDICATED

Thus, an analysis of scientific sources confirms that hydrogen energy is a key direction in global energy development, holding strategic significance for enhancing energy security and achieving climate goals. For Ukraine, developing

a hydrogen economy opens new prospects for integration into the European market but requires a systematic approach, investment support, and alignment of national policies with European standards.

#### **4. FORMULATION OF THE PURPOSES OF THE ARTICLE**

The aim of this scientific article is to analyze the role of hydrogen energy as a strategic component in shaping Ukraine's energy-efficient economy.

#### **5. PRESENTATION OF THE MAIN MATERIAL OF THE RESEARCH WITH FULL JUSTIFICATION OF THE OBTAINED SCIENTIFIC RESULTS**

Hydrogen energy is a strategic direction capable of ensuring a transition to an energy-efficient economy based on the rational use of resources. Its development contributes to diversifying the country's energy balance and implementing cutting-edge technologies in industry, transport, and other economic activities. Ukraine has significant potential for integrating hydrogen technologies, considering its natural resource base and geopolitical position. Implementing green hydrogen production projects can strengthen the country's energy independence, ensuring synergy between environmental and economic goals. In this context, hydrogen energy emerges as a key element of sustainable development, enhancing Ukraine's international competitiveness.

Hydrogen production in Ukraine has the potential to become a strategic factor in ensuring the energy independence of both the country itself and Europe. It can contribute to reducing reliance on Russian energy resources and accelerating the transition to renewable energy sources. For Ukraine, this also presents an opportunity to establish itself as a key supplier of hydrogen fuel for the European market.

According to pre-war estimates by the International Renewable Energy Agency, Ukraine has the potential to install more than 320 GW of wind power and 70 GW of solar power. These figures do not include the potential use of wind and floating power plants in the waters around Crimea, which, according to the World Bank, could exceed 250 GW. Thus, the total renewable energy capacity in Ukraine could reach 415 GW within the next decade, and with

the Crimean potential included, this figure could exceed 700 GW. However, a key challenge remains the need for immediate distribution and consumption of the generated energy, which is a complex technical task. In this context, green hydrogen plays a crucial role. Renewable energy sources can be used for water electrolysis, producing hydrogen, which has a wide range of applications, can be transported and stored, and helps balance the energy system. The development of hydrogen energy is essential for achieving the carbon neutrality goals set by the Net Zero 2050 initiative.

Hydrogen is already actively used in energy, chemical industries, agriculture, transportation, and other sectors. Therefore, the European Union views Ukraine as a strategic partner in hydrogen energy development, which will not only enhance regional energy security and stability but also contribute to the broader European climate goals by promoting decarbonization and creating a sustainable energy system.

The realization of such a vast renewable energy potential requires a comprehensive approach to managing and storing energy resources. Traditional electricity storage methods have significant limitations, including losses during transportation and storage. Additionally, integrating renewable energy into the existing power grid requires effective mechanisms for balancing generation and consumption. Hydrogen energy offers an optimal solution, enabling the conversion of surplus electricity into hydrogen, which can be stored and transported with minimal losses.

A key aspect is also the technological development of infrastructure for hydrogen production, storage, and transportation, ensuring its widespread application across various economic sectors. Thus, the active development of hydrogen energy will contribute not only to enhancing energy efficiency but also to forming a sustainable low-carbon economy in Ukraine. To ensure the effective implementation of hydrogen technologies in the national energy system, a clear strategy and action plan must be followed.

The Operational Plan for implementing Ukraine's Hydrogen Strategy until 2025, presented on the website of the Ministry of Energy of Ukraine, includes specific steps aimed at achieving strategic hydrogen energy goals. The key tasks include:

1. Regulatory and legal framework development – Establishing legal, economic, and organizational foundations for the sustainable development of hydrogen energy.

2. Scientific research infrastructure – Creating a hydrogen research center based at the National Academy of Sciences of Ukraine by 2025.

3. Financial and economic incentives – Developing tax incentives for hydrogen energy equipment and expanding the list of duty-free imported equipment.

4. Integration into key sectors – Developing hydrogen technology plans for electricity, heating, transport, and industry by 2025.

5. Water resource management – Conducting an analysis of water supply capabilities for hydrogen production sites.

6. Integration into the European energy infrastructure – Developing a roadmap for Ukraine's integration into the European Hydrogen Network by 2027.

7. Infrastructure development – Creating a network of hydrogen refueling stations in urban and intercity routes by 2035.

8. Investment stimulation – Creating conditions for investments in hydrogen production, transportation, and usage, with ongoing measures until 2050.

These measures form the foundation for implementing Ukraine's Hydrogen Development Strategy, aimed at ensuring a sustainable energy sector and integration into the European energy market.

The successful implementation of the Hydrogen Strategy requires active participation from both government agencies and private businesses. Collaboration between public authorities, investors, and private companies accelerates the adoption of innovative technologies and fosters favorable conditions for the growth of the hydrogen sector.

One of the leading companies driving hydrogen energy in Ukraine is H2U (Hydrogen Ukraine LLC). Based in Kyiv, H2U focuses on developing and implementing projects for producing green hydrogen for domestic and international markets. The company emphasizes integrating cutting-edge technological solutions, enhancing engineering processes, and ensuring economic sustainability.

H2U's Key Projects:

1. Odesa-Reni Hydrogen Valley – A large-scale energy cluster in the Odesa region and the city of Reni, focusing on hydrogen production, storage, and transportation using regional port infrastructure. The project aims to expand Ukraine's export potential and integrate hydrogen energy into international markets.

2. Zakarpattia Hydrogen Valley – Establishing an energy hub in the Zakarpattia region, utilizing local renewable resources for hydrogen production. Given its strategic location on the EU border, this initiative is crucial for ensuring Ukraine's energy independence and hydrogen exports to Europe.

Another major player in Ukraine's renewable energy sector is SPP Development Ukraine, which is developing Ukraine's first green hydrogen project with a focus on integrating clean technologies into the national energy system.

To unlock Ukraine's hydrogen energy potential, the following key priorities must be addressed:

- Investment in scientific research and technology for efficient hydrogen production from renewable sources such as wind and solar energy.

- Creating a favorable legislative environment to attract investments in hydrogen infrastructure.

- Developing national hydrogen production and usage standards to ensure safe and efficient applications.

- Enhancing international cooperation with leading hydrogen energy countries for knowledge and technology exchange.

- Training programs to develop a workforce skilled in hydrogen technologies.

The development of hydrogen energy can become a pathway to Ukraine's energy independence, reducing reliance on imported fossil fuels.

## 6. CONCLUSIONS FROM THIS RESEARCH AND PROSPECTS FOR FURTHER EXPLORATION IN THIS DIRECTION

Hydrogen energy is a strategic direction that can drive Ukraine's transition to an energy-efficient economy. Its development will diversify the energy mix, introduce cutting-edge technologies in industry and transport, and

strengthen Ukraine's competitiveness in the global renewable energy market.

Ukraine has a significant natural resource potential, particularly in green hydrogen production, making hydrogen energy a key factor for sustainable development. With over 415 GW of renewable energy potential, effective storage and balancing mechanisms are essential. Green hydrogen, produced via electrolysis, offers a solution for energy storage and transportation, ensuring energy system stability.

Implementing Ukraine's Hydrogen Strategy requires a comprehensive approach, including technological infrastructure development, regulatory frameworks, and investment

incentives. The proposed strategy outlines scientific research initiatives, refueling station networks, European energy integration, and financial incentives for investors.

However, successful strategy implementation depends on close collaboration between the government, businesses, and scientific institutions. By fostering innovation, attracting investments, and creating infrastructure, Ukraine can transform its energy sector and develop a low-carbon economy. Ultimately, hydrogen energy will not only ensure energy independence but also promote economic growth and European energy market integration.

## REFERENCES

1. Stel'mashenko, Y. O., & Filippova, V. D. (2023). State policy on hydrogen energy development as an alternative energy source. *Bulletin of Kherson National Technical University*, 1(84), 244–249.
2. Shrayber, O. A., Dubrovskiy, V. V., & Teslenko, O. I. (2021). Current state and prospects for the development of hydrogen energy in the world. *Scientific Notes of V. I. Vernadsky Taurida National University. Series: Technical Sciences*, 32(71), 199–209.
3. Zelenko, O. O., Hutsan, T. H., & Osmirko, I. V. (2022). Hydrogen energy and its development prospects in Ukraine's economy. *Business Inform*, 8, 20–26.
4. Kryl, Ya. M. (2024). Hydrogen energy in Ukraine: Preconditions, potential, and prospects for European integration. *Economy of Industry*, 4(108), 49–62.
5. Kudrya, S. O., Repkin, O. O., Yatsenko, L. V., & Shynkarenko, L. Ya. (2019). Concept of the roadmap for the development of Ukraine's hydrogen energy sector until 2035. *Renewable Energy*, 4(59), 22–28.
6. Ukraine can become a reliable supplier of green hydrogen to the EU. (2022, June 6). *UkraineInvest*. Retrieved from <https://ukraineinvest.gov.ua/news/06-06-22-2/>
7. Ministry of Energy of Ukraine. (n.d.). *Draft Hydrogen Strategy of Ukraine until 2050*. Retrieved from <https://www.mev.gov.ua/proyekt-normatyvno-pravovoho-aktu/povidomlennya-pro-oprylyudnennya-proyektu-vodnevoyi-stratehiyi>
8. Hydrogen Ukraine. (n.d.). *H2U*. Retrieved from <https://h2u.ua/ua/>
9. Green Hydrogen. (n.d.). *SPP Development*. Retrieved from <https://sppdevelopment.com.ua/uk/green-hydrogen-ua/>

## Анотація КРАВЧИК Юрій

### Воднева енергетика як ключовий елемент енергоефективної економіки України

У статті здійснено аналіз ролі водневої енергетики як стратегічного компонента формування енергоефективної економіки України. Відзначено, що воднева енергетика є важливим напрямом, що здатний забезпечити перехід країни до енергоефективної економіки, заснованої на раціональному використанні природних ресурсів. Зауважено, що розвиток водневої енергетики сприяє диверсифікації енергетичного балансу України та впровадженню інноваційних технологій у різних секторах економіки, зокрема в промисловості, транспорті та енергетичному секторі. Підкреслено, що Україна володіє значним потенціалом для інтеграції водневих технологій завдяки своїм природним ресурсам та геополітичному положенню. Виробництво «зеленого» водню здатне підвищити енергетичну незалежність країни та сприяти її інтеграції в європейський енергетичний ринок. Зазначено, що оцінки Міжнародного агентства з відновлюваних джерел енергії свідчать про високий потенціал України для розвитку відновлюваної енергетики, зокрема вітрової та сонячної, що становить понад 400 ГВт. Однак для ефективного використання цього потенціалу необхідно вирішити проблему миттєвого розподілу та споживання енергії, що може бути досягнуто завдяки технології «зеленого» водню. Констатовано, що воднева енергетика відіграє важливу роль у досягненні цілей вуглецевої нейтральності в рамках ініціативи «Net Zero 2050», при чому Європейський Союз розглядає Україну як стратегічного партнера у розвитку водневої енергетики, що сприятиме реалізації загальноєвропейських кліматичних цілей. У статті

також розглянуто важливість розробки комплексної стратегії для впровадження водневих технологій в Україні, зокрема через державні ініціативи, фінансово-економічні стимули, розвиток науково-дослідної інфраструктури та інтеграцію водневих технологій у ключові сектори економіки. Зокрема, проекти, як-от «Воднева долина Одеси» та «Воднева долина Закарпаття», сприяють розвитку водневої інфраструктури та інтеграції України в міжнародну енергетичну мережу. У статті підкреслено необхідність активної співпраці між державними органами, науковими установами та бізнесом для успішної реалізації водневої стратегії, що допоможе Україні стати важливим гравцем на міжнародному ринку водневої енергетики.

**Ключові слова:** воднева енергетика, енергоефективна економіка, зелений водень, воднева стратегія, сталій розвиток.

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