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GREEN INVESTMENTS AS FINANCIAL FLOWS AND INSTRUMENTS FOR ENERGY MODERNIZATION OF THE UKRAINIAN ECONOMY IN THE CONTEXT OF POST-WAR RECOVERY

Abstract. *This article examines the theoretical, methodological, and practical foundations of green investment as a key driver of the ecological transformation of the national economy. The relevance of the study is due to the need to modernize Ukraine's energy sector, which has suffered extensive damage as a result of the full-scale war. The article analyzes the nature and structure of the international capital market, where green investments are regarded as targeted financial flows aimed at decarbonization and the deployment of low-carbon technologies. It is demonstrated that the modernization of the energy sector in the context of post-war recovery should be based on the principles of the European Green Deal and sustainable development. The study provides a comprehensive analysis of the dynamics, composition, and structure of investments in Ukraine's renewable energy sector by funding source during 2022-2025. Structural shifts in the investment climate are identified, particularly the declining role of bank lending and the increasing importance of international financial institutions. Particular attention is paid to the main forms of international cooperation in the field of green investment during 2024-2025. The findings indicate that the integration of innovative financing instruments, including green bonds and ESG investment mechanisms, contributes to risk diversification and enhances investment attractiveness. Based on an analysis of financial flows into the renewable energy sector, a mechanism for stimulating capital investment through the expansion of public-private partnership models is proposed. Such an approach would reduce risks for donors and investors, mobilize domestic financial resources, and ensure the long-term sustainability and independence of Ukraine's energy system. The study substantiates that the effective application of green financing mechanisms can transform green investments into a powerful instrument for the energy modernization of Ukraine's economy during post-war reconstruction, while strengthening the country's energy independence and environmental security.*

Keywords: green investment, ESG investment instruments, financial investment, green bonds, sustainable development, public-private partnerships, financial flows, renewable energy, post-war recovery, energy modernization of the economy.

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ЗЕЛЕНІ ІНВЕСТИЦІЇ ЯК ФІНАНСОВІ ПОТОКИ ТА ІНСТРУМЕНТИ ЕНЕРГЕТИЧНОЇ МОДЕРНІЗАЦІЇ ЕКОНОМІКИ УКРАЇНИ В УМОВАХ ПОВОЄННОГО ВІДНОВЛЕННЯ

Анотація. У статті досліджено теоретико-методологічні та прикладні засади залучення зеленого інвестування як провідного драйвера екологічної трансформації національної економіки. Актуальність дослідження зумовлена необхідністю технологічного переозброєння вітчизняного енергетичного сектору, який зазнав суттєвих руйнувань внаслідок повномасштабних воєнних дій. Проаналізовано сутність та структуру міжнародного ринку капіталу, де зелені інвестиції розглядаються як цільові фінансові потоки, спрямовані на декарбонізацію та впровадження низьковуглецевих технологій. Доведено, що енергетична модернізація економіки в умовах повоєнного відновлення має відбуватися виключно на принципах Європейського зеленого курсу та концепції сталого розвитку. Комплексно досліджено динаміку складу та структури інвестицій у відновлювану енергетику України за джерелами фінансування впродовж 2022-2025 рр. Виявлено структурні зрушення в інвестиційному кліматі, спричинені зниженням частки банківського кредитування та зростанням ролі міжнародних фінансових інституцій. Зокрема, проаналізовано види міжнародного співробітництва за 2024-2025 рр. Показано, що інтеграція інноваційних інструментів, таких як зелені облігації та інструменти ESG-інвестування, дозволяє диверсифікувати ризики. На основі аналізу фінансових потоків у сектор, яким є відновлювана енергетика, запропоновано механізм активізації капіталовкладень через розширення моделей, на яких базується державно-приватне партнерство. Це дозволить мінімізувати ризики для донорів, мобілізувати внутрішні фінансові інвестиції та забезпечити довгострокову стійкість і незалежність енергетичної системи України. Обґрунтовано, що ефективне використання фінансового механізму дозволить перетворити зелені інвестиції на дієві фінансові потоки та інструменти енергетичної модернізації економіки України в умовах повоєнного відновлення, гарантуючи її енергетичну незалежність та екологічну безпеку.

Ключові слова: зелене інвестування, інструменти ESG-інвестування, фінансові інвестиції, зелені облігації, сталий розвиток, державно-приватне партнерство, фінансові потоки, відновлювана енергетика, повоєнне відновлення, енергетична модернізація економіки.

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Formulation of the problem. In the current context of global climate change, green investment has become increasingly important as one of the key instruments for achieving sustainable development. Rising environmental risks, stricter decarbonization requirements, and the need to meet sustainable development goals are driving the allocation of investment resources toward renewable energy projects, energy efficiency initiatives, and the environmental modernization of the economy. In the countries of the European Union, green investment has already become an important component of economic policy and a mechanism for implementing the objectives of the European Green Deal, which sets strategic development priorities for the coming decades.

For Ukraine, the issue of attracting green investment is particularly relevant in the context of martial law and the future post-war reconstruction process. Extensive damage to energy infrastructure, the need to diversify energy supply sources, and the necessity of strengthening energy security require substantial financial resources and the implementation of modern financing mechanisms. At the same time, the development of the renewable energy sector is viewed not only as a means of ensuring the country's energy independence but also as an important driver of economic growth, job creation, and Ukraine's integration into the European economic area.

Despite its significant natural potential for the development of solar, wind, and bioenergy, the process of

attracting green investment in Ukraine remains insufficiently effective. The main barriers include a high level of investment risk, shortcomings in government support mechanisms, limited access to international financial resources, and the underdevelopment of the green finance market. In this regard, examining the current state of green investment in Ukraine's renewable energy sector and identifying strategic directions for its expansion in line with global energy transition trends has become particularly important. The need to establish an effective system for attracting green capital highlights the importance of further research in this field and the development of practical recommendations aimed at improving its effectiveness.

Despite the significant natural potential for the development of solar, wind, and bioenergy, the process of attracting green investment in Ukraine remains insufficiently effective. Among the main constraints are high investment risks, imperfect state support mechanisms, limited access to international financial resources, and insufficient development of the market for green financial instruments. In this regard, it is particularly important to study the current state of green investment in Ukraine's renewable energy sector and to identify strategic directions for its revitalization in line with global trends in the energy transition. The need to establish an effective system for attracting green capital necessitates further scientific research in this field and the development of practical recommendations for its improvement.

Analysis of recent research and publications. The issue of green investment and the financing of environmentally sustainable economic development has attracted considerable attention from both domestic and international scholars. In contemporary economic literature, green investment is widely regarded as an important instrument for achieving sustainable development goals, reducing greenhouse gas emissions, and promoting the structural modernization of national economies. Particular attention is devoted to the study of financing mechanisms for renewable energy projects, the development of green bond markets, and the integration of Environmental, Social, and Governance (ESG) principles into investment activities.

The theoretical and methodological foundations of green investment have been examined in the works of Blavt A. and Bondarenko L. [1], who investigate the essence of green investment, the characteristics of investment flows, and their contribution to sustainable economic development. Significant contributions to the development of methodological approaches for assessing the effectiveness of environmentally oriented investments have been made by Turianska M. M. [6], Chugunov I. Ya., Kaneva T. V., Lyubchak I. S. [7], and other scholars. Their studies emphasize the importance of integrating environmental criteria into financial management systems and state investment policy.

Specific aspects of attracting investment to Ukraine's renewable energy sector have been explored in the works of Rushchyshyn N. M., Hrytsak O. S., Nohinova N. M. [5], Horbach V. [3], and other researchers. These studies highlight the need to create a favorable institutional environment for the development of renewa-

ble energy, improve state support mechanisms, and expand cooperation with international financial institutions. Recent research has also focused on the role of green bonds, climate funds, and other financial instruments in facilitating Ukraine's energy transition [4] and post-war reconstruction.

The conceptual conclusions of researchers Medynska T. V., Loboda N. O., and others [11] regarding the optimization of environmental taxation are crucial in the context of green investing as a component of Ukraine's energy modernization and post-war economic recovery. These processes must be implemented in accordance with modern environmental standards and require comprehensive technological modernization based on the principles of the European Green Deal and energy efficiency.

Despite the substantial body of academic literature on this topic, the formation of a comprehensive green investment system under conditions of wartime challenges and post-war recovery remains insufficiently explored. Further research is required to examine trends in attracting green investment to the renewable energy sector, assess its effectiveness under current conditions, and identify strategic development priorities in accordance with global energy transition trends and European Union requirements.

The purpose of the article. The purpose of this article is to substantiate the theoretical and methodological foundations and to develop practical recommendations for enhancing the attraction of green investments as strategic financial flows and instruments for the energy modernization of Ukraine's economy in the context of post-war recovery.

Presentation of the main research material. The global green investment market has demonstrated a steady growth trend. By the end of 2025, the total volume of green bonds in circulation exceeded USD 2.5 trillion, indicating a systematic reallocation of international capital toward environmentally sustainable assets. In the context of the full-scale Russian invasion that began in February 2022, these global trends have acquired particular significance for Ukraine, as green investment has become not only an environmental policy instrument but also a practical mechanism for strengthening energy security and facilitating the structural transformation of the national economy.

Systematic attacks on the country's energy infrastructure, with total damage estimated at USD 20.5 billion by the end of 2024, have created the conditions for a fundamental modernization of the energy sector. Rather than restoring an outdated centralized system characterized by coal-fired power generation and dependence on imported fuels, Ukraine has a unique opportunity to develop a modern, decentralized, and resilient energy system based on renewable energy sources and integrated into the European Union's Single Energy Market.

However, a substantial gap remains between the country's existing potential and the actual level of capital inflows. Bridging this gap requires not only international financial support but also a comprehensive understanding of the functioning of green financing mechanisms and the factors that continue to limit their effectiveness in Ukraine.

In the current economic environment, attracting investment has become particularly important for Ukraine, as investment serves as a key driver of economic growth and contributes to increasing the country's real GDP. In its broadest sense, investment is defined as the allocation of capital to business ventures and other economic activities with the objective of generating profit or achieving social benefits. According to the World Bank, investment refers to the allocation of capital with the expectation of generating future income or creating a positive social impact [1]. The Organization for Economic Co-operation and Development (OECD) emphasizes that investment activity is a key mechanism for the structural transformation of an economy and the enhancement of its competitiveness [2].

Green investment represents a relatively new yet increasingly important instrument for economic modernization in the context of global environmental challenges and climate change. The United Nations Environment Programme (UNEP) defines green investment as the targeted allocation of capital to projects and technologies that generate positive environmental outcomes, contribute to the reduction of greenhouse gas emissions, and promote the sustainable use of natural resources. The European Commission characterizes green investment as financial flows directed toward achieving climate neutrality and supporting the transition to a circular economy.

Unlike conventional investments, which are primarily aimed at maximizing financial returns, green investment seeks to achieve a dual objective: generating economic value while delivering positive environmental outcomes. This fundamental distinction determines the specific approach to evaluating the effectiveness of green investment projects, which must take into account not only financial performance indicators but also environmental and social impacts.

The key characteristics of green investment include its focus on achieving sustainable development goals, promoting the adoption of environmentally friendly and energy-efficient technologies, a long-term payback period, and the generation of positive societal externalities. Green investment is also characterized by the requirement to comply with international environmental standards, ensure transparency in environmental reporting, and participate in green project certification schemes.

International practice has established clear criteria for identifying green investment activities. The EU Taxonomy defines six environmental objectives: climate change mitigation; climate change adaptation; the sustainable use and protection of water and marine resources; the transition to a circular economy; pollution prevention and control; and the protection and restoration of biodiversity and ecosystems. An investment is considered green if it makes a substantial contribution to at least one of these objectives while causing no significant harm to the others.

Green investment is a component of the ESG investment concept, which incorporates environmental, social, and governance criteria into the investment decision-making process. The United Nations Principles for Responsible Investment (UN PRI), endorsed by more than 5,000 institutional investors managing assets exceeding

USD 120 trillion, require the integration of ESG factors into investment analysis, active engagement with companies regarding environmental practices, and transparent reporting on portfolio ESG performance.

Green bonds are currently the most standardized and scalable instrument for raising capital for environmentally sustainable projects. According to the International Capital Market Association (ICMA), a green bond is a debt instrument whose proceeds are exclusively allocated to the financing or refinancing of projects that generate positive environmental outcomes. The fundamental distinction between green bonds and conventional corporate bonds lies not only in the earmarked use of proceeds but also in the requirement to provide transparent reporting on the environmental impacts of the financed projects.

Among the principal financial instruments of green investment are green bonds and climate funds. By 2024, the global green bond market had exceeded USD 2.5 trillion. Climate funds are specialized financial mechanisms that mobilize resources for projects aimed at climate change mitigation and adaptation. The largest of these are the Green Climate Fund, which has mobilized more than USD 10 billion, and the Adaptation Fund. [10].

International practice has established four key requirements: the targeted use of funds exclusively for verified environmental projects; a transparent process for project selection and evaluation in accordance with established criteria; effective management of proceeds through segregated accounts or monitoring systems; and regular reporting on environmental impacts achieved in quantitative terms, including CO₂ emission reductions, energy savings, and installed capacity.

It is important to recognize that green bonds are not merely “environmentally labelled” debt instruments. They operate within a broader institutional ecosystem that includes the EU Taxonomy, ESG rating agencies, independent verifiers, and institutional investors that are required to maintain a specified share of green assets in their portfolios. It is precisely this institutional framework that generates demand for such securities even when their yields do not exceed those of conventional bonds issued by the same issuer. This phenomenon is commonly referred to as the “green premium”, or greenium, which often ranges from 5 to 15 basis points in favor of green securities.

For Ukraine, access to the green bond market remains more of a future opportunity than a current reality. To date, Ukraine has not issued any sovereign green bonds, although several Ukrainian banks – most notably Ukrgasbank – have gained experience in implementing green lending programs within the framework of EBRD initiatives [12]. A key systemic challenge is the absence of a nationally verified green taxonomy aligned with EU standards, which would enable Ukrainian issuers to obtain independent confirmation of the environmental status of their financial instruments. Without such a framework, accessing the institutional capital markets of London, Luxembourg, or Amsterdam with a competitive financial product remains highly challenging.

At the same time, the experience of neighboring countries demonstrates that this path is entirely feasible.

Poland became the first country in the world to issue a sovereign green bond in 2016, raising EUR 750 million [12]. Hungary, the Czech Republic, and Romania have also successfully issued similar instruments, thereby establishing a stable source of financing for climate-related programs over a period of 7-15 years. For Ukraine, such experience carries significant practical importance. The issuance of a sovereign green bond after the active phase of the war would serve as a powerful signal to international financial markets of the country's commitment to and readiness for a systemic green transformation.

In the absence of this conventional financial instrument, the domestic investment climate continues to adapt to the conditions of martial law. In particular, an analysis of investment flows into Ukraine's renewable energy sector since February 2022 reveals a complex yet relatively structured pattern. As of mid-2025, the total volume of attracted funds exceeded EUR 14.5 billion [8], however, the distribution across funding sources remains highly uneven and reflects a critical dependence on public and international public capital. The European Bank for Reconstruction and Development (EBRD) occupies a dominant position, having invested more than EUR 6.2 billion across various sectors, including energy, transport, and financial services. The EBRD's share of total investment inflows amounts to 42.8 % [9], representing an exceptionally high level of concentration for an investment market. While the Bank's contribution has been undeniably positive, such reliance on a single institution creates a structural risk: if the EBRD's strategic priorities change or the scale of its operations

in Ukraine declines, entire segments of green financing could be left without adequate support.

The EBRD's role is particularly important not only as a direct investor but also as a catalyst for mobilizing additional sources of capital. The credit risk guarantee mechanism applied by the Bank in cooperation with Ukrainian commercial banks, including JSC Ukrgasbank and JSC Oschadbank, enables these institutions to finance renewable energy projects that they would otherwise be unable to place on their balance sheets under wartime conditions. A notable example is the Sokal Wind Farm project in the Lviv region, developed by Eco-Optima. Financing of EUR 40 million provided by Oschadbank became possible due to a green letter of credit worth EUR 24.8 million issued with EBRD support [9].

The dynamics of the composition and structure of investments in Ukraine's renewable energy sector by funding source during 2022-2025 are presented in table 1.

Through the Investment Framework for Ukraine, the European Union provides substantial support for green projects. The total funding allocated under the Fund for Ukraine amounts to EUR 50 billion for the period 2024-2027, of which EUR 11.8 billion has been allocated through Pillar II for investment projects in 2024-2025 [15]. In 2024, the European Commission approved an Energy Rescue Plan providing up to EUR 600 million in financing for critical energy projects in both the public and private sectors, including the restoration of heat supply systems and the deployment of renewable energy sources.

Table 1

Structure of Investment in Ukraine's Renewable Energy Sector by Funding Source, 2022-2025*

Funding Sources	Investment Volume (EUR million)	Share (%)	Main Areas of Investment
EBRD	6 200	42,8	Energy security, decentralization
Ukraine Facility	1 200	8,3	Critical infrastructure, renewable energy
Elementum Energy	1 500	10,3	Wind and solar energy
Notus Energy	452	3,1	Wind energy
Ukraine Energy Support Fund	1 150	7,9	Generation capacity restoration
DTEK & Octopus Energy	100	0,7	Solar energy with battery storage
Other private investors	3 898	26,9	Various technologies
TOTAL	14 500	100	

*Note. Table 1 Compiled by the author based on source [2]

The Ukraine Energy Support Fund, which as of July 2025 had attracted 33 donors from 22 countries, has mobilized more than EUR 1.15 billion and directs these resources toward the restoration and expansion of generation capacity [2]. This mechanism represents an important example of multilateral donor financing, in which resources are provided not through bilateral assistance but through a common platform with unified standards for project verification and reporting. Such a financing structure reduces administrative costs for recipients and ensures broader geographical coverage of donors.

Private foreign capital currently accounts for a considerably smaller share, approximately 13.4 % of the total investment volume, although several individual cases are particularly noteworthy. Elementum Energy, which operates a network of 29 power plants with a total installed capacity of 636 MW, remains the largest foreign private investor, with a portfolio exceeding EUR 1.5 billion [9]. The fact that the company continues its operations and is even expanding its portfolio despite the full-scale war sends an important signal to other potential investors: Ukraine's renewable energy sector retains its commercial attractiveness even under extremely challenging conditions.

Since 2019, the German company Notus Energy has been actively developing renewable energy projects in Ukraine, with a particular focus on wind power generation. The company's flagship project is a 300 MW wind farm in the Odesa region with a total investment value of EUR 452 million [2].

Domestic bank lending demonstrates a significant gap between demand and supply. According to the National Bank of Ukraine, between June 2024 and May 2025, the Ukrainian banking sector received 4,500 applications from businesses seeking financing for energy projects, with a total value of UAH 86.4 billion. However, only UAH 18.2 billion was ultimately financed, representing less than one-quarter of the reported demand [2]. This gap reflects not so much a shortage of liquidity within the banking system as the absence of effective risk-sharing mechanisms among the government, international financial institutions, and commercial banks.

The concept of ESG investing, which integrates environmental, social, and governance criteria into the investment decision-making process, becomes particularly complex under conditions of armed conflict. The United Nations Principles for Responsible Investment (UN PRI), endorsed by more than 5,000 institutional investors managing assets exceeding USD 120 trillion [9], require signatories to integrate ESG factors into investment analysis. However, the standard methodologies underlying these principles were developed without taking into account the realities of an active military conflict.

The solar energy sector provides a particularly illustrative example. As of mid-2025, the National Energy and Utilities Regulatory Commission (NEURC) had registered 2,427 producers of electricity from renewable energy sources, of which 2,099 were solar power plants [2]. However, a significant proportion of these facilities are located in regions exposed to elevated wartime risks, including the Kherson, Zaporizhzhia, Donetsk, and

Kharkiv regions, where even basic monitoring of electricity generation and the technical condition of equipment is constrained by security restrictions. For an institutional investor required to provide EU regulators with annual reports on the climate impact of its green assets, such uncertainty represents a significant barrier.

At the same time, the wartime context is generating new ESG criteria that have not yet been incorporated into standard international methodologies. The decentralization of the energy system as a factor enhancing resilience to external attacks represents a distinctly Ukrainian concept that simultaneously combines environmental (renewable energy sources), social (the uninterrupted provision of critical services), and governance (strengthening municipal autonomy) dimensions.

Adapting international ESG standards to the conditions of armed conflict is not merely a technical task for rating agencies and independent verifiers. It represents a strategic challenge for the entire international green investment structure. With appropriate diplomatic and analytical efforts, Ukraine could play an active role in shaping new standards rather than merely serving as their passive recipient.

Historically, Ukrainian cities had limited autonomy in energy-related matters due to a highly centralized governance system. However, the war has compelled local authorities, including city mayors, to assume a critical role in ensuring electricity supply and to become key actors on the front line of the energy crisis. Wartime experience has demonstrated the considerable value of decentralization, as empowered local authorities have been able to respond effectively to community needs and allocate resources accordingly.

The city of Mykolaiv, located in southern Ukraine near the front line, provides a striking example of municipal initiative in the field of renewable energy. The city has installed 5.5 MW of its own generating capacity – a combination of diesel generators, solar photovoltaic systems, and battery storage systems – to ensure electricity supply to critical infrastructure facilities such as water pumping stations. In May 2025, the Nordic Environment Finance Corporation (NEFCO) approved a grant of EUR 7.2 million [2] to expand the project to several water supply infrastructure facilities in Mykolaiv.

The city of Vinnytsia, located in central Ukraine, supports the integration of renewable energy sources into its district heating system and is actively advancing plans to construct a municipal waste-to-energy plant. The proposed 10 MW facility is intended to convert municipal solid waste into electricity and heat, generating approximately 80 GWh annually. The feasibility study has already been completed, and the city is currently seeking approximately USD 30 million in investment through a public-private partnership [9].

Several solar power plants are currently operating in the Khmelnytskyi region, with a combined capacity of approximately 14.9 MW, located on municipally owned land. The deployment of battery storage systems alongside photovoltaic installations forms part of the region's strategic approach to enhancing energy resilience.

Examples of municipal renewable energy projects in Ukraine during 2024–2025 are presented in table 2.

Table 2

Municipal Renewable Energy Projects in Ukraine, 2024-2025*

City	Project Type	Capacity	Investment
Mykolaiv	Solar power + BESS for water utility infrastructure	5 MBТ + 1 MBТ·год	USD 7.8 million
Vinnytsia	Waste-to-energy plant	10 MBТ	USD 30 million
Khmelnyskyi	Solar power plants	14,9 MBТ	-

*Note. Table. 2 Compiled by the author based on source [9]

Table 3

Types of International Cooperation in the Field of Green Investment, 2024-2025*

Project	Partner Companies	Country of Origin	Investment Volume	Technology	Expected Outcome
RISE Initiative	DTEK, Octopus Energy	Ukraine, UK	EUR 100 million	Solar energy + BESS	100 projects over 3 years
SMR-160	Energoatom and Holtec	Ukraine, USA	TBD	Nuclear (SMR)	Strengthening energy security
Notus Wind Farm	Notus Energy	Germany	EUR 452 million	Wind	300 MW in the Odesa region
Elementum Portfolio	Elementum Energy	International	EUR 1,500 million	Wind and solar energy	636 MW in operation
The Sokal Project	Eco-Optima, EBRD	Ukraine, International	USD 43.2 million	Wind	Lviv region
BESS DTEK	DTEK, Ukrainian banks	Ukraine	USD 76.5 million	Energy storage	200 MW by 2030

*Note. Table 3 Compiled by the author based on source [9]

An analysis of completed municipal projects indicates that this model has significant potential for replication across other Ukrainian cities. Key success factors include the political commitment of local authorities, access to international financing in the form of grants and concessional loans, technical support from donors and international financial institutions (IFIs), as well as community participation in project planning and implementation. Scaling up this model requires the development of standardized project frameworks for different categories of cities, methodological support from the Ministry of Energy and the Association of Ukrainian Cities, and the simplification of procedures related to permitting and grid connection.

Ukraine's cooperation with international partners, particularly the United States and the European Union, is critical to the successful transformation of the energy sector. In May 2025, the U.S. – Ukraine Mineral Resources Agreement was signed, granting the United States preferential access to Ukraine's valuable natural resources and linking future assistance to the sharing of revenues generated from substantial reserves of rare earth minerals, oil, natural gas, and other hydrocarbons.

The Ukrainian company Energoatom and Holtec International signed a cooperation agreement aimed at deploying SMR-160 small modular reactors in Ukraine to strengthen the country's energy security. DTEK, in partnership with the British company Octopus Energy, launched the Resilient Independent Solar Energy initiative to support the development of renewable energy in Ukraine. The initiative aims to attract EUR 100 million in financing for 100 solar energy projects equipped with battery storage systems over the next three years.

Types of international cooperation in the field of green investment are presented in table 3.

An analysis of international cooperation demonstrates active technology transfer across several key areas. First, this includes small modular reactor (SMR) technologies, where the partnership with Holtec International involves not only the supply of equipment but also the transfer of operational and maintenance expertise related to next-generation nuclear facilities. Second, it encompasses battery energy storage systems (BESS) based on lithium-ion technology, through which Ukrainian companies gain access to advanced energy management solutions and grid integration technologies. Third, it includes wind turbines with capacities ranging from 3

to 5.5 MW, where the gradual localization of selected manufacturing processes is taking place.

The development of domestic manufacturing capacity for renewable energy equipment is an important factor in reducing import dependence and creating added value within the Ukrainian economy. Friendly Wind Technology has commissioned a new wind turbine manufacturing facility in Zakarpattia and plans to produce up to 20 wind turbines annually, each with a capacity ranging from 4.8 to 5.5 MW [12]. The company is currently the only domestic manufacturer of multi-megawatt wind turbines in Ukraine.

KNESS Group, which has specialized since 2015 in the production of steel structures and inverter equipment for photovoltaic power plants, has supplied equipment for the construction of 258 solar power plants and 13,000 low-voltage units, demonstrating the capacity of Ukrainian manufacturers to produce internationally competitive equipment.

Despite significant progress in attracting green investment, the systemic gap between investment needs and actual capital inflows remains substantial. The National Energy and Climate Plan through 2030 envisages increasing the share of renewable energy sources in final energy consumption to 27 %, which will require investments estimated at between USD 41.5 billion and USD 50 billion. The approved auction quotas for 2025–2029 cover only 5 % of the required solar generation capacity and 30 % of the required wind generation capacity [15].

Regulatory instability remains the most critical barrier to investment. In the late 2010s, highly attractive feed-in tariffs for renewable energy sources triggered a rapid expansion of the sector. However, subsequent retroactive tariff reductions and the accumulation of unpaid obligations to producers during 2020–2021 undermined investor confidence. Attempts to transition to an auction-based support mechanism were delayed for several years, and when pilot auctions were eventually conducted in late 2024 and 2025, they failed to attract significant investor interest due to political uncertainty and shortcomings in the auction design.

Currency restrictions introduced under martial law constitute another significant barrier. Investors remain concerned about their ability to repatriate returns in foreign currency, while the National Bank of Ukraine's policy rate, which stood at 15 % in early 2026, makes domestic financing for renewable energy projects considerably more expensive than financing obtained through international financial institutions.

Infrastructure challenges are related both to the physical condition of power grids and to transportation infrastructure. Ukraine's electricity networks require large-scale modernization to integrate substantial volumes of renewable energy characterized by variable generation patterns. Transportation infrastructure also requires improvement to facilitate the delivery of large-scale equipment, including wind turbines and transformers, to construction sites, particularly in remote regions. The presence of landmines and the need for demining prior to the commencement of construction activities increase both project costs and implementation timelines.

Labor shortages are becoming increasingly acute amid the demographic crisis and migration processes.

The recovery of the energy sector will require the mobilization and training of a new generation of workers, ranging from construction personnel to power system operators. The shortage of specialists in advanced technologies, including SMR, BESS, and hydrogen technologies, necessitates cooperation with international partners to provide training programs and professional internships for Ukrainian specialists abroad.

The strategic approach to overcoming these barriers should be based on three interconnected directions. The first is the establishment of a stable and predictable regulatory environment, without which no financial incentives can ensure an adequate investment climate. The second is the implementation of effective risk mitigation mechanisms, including guarantee funds, political risk insurance, and currency guarantees. The third is the development of a domestic technological and manufacturing base through the localization of production and the establishment of research centers, which will make it possible to retain added value within the national economy.

Conclusions and directions for further research.

An analysis of Ukraine's green investment mechanisms in the context of post-war recovery reveals a profound contradiction between the scale of investment needs and the actual capacity to meet them through existing financial instruments. On the one hand, Ukraine has already accumulated considerable experience in attracting external capital, securing more than EUR 14.5 billion since 2022, and has demonstrated successful renewable energy projects across regions ranging from Lviv to Odesa. On the other hand, systemic dependence on international public financing, regulatory instability, and the absence of a domestic green bond market continue to leave the country vulnerable to shifts in the priorities of external partners.

Green bonds and ESG financing instruments are not merely technical financial mechanisms but institutional bridges connecting Ukrainian reforms with the global green investment market. Their effective implementation requires simultaneous action at several levels: legislative, through the introduction of a green taxonomy; regulatory, through ensuring stability and predictability of support mechanisms; and institutional, through the development of verification and auditing infrastructure.

The municipal level has demonstrated its effectiveness as a platform for green transformation under martial law. Local communities, empowered by decentralization reforms, have shown a growing capacity to attract international financing and strengthen their own energy resilience. The experience accumulated to date requires systematic scaling, as it represents not merely a local phenomenon but a model for a new architecture of Ukraine's energy system.

For Ukraine, the green transition is not a choice between environmental objectives and economic interests. Rather, it is the only realistic strategy for building a competitive, energy-independent economy integrated into European Union markets. A country capable of transforming crisis into a platform for systemic modernization—drawing on international capital, domestic technological capabilities, and the innovative potential of local communities will emerge from the war not merely

rebuilt, but equipped with advanced technologies and a stronger foundation for sustainable long-term development.

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