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The management of energy and investment processes under the conditions of Ukraine's innovative and sustainable development

Abstract. The aim of this study was to identify and systematise effective managerial decisions aimed at aligning energy and investment processes in Ukraine with the requirements of innovative and sustainable development. The methodological basis of the research comprised comparative-structural, institutional, and regulatory-legal analyses, a problem-oriented approach, case analysis, and descriptive-analytical generalisation of the practice of implementing investment projects in the renewable energy sector. The main findings of the study demonstrated that in 2022, the volume of capital investment in Ukraine's energy sector declined by 49% compared with 2021; however, investment activity began to recover as early as 2023, with total capital investments reaching UAH 109.3 billion. During 2022-2025, annual investments in renewable and low-carbon energy amounted to USD 1.09 billion, whereas in the pre-war period their cumulative volume exceeded USD 12 billion. The share of renewable energy sources within the investment structure of the energy sector remained within the range of 1-5%, while the structure of investments was characterised by the predominance of solar generation (60-70%) and wind generation (20-30%). In 2023, investments in solar power plants for businesses amounted to approximately USD 150 million, providing profitability of 15-20% and a payback period of 5-7 years. During 2022-2025, more than 2 gigawatts of new capacity were commissioned, contributing to a reduction in CO_2 emissions by 5-7 million tonnes annually. The study developed practical recommendations for improving the management of energy and investment processes, based on a portfolio approach, long-term contractual models, and the reduction of military and regulatory risks. The practical significance of the research lies in the

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possibility of using its findings by public authorities, energy companies, and investors to substantiate managerial decisions in the field of renewable energy in Ukraine

Keywords: renewable energy sources; investments; energy efficiency; management; bioenergy; sustainable development; financing

INTRODUCTION

Ukraine's energy transition, under the conditions of wartime risks, European integration, and climate commitments, necessitates the combination of innovative development, investment activity, and energy security. The destruction of energy infrastructure, rising energy costs, limited access to capital, and dependence on imports reinforce the importance of effective management of energy and investment processes as a key prerequisite for sustainable economic recovery. Under these circumstances, the development of renewable energy sources, energy-efficient technologies, green investments, and institutional mechanisms for their promotion constitutes an essential component of the transformation of the energy sector. The limited alignment of investment decisions with the objectives of environmental transformation and the elevated risks within the energy sector complicate the selection of effective financing directions and long-term development planning. L.M. Ivashko (2024), in her study, focused on the management of green investment portfolios in energy enterprises, substantiating the expediency of applying a portfolio approach, integrating Environmental, Social and Governance (ESG) criteria, and employing multicriteria methods for evaluating investment decisions. The findings demonstrated an improvement in the validity of investment choices and a reduction in financial risks. At the same time, O.V. Kalinin *et al.* (2024) examined approaches to managing investments for the sustainable development of green energy by analysing regional and fuel-related shifts in investment flows, opportunities for replacing nuclear generation, and instruments for assessing the investment attractiveness of energy projects based on indicators such as Levelised Unit Energy Cost, Net Present Value (NPV), Internal Rate of Return (IRR), and Return on Investment (ROI). Their findings confirmed the appropriateness of combining renewable energy sources with innovative technologies, particularly small modular reactors, and highlighted the importance of infrastructure modernisation and adaptation of the regulatory environment.

The increasing instability of the economic environment, the scarcity of investment resources, and the technological deterioration of energy infrastructure complicate the achievement of long-term effectiveness in innovation and investment processes. D.V. Babych *et al.* (2024), in their studies, substantiated the key role of innovation and investment development in enhancing the efficiency of the energy complex. The authors demonstrated a close relationship between expenditure on research and development and the growth of energy supply volumes, while also emphasising the importance of state regulation, institutional mechanisms, and strategic planning for the modernisation of energy processes and the strengthening of energy security. The insufficient integration of sustainable development principles into the strategic management of the energy sector, combined with limited investment activity, regulatory fragmentation, and low energy efficiency, constrains the long-term transformation of Ukraine's energy system, as noted in the works of M. Shkvarylyuk & I. Petrunchak (2025). These researchers focused on strategic management in the context of sustainable development, substantiating the need to modernise managerial approaches, strengthen the role of state policy, promote renewable energy sources, and enhance corporate responsibility in order to achieve energy efficiency and environmental sustainability. Similar conclusions can be observed in the studies of K. Kraus *et al.* (2023), in which the strategic development of the energy sector is examined through the lens of innovation, digitalisation of managerial processes, the implementation of advanced technological solutions, the decentralisation of energy systems, and the expanding role of renewable

energy sources. The authors also emphasised that the systematic integration of innovation into production, investment, and managerial decisions creates conditions for improving energy efficiency, strengthening energy security, and enhancing the adaptability of companies to wartime and post-crisis challenges.

Insufficient alignment between economic, social, and environmental objectives in the operation of energy enterprises leads to imbalances in their long-term development and complicates the integration of sustainability principles into managerial decision-making. In the study by Y.S. Papizh *et al.* (2023), the issue of sustainable management of energy enterprises was examined through the lens of contradictions between market imperatives and the requirements of environmental and social responsibility. The authors emphasised the need to revise traditional management models and substantiated the expediency of applying a cluster approach as an instrument for enhancing managerial efficiency. Their proposed model of an autonomous specialised polystructural cluster was considered a mechanism for rationalising resource provision and reducing production costs. In a related field of research, N. Chaplynska & P. Makeienko (2023) focused on innovative approaches to ensuring energy security, paying particular attention to global trends in energy consumption, the development of renewable energy sources, and the role of innovation policy in the transformation of energy systems. Their study analysed the dynamics of global energy consumption, indicators of innovation activity within the energy sector, structural shifts in electricity generation, and reductions in carbon emissions, while also substantiating the importance of renewable energy as one of the key directions for strengthening the resilience of energy systems.

The low level of energy efficiency within economic systems, the high energy intensity of production, and the insufficient alignment of investment and managerial decisions with the principles of sustainable development constrain the possibilities for long-term modernisation and the reduction of Ukraine's energy dependence. These issues were examined in detail in the works of M.M. Klymchuk *et al.* (2021), in which the need for interdisciplinary approaches to energy-saving management was substantiated and the concept of energy-efficient development was proposed as an instrument for combining investment, managerial, and technological decisions. The authors systematised concepts of energy-efficient development, including environmental economics, green leases, passive houses, and urban economics, and demonstrated their suitability for establishing strategic mechanisms aimed at improving energy efficiency. The study also highlighted the potential economic and environmental effects of implementing energy-efficient projects and outlined the role of institutional and managerial factors in reducing energy consumption.

At the same time, issues concerning the integration of innovative managerial decisions with investment and financial mechanisms, the assessment of the long-term economic and financial sustainability of energy projects, and the adaptation of managerial models and strategic decisions to the conditions of wartime and post-war macroeconomic instability in Ukraine remain insufficiently explored. The aim of this study was to substantiate managerial approaches to the coordination of energy and investment decisions, taking into account innovative factors, the risks of a wartime economy, and the requirements of Ukraine's long-term sustainable development. To achieve this aim, the study set the following objectives: to analyse the condition, dynamics, and structure of investments in Ukraine's renewable and low-carbon energy sector under conditions of wartime instability; and to generalise the practice of managing energy and investment processes, together with the institutional, financial, and regulatory mechanisms supporting them.

MATERIALS AND METHODS

The study had a practical orientation and covered the period from 2022 to 2025, as this was the timeframe during which significant changes occurred in the management of energy and investment processes as a result of the full-scale invasion, extensive destruction of energy infrastructure, restricted access to financial resources, and the simultaneous intensification of

Ukraine's adaptation of its energy policy to European requirements in the fields of decarbonisation and sustainable development. Within the framework of the study, the volumes of investment in renewable and low-carbon energy during the specified period were analysed on the basis of materials from Capital Investments in the Energy... (2024) and the work of O. Chaika & I. Orel (2024). A comparative-structural analysis of statistical indicators was employed, involving the comparison of annual volumes of capital investment in the energy sector, their share within the overall structure of capital expenditure, and the proportion of renewable energy sources in 2022-2023 relative to the pre-war level of 2021.

The analysis of bioenergy enterprises in Ukraine during 2022-2025 was conducted using descriptive-analytical and structural-comparative methods. The descriptive-analytical approach was used to generalise open data from Bioenergy in Ukraine: Analytical... (2025) concerning the types of bioenergy enterprises, feedstock resources, generation formats, and the role of bioenergy in heat supply and the substitution of imported natural gas. Structural-comparative analysis was applied to compare bioenergy projects with solar and wind generation in terms of installed capacity scale, investment horizon, and management system organisation. The structure of investment in renewable energy sources (RES) was examined using a structural-comparative analysis by comparing the proportion of investments in solar, wind, bioenergy, and other renewable technologies during the wartime period with their pre-war proportions. This approach made it possible to identify inter-technological shifts and determine the factors underlying the dominance of particular technologies.

A separate section examined the sources of funding for investments in RES, in particular the involvement of the European Bank for Reconstruction and Development (EBRD, n.d.), the European Union (EU), the World Bank and the International Finance Corporation (n.d.). To this end, applied institutional analysis was employed to assess the financial, guarantee and regulatory mechanisms through which international financial organisations participate in the implementation of investment projects in the renewable energy sector within the context of a wartime economy. The effectiveness of investments in renewable energy in 2022-2025 was assessed through a descriptive and analytical synthesis of actual performance indicators for completed projects, including ROI, payback periods, and social and environmental impacts, based on data from Alternative Energy (n.d.). Barriers to the implementation of energy projects, in particular procedural and infrastructural constraints on connection to electricity grids, were examined using a problem-oriented analysis to identify key constraints in the investment process, based on official clarifications from the National Energy and Utilities Regulatory Commission (n.d.a), published in a "question-and-answer" format regarding connection to electricity grids.

The functioning of "green" auctions was analysed using a case study based on data from the first "green" auction of 2025, selected as an example of the initial practical implementation of the auction mechanism within the context of a wartime economy. Within the framework of the case analysis, the announced quota parameters, feed-in premium conditions, the level of investor interest, and the actual results of the auction were assessed, including the absence of participants in the solar energy segment, which made it possible to identify the factors limiting the investment attractiveness of this instrument (The First "Green" Auction..., 2025). Wartime risk insurance mechanisms were examined within the framework of an applied institutional analysis using the instruments of the Multilateral Investment Guarantee Agency (MIGA) (n.d.) as an example. This involved the generalisation of information regarding insurance coverage parameters, premium levels, and certain limitations associated with the application of these instruments in financing renewable energy investment projects under conditions of wartime instability. Following the same methodological approach, government programmes supporting investment and energy efficiency were analysed using applied institutional-descriptive analysis, taking as examples the "Energy Conscious" programme (n.d.), Energodim (n.d.) and the "5-7-9%" programme, in which Privatbank is a participant... (n.d.), selected as the most representative instruments of state support that were directly

utilised between 2022 and 2025 to stimulate investment in energy efficiency and renewable energy. The analysis examined the programmes' objectives, financial support mechanisms, the range of beneficiaries, as well as their role in reducing financial barriers and shaping management decisions regarding energy consumption, modernisation and the decentralisation of generation, which made it possible to link these instruments to the practice of managing energy processes at corporate and regional levels. European regulatory instruments, in particular Directive (EU) 2018/2001 (2018) and Regulation (EU) 2022/869 (2022), were analysed through a legal and regulatory review, which involved examining their objectives, regulatory requirements and the instruments provided to support the development of renewable energy. Ukraine's strategic documents, in particular Resolution of the Cabinet of Ministers of Ukraine No. 868-p (2021), the National Strategy for Low-Carbon Development until 2050… (n.d.) and the National Energy and Climate Plan… (2024), were examined using institutional-descriptive analysis to identify priorities, targets and mechanisms for state governance of energy and investment processes. In the final stage of the research, using methods of synthesis, generalisation and systematisation, practical recommendations were developed to improve the efficiency of managing energy and investment processes, in particular based on an analysis of the case study of the implementation of the LLC "Wind power GSI Volyn 3" project (n.d.), selected as a representative example of an investment project in the renewable energy sector under a wartime economy, and an assessment of legislative changes in the energy and heat supply sectors adopted in 2024-2025, in particular Law of Ukraine No. 4213-IX (2025), which enabled the formulation of practical approaches to improving management decisions in the context of wartime and post-war transformation.

RESULTS AND DISCUSSION

The current state and practice of managing energy and investment processes in Ukraine

Between 2022 and 2025, investment in Ukraine's renewable and low-carbon energy sectordeveloped against a backdrop of profound structural shifts caused by the war, damage to energy infrastructure and the concentration of funding on supporting baseload generation. The lack of a single aggregate indicator for investment in renewable energy means that fragmentary data must be used; however, this data does allow for an assessment of general trends and the proportions of investment. Annual investment in renewable and low-carbon energy during the period 2022-2025 amounted to USD 1.09 billion, whilst in 2011-2021 the total volume exceeded USD 12 billion. Following a sharp decline in capital investment in 2022 (-49% compared with 2021), investment activity in the energy sector began to recover as early as 2023, when total capital investment rose to UAH 109.3 billion, exceeding pre-war levels (Capital investments in the energy… 2024). At the same time, the share of renewable energy sources in the overall investment structure remained limited, fluctuating between 1 and 5%, as the bulk of financial resources was channelled into the refurbishment of thermal power stations, electricity grids and gas sector facilities. In 2023, investment in solar energy alone amounted to around USD 150 million, equivalent to approximately UAH 6 billion, and accounted for around 5.5% of total capital investment in the energy sector (Chaika & Orel, 2024).

The structure of investment in renewable energy sources (RES) in 2022-2025 was characterised by the clear dominance of solar energy, which accounted for 60-70% of all investment. This was due to the speed of project implementation, relatively low capital intensity and the widespread adoption of self-consumption models for businesses. Wind energy accounted for 20-30% of investment, mainly through large-scale infrastructure projects, in particular the construction of wind farms with a capacity exceeding 800 MW, planned for completion by 2030. Bioenergy and small-scale hydropower together accounted for no more than 10-15% of investment, whilst bioenergy projects differed in their management logic from solar and wind generation, as their implementation depended on the stability of raw material supply, biomass contracting and supply logistics, as well as the possibility of combining electricity and heat generation; hydrogen projects remained at the

pilot stage and accounted for less than 1% due to high technological and financial barriers, as noted by O. Dluhopolskyi *et al.* (2023) and I. Bondarchuk (2025). Between 2022 and 2025, bioenergy enterprises in Ukraine formed a distinct segment of the renewable energy sector with a distinct production, management and investment logic, driven by the specific nature of the raw material base, the generation format and integration with the agricultural and municipal sectors. The dominant enterprises were those utilising solid biomass, in particular wood waste, straw, maize stalks and sunflower husks, the resource potential of which is estimated at approximately 94 million tonnes per year, of which less than 15% is actually utilised. It was these enterprises that accounted for around 3.5% of thermal energy production and contributed to replacing up to 17% of imported natural gas, which underscored their importance for regional energy security (Bioenergy in Ukraine: Analytical..., 2025).

The typical feedstock base for bioenergy enterprises in Ukraine is agro-industrial in nature and includes agricultural residues, wood biomass and organic by-products, which amounts to over 90 million tonnes of potential annually and determines how the efficiency of projects depends on the logistics of collection, processing, storage and transport of biofuel. Under these conditions, the management system for bioenergy enterprises was based on long-term contractual relationships with biomass suppliers, the planning of logistics flows and the consideration of the seasonality of agricultural waste, which distinguishes it from management models for solar and wind power generation. The predominant form of energy production was thermal generation and cogeneration, which accounted for over 90% of total bioenergy production, whilst electricity generation played a secondary role due to regulatory constraints and the specific nature of tariff incentives. Bioenergy projects generally have a lower installed capacity (1-10 MW) and a longer investment horizon compared with solar and wind power stations, due to the high capital intensity of the raw material and logistics infrastructure, but at the same time provided stable cash flows through the production of thermal energy (Zhelezna *et al.* 2021). This model reduces enterprises' dependence on fluctuations in the electricity market and enhances the role of bioenergy as a tool for decentralised energy supply, integrated with local communities, agricultural production and district heating systems, which determined its role in enhancing the resilience of Ukraine's energy system amid the instability caused by the war.

Solar projects for self-consumption (solar power stations (SPS) on business rooftops) grew by 20-40% due to reduced costs, whilst wind energy grew due to large wind farms (the 400 MW Tyligulska wind farm). Investment activity in bioenergy and hydropower during 2022-2025 was limited due to logistical factors. Hydrogen projects during this period did not progress to the mass implementation stage and were primarily considered in the medium term, after 2025, with the involvement of international partners. In particular, the strategic project portfolios of certain foreign investors envisaged a combination of wind and solar generation as a basis for the further development of hydrogen infrastructure: ONUR Group (n.d.) announced projects with an installed capacity of approximately 320 MW of wind and 50 MW of solar generation. General approaches to the development of hydrogen energy and its integration with renewable energy sources are consistent with the provisions of strategic documents on the post-war transformation of the energy sector. Overall, the share of renewable energy sources in the energy sector stands at 2-5%, with plans to increase this to 10% (Savchenko, 2025).

In terms of funding sources, investment in renewable energy was predominantly private. Own funds from Ukrainian enterprises and private investors accounted for 50-60% of investment, whilst international financial organisations contributed a further 30-40%. The state budget and grant programmes together did not exceed 10-15%, which is explained by the limited fiscal space in wartime conditions. The EBRD (n.d.), the EU, the World Bank and the International Finance Corporation (n.d.) (IFC) played a key role, not only by financing individual projects but also by reducing risks for private capital through guarantee mechanisms. In particular, the EBRD has earmarked up to EUR

1 billion for investment in renewable energy and energy networks in 2024-2025, whilst also providing a loan of EUR 160 million to Ukrnafta to finance the construction of approximately 250 MW of gas-fired power stations across Ukraine, and has also signed a letter of mandate with Concern Galnaftogaz (n.d.) to raise EUR 60 million for the development of wind energy (The EBRD invests in Ukraine from..., 2025). In addition, the EBRD, together with international partners, is establishing a new financial mechanism with the potential to mobilise up to EUR 2 billion in investment for renewable energy projects, which, together with EU guarantees totalling EUR 9.3 billion, has created the conditions for intensifying auctions and scaling up "green" generation amid the risks posed by the war (Perun, 2025). The IFC invested EUR 60 million in the OKKO wind farm (n.d.) (147 MW) in partnership with the EBRD and the Black Sea Trade and Development Bank (BSTDB, n.d.) in 2025, which will reduce CO_2 emissions by 245,000 tonnes annually. The Corporation is preparing four energy projects for financing, including solar and wind generation, and is developing distributed generation with energy storage systems (Mykhaylova, 2025). The World Bank allocated USD 116 million in grants in 2025 for gas-fired cogeneration plants and district heating equipment in seven cities (Kharkiv, Sumy, Chernihiv, etc.), which enhances the resilience of the systems and promotes low-carbon solutions. A further USD 88 million was allocated to business support programmes, including green technologies and industrial parks with a renewable energy component (The World Bank will provide an..., 2025). The EU, for its part, has allocated EUR 9.3 billion in guarantees under the Embassy of Ukraine to the United Kingdom... (n.d.) to attract private investment in renewable energy, including solar and wind projects, with EUR 2.3 billion in agreements in 2025 (EUR 1.8 billion in loan guarantees + EUR 580 million in grants). The European Investment Bank (EIB, n.d.) has provided EUR 600 million for decentralised generation and EUR 20 million in grants for renewable energy for municipalities in 2024-2025 (New financing from the EIB..., 2024).

The performance of investments in renewable energy in 2022-2025 confirms their economic and social viability. Investments totalling USD 150 million in 2023 yielded an average ROI of 15-20% due to the "green tariff" (EUR 0.117/kWh) and corporate Power Purchase Agreements (PPAs), with an average payback period of 5-7 years for solar power stations. The social impact was evident in the commissioning of over 1,400 new renewable energy facilities, the creation of 10-15 thousand jobs, and the improved resilience of the power system during blackouts (Alternative Energy, n.d.). In total, over 2 GW of new renewable energy capacity was commissioned between 2022 and 2025, enabling a reduction in gas consumption of 1-5 billion cubic metres and a cut in CO_2 emissions of 5-7 million tonnes annually (Nedylko, 2025). The implementation of energy projects in Ukraine between 2022 and 2025 took place against a backdrop of regulatory, financial, institutional and military constraints, which reduced the investment attractiveness of renewable and low-carbon energy. The most critical barrier remained grid connection, the duration of which, depending on capacity, was up to 280 days for 400-1,000 kW facilities and up to 350 days for 1-5 MW projects, including the design, approval and land allocation stages, which in some cases was extended by a further 180 days. Even for distributed generation with a capacity of up to 400 kW, connection times exceeded six months, which hindered the development of rooftop solar power stations and small-scale projects by small and medium-sized enterprises (SMEs). Formally, the least problematic stage was licensing, which is carried out by the National Energy and Utilities Regulatory Commission (NEURC, n.d.) and was nominally set at 10-30 working days; but in practice it dragged on for up to three months due to inspections and deliberations at meetings, whilst a rejection blocked the resubmission of documents for a further three months, which negatively affected the start dates of renewable energy projects (National Energy and Utilities Regulatory Commission, n.d.b).

An additional regulatory factor contributing to low predictability was "green" auctions, the effectiveness of which remained limited due to small quotas, uncertainty regarding feed-in-premium parameters, land-use barriers and war risks. In 2025, the total renewable

energy support quota stood at 330 MW; however, the auction for solar power plants in March (33 MW) did not take place due to a lack of participants, which demonstrated the low investment attractiveness of the proposed terms (The first "green" auction..., 2025). Restrictions limiting participation to 25% of the quota per investor, debts under the "green" tariff scheme and a lack of alignment with the corporate PPA market further undermined business confidence. Although corporate PPAs were gradually gaining ground as a tool for stabilising revenues, their development was hampered by a capacity shortfall following the loss of over 9 GW of generation capacity, the risk of blackouts and the absence of a long-term energy strategy (White paper "Corporate PPAs..., 2024). War-related risks reduced the investment attractiveness of energy projects, as 63,000 energy infrastructure facilities were destroyed between 2022 and 2025, and capacity losses exceeded 9 GW (In Ukraine, during the three years..., 2025). This increased the weighted average cost of capital (WACC) by a further 3-5% and led investors to avoid the eastern and southern regions, concentrating their investments in the west of the country, although even there the risk of repeated attacks made ROI figures less predictable. Insurance against war risks through MIGA (n.d.) and other institutions provided cover for 70-90% of potential losses; however, the high cost of insurance premiums (5-10% of asset value) and the exclusion of force majeure outages limited its effectiveness, particularly for SMEs (MIGA insured the first investment..., 2023).

State guarantees and programmes in 2022-2025 partially offset these barriers through preferential lending, compensation mechanisms provided by the Energy Efficiency Fund, and guarantees of the origin of "green" energy. The "Energy Conscious" programme (n.d.) in 2022-2024 took on a comprehensive nature and covered various groups of beneficiaries, creating the institutional conditions for scaling up energy-efficient and renewable energy solutions. For households, the programme provided preferential loans at 0% per annum of up to UAH 480,000 for the installation of solar panels, small wind turbines and energy storage systems, which contributed to the development of distributed generation and increased energy self-sufficiency in the face of widespread power cuts. For associations of co-owners of multi-apartment buildings (associations of co-owners of multi-apartment buildings and housing and construction cooperatives), the GreenDIM grant scheme (n.d.) was utilised, which provided compensation of up to 70% of the cost of energy efficiency projects, with a maximum funding limit of UAH 2 million, thereby encouraging the modernisation of buildings and a reduction in energy consumption (Energy-Aware: The government..., 2024). The Energodim programme (n.d.), implemented through the Energy Efficiency Fund (n.d.), provided partial reimbursement of costs for the thermal modernisation of buildings, the modernisation of building services systems and the introduction of energy-saving technologies, primarily for associations of co-owners of multi-family residential buildings. Indirectly, this helped to reduce peak loads on the power system and generate additional demand for energy-efficient technologies, thereby creating a favourable environment for investment decisions in related energy sectors. The expansion of the "5-7-9 %" state loan programme (Privatbank is a participant in the programme..., n.d.) between 2022 and 2025 provided small and medium-sized enterprises with access to preferential long-term financing for investment projects in the fields of energy efficiency and renewable energy. The use of interest rate subsidies and the option of partial state loan guarantees helped to reduce the financial burden on businesses, lower the weighted average cost of capital, and enhance enterprises' investment capacity for the deployment of solar power stations, energy-saving equipment and decentralised generation technologies.

A comparison with the study by C. Bistuer-Talavera *et al.* (2024) helped to identify the structural limitations of investment analysis within the context of the energy transition. Similar to this study, the authors interpreted the energy transition as a capital-intensive process, the effectiveness of which is determined by access to finance, institutional stability and the coherence of government policy. At the same time, the focus of C. Bistuer-Talavera *et al.* was

on the micro-financial level – the capital structure of Spanish energy companies, in particular the dominance of debt instruments and project finance. Against this backdrop, the present study broadened the analytical framework, shifting the emphasis to macro- and institutional governance of energy and investment processes in Ukraine, where war risks, infrastructure destruction and limited capital mobilisation remained key determinants. A further comparison with the work of K. Si Mohammed *et al.* (2025) highlighted methodological differences in the study of the impacts of green investments. In both approaches, investments in the energy and green sectors were viewed as a key instrument for decarbonisation and environmental sustainability. However, K. Si Mohammed *et al.* applied a quantitative econometric approach, focusing on the relationship between green technology, investment and CO_2 emission trends in Chinese provinces within the framework of the Kuznets environmental curve model. In contrast, this study prioritised the managerial and institutional dimensions, where environmental outcomes were viewed as derivatives of the system's ability to adapt investment decisions to conditions of high military and macroeconomic uncertainty. A logical extension of this comparison was to draw on the work of C. Han & L. Yang (2024), which presented a corporate-level analysis of the energy transition. Similar to this study, the authors emphasised the role of investment in renewable energy and green finance as drivers of sustainable development. At the same time, their approach focused on the internal management and financial strategies of a single energy corporation in China, utilising machine learning tools. In contrast, this study went beyond the corporate level, analysing the systemic coordination of energy and investment decisions at the national level against a backdrop of military risks and structural instability.

A comparison with the study by A. Thomas *et al.* (2024) enabled to supplement the analysis with a behavioural dimension of investment decisions. As in this paper, the authors interpreted the energy transition as a multi-factorial process dependent on the institutional environment, government policy and managerial decisions. As in the present study, the authors regarded the energy transition as a multifactorial process dependent upon the institutional environment, public policy, and managerial decisions. However, A. Thomas *et al.* focused on the willingness of small and medium-sized enterprises in Italy to invest in the energy transition, demonstrating the predominance of country-specific and socio-psychological factors, while financial constraints played a relatively minor role. In the present study, by contrast, investment behaviour was shaped primarily by wartime risks, infrastructure losses, and limited access to capital, which fundamentally altered the logic of decision-making. A comparison with the work of I. D'Adamo & E.N. Rossi (2025), which emphasised the regional and institutional aspects of investment in sustainable development, enabled to broaden the analytical framework of the study and clarify the role of territorial disparities in shaping investment flows. In both studies, investment was viewed as a key instrument for achieving sustainable development goals and reconciling economic, social and environmental priorities. However, I. D'Adamo & E.N. Rossi focused on analysing the regional distribution of investment in Italy and the impact of Next Generation EU funding on reducing territorial disparities. In contrast, this study focused on the management of energy and investment processes in Ukraine, where the risks of war and a shortage of financial resources have shaped a fundamentally different trajectory for the implementation of sustainable transformations. In both studies – by I. Alvarez & J. Uxó (2025) and the present one – the energy transition was viewed as a driver of long-term economic transformation, whilst investment in renewable energy sources was seen as a tool for enhancing the economy's resilience and competitiveness. Another common feature was the recognition of the key role played by government policy and institutional mechanisms in stimulating investment processes. At the same time, I. Alvarez & J. Uxó focused on a macroeconomic analysis of Spain's energy transition against a backdrop of institutional stability and large-scale support from the EU, particularly through the Next Generation EU funds. In contrast, this study focused on the management of

energy and investment processes in Ukraine amidst the risks of war, infrastructure destruction and limited access to capital, which dictated a different logic for investment decisions and the mechanisms for their implementation. Thus, investment trends in Ukraine's renewable and low-carbon energy sector in 2022-2025 were characterised by a gradual recovery following a sharp decline in 2022, yet remained structurally constrained by military risks, regulatory uncertainty and a shortage of financial resources. Despite the dominance of solar and wind energy and the growing role of private capital and international financial organisations, the share of renewable energy sources in total investment in the energy sector remained low due to the priority given to restoring basic infrastructure. At the same time, the results of completed projects demonstrated the economic viability and significant social impact of investments in renewable energy, laying the groundwork for their scaling up, provided that regulatory and military risks are reduced and support mechanisms are strengthened.

Practical mechanisms for managing investments in the context of the green transition

The transformation of Ukraine's energy sector between 2022 and 2025 took place against a backdrop of a war economy, limited access to financial resources, infrastructure risks and regulatory alignment with European requirements. In such circumstances, the management of investments in renewable energy projects takes on a systemic nature and requires a combination of financial, institutional and risk-oriented mechanisms. A key factor is aligning investment decisions with long-term energy policy objectives, in particular increasing the share of renewable energy sources to 27% by 2030, in accordance with "Green" transformation in the world... (2022). One of the fundamental instruments for institutional support of investment in "green" energy is the introduction of a system of guarantees of origin for electricity from renewable sources. In accordance with the requirements of European legislation, in particular Directive (EU) 2018/2001 (2018) and Regulation (EU) 2022/869 (2022), electricity from renewable sources, biomethane, and, in the future, renewable hydrogen must be verified by means of guarantees of origin; this is a prerequisite for their circulation within the EU internal market and participation in cross-border trade. Between 2022 and 2025, work in Ukraine is intensifying on establishing a mechanism for the circulation of such guarantees, which involves the creation of registers, rules for transfer and control over their use. The existence of guarantees of origin adds financial value to electricity from renewable energy sources and enhances the predictability of cash flows within corporate power purchase agreements. The development of the system of guarantees of origin is directly linked to the implementation of Ukraine's strategic climate documents. In particular, Resolution of the Cabinet of Ministers of Ukraine No. 868-p (2021), the National Energy and Climate Plan... (2024) and the Strategy for Low-Carbon Development... (n.d.) provide for a phased increase in the share of renewable sources in final energy consumption and a reduction in greenhouse gas emissions. In these documents, the system of guarantees of origin is regarded as a tool for market-based verification of "clean" energy and a prerequisite for Ukraine's integration into the European energy area.

The financing of investment projects in the renewable energy sector for 2022-2025 was based on a combination of private capital, state support instruments and resources from international financial organisations. The models actually implemented included limited recourse project finance, corporate PPAs, blended finance incorporating grant components, and mechanisms for insuring against war risks. Some of the large-scale wind and solar projects during this period were implemented with the participation of international financial organisations, notably the EBRD (n.d.), the IFC (International Finance Corporation, n.d.) and the Credit Institution for Reconstruction (KFW) (n.d.), within the framework of EU financial programmes. The involvement of such institutions provided not only direct lending or quasi-equity financing, but also mitigated risks for private investors through co-financing mechanisms, the provision of guarantees, technical assistance and the standardisation of environmental and

social responsibility requirements for projects. The use of blended finance models, in which grant funds were combined with concessional loans, made it possible to reduce the weighted average cost of capital, increase the internal rate of return on investment projects and offset heightened war and regulatory risks. In the practical implementation of investment projects, the Ukraine Facility (n.d.) was utilised, under which funding of approximately EUR 2.3 billion was earmarked for decarbonisation measures and the restoration of energy infrastructure. Resources from this programme were used to support investment in renewable generation, the modernisation of electricity grids, the development of energy storage systems and the implementation of decentralised energy solutions. The combination of grant components, concessional debt financing and EU guarantees created the conditions for launching investment projects even in the face of limited access to commercial capital and heightened uncertainty linked to military risks, which significantly expanded the scope for implementing renewable energy projects in Ukraine (Ukraine received 2.3 billion euros..., 2025).

The development of wind energy during 2022 and 2025 illustrates the practical application of such financial models. Prior to the full-scale invasion, the installed capacity of wind farms in Ukraine exceeded 2 GW, accounting for over 20% of the renewable generation mix. Despite the loss of some assets in the temporarily occupied territories, around 230 MW of new capacity was commissioned during the full-scale war, and the project portfolio exceeds 7 GW. Achieving the targets of 6.1 GW of onshore and 0.1 GW of offshore wind generation by 2030 will require investment of around USD 20 billion. In this context, annual feed-in-premium auctions and corporate PPAs are used as mechanisms to mitigate price risks and secure long-term contractual revenues. Regulatory changes in 2024-2025 play a distinct role in the practical management of investments, in particular the introduction of a cable pooling mechanism and new grid connection rules for facilities with a capacity exceeding 20 MW. Transparent grid capacity allocation and municipal incentives for the deployment of renewable energy facilities reduce administrative delays and enhance the predictability of investment schedules (Ukraine's 2025 wind market..., 2025). This is significant both for large centralised projects and for distributed generation, which is actively developing in the form of rooftop solar power stations for small and medium-sized businesses. Managing investments in a wartime and post-war economy requires the systematisation of risks and the selection of appropriate tools to mitigate them. The main types of risks and response mechanisms are set out in Table 1.

Table 1. Key risks of investment projects in Ukraine's renewable energy sector and management instruments (2022-2025)

Risk group	Characteristics	Practical management instruments
Military	Physical damage to facilities, suspension of power generation, restrictions on access to sites	Insurance by MIGA, distributed generation, and project modularity
Currency	Exchange rate volatility of the hryvnia under foreign currency debt financing	PPAs with currency indexation, hedging, and currency diversification
Regulatory	Changes in tariff policies, payment delays, and adaptation to EU regulations	Long-term contracts, Ministry of Finance guarantees, and the involvement of multilateral financial organisations (MFOs)
Infrastructure	Limited grid transmission capacity and damage to substations	Cable pooling, local energy storage systems, and backup grid connections
Financial	Restricted access to capital and an increase in the weighted average cost of capital (WACC)	Blended finance, preferential loans from the EBRD and IFC, and EU grants

Source: compiled by the authors based on Ukraine's 2025 wind market... (2025), Y.I. Shcherbak & T.V. Nagachevska (2025), EBRD (n.d.), International Finance Corporation (n.d.)

The risks associated with investment projects in Ukraine's renewable energy sector for 2022-2025, as summarised in the table, are multi-layered in nature and form an interlinked system of constraints on investment activity. The predominance of security and macro-financial factors is leading to a shift in management decisions towards risk-oriented and contractual models, within which mechanisms for guaranteeing, diversifying and distributing risks among project participants play a key role. The combination of financial and non-financial management tools signals a shift from isolated responses to individual threats towards a comprehensive approach aimed at maintaining the investment viability of projects amid military and regulatory uncertainty. The use of appropriate tools ensures that investment decisions are aligned with ESG principles, which are gradually being incorporated into the financial and management models of energy projects. The environmental dimension is realised through the reduction of emissions and the decarbonisation of production processes, whilst the social dimension is achieved through the expansion of distributed generation and an increase in the energy self-sufficiency of businesses and households, whilst the governance component is based on the use of transparent contractual mechanisms, standardised financial reporting and compliance with the requirements of international investors. In practical terms, this creates the conditions for attracting financial resources on more favourable terms and reducing the weighted average cost of capital for renewable energy projects. Consequently, investment management in the context of Ukraine's green transition in 2022-2025 emerges as a multi-level system that integrates financial models, regulatory mechanisms and risk management tools. The development of guarantees of origin, the proliferation of PPAs, the involvement of international financial organisations and the adaptation of infrastructure solutions form the institutional framework for scaling up renewable energy in the context of post-war recovery and further integration into the European energy area.

A comparative analysis with the study by X. Shi & D. Shi (2025) made it possible to outline the financial dimension of managing the green transformation. Similar to the present study, the authors considered investment to be a key instrument for enhancing the efficiency of energy systems and reducing barriers to the deployment of renewable technologies. At the same time, their analysis focused primarily on the functioning of green financial instruments – green lending, green bonds and government incentives – within China's relatively stable institutional environment. Against this backdrop, this study expanded the financial logic by combining it with regulatory and risk-oriented mechanisms adapted to conditions of high uncertainty, thereby transforming investment from a development tool into a means of simultaneously stabilising and restoring the energy system. A shift in focus from financial instruments to technological outcomes was evident when compared with the work of H.P. Zhou & Y.H. Liu (2025). In both studies, investment, energy efficiency and government policy were considered as interrelated elements of sustainable development. However, H.P. Zhou & Y.H. Liu concentrated on the technological and innovative dimensions of the energy transition, analysing the role of digitalisation and improved energy efficiency within a context of institutional stability. In contrast, this study examined technological solutions through the prism of investment management, where access to capital, military risks and the state of infrastructure significantly limited the potential for implementing even economically viable technologies. A similar distinction between quantitative and managerial approaches was evident when comparing this study with that of S.D. Nabella *et al.* (2025). The authors empirically demonstrated the positive impact of green investments on the structure of the renewable energy mix under conditions of relative macroeconomic stability, emphasising the role of economic factors and government policy. At the same time, this study went beyond quantitative relationships, focusing on practical mechanisms for managing investments in a situation where macroeconomic stability had been disrupted by military action, and investment decisions were determined not only by economic feasibility but also by security and institutional constraints. The institutional

dimension of the energy transition was interpreted differently compared with the work of H. Wibisono *et al.* (2024). Both studies viewed the energy transition as a complex socio-technical process dependent on the quality of governance and policy coherence. However, H. Wibisono *et al.* focused on the consequences of failures in renewable energy projects, analysing how technical and managerial failures undermine public trust in the transition process itself. In contrast, this study aimed to prevent such failures by developing adaptive investment mechanisms, in which financial, regulatory and risk-oriented instruments were viewed as a means of enhancing the resilience of the energy system.

A comparison with the work of A. Idris & A. Rahman Razak (2025) added a macroeconomic perspective to the analysis. In both studies, the energy transition and green growth were treated as prerequisites for long-term development. At the same time, A. Idris & A. Rahman Razak used spline modelling to identify the non-linear impact of these processes on economic growth in the Asia-Pacific region, whilst disregarding the practical aspects of investment implementation. In contrast, this study focused specifically on investment management mechanisms, where war risks, infrastructure destruction and capital shortages determined not only the scale but also the form of the green transition. A comparison with the work of I. Farida & D. Setiawan (2024) made it possible to clearly distinguish between the corporate and systemic levels of analysis. Like this study, the authors recognised the importance of green investments for sustainable development, but focused on the financial performance of such investments at the level of individual companies. In contrast, the present study considered investments as an element of the national energy sector governance system, within which corporate decisions were strictly constrained by institutional conditions, the state of infrastructure and military uncertainty. Between 2022 and 2025, the management of investments in Ukraine's renewable energy sector took place against a backdrop of military risks, a transforming regulatory environment and gradual integration into the European energy market. The implementation of investment projects during this period was based on the use of long-term pricing contract models, energy origin guarantee instruments, the involvement of international financial organisations, and multi-level risk management mechanisms. The establishment of a system of guarantees of origin, the development of corporate PPAs, and the introduction of auction mechanisms and blended finance have created the institutional conditions for stabilising cash flows and reducing investment uncertainty. Taken together, these instruments ensure that investment decisions are aligned with Ukraine's climate commitments, the requirements of European legislation and the objectives of post-war energy infrastructure reconstruction.

Recommended approaches to improving the management of energy and investment processes

The management of energy and investment processes in Ukraine during the period of the war economy was characterised by a combination of infrastructure losses, financial constraints and regulatory transformation. The combination of these factors has created a need not only to adapt current management practices but also to systematise applied management decisions aimed at preserving the energy sector's investment capacity in conditions of heightened uncertainty. In this context, it is appropriate to identify key directions for improving the efficiency of managing energy and investment processes. The first direction is the development of management decisions for enterprises in the energy sector, which was implemented in 2022-2025 through the gradual introduction of long-term strategic planning and the formalisation of investment procedures. Following the loss of around half (35 GW) of generating capacity as a result of missile attacks in 2022-2024, companies were forced to shift from a focus on large-scale centralised facilities to portfolio management of projects, particularly in the solar and wind generation segments. In practice, this has manifested itself in the creation of internal investment committees, the phased commissioning of capacity, and a shift towards corporate PPA models, which allow future cash flows to be locked in

without direct dependence on state tariff mechanisms. Such management approaches are already being applied in the implementation of large-scale wind projects financed through limited recourse project finance arrangements involving international financial organisations (Kryzhny, 2024). In particular, in 2024-2025, an investment project was carried out to construct a wind farm with an installed capacity of 147 MW, implemented by a specially established project company, LLC "Wind power GSI Volyn 3" (n.d.). The project was implemented under a limited recourse project finance model, under which funding was provided in the form of a long-term senior secured loan of up to EUR 60 million, with future cash flows from the generation and sale of electricity identified as the primary source of debt service. The financing was structured as secured debt involving the EBRD, IFC and BSTDB, which entailed the application of project analysis standards, environmental and social requirements, as well as risk management procedures typical of participation by international financial organisations. The loan was secured by the project company's assets and contractual rights relating to the sale of electricity. An additional element of the project's financial architecture was the use of a first-loss coverage mechanism under the European Union launches... (2024), which was applied to redistribute war and country risks between private investors and public institutions. The use of this instrument helped to reduce the risk burden on lenders and created conditions for attracting long-term debt financing amid military instability (Galnaftogaz Wind, n.d.).

The second direction involves stimulating investment in renewable energy at the regional level, where institutional changes linked to the decentralisation of energy decision-making took place between 2022 and 2025. Local authorities became increasingly involved in creating the conditions for the deployment of renewable energy facilities by streamlining land-use procedures, co-financing grid infrastructure and supporting distributed generation projects. In 2024-2025, government policy was supplemented by the launch of tenders for the construction of new generation capacity ranging from 5 to 80 MW, as well as major tenders for 700 MW, to be commissioned by the end of 2027. This approach combines regional interests with the national objective of increasing the share of renewable energy sources to 27% of the energy mix by 2030, in line with the government-approved plan involving total investment of around USD 20 billion (Ukraine approves $20 billion plan..., 2024). The third direction relates to instruments designed to enhance the investment attractiveness of projects for private investors, which, during the period under review, were implemented primarily through a combination of financial and insurance mechanisms. Practical experience shows that, in wartime conditions, private capital is mainly attracted through the involvement of international financial organisations in the form of blended finance. The use of such models helps to reduce investment risks for private investors whilst maintaining the market-based nature of financing without complete dependence on budgetary resources.

The fourth direction concerns the adaptation of management models to the conditions of green and military-economic transformation, which entails a review of approaches to risk management, financial planning and institutional interaction. Between 2022 and 2025, legislative changes were adopted in Ukraine in the energy and heat supply sectors, notably Law of Ukraine No. 4213-IX (2025). This law was aimed at removing regulatory barriers to the operation of energy enterprises by simplifying grid connection procedures, extending the validity of technical specifications and adapting requirements for the implementation of energy projects under martial law. These changes created a regulatory framework for the accelerated connection of renewable energy facilities to electricity grids, the introduction of a cable pooling mechanism, and the extension of the validity periods of technical specifications for projects whose implementation had been suspended due to hostilities. As a result, management models are gradually evolving towards greater flexibility, modularity and scalability following the conclusion of the active phase of hostilities. The systematisation of practical management solutions applied within the energy sector is presented in Table 2.

Table 2. Main directions for improving the efficiency of energy and investment process management

Management direction	Content of managerial decisions	Practical instruments
Corporate governance	Alignment of investment decisions with long-term energy objectives	Strategic development plans and internal investment committees
Financial planning	Enhancement of cash flow predictability	NPV, IRR, ROI, and long-term PPAs
Risk management	Formalisation and monitoring of key risks	Insurance, currency indexation, and diversification
Regional policy	Promotion of investment at the local level	Municipal programmes and infrastructure co-financing
Institutional support	Attraction of external sourcesof financing	Blended finance and the participation of multilateral financial organisations (MFOs)
Adaptation to wartime conditions	Flexibility in project implementation	Modularity and the phased commissioning of capacities

Source: compiled by the authors based on Ukraine approves $20 billion plan... (2024), Galnaftogaz Wind (n.d.)

Table 2 summarises the key directions for improving the efficiency of energy and investment management in Ukraine for the period 2022-2025 and demonstrates how they complement one another. The combination of corporate strategic planning, financial tools for cash flow forecasting and formalised risk management provided the basis for sustaining investment activity in an environment of limited access to capital. At the same time, the intensification of regional policy and institutional support in the form of blended finance, with the participation of international financial organisations, helped to reduce investment risks and enhance the projects' attractiveness to banks. Adapting management models to wartime conditions through modularity and the phased commissioning of capacity increased the flexibility of project implementation and laid the groundwork for the further scaling up of renewable energy in the post-war period.

A comparison with the study by M. Kowalska *et al.* (2025) made it possible to clearly delineate the difference between strategic-normative and operational-managerial approaches to energy transition. As in this study, the authors emphasised the need to integrate economic, social and environmental objectives into the development of the energy sector and highlighted the role of institutional mechanisms and public policy. At the same time, their analysis focused on the macro level – the interrelationship between socio-economic cohesion and sustainable energy development in EU countries, which led to recommendations being formulated primarily in terms of policy alignment and cross-sectoral coordination. Against this backdrop, the present study shifted the focus to applied mechanisms for managing energy and investment processes, detailing financial, regulatory and risk-oriented instruments adapted to capital shortages and heightened military risks. E. Cutore *et al.* (2023) proposed a formulation of the problem that was similar in content but different in logic. In both studies, the energy transition was viewed as a process requiring targeted management of investment flows and institutional support, as well as the creation of predictable conditions for attracting private capital. However, E. Cutore *et al.* operated within the context of a stable institutional environment, focusing on the optimisation of regulatory and policy instruments. In contrast, the present study was based on conditions of high uncertainty, where practical investment management mechanisms had to fulfil not only the function of improving efficiency, but also that of ensuring the continuity of energy projects given limited access to capital. The institutional dimension of the energy transition was explored in greater theoretical depth in the work by M.R. Di Nucci & A. Prontera (2023). Similar to the present study, the authors emphasised that the effectiveness of investments in renewable energy depends not only on financial resources, but also on the stability of regulatory frameworks, policy consistency and trust between the state, business and society. At the same time, M.R. Di Nucci & A. Prontera focused primarily on a political and institutional analysis of the energy transition within the framework

of stable European multilevel governance. In contrast, this study examined institutional decisions in conjunction with financial, guarantee and risk-oriented instruments, driven by the need to sustain investment activity amid the risks of war and infrastructure destruction.

A comparison with the study by A. Raihan *et al.* (2024) added an environmental and economic perspective to the analysis. In both studies, investment in renewable energy and energy efficiency was treated as a key instrument for decarbonisation and reducing the environmental impact, whilst government policy was seen as a factor in stimulating "green" transitions. However, A. Raihan *et al.* focused on macroeconomic and environmental analysis, assessing the impact of energy consumption and economic growth on greenhouse gas emissions in relatively stable economies. In contrast, this study examined environmental objectives through the prism of investment management in the energy sector, where the risks of war, infrastructure losses and limited access to financial resources significantly altered the practical logic of implementing the green transition. Between 2022 and 2025, the management of energy and investment processes in Ukraine evolved from centralised, tariff-oriented models towards more flexible, portfolio-based and risk-adapted approaches capable of functioning amid the uncertainty of war and limited access to capital. The key outcomes of this period were the institutionalisation of strategic planning, the expansion of project finance and corporate PPAs, the decentralisation of investment decisions, and the active use of blended finance mechanisms involving international financial organisations. Taken together, these changes formed the practical basis for enhancing the resilience of the energy sector, reducing investment risks and creating the conditions for post-war recovery and the scaling up of renewable energy in line with European strategic guidelines.

CONCLUSIONS

The conducted study demonstrated that the management of energy and investment processes in Ukraine during 2022-2025 evolved under conditions of unprecedented wartime risks, extensive destruction of energy infrastructure, and restricted access to financial resources, which substantially altered the logic of implementing an innovative and sustainable energy transition. It was established that, following a sharp decline in investment in 2022 (-49% compared with 2021), capital expenditure recovered in 2023 to UAH 109.3 billion, exceeding the pre-war level. Nevertheless, the structure of investment remained imbalanced due to the priority given to financing the restoration of core infrastructure, while the share of renewable energy sources accounted for only 1-5% of total investment. The analysis showed that annual investment in renewable and low-carbon energy during 2022-2025 amounted to USD 1.09 billion, whereas in the pre-war period the cumulative volume exceeded USD 12 billion. The dominance of solar energy (60-70% of investment) and the significant share of wind projects (20-30%) were driven by the speed of implementation, relatively lower capital intensity, and the growing prevalence of self-consumption models and corporate PPAs. In 2023 alone, investment in solar energy for businesses amounted to approximately USD 150 million, providing an average return on investment of 15-20% and a payback period of 5-7 years, thereby confirming the economic viability of such projects even under conditions of high uncertainty. It was established that international financial institutions played a key role in sustaining investment activity, providing 30-40% of financing for renewable energy projects and complementing private capital (50-60%) through guarantee and insurance mechanisms. In particular, the mobilisation of up to EUR 1 billion in investments for renewable energy and energy networks in 2024-2025, together with the establishment of new financial instruments with the potential to mobilise up to EUR 2 billion, created conditions for the partial mitigation of wartime risks and the reduction of investment uncertainty. Practical recommendations for improving the management of energy and investment processes involve a transition towards flexible and risk-adaptive management models capable of operating under wartime and post-war uncertainty. The application of a portfolio approach to the implementation of energy projects, with the phased commissioning of capacities, is considered appropriate, as it reduces

investment risks and enhances the financial resilience of enterprises. One of the key directions is the broader use of long-term contractual instruments (corporate PPAs and auction mechanisms with market premiums), which ensure the predictability of cash flows and income stability. At the institutional level, the efficiency of investment management may be enhanced through greater utilisation of blended finance mechanisms, guarantees, and wartime risk insurance involving international financial institutions, as well as through the further simplification of grid connection procedures and the development of cable pooling mechanisms. Prospects for further research lie in the more in-depth quantitative assessment of the effectiveness of investment instruments and energy project management models, taking into account post-war reconstruction and Ukraine's integration into the European energy market.

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Управління енергетичними та інвестиційними процесами в умовах інноваційного та сталого розвитку України

Анотація. Метою дослідження було визначення та систематизація ефективних управлінських рішень щодо узгодження енергетичних і інвестиційних процесів в Україні з вимогами інноваційного та сталого розвитку. Методологічною основою дослідження були порівняльно-структурний, інституційний, і нормативно-правовий аналізи, проблемно-орієнтований підхід, кейс-аналіз та описово-аналітичне узагальнення практики реалізації інвестиційних проєктів у сфері відновлюваної енергетики. Основні результати засвідчили, що у 2022 році обсяг капітальних інвестицій в енергетичний сектор України скоротився на 49 % порівняно з 2021 роком, однак уже у 2023 році інвестиційна активність почала відновлюватися, а загальні капітальні вкладення досягли 109,3 млрд грн. У 2022-2025 роках щорічні інвестиції у відновлювану та низьковуглецеву енергетику становили 1,09 млрд дол., тоді як у довоєнний період їх сукупний обсяг перевищував 12 млрд дол. Частка відновлюваних джерел енергії у структурі інвестицій енергетичного сектору залишалася в межах 1-5 %, а структура вкладень характеризувалася домінуванням сонячної (60-70 %) та вітрової генерації (20-30 %). У 2023 році інвестиції у сонячні електростанції для бізнесу становили близько 150 млн дол., забезпечуючи рентабельність 15-20 % і строк окупності 5-7 років. Упродовж 2022-2025 було введено понад 2 гігавати нових потужностей, що сприяло скороченню викидів CO_2 на 5-7 млн тонн щорічно. У ході дослідження було сформовано прикладні рекомендації з підвищення ефективності управління енергетичними та інвестиційними процесами, засновані на портфельному підході, довгострокових контрактних моделях і зниженні воєнних та регуляторних ризиків. Практичне значення дослідження полягає у використанні його результатів органами державної влади, енергетичними компаніями та інвесторами для обґрунтування управлінських рішень у сфері відновлюваної енергетики в Україні

Ключові слова: відновлювані джерела енергії; інвестиції; енергоефективність; менеджмент; біоенергетика; сталий розвиток; фінансування