Received: 18.06.2024. Revised: 29.11.2024. Accepted: 13.03.2025.

EKONOMIKA APK

https://doi.org/10.32317/ekon.apk/2.2025.87

Ekonomika APK, 32(2), 87-99

UDC 338.27:621.311.2(045)

Innovative financial instruments to stimulate the development of renewable energy

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► **Abstract.** This study examined contemporary financial mechanisms and instruments that facilitate investment in renewable energy sectors. The research methodology employed statistical analysis of electricity production and consumption data from renewable sources across the European Union and Ukraine. The findings demonstrated that the European Union has experienced substantial growth in renewable electricity generation, primarily attributable to effective investment attraction strategies. In contrast, Ukraine exhibits inconsistent development patterns in its renewable energy sector. The analysis underscored the correlation between robust financial frameworks and successful renewable energy adoption. While the European Union has implemented cohesive mechanisms yielding demonstrable results, Ukraine's renewable energy landscape reflects the consequences of less stable financial infrastructure. Total generation in the European Union increased from 750.9 thousand GWh in 2014 to 1,130.2 thousand GWh in 2023, which indicates a stable expansion of the sector. The most promising financial instruments were green bonds, which allow attracting significant capital investments for environmental projects, and energy cooperatives that contribute to the decentralisation of energy and the development of local communities. The mechanisms of financing renewable energy in the agricultural sector of European Union countries, in particular Germany, France, Poland, and the Netherlands, were analysed. The research examined the implementation of renewable energy within the agriculture sector, exemplified by RWE (Germany) and Astarta-Kyiv (Ukraine). It was shown that government subsidies, concessional lending, international investment, and corporate finance mechanisms played an important

► **Suggested Citation**: Reshetilov, G., Kuzoma, V., Bilichenko, O., & Tkachenko, M. (2025). Innovative financial instruments to stimulate the development of renewable energy. *Ekonomika APK*, 32(2), 87-99. doi: 10.32317/ekon.apk/2.2025.87.

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role in overcoming barriers. Ensuring sustainable financing of renewable energy in Ukraine requires an integrated approach, including active attraction of public, private, and international investment

▸ **Keywords:** alternative sources; environmental sustainability; investment mechanisms; government regulation; climate policy

▸ Introduction

The advancement of renewable energy technologies represents a critical component in addressing energy security concerns and mitigating climate change effects, particularly as global energy demands increase amidst finite conventional resource supplies. Solar, wind, hydroelectric, and bioenergy implementations serve not only to diminish fossil fuel dependence but also contribute significantly to agricultural sector development through bioenergy technology integration. Nevertheless, substantial financial impediments, including high capital expenditures and extended return-on-investment timeframes, necessitate the deployment of innovative financial instruments such as green bonds, specialised investment funds, and fiscal incentives to facilitate broader adoption. Research on these tools is important for raising capital and creating favourable conditions for the transition to a sustainable energy model.

Many researchers have considered various aspects of financing renewable energy and the possibility of using innovative financial instruments to stimulate it. X. Ye & E. Rasoulinezhad (2023) conducted a thorough analysis of the influence of green bonds on securing long-term investments in renewable energy. Their investigation focused on how the issuance of these bonds contributed to lowering the capital costs for renewable energy firms and enhancing investor trust. T. Kurbatova *et al.* (2021) examined the efficacy of governmental subsidies and tax incentives in Ukraine. V. Shebanina *et al.* (2024) examined approaches to the management of sustainable land use projects, considering the requirements of the European Union (EU), in particular, the need to attract innovative financial mechanisms, such as "green financing" and environmentally oriented investments. This highlights the importance of implementing comprehensive financial instruments to support the sustainable development of the agricultural sector, including renewable energy.

S.A. Sarkodie *et al.* (2020) examined the influence of foreign direct investment on the funding of renewable energy initiatives. Their analysis showed that in the presence of a stable political environment and transparent regulatory norms, international investors are ready to invest heavily in this sector. They also stressed that the lack of a clear government strategy and the risks associated with regulatory unpredictability may hinder the flow of foreign capital. L. Kostyrko *et al.* (2024) reviewed the public-private partnership (PPP) mechanism for financing renewable energy.

L.R. Vásquez-Ordóñez *et al.* (2023) explored the possibilities of raising funding through crowdfunding platforms. They proved that such platforms are an effective tool for financing small projects in the field of renewable energy sources, especially at the local level. Their research showed that the public actively supports clean energy projects if they have a transparent financial model and clearly defined environmental benefits. R. Yankovoy (2024) pointed to the role of venture capital in financing startups working on innovative technologies in the field of renewable energy. The researcher found that venture funds are willing to invest in high-risk projects if they have significant scaling potential and can deliver high returns in the future.

N. Fatima *et al.* (2021) examined the impact of companies' environmental ratings on their ability to attract funding for renewable energy projects. Their analysis showed that companies with high levels of environmental responsibility gain access to more favourable credit conditions and a wider range of investors. X. Zhang *et al.* (2022) devoted their research to the role of "green" banks specialising in financing environmental projects. They found that such financial institutions play a key role in stabilising investment flows in the renewable energy sector, as they minimise risks for investors and offer special credit products for sustainable development.

F. Egli (2020) reviewed risk insurance mechanisms for renewable energy investors. His research has confirmed that insurance products specifically designed for this industry significantly increase investor confidence and help to increase funding. The researcher further highlighted that insurance coverage accessibility for renewable energy initiatives contributes to capital cost reduction and enhances lending opportunities. O. Desyatnyuk *et al.* (2024) investigated digital technologies' impact on financial transparency within renewable energy sectors, demonstrating that blockchain implementation and smart contract integration can substantially enhance investment efficiency while minimising fraudulent activities and financial misconduct.

The introduction of green bonds, public-private partnerships, crowdfunding, venture financing, and other mechanisms creates new opportunities for attracting investment, which is critical for the sustainable growth of the industry (Khalegi *et al.*, 2024). However, there is a need for further analysis of their effectiveness and adaptation to modern economic and technological conditions. In particular, there is a lack of a comprehensive analysis of the effectiveness of various financial instruments in the long term, especially in conditions of macroeconomic instability. In addition, the issues of integrating digital technologies into financial mechanisms to increase their transparency and accessibility remain poorly researched.

This study aimed to assess the effectiveness of innovative financial mechanisms in catalysing renewable energy development and to identify potential enhancements in light of contemporary economic challenges. The research evaluated the influence of diverse financial instruments on renewable energy growth in both Ukraine and global contexts. It further examined the potential of digital technologies to enhance renewable energy

financing efficiency. Additionally, the study developed risk mitigation strategies specific to renewable energy investment. Through this comprehensive analysis, the research sought to inform policy and practice regarding optimal financial approaches to accelerate the renewable energy transition amid evolving economic conditions.

▸ Materials and methods

The research methodology was aimed at using secondary data from various sources, such as statistical reports, scientific publications, international reports and official data from national statistical authorities, which facilitated a comprehensive analysis of existing financial mechanisms and their impact on the development of renewable energy sources in Ukraine and EU countries. The main source for collecting information were Eurostat publications (2025a, 2025b) and research by international organisations such as the International Energy Agency (IEA) (n.d.) and the World Bank Group (n.d.). National programmes, including reports and documents on the implementation of energy reforms in Ukraine and international technical assistance programmes, were also used to analyse the financing mechanisms for renewable energy sources in Ukraine. Data regarding this matter was sourced from legitimate governmental entities, including the Ministry of Energy of Ukraine (n.d.). Prior resources have been utilised to examine financial processes including green bonds, energy cooperatives, crowdsourcing, and digital financial instruments.

The research methodology also encompassed a comparative examination of the indices of power generation from renewable sources in the European Union and Ukraine, with a specific focus on agriculture. For this purpose, data for the period from 2014 to 2023 from Eurostat publications (2025a, 2025b), and statistical reports of the national statistical agency of Ukraine, in particular, State Statistics Service of Ukraine (n.d.) were used. The comparative analysis allowed assessing the dynamics of renewable energy development in both regions and identifying key factors influencing the pace of its development. Restrictions: in Ukraine, there are no data for 2021-2023. This may be conditioned by economic difficulties, instability in the energy market, or military operations. To analyse the effectiveness of implementing renewable energy sources in the agricultural sector, several real-world cases of successful use of such technologies in different countries were selected. Particular emphasis was placed on examining the practices of prominent firms, such RWE (2024) in Germany and Astarta-Kyiv (n.d.) in Ukraine, which aggressively utilise biogas facilities and other renewable energy sources. Comparative analytic methodologies were employed to gather data on the adoption of renewable energy in the agricultural sector, facilitating the evaluation of project effectiveness exemplified by RWE and Astarta-Kyiv.

Furthermore, data about the application of digital financial solutions, including blockchain technology and smart contracts, utilised to enhance the transparency of financial transactions within the renewable energy sector was organised to evaluate financial processes. This helped to explore the potential of using digital financial instruments to reduce investment risks and increase confidence among agricultural market participants. The methods included qualitative and quantitative analysis, a comparative approach, and content analysis of scientific papers and reports of international organisations specialising in renewable energy sources. This facilitated the acquisition of information regarding the advancement of renewable energy across many regions. The methodologies employed in the study facilitated an exhaustive examination of renewable energy finance across the EU and Ukraine, specifically in the agriculture sector, and identified the most efficacious financing instruments for this business.

▸ Results

The modern world is rapidly moving towards energy transformation, where the main role is played by renewable energy sources. However, large-scale development of this industry is impossible without proper financial support. Conventional approaches to financing energy projects are often not effective enough, as renewable energy requires significant capital investment at the initial stage and has a long payback period. The most promising financial mechanisms include green bonds, energy cooperatives, crowdfunding, and digital financial solutions that combine state-of-the-art technologies and financial instruments to encourage environmental projects.

Green bonds are one of the most effective financial instruments for raising funds in the field of renewable energy (Rats & Alfimova, 2023). They operate on the principle of traditional bonds, but with the difference that the funds raised are directed exclusively to environmental projects. Government entities, private enterprises, and financial institutions issue these bonds to fund the development of solar, wind, and biofuel facilities. Their primary advantages include a decrease in capital costs attributable to state guarantees, enhanced investor confidence stemming from transparency in money utilisation, and the potential to secure foreign finance (Jain *et al.,* 2024). As of 2025, this tool is widespread in the EU countries, while in Ukraine it is just beginning to gain popularity.

Energy cooperatives are a form of collective financing that allows communities and individual consumers to invest in the creation of local renewable energy facilities. Members of the cooperative pool their resources to finance the construction of solar or wind power plants, and in return receive the benefit of cheaper or even free electricity. This mechanism contributes to the decentralisation of energy, reduces energy costs, and encourages local economic development (Gajdzik *et al.,* 2024). As of 2023, there were about 850 such cooperatives in Germany (Berg, 2023).

Crowdfunding is an innovative financial method that facilitates the acquisition of funds from numerous private investors via internet platforms. This approach is particularly effective for financing small projects that cannot receive traditional bank loans or government support. The main advantages of crowdfunding are the availability of financing for a wide range of investors, transparency and trust due to open online platforms, and the ability to quickly raise funds without bureaucratic procedures (Mukherjee *et al.*, 2024). In Western Europe, there are specialised platforms such as Solar Mosaic and Trine that

allow financing solar energy projects through contributions from individuals. In Ukraine, this mechanism, as of 2025, is not widely used, but it can become an effective tool for the development of local energy initiatives.

Modern digital financial solutions open up new opportunities for investing in renewable energy. Blockchain and smart contracts enhance the transparency of financial transactions and mitigate the risk of fraud. The use of decentralised financial platforms allows investors to interact directly with project developers without the participation of banks or other financial intermediaries (Razzaq *et al.,* 2023). These technologies ensure transaction transparency, automation of financial obligations, and global availability of investment opportunities.

The agricultural sector exhibits distinctive characteristics in renewable energy financing, primarily stemming from agricultural production's seasonal nature, autonomous energy requirements, and capital acquisition challenges faced by small and medium-sized farms. The implementation of renewable energy technologies in agricultural contexts offers dual benefits: reducing electricity expenditures while enhancing energy self-sufficiency for agricultural enterprises (Luchechko & Gordiichuk, 2023). Nevertheless, financial accessibility for such initiatives remains constrained, attributable to substantial initial investment requirements and insufficient collateral mechanisms to satisfy creditor demands.

Many countries around the world have programmes to support farmers who invest in solar panels, biogas plants, or wind turbines. For example, in the European Union, there are grant programmes under the Common Agricultural Policy (CAP), which provide for reimbursement of part of the cost of building renewable energy facilities (Gorokhova *et al.,* 2023). In Ukraine, there are separate state programmes to compensate for the cost of solar power plants for farmers, but their availability and efficiency remain limited due to insufficient funding and bureaucratic procedures.

An additional significant source of finance comprises international investment funds and loans from environmental financial institutions. The European Bank for Reconstruction and Development (EBRD) (n.d.) actively endorses initiatives concerning energy efficiency and renewable energy within the agriculture sector, offering loans at preferential interest rates. The World Bank Group and the Global Environment Facility (2023) offer co-financing programmes designed to mitigate greenhouse gas emissions by modernising agricultural infrastructure.

A separate niche in financing is occupied by energy cooperatives and corporate financing, which allow farmers to combine their resources for the construction of joint renewable energy plants. This model works well in Europe, where farmers' cooperatives receive financial support from local authorities and international investors. No less promising is the use of crowdfunding platforms and private financing, when farmers raise funds from citizens or private investors through specialised online platforms. This allows small farms to implement energy projects without having to take out expensive bank loans (Kragt *et al.,* 2021).

The advancement of renewable energy within the agricultural sector presents substantial prospects for small and medium-sized agricultural enterprises (SMAE), enabling them to not only decrease energy expenses but also to generate additional revenue from the sale of surplus electricity. Nonetheless, notwithstanding the economic advantages, securing money for the execution of such projects continues to be a challenging endeavour. The high cost of equipment, long-term payback and limited access to credit resources create serious financial barriers for farmers. Financing of SMAEs in the field of renewable energy is carried out through several main mechanisms. The traditional source is bank lending, but commercial banks are usually reluctant to lend to farmers due to the seasonal nature of agribusiness and high risks. In Ukraine, there is a programme of state lending, in particular, "Affordable loans 5-7-9%", which supports the agricultural sector, but its focus on renewable energy projects is limited (Ministry of Finance…, 2023).

One of the most effective mechanisms is equipment leasing, which allows SMAEs to install solar panels, biogas plants, or wind generators without the need for significant initial investment. For example, in Germany, more than 35% of agricultural enterprises use leasing to finance renewable energy, which significantly increases their level of energy independence (REN21, 2022). In addition to bank lending, government grants and subsidies play an important role. Other EU countries have the CAP programme, which includes funding for bioenergy projects in the agricultural sector (The common agricultural..., n.d.).

PPPs are an effective mechanism for attracting funding. This model allows agricultural enterprises to implement large-scale projects in cooperation with government agencies and private investors. For example, Denmark has implemented the Green Farm Energy programme, under which the government co-finances projects for the construction of biogas plants on farms, which significantly reduces the financial burden on farmers. New opportunities are being opened up by digital financial platforms that allow raising funds directly from the public. In the Netherlands, there is a model of energy cooperatives, in which farmers combine resources to jointly invest in wind and solar power plants (Technopolis, 2023).

Thus, the specifics of financing renewable energy in the agricultural sector are determined by a number of challenges, including high initial costs, the need for state support, difficulties in attracting loans for small businesses, and the seasonal nature of farm incomes. Successful development of this area is possible only if various financial mechanisms are actively involved, in particular green bonds, energy cooperatives, crowdfunding, government grants, and digital financial solutions (Rijanto, 2021). Considering the significant potential of renewable energy in agriculture, it is essential to design innovative finance solutions to promote investment and expedite the energy transition in rural areas. The European Union occupies a prominent role in renewable energy, executing extensive programmes to diminish reliance on fossil fuels and lower greenhouse gas emissions. Table 1 presents the generation of power from renewable sources.

Table 1. Volume of electricity production from renewable sources in the EU and Ukraine for 2014-2023, thous. GWh

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
EU	750.9	762.2	775.4	778.7	838.0	869.9	954.6	960.3	978.9	1,130.2
Austria	53.3	49.8	52.4	53.9	52.3	56.7	57.5	56.0	54.7	62.8
Belgium	10.1	11.1	11.1	12.4	13.8	16.1	20.3	19.9	22.3	26.2
Bulgaria	8.3	9.5	8.1	7.1	8.4	6.6	6.8	8.2	7.5	8.3
Greece	12.2	14.7	14.7	13.6	15.9	15.8	17.3	21.8	22.2	24.2
Denmark	13.7	14.8	13.5	15.5	14.9	17.1	17.5	17.4	21.2	22.8
Spain	112.5	97.8	105.9	87.3	102.9	99.9	114.6	125.2	125.1	150.1
Italy	105.4	92.4	92.2	88.2	98.7	100.0	101.2	101.4	86.6	103.7
Netherlands	6.6	8.8	9.9	12.8	14.3	17.0	23.9	29.5	38.3	49.2
Germany	126.0	150.3	149.9	177.4	183.6	202.1	213.7	195.2	215.6	235.1
Norway	139.1	142.1	146.1	146.7	144.3	132.3	153.1	156.7	145.5	-
Poland	11.0	14.0	15.8	18.6	15.9	19.2	21.5	24.0	32.2	40.3
Portugal	30.2	23.5	31.6	22.8	28.7	26.9	29.4	30.6	28.1	36.2
Finland	14.5	19.1	18.9	19.6	19.2	18.6	24.4	24.6	25.9	31.0
France	100.0	95.7	101.6	95.6	116.4	114.4	126.1	121.8	115.8	138.9
Czech Republic	6.6	7.2	7.0	7.0	6.7	7.4	7.7	7.7	7.3	8.1
Sweden	75.3	92.0	77.9	83.0	79.3	85.9	101.1	102.7	105.3	103.7
Ukraine	11.7	10.1	12.4	13.8	15.9	14.2	16.8	-	-	-

Source: compiled by the authors based on Eurostat (2025a) and State Statistics Service of Ukraine (n.d.)

Total generation in the EU increased from 750.9 thousand GWh in 2014 to 1,130.2 thousand GWh in 2023, which indicates a stable expansion of the sector. Germany shows a particularly significant increase (from 126 to 235.1 thousand GWh), the Netherlands (from 6.6 to 49.2 thousand GWh), Poland (from 11 to 40.3 thousand GWh) and Spain (from 112.5 to 150.1 thousand GWh). In some countries, such as Bulgaria and the Czech Republic, indicators remain almost unchanged, which may indicate insufficient state support or technical restrictions. The figures generally demonstrate the vigorous advancement of renewable energy across most European nations, however, the growth rate is inconsistent. The results reveal erratic trends in the advancement of renewable energy in Ukraine. Since 2014, generation volumes have ranged from 10.1-16.8 thousand GWh, which is significantly less compared to other European countries.

The EU's policy seeks to attain climate neutrality by 2050, necessitating substantial investment in renewable energy sources. The agricultural sector is essential in this setting, serving as both a major energy consumer and a potential energy producer through biogas plants, solar panels, wind turbines, and other technologies (Perissi & Jones, 2022). Table 2 shows the consumption of electricity from renewable sources by agriculture. Such projects are financed through a multi-level support system that includes government grants, loans, tax incentives, mechanisms for attracting private investment, and digital financial solutions. Based on these tools, farmers and agricultural enterprises can obtain financial resources to implement environmentally friendly technologies that not only reduce energy costs, but also create additional sources of income.

In general, the indicators show growth until 2021, after which there is a slight decline. Total consumption in the EU increased from 27.5 thousand GWh in 2014 to a peak of 38.8 thousand GWh in 2021, after which it decreased to 36.1 thousand GWh in 2023. This may be conditioned by changes in the production structure, increased energy efficiency, or economic factors. The highest rates are traditionally shown in Germany, where consumption increased from 7.1 to 9.4 thousand GWh, which reflects the active development of agricultural renewable energy. A significant increase in consumption is observed in France (from 1.9 to 5.0 thousand GWh) and the Netherlands (from 1.8 to 4.7 thousand GWh in 2021, with a further decline). However, in some countries, such as Poland and Finland, after a period of growth, there was a decline in indicators, which may suggest a change in energy policy or optimisation of consumption. The overall trend indicates a gradual increase in the role of renewable energy in EU agriculture, although in some countries, the dynamics are unstable. As for Ukraine, from 2014 to 2020, a gradual increase in the use of renewable electricity in the agricultural sector was recorded – from 173.1 GWh in 2014 to 321.7 GWh in 2020.

Table 2. Volume of electricity consumption from renewable sources by agriculture in the EU and Ukraine in 2014-2023, GWh

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
EU	27,535.9	29,415.4	32,173.0	33,710.1	34,762.5	35,377.9	36,487.8	38,797.8	37,847.4	36,064.6
Austria	2,050.1	2,102.2	2,140.6	2,224.7	2,023.3	1,884.2	1,831.2	2,149.8	2,033.7	1,985.0
Belgium	542.4	578.6	555.8	513.5	492.8	460.6	489.8	407.5	397.4	344.3
Bulgaria	80.0	130.6	205.8	90.3	57.1	56.2	65.8	119.4	115.0	128.3
Greece	346.4	363.3	360.3	349.4	370.1	379.0	328.4	314.6	348.2	366.4

Table 2, Continued

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Denmark	621.8	632.9	641.9	632.0	634.6	628.1	610.5	660.2	638.0	638.5
Spain	873.6	833.3	801.0	810.0	830.0	831.1	829.5	828.9	856.0	833.5
Italy	433.3	583.6	587.8	591.0	580.0	619.1	611.9	880.7	864.8	795.4
Netherlands	1,783.6	2,220.8	2,372.2	2,637.8	3,241.3	4,008.0	4,418.4	4,718.8	4,631.0	3,548.9
Germany	7,078.2	7,644.1	8,092.2	8,451.0	8,879.3	8,940.0	9,510.4	9,702.4	9,619.1	9,374.4
Norway	0.9	0.5	1.0	1.4	1.0	2.8	1.9	5.8	0.9	1.7
Poland	5,455.0	5,733.6	6,064.2	6,020.0	5,859.2	5,549.2	5,677.3	6,732.6	5,500.7	5,083.8
Portugal	56.4	51.7	37.2	31.0	55.0	63.5	64.9	70.7	33.3	35.0
Finland	2,009.1	1,805.1	2,011.6	1,942.2	1,894.9	1,868.3	1,680.8	1,983.6	1,893.2	1,939.0
France	1,884.7	1,994.2	2,947.0	3,589.1	4,137.8	4,162.7	4,482.9	4,533.3	4,506.0	4,968.3
Czech Republic	1,413.3	1,436.4	1,707.5	1,626.4	1,560.6	1,550.8	1,575.0	1,782.7	1,781.9	1,764.3
Sweden	1,727.6	1,778.7	2,048.7	2,404.6	2,393.9	2,605.1	2,542.8	2,319.3	2,951.3	2,545.4
Ukraine	173.1	225.0	229.2	295.3	427.2	321.1	321.7	-	-	-

Source: compiled by the authors based on Eurostat (2025b) and State Statistics Service of Ukraine (n.d.)

One of the key sources of financing for renewable energy is European support programmes and funds, among which the Horizon Europe programme occupies a special place. It is aimed at financing research and innovation projects in the field of clean energy, in particular, supporting farms in the introduction of biogas plants, solar panels, energy storage systems, and energy saving technologies. Horizon Europe provides funds for projects that facilitate the transition to sustainable energy. The European Green Deal significantly influences finance, shaping the strategic trajectory of the EU's environmental reform efforts. This initiative funds programmes to adapt agriculture to climate change, introduce low-carbon technologies, and support farmers who invest in clean energy (Onabowale, 2025).

In addition to grant financing, EU countries actively use lending mechanisms through the European Investment Bank (EIB), which provides soft loans for the construction of solar and wind power plants in the agricultural sector. The EIB supports projects on biomethane production, modernisation of agricultural infrastructure and introduction of energy-efficient technologies. In addition, the European Strategic Investment Fund (EFSI) plays an important role, which helps to attract additional private financing for the development of renewable energy. An important component of financing is also the activities of national development banks, such as the Credit Institute for Reconstruction in Germany, Deposits and Consignments Fund in France and Deposits and Loans Fund in Italy, which provide special loans to farmers for the introduction of green technologies (Bourgeois *et al.*, 2022).

One of the most common types of renewable energy sources in the European agricultural sector is biogas plants, which allow processing agricultural waste, manure, silage, and food residues into biogas used to generate electricity, heat, or biomethane. The French government aims to elevate the proportion of renewable gases in natural gas consumption to 10% by 2030. The long-term energy plan (PPE) stipulates the injection of biomethane ranging from 14 to 22 TWh by 2028. As of the end of 2022, there were 1,705 biogas plants operating in France, of which 514 processed it into biomethane for injection into the grid. This indicates significant progress in the development of biogas technologies in the country (Bioenergy Association of Ukraine, 2024). Poland actively supports the introduction of biogas technologies in agriculture. In September 2024, the European Commission approved a EUR 1.2 billion state aid scheme for Poland to support investments in strategic sectors, including renewable energy. This scheme aims to promote the transition to a zero-net-emission economy and support projects related to biogas plants (Commission approves..., 2024).

The use of photovoltaic panels on farm roofs and farmland reduces energy costs and makes a profit from selling excess electricity to the general grid. The Netherlands is actively developing this area through the SDE++ (n.d.) programme, which provides subsidies for the installation of solar panels and guarantees farmers favourable tariffs. Due to this programme, more than 500 solar projects have been implemented in farmers' cooperatives. Solar power in Germany is experiencing a significant upswing. In 2023, about 14 gigawatts of new photovoltaic capacity were put into operation, which is equivalent to the capacity of 12-14 nuclear power units. This is an 85% increase compared to 2022. About 31% of the increase was provided by new large solar power plants built by energy companies in the fields and along autobahns. Approximately 18% of the new capacity was installed on the roofs of commercial buildings, such as factories, warehouses, and agricultural structures (Hurkov, 2024). In Germany, through the Renewable Energy Programme (Credit Institute for Reconstruction Development Bank, n.d.), agricultural producers can receive soft loans at 1.5% per annum for the installation of photovoltaic systems, and grants covering up to 40% of the cost of installing solar power plants with a capacity of up to 100 kW. France also actively supports farm solar initiatives through the The Solar Plan (n.d.) programme, within which EUR 300 million is allocated annually for subsidies for farmers who invest in photovoltaic installations.

The development of renewable energy in Ukraine has gained significant momentum as the nation pursues energy independence, economic decarbonisation, and sustainable investment attraction. Within the context of the global environmental crisis and escalating conventional energy prices, renewable energy utilisation has emerged as an area of strategic importance. Financial mechanisms warrant particular attention, as without effective funding structures, green energy implementation in Ukraine risks

remaining confined to localised initiatives without achieving the transformative impact necessary for the national energy infrastructure. E. Shahini *et al.* (2024) analysed the prospects for the development of renewable energy in Ukraine in the context of energy crises and military operations, focusing on the need to introduce new financial mechanisms to encourage investment in this area.

The Ukrainian renewable energy market is developing unevenly. Until 2020, a significant role in stimulating the industry was played by the "green tariff", which provided attractive conditions for investors. However, over time, political and economic instability, and debts to renewable energy producers, slowed down the growth dynamics. The government was forced to renegotiate the terms of support for the industry, which led to a decrease in investor interest and the search for alternative financial mechanisms (Voloshyna-Sidei *et al.,* 2023).

The attraction of investment capital into renewable energy projects in Ukraine presents significant potential through green bonds. This financial instrument facilitates capital mobilisation for environmentally sustainable initiatives, particularly the development of solar and wind power infrastructure. However, it is noteworthy that the green bond market in Ukraine remains in its nascent stages, necessitating both governmental support mechanisms and enhanced investor confidence to achieve maturity. The agricultural sector represents a critical domain for renewable energy financing in Ukraine. The country possesses considerable bioenergy development potential, given the substantial organic waste generation within its agricultural operations-materials suitable for conversion to biogas and bioethanol. Nevertheless, the financing of such initiatives encounters persistent obstacles, primarily attributable to the capital-intensive nature of necessary equipment and insufficient availability of tailored credit programmes. Agricultural producers typically face prohibitive constraints in self-financing biogas facilities or photovoltaic installations due to extended amortisation periods, which presents a significant barrier to adoption.

Addressing this issue necessitates the engagement of international financial organisations, specifically the European Bank for Reconstruction and Development, the World Bank, and other entities that actively endorse energy reforms in Ukraine. In addition, it is promising to introduce energy cooperatives that allow combining the financial resources of agricultural producers for joint production and consumption of green energy. Successful examples of such initiatives exist in Europe as of 2025, and their adaptation in Ukrainian conditions can contribute to a faster transition of the agricultural sector to renewable energy.

The integration of renewable energy into the agricultural sector is a crucial aspect of contemporary advancements in sustainable and eco-friendly technology in agriculture. This diminishes reliance on traditional energy sources, mitigates greenhouse gas emissions, and offers economic advantages for farmers. The European Union and Ukraine have executed several successful instances of renewable energy utilisation in agriculture, employing various financial models and methodologies.

RWE (2024) is one of the largest energy companies in Germany and is active in the field of renewable energy sources, in particular biogas, through its RWE Bioenergy project. This project focuses on generating energy from biogas obtained by processing organic waste such as manure, straw and crop residues produced on farms. In addition to reducing the burden on conventional energy sources, the project helps farms reduce energy costs and simultaneously improve their financial results.

One of the key areas of RWE's work is the integration of biogas plants in agricultural enterprises, which allows optimising energy consumption in rural areas. One such project, located in southern Germany, consists of several biogas plants that run on organic agricultural waste. The system uses materials produced during the agricultural cycle, such as manure, organic residues from grain processing, and straw. Due to this process, RWE biogas plants are capable of generating up to 50 MW of electrical energy. This allows meeting the energy needs of not only farmers themselves, but also surrounding rural communities, which helps to reduce dependence on external energy suppliers. In addition, the electrical energy coming from biogas plants is used to heat agricultural buildings and other facilities on farms.

The RWE Bioenergy project also contributes to the development of the local economy, as the construction and operation of biogas plants creates new jobs, both at the stage of project implementation and at the stage of their operation. Farmers and other local residents have the opportunity to get involved in such enterprises, which contributes to the development of rural areas and reduces the unemployment rate in the regions. Through the use of biogas for energy production, farmers can not only reduce energy costs, but also integrate modern technologies into their production processes. This is an important part of Germany's strategy to move towards sustainable agriculture, which actively uses renewable energy sources.

Astarta-Kyiv (n.d.) is among the major agricultural enterprises in Ukraine, specialising in the cultivation of cereals, oilseeds, and the production of sugar and various agricultural products. The corporation actively integrates advances in the energy industry, particularly through the utilisation of renewable energy sources, alongside traditional fields. These programmes seek to diminish reliance on traditional energy sources, enhance energy efficiency, and minimise the environmental impact. Astarta-Kyiv's primary focus on renewable energy is bioenergy. The corporation is actively establishing biogas facilities to convert organic waste from agricultural produce into electricity.

The company's bioenergy project provides for the creation and operation of biogas plants at its agricultural enterprises. One of these stations operates at the production facilities of Astarta in the Poltava Oblast. This station processes organic waste generated during the production of agricultural products, in particular, after processing grain and other products. The capacity of this plant allows generating up to 5 MW of electric and thermal energy for the needs of the enterprise. The installed capacity of the plant allows generating electric and thermal energy for the company's needs, which significantly reduces energy supply costs.

The implementation of the company's bioenergy projects also has a positive impact on local communities, in particular, on the economic development of rural regions. Since biogas plants require organic raw materials to operate, this provides an opportunity for cooperation with

local farms, which provides additional income for rural residents. In addition, bioenergy projects allow creating new jobs, which is important for the development of the rural economy. V. Havrysh *et al.* (2023) note that the development of bioenergy projects based on agricultural revenues requires the introduction of financial incentives, such as soft loans and "green tariffs", to attract investment and minimise risks for investors.

Successful deployment of renewable energy sources in agriculture necessitates consideration of financial risks stemming from substantial initial investments, technological uncertainty, and potential volatility in the energy market. To minimise these risks, it is necessary to carefully assess the financial stability and technical reliability of projects at the planning stage. Investors should not only count on the economic benefits of implementing such projects, but also consider the potential risks associated with possible changes in technology or market prices for energy.

Utilising public-private partnership arrangements is one of the most successful strategies for mitigating financial risks, since it facilitates the distribution of risks between public and private investors. Attracting state support in the form of subsidies, concessional loans or tax incentives provides investors with additional guarantees, which significantly reduces the impact of high initial costs and long payback periods for projects. This approach creates conditions for balancing the interests of all participants, which ensures efficient use of resources and stable development of the sector.

To further reduce risks, attention should be paid to the introduction of insurance mechanisms that help to protect investments from unexpected circumstances, such as natural disasters or changes in legislation. Insurance of investments or the use of special financial products for renewable energy sources will help to reduce financial risks and attract additional funds for the implementation of such projects. In addition, it is important to diversify sources of financing, in particular, by attracting international funds that actively support initiatives in the field of clean energy.

The last but not least step is to constantly monitor and adapt projects to changing market conditions and technologies. As the renewable energy industry is changing rapidly, it is important to have mechanisms in place to continuously analyse and adjust financial and technological strategies in line with new trends. This approach will ensure the stability and sustainable development of renewable energy projects, reducing financial risks, and maximising their efficiency.

▸ Discussion

The financing of renewable energy projects in Ukraine, especially within the agricultural sector, is essential for attaining energy independence and sustainable development. The study's findings indicate that several viable finance mechanisms are now employed in Europe, and their adoption in Ukraine could facilitate the robust advancement of renewable energy. Specifically, instruments like green bonds, energy cooperatives, crowdsourcing, and digital financial solutions can markedly diminish financial obstacles and promote investment in renewable energy sources.

A highly promising mechanism is the utilisation of green bonds. These instruments facilitate the attraction of investment to fund ecologically sustainable initiatives, namely for the development of solar, wind, and bioenergy facilities. The European experience demonstrates that green bonds not only lower capital costs through governmental guarantees but also facilitate the acquisition of international funding (Kubiczek, 2020). In Ukraine, this mechanism is just beginning to gain popularity, and its development requires the creation of favourable conditions both at the level of state policy and in the context of building confidence among investors. L. Zhao *et al.* (2022) also focused on the analysis of financing mechanisms for renewable projects through green bonds, noting that in Europe, this tool allows attracting significant investment in solar, wind, and bioenergy, reducing the cost of capital through state guarantees and opening up access to international financing.

O. Dovgal *et al.* (2024) notes that the circular economy can be effectively combined with innovative financial instruments that promote the development of renewable energy even in crisis conditions, providing comprehensive support for "green" investments. U.S. Bhutta *et al.* (2022), in turn, suggest that for its effective development, it is necessary to create favourable conditions at the level of public policy and ensure confidence among investors. This coincides with the results of the current study, which also highlighted the importance of green bonds for attracting investment in renewable energy sources, although it was noted that for their widespread implementation, several barriers, including legal and economic ones, need to be overcome.

Another important area is energy cooperatives, which allow communities and individual consumers to pool resources to finance renewable energy sources. In Ukraine, this mechanism is just beginning to develop, but it has great potential in rural areas, where the issue of energy independence is extremely important. The development of cooperatives can be an important step in decentralising energy and reducing electricity costs for the rural population. J. Jasiński *et al.* (2021) investigated the role of energy cooperatives in the development of renewable energy, in particular, on the example of rural communities. The researchers argued that energy cooperatives are an important tool for decentralising the energy system, allowing communities to create their own energy sources and reduce energy costs. T. Bauwens *et al.* (2020) suggest that such cooperatives can become particularly effective in rural areas, where access to centralised energy resources is limited and energy independence is of great importance. This approach can reduce electricity costs for the rural population, although there is a need to improve the legal framework and the existence of investment barriers.

Crowdfunding is another promising tool for attracting financing for renewable energy projects, in particular, for small projects that cannot receive traditional bank lending. The transparency of crowdfunding platforms, the speed of fundraising, and involvement of a wide range of investors make this mechanism particularly attractive for projects in the renewable energy sector. In Western Europe, there are specialised platforms for financing solar projects, and this experience can be adapted in Ukraine. I. Appiah-Otoo *et al.* (2022) investigated the use of

crowdfunding to raise funds for small renewable energy projects, in particular, for solar and bioenergy installations, which allows small agricultural enterprises and citizens to implement energy projects without having access to conventional financing. The researchers emphasised the speed of fundraising through crowdfunding platforms, and the broad involvement of investors from different regions. This coincides with current findings, which also identified crowdfunding as an important tool for supporting small projects in the renewable energy sector, especially in the agricultural sector, where conventional funding is limited.

Digital financial solutions, such as blockchain technologies and smart contracts, can play a significant role in financing renewable energy sources, which ensure transparency of transactions, automate financial obligations, and reduce the risk of fraud. This opens up new opportunities for investors and project developers to interact without intermediaries, such as banks, which significantly reduces project implementation costs. P. Vionis & T. Kotsilieris (2024) explored the role of digital financial technologies, such as blockchain and smart contracts, in financing renewable energy projects, noting that these technologies can significantly reduce costs and increase the transparency of financial transactions, while reducing the risk of fraud. P. Zhao *et al.* (2022), in turn, noted that digital tools open up new opportunities for farms that do not have access to conventional financing, providing them with transparent and accessible mechanisms for attracting investment.

In agriculture, renewable energy can be a powerful driver for reducing energy costs and increasing energy independence (Havrysh *et al.*, 2022). This is especially important for farmers who have limited access to funding for the introduction of solar panels or biogas plants. Government support in the form of subsidies and soft loans, and international funding from institutions such as the EBRD and the World Bank, can play an important role in this. A.T. Hoang *et al.* (2021) emphasised that such funding is important for reducing the initial cost of renewable energy plants, which is especially important for small farms. These findings coincide with the conclusions of the current study, and the importance of state support for stimulating the transition to renewable energy sources was also emphasised. However, more attention has been paid to innovative financial mechanisms such as green bonds, rather than just conventional subsidies.

However, as the experience of Ukraine shows, the introduction of financial mechanisms to support renewable energy faces certain difficulties. High initial costs for renewable energy plants, an unstable legal framework and a lack of long-term funding are the main obstacles to the development of this area (Andreitsev *et al.*, 2024). In addition, it is necessary to solve the issues of bureaucratic procedures and create more attractive conditions for investors. T.S. Kabel & M. Bassim (2020) investigated barriers to the development of renewable energy, in particular, the economic and legal factors that slow down this process. High initial costs for renewable energy plants, an unstable legal framework, and difficulties in obtaining long-term funding are the main obstacles that need to be overcome to achieve sustainable development in this industry. The present article identifies these obstacles, indicating that legal and economic instability are the primary reasons constraining the advancement of renewable energy. Consequently, the present results align with the researcher's conclusions, but the current study emphasised financial methods that may assist in surmounting these obstacles.

▸ Conclusions

The results showed that progress in the use of renewable energy sources in EU countries, in particular, in Germany, Poland, Spain, the Netherlands, and France, is significant. In particular, in the EU, electricity production from renewable sources increased from 750.9 thousand GWh in 2014 to 1,130.2 thousand GWh in 2023, which indicates the sustainable development of this sector. However, Ukraine is experiencing slow growth, where electricity production from renewable sources remained in the range of 10.1-16.8 thousand GWh from 2014 to 2020. Such a difference in the pace of development between Ukraine and the EU may be conditioned not only by technical and economic barriers, but also by insufficient state support and limited access to funding. An important segment is the financing of renewable energy in agriculture. Given the seasonality of agricultural production and the specific needs for autonomous energy solutions, agriculture faces difficulties in financing renewable energy projects due to high start-up costs. Government subsidies and concessional lending are important support mechanisms. However, for small and medium-sized farms, these mechanisms are not available due to limited funding and bureaucratic obstacles.

Total consumption of renewable energy by agriculture in the EU increased from 27.5 thousand GWh in 2014 to a peak of 38.8 thousand GWh in 2021, after which it decreased to 36.1 thousand GWh in 2023. In Ukraine, from 2014 to 2020, a gradual increase in the use of renewable electricity in the agricultural sector was also recorded – from 173.1 GWh in 2014 to 321.7 GWh in 2020. The mechanisms of financing renewable energy in the agricultural sector of EU countries, in particular Germany, France, Poland, and the Netherlands, were analysed. The experience of these countries demonstrates that an effective combination of financial incentives, such as subsidies, tax breaks, and auction mechanisms, contributes to the development of sustainable energy in agriculture, reducing greenhouse gas emissions and increasing the energy independence of farms. The research demonstrated that the implementation of renewable energy in the agricultural sector, exemplified by RWE in Germany and Astarta-Kyiv in Ukraine, serves as an effective mechanism for enhancing energy efficiency, diminishing reliance on conventional energy sources, and lowering greenhouse gas emissions. Further research may include expanding the analysis to other regions and evaluating the effectiveness of various financial mechanisms at the national level.

▸ Acknowledgements

None.

▸ Funding

None.

▸ Conflict of interest

None.

References

[1] Andreitsev, V., Moroz, V., Shuvar, A., Pugachov, V., & Sliusarchuk, O. (2024). Exploring opportunities for renewable energy adoption in business operations: Enhancing emission reduction and climate resilience. *Multidisciplinary Reviews*, 7, article number e2024spe002. doi: 10.31893/multirev.2024spe002.

[2] Appiah-Otoo, I., Song, N., Acheampong, A.O., & Yao, X. (2022). Crowdfunding and renewable energy development: What does the data say? *International Journal of Energy Research*, 46(2), 1837-1852. doi: 10.1002/er.7301.

[3] Astarta-Kyiv. (n.d.). Retrieved from https://astartaholding.com/.

[4] Bauwens, T., Huybrechts, B., & Dufays, F. (2020). Understanding the diverse scaling strategies of social enterprises as hybrid organizations: The case of renewable energy cooperatives. *Organization & Environment*, 33(2), 195-219. doi: 10.1177/1086026619837126.

[5] Berg, K. (2023). *Generating green electricity collaboratively*. Retrieved from https://www.deutschland.de/en/topic/environment/energy-transformation-in-the-hands-of-the-people-green-power-in-germany.

[6] Bhutta, U.S., Tariq, A., Farrukh, M., Raza, A., & Iqbal, M.K. (2022). Green bonds for sustainable development: Review of literature on development and impact of green bonds. *Technological Forecasting and Social Change*, 175, article number 121378. doi: 10.1016/j.techfore.2021.121378.

[7] Bourgeois, M., *et al.* (2022). *City climate finance: Landscape, barriers and best practices*. Retrieved from https://netzerocities.eu/wp-content/uploads/2023/11/D7.1-City-climate-finance.pdf.

[8] Commission approves €1.2 billion Polish state aid scheme to support investments in strategic sectors to foster the transition to a net-zero economy. (2024). Retrieved from https://surl.li/anvinx.

[9] Credit Institute for Reconstruction Development Bank. (n.d.). *Renewable Energy Programme*. Retrieved from https://www.kfw-entwicklungsbank.de/Evaluierungsbericht/Evaluierungen/Programm-zur-F%C3%B6rderung-erneuerbarer-Energien/index-2.html.

[10] Desyatnyuk, O., Naumenko, M., Lytovchenko, I., & Beketov, O. (2024). Impact of digitalization on international financial security in conditions of sustainable development. *Eco-development Problems*, 19(1), 104-114. doi: 10.35784/preko.5325.

[11] Dovgal, O., Potryvaieva, N., Bilichenko, O., & Kuzoma, V. (2024). Circular economy development in the context of war: Global challenges. *Interdisciplinary Journal of Applied Science*, 8(13). doi: 10.18226/25253824.v8.n13.04.

[12] Egli, F. (2020). Renewable energy investment risk: An investigation of changes over time and the underlying drivers. *Energy Policy*, 140, article number 111428. doi: 10.1016/j.enpol.2020.111428.

[13] European Bank for Reconstruction and Development. (n.d.). *Energy*. Retrieved from https://www.ebrd.com/energy.html.

[14] Eurostat. (2025a). *Gross and net production of electricity and derived heat by type of plant and operator*. doi: 10.2908/NRG_IND_PEH.

[15] Eurostat. (2025b). *Simplified energy balances*. doi: 10.2908/NRG_BAL_S.

[16] Fatima, N., Li, Y., Ahmad, M., Jabeen, G., & Li, X. (2021). Factors influencing renewable energy generation development: A way to environmental sustainability. *Environmental Science and Pollution Research*, 28, 51714-51732. doi: 10.1007/s11356-021-14256-z.

[17] Bioenergy Association of Ukraine. (2024). *French biomethane sector: Features and development*. Retrieved from https://uabio.org/en/materials/16730/?utm.

[18] Gajdzik, B., Jaciow, M., Wolniak, R., Wolny, R., & Grebski, W.W. (2024). Diagnosis of the development of energy cooperatives in Poland – a case study of a renewable energy cooperative in the upper Silesian Region. *Energies*, 17(3), article number 647. doi: 10.3390/en17030647.

[19] Gorokhova, T., Shpatakova, O., Toponar, O., Zolotarova, O., & Pavliuk, S. (2023). Circular economy as an alternative to the traditional linear economy: Case study of the EU. *Revista De Gestão Social E Ambiental*, 17(5), article number e03385. doi: 10.24857/rgsa.v17n5-002.

[20] Hurkov, A. (2024). *Solar energy boom to continue in Germany into 2024*. Retrieved from https://www.dw.com/uk/bum-sonacnoi-energetiki-trivatime-u-nimeccini-j-u-2024-roci/a-67882474?utm.

[21] Havrysh, V., Kalinichenko, A., Pysarenko, P., & Samojlik, M. (2023). Sunflower residues-based biorefinery: Circular economy indicators. *Processes*, 11(2), article number 630. doi: 10.3390/pr11020630.

[22] Havrysh, V., Nitsenko, V., & Hruban, V. (2022). Sorghum-based power generation in Southern Ukraine: Energy and environmental assessment. *Agriculture*, 12(12), article number 2148. doi: 10.3390/agriculture12122148.

[23] Hoang, A.T., *et al.* (2021). Impacts of COVID-19 pandemic on the global energy system and the shift progress to renewable energy: Opportunities, challenges, and policy implications. *Energy Policy*, 154, article number 112322. doi: 10.1016/j.enpol.2021.112322.

[24] International Energy Agency (IEA). (n.d.). Retrieved from https://www.iea.org/.

[25] Jain, K., Gangopadhyay, M., & Mukhopadhyay, K. (2024). Prospects and challenges of green bonds in renewable energy sector: Case of selected Asian economies. *Journal of Sustainable Finance & Investment*, 14(3), 708-731. doi: 10.1080/20430795.2022.2034596.

[26] Jasiński, J., Kozakiewicz, M., & Sołtysik, M. (2021). Determinants of energy cooperatives' development in rural areas – evidence from Poland. *Energies*, 14(2), article number 319. doi: 10.3390/en14020319.

[27] Kabel, T.S., & Bassim, M. (2020). Reasons for shifting and barriers to renewable energy: A literature review. *International Journal of Energy Economics and Policy*, 10(2), 89-94.

[28] Khalegi, F., Kadyraliev, A., Tursunalieva, D., Orozbekov, A., & Bigali, A. (2024). Blockchain and sustainable finance: Enhancing transparency and efficiency in green investments. *Scientific Bulletin of Mukachevo State University. Series "Economics"*, 11(3), 125-137. doi: 10.52566/msu-econ3.2024.125.
[29] Kostyrko, L., Kostyrko, R., Zaitseva, L., Solomatina, T., & Lubenchenko, O. (2024). Public-Private Partnership as a tool for financial support of the energy sector in Ukraine: Analysis, mechanism, financial reporting. *Financial and Credit Activity Problems of Theory and Practice*, 2(55), 180-198. doi: 10.55643/fcaptp.2.55.2024.4285.
[30] Kragt, M.E., Burton, R., Zahl-Thanem, A., & Otte, P.P. (2021). Farmers' interest in crowdfunding to finance climate change mitigation practices. *Journal of Cleaner Production*, 321, article number 128967. doi: 10.1016/j.jclepro.2021.128967.
[31] Kubiczek, J. (2020). Corporate bond market in Poland – prospects for development. *Journal of Risk and Financial Management*, 13(12), article number 306. doi: 10.3390/jrfm13120306.
[32] Kurbatova, T., Sotnyk, I., Kubatko, O., Baranchenko, Y., Arakpogun, E.O., & Roubik, H. (2021). State support policy for renewable energy development in emerging economies: The case of Ukraine. *International Journal of Global Environmental Issues*, 19(1-3), 26-52. doi: 10.1504/IJGENVI.2020.114864.
[33] Luchechko, Yu., & Gordiichuk, A. (2023). Regional trends and priorities of agricultural business development in Ukraine during the war. *Economic Forum*, 13(3), 22-28. doi: 10.36910/6775-2308-8559-2023-3-3.
[34] Ministry of Energy of Ukraine. (n.d.). Retrieved from https://www.mev.gov.ua/en/home.
[35] Ministry of Finance: During the martial law period, 42,847 preferential loans worth UAH 170.5 billion were issued within the framework of the State Program "Affordable Loans 5-7-9%". (2023). Retrieved from https://www.mof.gov.ua/uk/news/minfin_za_chas_dii_voiennogo_stanu_v_mezhakh_derzhavnoi_programi_dostupni_krediti_5-7-9_vidano_42847_pilgovikh_kreditiv_na_1705_mlrd_grn-4345.
[36] Mukherjee, A., Griffiths, P., Sinha, P., & Deol, S. (2024). Finance for sustainability: A systematic review on crowdfunding for renewable energy projects. *Review of Financial Economics*, 42(4), 467-490. doi: 10.1002/rfe.1211.
[37] Onabowale, O. (2025). Energy policy and sustainable finance: Navigating the future of renewable energy and energy markets. *World Journal of Advanced Research and Reviews*, 25(1), 2235-2252. doi: 10.30574/wjarr.2025.25.1.0319.
[38] Perissi, I., & Jones, A. (2022). Investigating European Union decarbonization strategies: Evaluating the pathway to carbon neutrality by 2050. *Sustainability*, 14(8), article number 4728. doi: 10.3390/su14084728.
[39] Rats, O., & Alfimova, A. (2023). Green bonds as a perspective financial instrument for bank investment in Ukraine. *Development Management*, 22(1), 8-18. doi: 10.57111/devt/1.2023.08.
[40] Razzaq, A., Sharif, A., Ozturk, I., & Skare, M. (2023). Asymmetric influence of digital finance, and renewable energy technology innovation on green growth in China. *Renewable Energy*, 202, 310-319. doi: 10.1016/j.renene.2022.11.082.
[41] REN21. (2022). *Renewables 2022 global status report*. Retrieved from https://www.ren21.net/wp-content/uploads/2019/05/GSR2022_Full_Report.pdf.
[42] Rijanto, A. (2021). Business financing and blockchain technology adoption in agroindustry. *Journal of Science and Technology Policy Management*, 12(2), 215-235. doi: 10.1108/JSTPM-03-2020-0065.
[43] RWE. (2024). *Better energy for a better future. Annual report 2024*. Retrieved from https://www.rwe.com/-/media/RWE/documents/05-investor-relations/finanzkalendar-und-veroeffentlichungen/2024-gj/2025-03-20-rwe-annual-report-2024.pdf.
[44] Sarkodie, S.A., Adams, S., & Leirvik, T. (2020). Foreign direct investment and renewable energy in climate change mitigation: Does governance matter? *Journal of Cleaner Production*, 263, article number 121262. doi: 10.1016/j.jclepro.2020.121262.
[45] SDE++: Grant for renewable energy and CO_2 reducing technologies in the Netherlands. (n.d.). Retrieved from https://www.egen.green/grants/sde/.
[46] Shahini, E., Fedorchuk, M., Hruban, V., Fedorchuk, V., & Sadovoy, O. (2024). Renewable energy opportunities in Ukraine in the context of blackouts. *International Journal of Environmental Studies*, 81(1), 125-133. doi: 10.1080/00207233.2024.2320021.
[47] Shebanina, V., Kormyshkin, A., Kliuchnyk, V., Reshetilov, G., & Zhebko, O. (2024). Management of sustainable land use projects in accordance with EU requirements. *Scientific Horizons*, 27(10), 148-161. doi: 10.48077/scihor10.2024.148.
[48] State Statistics Service of Ukraine. (n.d.). Retrieved from https://www.ukrstat.gov.ua/.
[49] Technopolis. (2023). Netherlands. In *Energy communities* (pp. 95-102). Oslo: Nordic Energy Research.
[50] The common agricultural policy at a glance. (n.d.). Retrieved from https://surl.lu/ptmspl.
[51] The Solar Plan: Increasing the share of renewable energy in total electricity production to 30%. (n.d.). Retrieved from https://www.giz.de/en/worldwide/61321.html.
[52] Vásquez-Ordóñez, L.R., Lassala, C., Ulrich, K., & Ribeiro-Navarrete, S. (2023). Efficiency factors in the financing of renewable energy projects through crowdlending. *Journal of Business Research*, 155(B), article number 113389. doi: 10.1016/j.jbusres.2022.113389.
[53] Vionis, P., & Kotsilieris, T. (2024). The potential of blockchain technology and smart contracts in the energy sector: A review. *Applied Sciences*, 14(1), article number 253. doi: 10.3390/app14010253.
[54] Voloshyna-Sidei, V., Ievsieieva, O., Maslyhan, O., Syrtseva, S., Nesterenko, O., & Harkusha, S. (2023). Strategic guidelines for the development of the economy in the conditions of global challenges and military aggression (Ukrainian case). *Financial and Credit Activity Problems of Theory and Practice*, 1(48), 219-228. doi: 10.55643/fcaptp.1.48.2023.3942.

[55] World Bank Group and the Global Environment Facility. (2023). Retrieved from https://www.worldbank.org/en/topic/environment/brief/world-bank-group-and-the-global-environment-facility.
[56] World Bank Group. (n.d.). Retrieved from https://www.worldbank.org/ext/en/home.
[57] Yankovoy, R. (2024). Innovation financing models in the Ukrainian business environment. *Development Service Industry Management*, 1, 82-87. doi: 10.31891/dsim-2024-5(11).
[58] Ye, X., & Rasoulinezhad, E. (2023). Assessment of impacts of green bonds on renewable energy utilization efficiency. *Renewable Energy*, 202, 626-633. doi: 10.1016/j.renene.2022.11.124.
[59] Zhang, X., Wang, Z., Zhong, X., Yang, S., & Siddik, A.B. (2022). Do green banking activities improve the banks' environmental performance? The mediating effect of green financing. *Sustainability*, 14(2), article number 989. doi: 10.3390/su14020989.
[60] Zhao, L., Chau, K.Y., Tran, T.K., Sadiq, M., Xuyen, N.T.M., & Phan, T.T.H. (2022). Enhancing green economic recovery through green bonds financing and energy efficiency investments. *Economic Analysis and Policy*, 76, 488-501. doi: 10.1016/j.eap.2022.08.019.
[61] Zhao, P., Zhang, W., Cai, W., & Liu, T. (2022). The impact of digital finance use on sustainable agricultural practices adoption among smallholder farmers: An evidence from rural China. *Environmental Science and Pollution Research*, 29, 39281-39294. doi: 10.1007/s11356-022-18939-z.

Інноваційні фінансові інструменти для стимулювання розвитку відновлювальної енергетики

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▸ **Анотація.** У цьому дослідженні були розглянуті сучасні фінансові механізми та інструменти, які сприяють інвестиціям у сектори відновлюваної енергетики. Методологія дослідження включала статистичний аналіз даних про виробництво та споживання електроенергії з відновлюваних джерел у Європейському Союзі та Україні. Результати дослідження продемонстрували, що в Європейському Союзі спостерігається значне зростання виробництва електроенергії з відновлюваних джерел, в першу чергу завдяки ефективним стратегіям залучення інвестицій. На противагу цьому, Україна демонструє непослідовні моделі розвитку сектору відновлюваної енергетики. Аналіз підкреслив взаємозв'язок між надійною фінансовою базою та успішним впровадженням відновлюваної енергетики. У той час як Європейський Союз впровадив узгоджені механізми, що дають очевидні результати, ландшафт відновлюваної енергетики в Україні відображає наслідки менш стабільної фінансової інфраструктури. Загальна генерація в Європейському Союзі зросла з 750,9 тис. ГВт-год у 2014 році до 1130,2 тис. ГВт-год у 2023 році, що свідчить про стабільне розширення сектору. Найбільш перспективними фінансовими інструментами стали зелені облігації, які дозволяють залучати значні капітальні інвестиції в екологічні проекти, та енергетичні кооперативи, що сприяють децентралізації енергетики та розвитку місцевих громад. Проаналізовано механізми фінансування відновлюваної енергетики в аграрному секторі країн Європейського Союзу, зокрема Німеччини, Франції, Польщі та Нідерландів. Досліджено впровадження відновлюваної енергетики в аграрному секторі на прикладі компаній RWE (Німеччина) та «Астарта-Київ» (Україна). Показано, що державні субсидії, пільгове кредитування, міжнародні інвестиції та механізми корпоративного фінансування відіграли важливу роль у подоланні бар'єрів. Забезпечення сталого фінансування відновлюваної енергетики в Україні потребує комплексного підходу, включаючи активне залучення державних, приватних та міжнародних інвестицій

▸ **Ключові слова:** альтернативні джерела; екологічна стійкість; інвестиційні механізми; державне регулювання; кліматична політика