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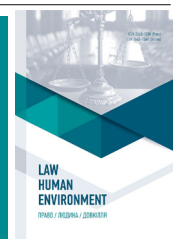

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International experience in the use of alternative energy sources (within the European Union)

Nataliia Lytvyn*
Doctor of Law, Professor
Taras Shevchenko National University of Kyiv
01033, 60 Volodymyrska Str., Kyiv, Ukraine
https://orcid.org/0000-0003-4199-1413
Yaroslav Zhuravel
Doctor of Law, Professor
Academy of Labour, Social Relations and Tourism
03187, 3-A Kiltseva Rd., Kyiv, Ukraine
https://orcid.org/0000-0002-7623-9144
Olena Artemenko
PhD in Law, Professor
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine
https://orcid.org/0000-0003-2041-8925
Olena Yara
Doctor of Law, Professor
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine
https://orcid.org/0000-0002-7245-9158
Olena Uliutina
PhD in Law, Associate Professor
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine
https://orcid.org/0000-0003-1982-9911

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*Corresponding author

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Abstract

The relevance of the chosen subject is due to the problem of the lack of conventional energy resources in the global and Ukrainian energy sectors. This problem is caused by a combination of external factors (outdated technologies, lack of oil, coal, and gas reserves) and internal factors, such as Russia's military aggression against Ukraine, and its manipulative policy towards other countries, which encourages the European community to look for other options to ensure energy security. This gave a new urgency to the issue of activating the development of alternative energy. The purpose of the study is to analyse international experience in the use of alternative (renewable) energy and formulate conceptual methods and approaches to solving global energy problems. A combination of general scientific methods was used, primarily dialectical, analytical, concrete-sociological, and from special legal methods – comparative legal. The results obtained indicate that the use of alternative energy sources in the European Union countries will continue to develop in the future. Based on data from Regulatory Indicators for Sustainable Energy, it is confirmed that Denmark, Germany, and the Republic of Poland are currently the leaders in the use of renewable energy sources in the EU countries. The study analyses the successful experience of these countries in the use of renewable energy sources. It is concluded that there is a dynamic in the development of alternative energy sources in European countries, but in order for alternative energy sources to fully compete with conventional energy sources, it is necessary to maintain and regulate incentives for increasing the use of renewable energy sources at the national level. The practical value of the study lies in the fact that its results can serve as recommendations for increasing the share of alternative energy sources in Ukraine

Keywords: energy; renewable resources; green energy; energy system; energy crisis; solar, wind, hydro, and bioelectric power plants; European countries

Introduction

Alternative energy is a special energy industry, the role of which in the countries of the European Union is becoming more and more relevant every year. This is due to the fact that conventional energy sources (oil, gas, and coal) are gradually decreasing in volume, and non-conventional natural sources (hydropower, solar, wind and thermal energy) are becoming relevant and widely available due to the latest technical achievements (Kucheriava & Sorokina, 2019). In most European countries, the development of alternative energy is supported at the level of national policy, which is aimed at reducing the consumption and production of conventional energy sources and improving the level of state energy security (International Energy Agency, 2019).

As for Ukraine, despite a fairly substantial array of regulatory legal acts that control and regulate relations in the use of alternative energy sources, the legal framework in this area continues to form.

A number of authors have examined the use of alternative energy sources. In the dissertation by N. Riazanova (2021), the methodology and implementation principles for determining strategic guidelines for the development of alternative energy in the national economy of Ukraine were

considered. In the study by O. Babyna (2020), the factors of innovation and investment activity in the development of alternative energy are systematised and groups of factors that have a dominant influence on the process of ensuring innovation and investment activity in the development of alternative energy are classified. In addition, in this dissertation, the papers of recent years are considered, which describe the relevance and need for the use of regenerative energy sources.

According to the Law of Ukraine "On Alternative Energy Sources" (2003), which describes the fundamental principles of national policy in the use of alternative (renewable) energy sources, state management of this area, promotion of production and consumption of energy that is produced from alternative sources, indicates green tariffs for all types of renewable energy and state guarantees for entities that use non-conventional (alternative) sources in production.

Investigating the efficiency of using alternative energy sources, S. Rohach (2020) notes: "...considering the energy and environmental situation in the world, almost all countries have an urgent need to switch to alternative energy, which can increase the range of available energy sources, strengthen energy and environmental security."

Ye. Ziabina *et al.* (2019) state: "...the introduction of technologies for generating alternative energy is of an investment nature, so Ukraine needs to encourage internal producers to develop and manufacture biotechnologies to further attract them."

As the analysed experience of using various types of alternative energy in European countries in recent years shows, they are increasing the use of alternative energy sources and completely abandoning the use of conventional energy sources, including CO_2.

The use of renewable energy sources in modern conditions is a particularly urgent scientific and practical task. The global shortage of conventional energy resources encourages the efficient use of alternative energy sources.

Despite thorough research on this issue and considering modern conditions, regenerative energy is insufficiently examined in the process of use and development on the territory of Ukraine.

The purpose of this study is to review and analyse the international experience of European countries in the use of alternative (renewable) energy and formulate conceptual ways and means of solving global energy problems.

Materials and Methods

The methodological basis of the study is a combination of general scientific methods, primarily, the dialectical method, the method of analysis and the specific-sociological method, and from special legal methods – the comparative-legal one. The use of the comparative legal method allowed comparing national and international legislation in the field of alternative energy sources. Using the dialectical method, trends in the development of regenerative energy in the European Union countries were examined. The method of analysis is used in reviewing papers of researchers according to the study subject and describing international, European, and national legislation in the field of using alternative energy sources. In turn, the specific sociological method is used in the analysis of statistical data of international organisations that assess the development of alternative energy in countries around the world.

The main provisions and results of the study are formulated based on an analysis of the norms of international, and national legislation. In particular, the study used the following provisions: Kyoto Protocol to the United Nations Framework Convention on Climate Change (1997), Law of the Republic of Poland "On Renewable Energy" (2015),

Regulation of the Minister of Economy of the Republic of Poland No. 671 (2014), and national regulatory legal acts, in particular, the law of Ukraine "On Alternative Energy Sources" (2003) with the current version dated January 01, 2023. In addition, statistical data were analysed in this study, such as: International Energy Agency (IEA) data for 2020 (International Energy Agency..., 2020), latest RISE statistics (Regulatory Indicators for Sustainable Energy) for 2021 (World Bank Group, 2022).

Results

Alternative energy sources that can be used: solar, wind, water, and biomass energy. These energy sources are renewable and have unlimited storage potential, unlike conventional ones.

The increase in energy consumption produced from renewable resources accounts for a significant share of the package of measures required to comply with the Kyoto Protocol to the United Nations Framework Convention on Climate Change (1997). Therefore, the main requirement for resolving the energy crisis is clear coordination of measures and decisions of governments of different countries.

According to the "2020 World Energy Outlook" report (International Energy Agency..., 2020), the main role in helping states achieve climate goals and sustainable development is assigned to renewable hydropower, the services of which will become even more relevant.

The volatility of electricity demand and the rapid increase in solar and wind generation increase the flexibility needs of power systems. Therefore, in the process of increasing these needs, hydropower, due to the ability to provide a large set of system services, ranging from improving the quality of electricity to balancing output and demand, will be of the greatest value to the energy system.

According to the Sustainable Development Scenario of the International Energy Agency, hydroelectric power plants are expected to produce more electricity than thermal power plants by 2030. Accordingly, it is planned to attract almost 850 GW of additional hydropower capacity until 2040, mainly in the Pacific region and Asia (International Energy Agency..., 2020).

In 2021, renewable resources accounted for almost 60% of global electricity production growth. Currently, the share of renewable sources is 25% in the world's energy production. According to RISE data (Fig. 1), Denmark and Germany are leading the way in implementing renewable energy sources in the EU. Thus, in 2021, the share of renewable energy sources in total final energy consumption is 38% and 17%, respectively. Therewith, in the analysed countries in the period 2017-2021, there is a significant increase in alternative energy sources, which is explained by the positive actions of the governments of these countries to encourage the development of alternative energy sources (World Bank Group, 2022).

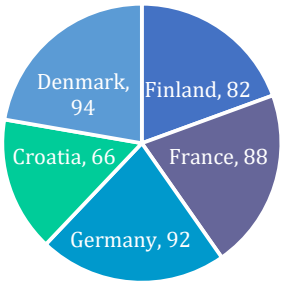

Figure 1. Share of renewable energy sources in EU countries according to RISE estimates as of 2021, %

Source: compiled by the author based on RISE estimates (World Bank Group, 2022)

Denmark has one of the most systematic and long-term energy saving experiences among

all EU countries: 40 years ago, the country was completely dependent on energy imports. Today, it not only provides itself with electricity, but also exports it to neighbouring countries (Dombrovska & Chernikova, 2019).

Denmark earns almost twice as much from exporting energy-efficient technologies as from exporting agricultural products. In the next five years, up to 50%, and by 2025, up to 75% of energy will come from wind energy. Researchers note that it would be possible to fully meet the country's need for wind energy if, for example, somewhere in the north of the country, an area of 1.000 km^2 of wind turbines was installed (Problems and prospects..., n.d.).

After the Chornobyl nuclear power plant accident, the Danish parliament banned the construction of nuclear power plants, and today 20% of electricity is generated from wind power. According to the International Energy Agency (IEA), European wind farms are already becoming competitive compared to conventional thermal power plants running on coal and heavy oil (International Energy Agency..., 2020).

Denmark's energy policy is being implemented as part of a constantly updated energy programme. Thus, the first programme (1976) was aimed at preventing an energy crisis. In the second programme, special attention was paid to solving socio-economic and environmental problems and reducing dependence on fuel imports. The third programme, Energy 2000, was aimed at expanding the use of environmentally friendly fuels. The fourth programme, Energy 21, aims to increase the share of renewable energy sources in the country to 12-14% by 2005. Denmark currently has an energy strategy until 2025. The programme provides for reducing energy consumption and dependence on petroleum products, in particular in the transport sector, through the development of efficient technologies and the use of alternative fuels, their development and creating the necessary conditions for their integration into the national energy system by 2035 (National Institute of Strategic Studies, 2010).

Denmark also has a green certificate system. A green certificate is "a document certifying that every MWh of electricity is generated from renewable energy sources." Denmark has a mandatory share of green electricity in total production. Electricity distribution companies accept and pay for it, and consumers are required to buy it in accordance with the established quota. If the electricity supplier does not meet this quota, it must buy green electricity certificates on the market or pay a fine that usually exceeds the cost of the green electricity certificate. In Denmark, certificates are securities that can be bought and sold independently of energy sales. Quota systems and green electricity certificates also apply in countries such as Sweden, Italy, Poland, Romania, the United Kingdom, and Belgium, where quota systems and green electricity certificates have also been introduced (Problems and prospects..., n.d.).

It is also worth considering Germany's experience in using alternative energy. The Act on Granting Priority to Renewable Energy Sources (2000) operates in Germany. Special work was conducted to save energy and improve the energy efficiency of the system. Notably, since 2006, annual investment in renewable energy has increased significantly and now amounts to about 1 billion euros. The German authorities actively attract private capital to take part in new projects, organising and holding competitions for loans to improve energy efficiency and offering tax incentives. Today, Germany produces more electricity from alternative energy sources (wind, solar, and biomass) and less from conventional energy sources (nuclear, natural gas, and petroleum

products). Germany is one of the EU countries where modern energy-saving technologies and alternative energy sources, such as solar and wind energy, are most actively used (National Institute of Strategic Studies, 2010).

In 2020, Germany exceeded its main target of 18% of total final energy consumption, set in accordance with the EU Renewable Energy Directive, by 19.3 %; in 2021, according to the RED (Renewable Energy Directive) calculation specifications, it increased slightly and amounted to 19.7% of total final energy consumption (Working Group on Renewable Energy-Statistics, 2022).

In Germany, wind power industry is one of the largest in the world and a leader in technological development. As a result, a total of 28,230 ground-based turbines with a total capacity of 56 GW were operating nationwide in 2021. Germany's new goal is to increase capacity by 10 GW per year by 2025 and achieve a total installed capacity of 115 GW by 2030 (Official Website of the Federal…, n.d.).

Despite the smallest amount of sunlight, the country is one of the world leaders in solar energy production. According to the International Renewable Energy Agency (IRENA), by 2020, it ranked fifth in the world for the first time in several years. This gives grounds to argue that other countries are creating systems for the proper use of alternative resources in the industrial use of green energy (Wehrmann, 2019). Civil society is actively involved in the development of renewable energy in the country, in particular through the creation of energy cooperatives (Shpykuliak & Ivanchenko, 2018). This contributes to the decentralisation of the industry and, in particular, helps to fight monopolists in this area.

Notably, in 2021 Germany added approximately 5.3 MW of solar photovoltaic capacity, up 10% from 2020. Now an increase in the number of installations in the industrial sector can be wxpected, which is due to the country's desire to increase its energy independence after the Russian invasion of Ukraine (Wehrmann, 2022).

The new German government has promised that by 2030, renewable energy sources such as wind and solar will account for between 42% and 80% of electricity production; by 2035, it has stated that electricity production will be carbon-neutral (Rooks, 2022).

The country's bioenergy sector, which accounts for the largest share of renewable energy sources, should also be considered. Ultimately, when using biomass for energy production, no more carbon dioxide is released than was absorbed by plants. In addition, bioenergy is a source of added value for agriculture, forestry, and rural areas in general (Federal Ministry for Economic Affairs and Climate Action, n.d.). However, bioenergy is obtained not only from renewable raw materials but also from biogenic residues and waste: in 2021, biomass with a share of 52% still dominates wind (almost 28%), solar (photovoltaic and solar, thermal) (12%), hydroelectric (4%), and geothermal (4%) energy and continues to make the largest contribution to the production of renewable energy (Electricity imports to France…, 2020).

The expansion of biomass power plants over several years has mainly contributed to increased flexibility in electricity generation. This so-called excess capacity has hardly led to an increase in annual electricity production in recent years, but it has allowed for more flexible supply of alternative energy when needed (United Nation Department of Economic and Social Affairs, n.d.).

The Republic of Poland, which is a neighbouring European country, deserves attention. This country attaches great importance to the use of alternative energy sources. At the level of the European Union until 2020, Poland was supposed to reach 15% of the market share of final

consumption of electricity produced from alternative energy sources (European Environment Agency, 2023). According to published calculations, this share was already 15.624% in 2021 and tends to grow as of 2023. An important role is played by stimulating electricity producers from alternative energy sources, which is characterised by a successful combination of economic and regulatory mechanisms (Eurostat, 2023).

The legal basis for stimulating the use of alternative energy sources in the Republic of Poland is mainly the Law of the Republic of Poland "On Renewable Energy" (2015) and other laws and regulations. According to the law, producers of electricity from alternative energy sources can choose a method of incentive measures based either on the green certificate system or on the auction system.

Until 2016, the main method of stimulating the use of alternative energy sources was the green certificate system combined with the quota system. The green certificate market was opened to ensure the free circulation of green certificates and the possibility of their purchase and sale to achieve quotas for the mandatory use of alternative energy: by the Regulation of the Minister of Economy on May 5, 2014 (Regulation of the Minister of Economy of the Republic of Poland No. 671..., 2014) annual quotas were set until 2021.

In the future, producers of electricity from alternative energy sources who put their facilities into operation before 2016 can either continue to use the green certificate system or switch to the auction system – a new innovation in Polish legislation. Currently, the auction system is the main way to encourage the use of alternative energy sources in the Republic of Poland.

Auctions are held at least once a year. During auctions, producers of electricity from alternative energy sources who are eligible for incentives can choose: 1) contracts for the supply of electricity with a "buyer's guarantee" at the price agreed during the auction; 2) the right to sell the factual electricity produced at the price agreed at the auction and receive compensation for the difference between the expected revenue and the market price of the same electricity (calculated based on the average daily price of electricity on the commodity exchange for the previous one to two days) (Regulation of the Minister of Economy of the Republic of Poland No. 671…, 2014).

According to the Polish legislature's decision to encourage foreign electricity producers from alternative sources, the auction system can also be applied to alternative energy facilities located abroad, if several conditions are met (preliminary signing of an intergovernmental agreement between the Republic of Poland and the country where the alternative energy facility is located, which provides for mutual access to incentives for producers located in both countries) (Paragraph 8 of Decree No. 73). Therewith, the maximum amount of electricity produced abroad and purchased at Polish auctions should not exceed the threshold determined in accordance with the decision of the Cabinet of Ministers, and in no case should the threshold exceed 5% (Law of the Republic of Poland No. 478…, 2015).

Many EU countries have created alternative energy development programmes aimed at making this type of energy affordable for both industrial enterprises and households to further increase the production and consumption of alternative energy. Notably, this positive experience of using renewable energy sources can also be applied on the territory of Ukraine, namely: one of the incentive measures is special tariffs for electricity from renewable energy sources, that is, green tariffs, but here it should be noted that green tariffs in Ukraine in the pre-war period were among the highest in the world, and the

legal conditions for investment and production of green energy were very competitive compared to other European countries (Hritsyshyna, 2020; Topalov, 2023). In the European countries under consideration, an important guarantee for investment in green energy is the Power Purchase Agreement (PPA), which is understood as a special long-term electricity purchase and sale agreement that sets the conditions for future energy supply (quantity, price, obligations, etc.). The advantage of this scheme is that the project can be secured by contractual relations with future buyers already at an early stage of the investment project, that is, before the actual completion of the power plant construction. In turn, for the investor, this is a guarantee that his product will be purchased. Therefore, this experience can be used on the territory of Ukraine to improve the situation using alternative energy sources and to ensure guarantees for sellers of relevant energy sources.

Discussion

The world is facing the problem of global climate change, which has negative consequences for life on our planet. That is why researchers are showing great interest in the use of green energy. They investigate the impact of energy derived from renewable sources on the socio-economic development of Ukraine and international security in the context of dependence on conventional methods of energy production. V. Kovalskyy (2019) notes that Ukraine should make more active use of biofuels, in addition, there should be opportunities for the regeneration of spent fuel and lubricants.

However, it is necessary to make some adjustments, for more active use of biofuels in the country, it is necessary to update the legislative framework: by creating a regulatory act that will describe the stages of creating plants and regulate their activities.

As for the opinion of foreign researchers who have examined this problem, for example, A.S. Flaksman *et al*. (2021) note, that the global trend of energy development, which was formed under the influence of changes in energy policy, the development of new technologies and the transition to an industrial revolution, leads to the rapid development of alternative energy sources, which in the future will provide almost half of the world's electricity production.

This means the emergence of structural shifts in the fuel balance, namely fossil fuel gas. Therewith, the share of coal will decrease, and the share of using hydrogen and biofuels will increase.

It can be agreed with the arguments of these researchers, but when using this experience, it is necessary to consider the high cost of the latest technologies, which can slow down the fast implementation.

Another study worth paying attention to was conducted Z. Ahmed *et al.* (2022). In the study, the developed countries that are also experiencing difficulties associated with climate change, mainly due to the inability to limit greenhouse gas emissions into the atmosphere, are examined. To reduce emissions, especially carbon dioxide, it is important to increase the share of green energy in total energy supplies. Accordingly, public sector investment in the renewable energy sector is expected to play a vital role in specifically improving the technological level needed to significantly increase the production and supply of green energy.

It is worth noting that the paper of these researchers characterised the problematic areas of activity of some countries in the use of green energy and the possibility of preventing the occurrence of negative consequences.

As noted by J. Brodny & M. Tutak (2020), renewable energy sources should replace conventional energy sources as soon as possible, which

is particularly relevant for the heating and cooling sector and the transport sector. Ultimately, these sectors are most dependent on conventional energy sources (coal, oil, and gas). The integration of these sectors, especially the heating and cooling sectors and the electric power industry should take place in two ways: electrification and technological innovation. The implementation of these solutions requires the development of a comprehensive energy policy by states based on both know-how and technological innovation.

The opinion of the authors can be agreed with, but it is important to note that not all countries can use all types of renewable energy sources in their territories, it is necessary to consider the natural conditions of the country for the comprehensive development of alternative energy.

Conclusions

After analysing the experience of EU countries in using alternative energy sources, it can be concluded that renewable energy sources cannot yet compete on an equal footing with conventional energy sources. Therefore, their development should be supported and regulated by various methods at the national level.

In European countries, models of state support for the use of alternative energy are different, mostly based on the use of subsidies for relevant projects and tariff policies (German system). This study examines in more detail Denmark, Germany, and the Republic of Poland, which, according to RISE, are the leading EU countries for the introduction of renewable energy sources. Each country has different approaches and methods for using alternative energy sources. As for Denmark, it is worth noting the quota of green electricity as a percentage of total production and the fact that certificates, which are securities that can be bought and sold independently of energy sales, are mandatory. The German authorities actively attract private capital to new projects in various ways and means, for example, by organising and holding competitions for energy efficiency loans and offering tax incentives. A characteristic feature of the legislation of the Republic Of Poland in this area is an introduction of incentives for electricity producers from alternative energy sources in foreign countries, subject to the conclusion of intergovernmental agreements with the foreign country where the producer is located, and the amount of energy purchased. These countries are actively promoting the use of all types of alternative energy (biogas, solar, hydro, wind, and thermal energy), mainly because of the challenges facing the EU community in general.

The scientific originality of the study is a comprehensive examination of the experience of European countries in the use of alternative energy sources, borrowing effective measures that the Ukrainian state can take for the active development and use of regenerative energy. Therefore, it is advisable to consider the experience of the EU countries, namely: encourage the application of the contract for the purchase and sale of renewable electricity on the territory of Ukraine to provide a guarantee to investors in the purchased product, thereby attracting new investors to Ukraine; actively attract private capital for the development of alternative energy in Ukraine, creating appropriate conditions; involvement of citizens in the development of the renewable energy sector, a common form of which is the creation of energy cooperatives in Germany (the need for state support for small producers of electricity from renewable sources). Thus, this experience of European countries, including flexible legal structures regulating energy cooperation, is suitable for application in Ukrainian legislation.

The experience of these countries should be considered when determining the most appropriate legal mechanism for creating a national model to support development and encourage the use of alternative energy sources. That is why the perspective of the study should be comparative studies of Ukrainian legislation in the field of green energy and relevant legislation of leading countries in this area to implement positive experience in the development and support of wind, solar, hydro, and bioelectric power plants in Ukraine. There is also a need for studies that, considering the losses and difficulties associated with military operations on the territory of the country, will offer effective measures of national policy in the conditions of war and for the post-war settlement of the situation in the field of alternative energy.

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Conflict of Interest

There is no conflict of interest in this study.

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Міжнародний досвід використання альтернативних джерел енергії (у межах держав Європейського Союзу)

Наталія Анатоліївна Литвин
Доктор юридичних наук, професор
Київський національний університет імені Тараса Шевченка
01033, вул. Володимирська, 60, м. Київ, Україна
https://orcid.org/0000-0003-4199-1413

Ярослав Володимирович Журавель
Доктор юридичних наук, професор
Академія праці, соціальних відносин і туризму
03187, вул. Кільцева дорога, 3-А, м. Київ, Україна
https://orcid.org/0000-0002-7623-9144

Олена Вікторівна Артеменко
Кандитат юридичних наук, професор
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна
https://orcid.org/0000-0003-2041-8925

Олена Сергіївна Яра
Доктор юридичних наук, професор
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна
https://orcid.org/0000-0002-7245-9158

Олена Анатоліївна Улютіна
Кандитат юридичних наук, доцент
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна
https://orcid.org/0000-0003-1982-9911

Анотація

Актуальність обраної теми зумовлено проблемою нестачі традиційних енергетичних ресурсів у світовому та українському енергетичному секторі. Цю проблему викликало поєднання зовнішніх чинників (застарілі технології, відсутність запасів нафти, вугілля і газу) і внутрішніх чинників, як-от військова агресія Росії проти України, а також її маніпулятивна політика щодо інших країн, що спонукає Європейське співтовариство шукати інші варіанти гарантування енергетичної безпечності. Це надало нової актуальності питанню активізації розвитку альтернативної енергетики. Мета дослідження – вивчити міжнародний досвід використання альтернативної (відновлюваної) енергії та сформулювати концептуальні

методи й підходи до вирішення глобальних енергетичних проблем. У роботі застосовано поєднання загальнонаукових методів, насамперед діалектичного, аналітичного та конкретно-соціологічного, а зі спеціально-юридичних методів – порівняльно-правового. Результати наукового дослідження свідчать про те, що використання альтернативних джерел енергії в країнах Європейського Союзу розвиватиметься і надалі. На основі даних Regulatory Indicators for Sustainable Energy підтверджено, що наразі Данія, Німеччина та Республіка Польща – лідери з використання відновлювальних джерел енергії в країнах ЄС. Проаналізовано успішний досвід цих країн у використанні відновлюваних джерел енергії. Зроблено висновок про наявність динаміки в розвитку альтернативних джерел енергії в європейських країнах, однак, для того щоб альтернативні джерела енергії повною мірою конкурували з традиційними джерелами енергії, необхідно підтримувати та регулювати стимули для збільшення використання відновлюваних джерел енергії на національному рівні. Практична цінність дослідження полягає в тому, що його результати можуть слугувати рекомендаціями для збільшення частки альтернативних джерел енергії в Україні

Ключові слова: енергетика; відновлювальні ресурси; зелена енергетика; енергетична система; енергетична криза; сонячні, вітрові, гідро- та біоелектростанції; країни Європи