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The impact of renewable energy sources on economic recovery in Ukraine

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Abstract

The current economy of Ukraine is marked by the urgent need to explore pathways for post-war economic recovery. Considering the severe damage inflicted on the country's energy infrastructure, restoring energy capacity and providing energy resources to both industries and private consumers are becoming critical issues. The conversation surrounding alternative energy sources and renewable energy technologies is gaining traction in this regard. These technologies are often called green technologies, as they prioritize preserving natural resources and promoting the sustainable use of various resources. It is evident that the financing of green technologies requires government involvement; however, a vital responsibility of the state should be to foster a market environment that incentivizes investors to contribute financially to green initiatives, highlighting the complexity and multifaceted nature of the issue at hand. Given this topic's significance, this study aims to assess the impact of renewable energy source utilization on Ukraine's economic recovery efforts. To accomplish this, the following tasks will be undertaken: conducting a statistical analysis of the renewable energy landscape in Ukraine, identifying the primary mechanisms for financing renewable energy projects, and performing a SWOT analysis of the renewable energy sector to gauge potential investor interest. The methodological framework for this research includes statistical analysis and SWOT analysis, which help clarify the strengths, weaknesses, opportunities, and threats associated with adopting green technologies in Ukraine. The findings suggest that one of the principal avenues for financing green technologies should involve green bonds, which serve as a means to attract investments from individuals and organizations to pursue ambitious projects focused on resource conservation and environmental safety. Additionally, the statistical analysis indicates that while Ukraine possesses significant potential for renewable energy development, progress in this area hinges on securing investment resources.

Keywords: Renewable energy, Green technologies, Economic recovery, Green bonds, Investment attraction

1. Introduction

Adopting green technologies has become essential today, as energy demand rises while available resources diminish yearly. Consequently, harnessing energy from renewable sources is increasingly vital. Green technologies, often called environmental technologies or Greentech, can be broadly characterized as processes designed to make production methods and supply chains more environmentally sustainable or less harmful than traditional practices [1, 2]. These technologies find application across environmental, economic, technological, and innovative sectors and address challenges related to waste recycling, alternative energy sources, and more. Notable examples include wind, solar, hydropower, and green manufacturing techniques. By 2023, the market for goods and services in the renewable energy and green technologies sector will reach $18 trillion, representing 4.3% of global GDP. Moreover, over 30 million people are employed in the renewable energy field [3].

Using renewable energy sources necessitates substantial financing and investment, highlighting the need to examine the specifics of funding innovative resource conservation technologies. As Ukraine embarks on its post-war recovery journey, practical strategies for developing renewable energy production and consumption are critical, especially given the extensive damage to its energy sector. Introducing several regulations into the legal framework indicates the government's commitment to the industry's future. A significant milestone in promoting green technologies within the energy sector was the approval of the Concept of the State Target Economic Program for Stimulating the Development of Distributed Electricity Generation from Renewable Energy Sources for the period leading up to 2030 [4]. With considerable attention from the government towards the legislative advancement of renewable energy, financial instruments to support innovative energy technologies are also being formulated.

In this context, the concept of green financing emerges, which is understood today as the process of funding projects that directly or indirectly mitigate the negative impacts of the energy sector on the environment. This article centers on the specifics of employing renewable energy sources to facilitate the recovery of Ukraine’s economy.

The primary aim is to clarify the influence of renewable energy sources on the country's economic recovery efforts. To achieve this goal, several tasks must be addressed:

- Conduct a statistical analysis of Ukraine's current state of renewable energy.
- Identify the key components available for financing renewable energy projects.
- Perform a SWOT analysis of Ukraine's renewable energy sector to assess potential investor interest.

Despite the growing attention from the scientific community towards financing renewable energy, this matter remains relatively new for Ukraine. Consequently, the search for optimal financing tools for innovative energy-saving technologies continues as legislation and academic research in this field evolve.

2. Research method

This paper examines the current condition of Ukraine’s energy sector and evaluates the activity level regarding adopting renewable energy sources. The analysis utilized time series methods and statistical data examination. Overall, the findings suggest that Ukraine is advancing towards developing innovative technologies related to energy efficiency and a green economy. Additionally, the study identifies critical financial challenges that companies and organizations may encounter while implementing innovative energy-saving technologies.

The research was conducted in two phases. The first phase involved analyzing statistical data concerning the growth of renewable energy in Ukraine [5] to validate the country's engagement in fostering innovative energy-saving technologies. The second phase concentrated on the financial considerations involved in introducing these technologies, acknowledging that innovative economic advancement can be expensive and demands substantial financial investments, especially during the post-war economic recovery process in Ukraine. During this phase, SWOT analysis was employed to uncover primary directions and potential opportunities for further

advancements in energy-saving technologies, emphasizing the rationale for securing investment resources in this sector.

Various general scientific methods were employed throughout the study, including analysis, synthesis, generalization, systematization, induction, deduction, and graphical techniques. The combination of these methods and the specific SWOT analysis enabled a thorough understanding of the primary directions for the future of renewable energy in Ukraine and an assessment of the leading financial risks associated with their implementation. By emphasizing the financial and economic dimensions of energy-saving technology development, the study offers a comprehensive and objective perspective on renewable energy initiatives, highlighting not only governmental efforts but also the often-passive role of business entities in resource conservation due to a lack of awareness regarding the actual advantages of renewable energy.

3. Results

The discussion surrounding developing and implementing renewable energy technologies across various sectors of Ukraine's economy has gained momentum over the past two decades. While some technologies have been integrated into production processes and infrastructure, the year 2022 was significantly affected by the onset of a full-scale war in Ukraine, resulting in widespread destruction of the energy sector. This devastation led to extended blackouts and considerable constraints on energy resource usage for businesses and the general public [6-8].

In recent years, scholars have increasingly emphasized the paths for Ukraine's energy and economic recovery, which are closely tied to the shift towards a green economy. This transition presents additional challenges across various sectors, including 1) improving efficiency in the use and management of resources, such as energy, water, land, and living organisms; 2) modernizing existing energy infrastructure while constructing new facilities; 3) enhancing the well-being of the population and environmental quality by employing cost-effective strategies to mitigate impact from non-renewable energy sources; and 4) strengthening national security, including energy security.

A primary barrier to addressing Ukraine's energy system inefficiency is the insufficient funding needed for essential modernization initiatives. This issue cannot be resolved solely by individual state authorities or local governments. A comprehensive approach is required, necessitating coordination among central and local executive bodies and local governments.

Overall, statistical data analysis indicates that the active development of renewable energy in Ukraine began in 2015, coinciding with global trends that highlighted interest in renewable energy advancement. Figure 1 shows the annual growth dynamics of renewable energy source capacities in Ukraine.

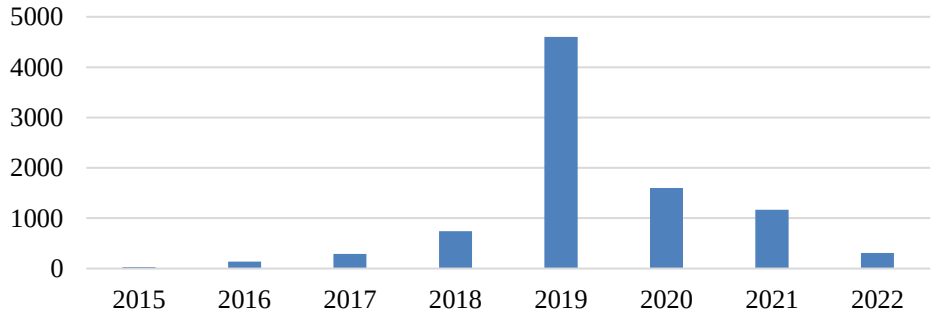
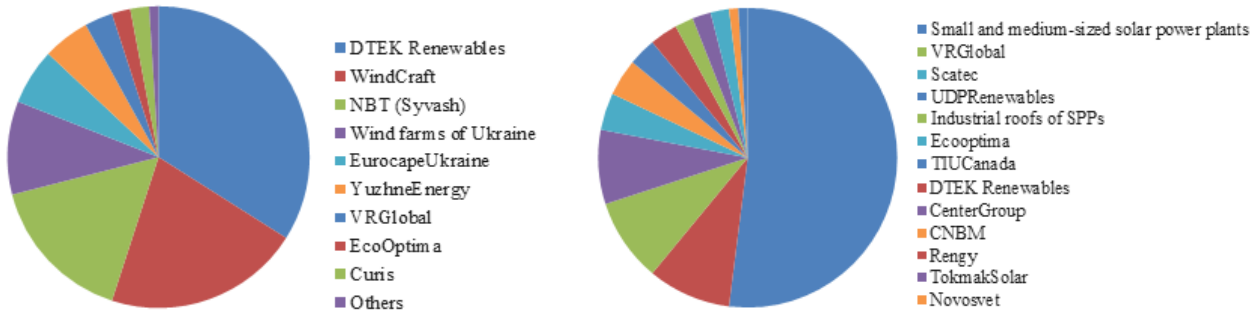


Figure 1. Annual Growth Trends of Renewable Energy Capacity in Ukraine, MW [5]

It is essential to highlight those investments in the renewable energy sector amounted to over USD 12 billion up until 2022. However, since 2022, investment flows in this sector, as well as in the overall Ukrainian economy,

have significantly decreased. Figure 2 illustrates the primary investors in renewable energy as of early 2022, before the onset of the full-scale war.



a) Wind energy b) Sun energy

Figure 2 a, b. The structure of major investors in renewable energy as of the beginning of 2022 (before the start of a full-scale war) [5]

It is essential to observe that over 50% of all alternative energy facilities, including those fueled by wind and solar sources, were concentrated in Ukraine's southern and eastern regions due to the country's climatic and geographical characteristics. By mid-2022, many of these facilities had either been destroyed or were located in occupied areas resulting from ongoing hostilities. Therefore, to advance renewable energy, it is essential to implement measures to restore damaged power plants and develop resource-efficient technologies, as energy management must be integrated with water conservation, lean production across sectors, and the optimal use of all resources.

Looking ahead, Ukraine's economic recovery should prioritize the transition to a "green economy," mirroring the strategies of leading countries globally. Ukraine could benefit from advancements in several areas directly or indirectly linked to alternative energy development, including:

- Promoting the adoption of renewable energy sources by businesses and households.
- Attracting international investors to fund green initiatives.
- Ensuring sustainable water resource management.
- Fostering the economical utilization of energy resources and advancing sustainable agriculture practices.
- Enhancing energy savings and efficiency within the industrial sector.
- Developing the energy industry and establishing waste management systems at various production stages.
- Mitigating air pollution through the utilization of renewable energy sources.
- Preserving and effectively managing ecosystems.

It is crucial to emphasize that successfully implementing green technologies requires a holistic approach rather than focusing on a single area or direction. Therefore, advancing renewable energy should not be isolated from developing energy-saving technologies. Ukraine should prioritize attracting investments for green projects despite a recent slowdown in investor activity in this sector as part of its economic recovery efforts. This trend of decreased investment activity has affected green technologies and various production sectors across many European nations due to the COVID-19 pandemic. For instance, in the United States, the investment growth rate in green initiatives declined from 8% to 3% in 2020 but regained momentum in 2021 [9, 10].

For Ukraine, investing in renewable energy projects is still a relatively new endeavor that has yet to establish a solid foothold in the investment landscape. Moreover, the regulatory framework governing all aspects of investment in this field is not fully developed, leading to investor apprehension before and during the full-scale war. For many investors, green projects are perceived as high-risk alternatives to traditional investments in

securities or production. Conversely, green initiatives have gained immense popularity in well-developed European nations like Norway and Denmark, primarily due to robust government support, which is a significant driving force behind these investments.

The experience of Sweden [11-13], which boasts one of the largest wind farm networks in the world, could serve as a valuable reference for Ukraine. Although Ukraine's climate is conducive to increased wind energy utilization, such developments have not been realized. In Sweden, establishing wind farms involved co-financing from state and private investors, with the government playing a pivotal role in promoting the concept of building wind farms through effective information policies. Overall trends suggest a rise in innovatively active enterprises, with the government facilitating conditions that create new opportunities for businesses engaged in environmental technology innovations.

The United States stands out as a global leader in the number of innovatively active companies, fostering an environment conducive to attracting capital for innovative projects. Established venture centers, innovation hubs, and similar initiatives have achieved this. As a result, the U.S. is home to many innovative technologies, including those focused on energy savings. Consequently, Ukraine might benefit from establishing innovation hubs in collaboration with universities or major industrial entities, drawing lessons from the U.S. model.

Turning to the investment landscape in environmental protection, it is essential to note that over the past decade, investments in this area have accounted for no more than 1.5% of total investment resources [5]. This figure reflects a relatively low interest among investors in environmental projects, primarily due to their low returns and lengthy payback periods; often, the benefits derived are more social than financial. Recently, cutting-edge environmental technologies have predominantly centered on developing market-compliant products that do not adversely affect the environment. Nonetheless, manufacturers should consider future economic, social, and technological advancements in their production lines and products.

Substantial financial support is crucial for the advancement and implementation of these technologies. Without such backing, achieving favorable results in Ukraine's economic recovery will be complicated. Consequently, financing energy projects—a significant trend in the global financial landscape in recent years—is gradually being adopted in Ukraine as a vital component of promoting green technology initiatives [14-17]. Green finance encompasses financial instruments designed to fund environmentally sustainable and low-carbon projects [18-21], such as green bonds and loans. Worldwide, financial institutions and industrial entities are issuing green bonds, which are used to finance infrastructure projects actively. The issuance of green bonds presents an opportunity to attract the investment necessary to restore energy infrastructure and advance renewable energy during Ukraine's post-war recovery.

However, it is anticipated that, in the short term, private enterprises may show limited interest in acquiring green bonds due to perceived high risks, in contrast to European nations where green bonds are considered an appealing financial and investment asset. Before 2022, the financing of green initiatives predominantly came from banks with government support. Yet, examples from leading European countries [11, 22, 23], such as Norway, Sweden, and Denmark, indicate that the government should prioritize the development and execution of strategies to encourage investments in green technologies. This approach minimizes reliance on public funding while establishing mechanisms that render green projects financially appealing to investors [24-26].

For Ukraine, the expansion of green finance is especially pertinent in solar and wind energy production. Overall, the country has significant potential for developing green finance within the energy sector, encompassing energy conservation and electricity generation. Research into the green technology sector, particularly renewable energy, demonstrates that this industry holds substantial growth prospects despite existing challenges. One such challenge is the lack of investor interest in financing green projects, which currently entail lengthy payback periods and provide limited financial incentives amidst military conflicts. However, this situation may improve substantially during the post-war recovery phase, particularly with enhanced security guarantees.

Looking ahead to 2024, it is noteworthy to acknowledge the collaborative efforts between Ukraine and the European Bank for Reconstruction and Development. The EBRD and the European Union have established and are expanding the Climate Innovation Vouchers grant program. This initiative will offer companies grants totaling EUR 442,000 for developing and implementing green technologies. Conducting a SWOT analysis would be beneficial to systematically analyze the factors affecting the dynamics of the green technology market and the potential increase in demand for green bonds [27-29]. This analysis will clarify the strengths and weaknesses within Ukraine's green technology sector and identify opportunities and risks associated with this area in the context of the country's post-war economic recovery (Table 1).

Table 1. SWOT analysis of Ukraine's green technology sector, highlighting its potential opportunities and associated risks within the framework of post-war economic recovery

Strengths	Weaknesses
• Favorable geographical location and climatic opportunities for renewable energy development. • The presence of a population interested in the introduction of green technologies, especially among young people. • High investment potential of the Ukrainian economy, which provides significant opportunities for economic development. • Opportunities to minimize the costs of various types of production by using energy resources from renewable sources. • Strong government support for the construction industry and the adoption of green technologies in the sector, especially in areas designated for reconstruction following active conflict. • Interest from external investors experienced in funding environmental projects in developing renewable energy initiatives in Ukraine.	• Significant destruction of infrastructure, industrial and residential facilities, and the territory of the eastern and southern regions of Ukraine. • Concentration of significant influence on the economy with external partners due to high external debt levels. • The need for significant capital investments in the reconstruction of existing energy, infrastructure and industrial facilities. • Dependence on global trends in alternative energy development. • The need to invest large sums of money at the start-up stage of green projects. • A long payback period for green projects. • The necessity for ongoing observation of global trends in green technology development and their adaptation to the specific conditions of the Ukrainian economy and industry, particularly in light of the post-war economic context.
Features	Threats
• Expanding the existing environmental infrastructure and taking advantage of its favorable geographical location. • Ensuring optimal use of available renewable resources: wind, solar, and water energy. • Developing the potential to produce energy-saving equipment at Ukrainian enterprises. • Creation of additional jobs. • Maximizing the involvement of foreign investors to finance green projects. • Creation of jobs because of green projects. • Opportunities to create a positive image and develop corporate responsibility for companies implementing green technologies.	• Limited investor awareness of the opportunities to invest in green projects. • Increased spending on research and development to implement green technologies. • High financial risks from the introduction of green technologies, the inability to predict the exact financial effect of their implementation. • A decline in demand for green technologies due to their financial unpredictability. • Increasing pressure from international organizations to introduce certain innovative technologies.

Source: compiled by the authors.

Based on the results of the SWOT analysis, we can state that green technologies and renewable energy, in particular, have huge potential not only for the environment but also for Ukraine's financial recovery; to realize this potential, the state must first carry out explanatory work and show potential investors how they can profit from the implementation of such projects and how their interests will be protected.

4. Discussion

Numerous scientists, theorists, and practitioners are highly interested in implementing green technologies and utilizing renewable energy sources. This primarily relates to the condition of the energy system and the potential for optimizing energy usage to lessen reliance on non-renewable energy sources while increasing the proportion of renewable energy in overall consumption.

Many authors consider the technological features of green technology implementation [30-32]. In particular, emphasis may be placed on the fact that the business should be primarily interested in adapting green technologies to the specifics of its production and implementing them to minimize energy costs. However, this view can be argued, as it is possible to consider investing in green bonds and view such projects solely as a capital appreciation tool.

Researchers also consider green technologies in terms of lean production [33-35] and the introduction of resource-saving technologies [36, 37], which are focused not only on the economical use of energy resources but also on all types of resources (material, human, financial). This opinion is quite reasonable and challenging to argue with.

The issue of financial support for the implementation of green technologies occupies a separate place in the scientific literature [38-40], emphasizing that banks play a significant role in financing green technologies, which is confirmed in the scientific literature. Researchers [41-43] emphasize that the state's role in creating favorable conditions for preferential financing of innovative green technologies is also important. For example, joint projects of the state and commercial banks aimed at financing large resource-saving projects can be implemented if such projects are strategically crucial for the state or a particular industry [44]. This is quite logical since it would be too difficult for a single company or bank to provide financing for large projects. Another way to ensure the inflow of financial resources into green technologies is through co-financing by business representatives when companies from the same industry or sector invest in innovative developments and stimulate the growth of technologies. However, statistics show that green technologies are primarily implemented through self-financing, which means businesses implement the most innovative technologies for resource conservation at their own expense.

The adoption of green technologies significantly influences budgets and financial burdens at different levels [45]. One of the government's responsibilities is to empower private investors to fund green projects. In this regard, business leaders are progressively prioritizing financing innovative technologies, especially within the energy sector, which is critical for green technology deployment [46]. Consequently, this has led to the merging of the energy and financial sectors, making energy projects more appealing to private and corporate investors.

Environmental protection issues that business representatives have highlighted in recent years can become the basis for the formation of social responsibility of large companies and will allow them to obtain financial and social benefits from investing in green technologies [43, 47]. It is essential to recognize that during the post-war recovery phase, the government can revitalize specific sectors and industries by aligning with modern environmental and energy standards, in contrast to the industrial landscape that existed before the war in Ukraine. Researchers have also highlighted the regional dimensions of green technology development, emphasizing that there is no one-size-fits-all approach to innovation implementation in different areas; instead, it is crucial to consider the unique characteristics of each region and its inclination towards specific types of production [48]. Additionally, the climatic and geographical traits of particular areas must be considered.

The literature extensively addresses the risks of financing green technologies [49, 50]. Specifically, some researchers [20, 51, 52] assert that effective execution of resource-saving technology projects necessitates thorough business planning during development and implementation. It's also important to acknowledge the risk of incurring financial losses [53] that may not be recovered by introducing green technologies or that the payback period could extend far beyond initial projections. Hence, when planning initiatives for implementing green technologies, business stakeholders and government entities should consider a wide range of factors that could influence the outcomes and timelines of project execution.

5. Conclusions

The study suggests that in Ukraine, how effectively green technologies and renewable energy sources are integrated into the economic planning process will significantly impact economic recovery in the short term.

Unfortunately, Ukraine cannot fully comply with global trends and reach the level of green technology development in the US or Scandinavia. Still, its plans to develop innovations in the environmental and energy sectors are ambitious and have some results.

Ukraine is facing a shortage of financial resources to finance green projects, so the issue of mobilizing the funds needed to invest in sustainable growth projects of green technologies is coming to the fore.

An analysis of statistical data showed that the renewable energy market is currently unsatisfactory, mainly due to active hostilities in the eastern and southern regions. Its development in the country requires government support, which primarily consists of the adoption of an appropriate legislative and regulatory framework. However, it is also important to constantly promote the development of green technologies and emphasize the importance of using renewable energy.

Attention was focused on the possibility of using Sweden's experience in financing wind farm projects and the United States' experience in financing research and development and creating innovation hubs.

An examination of the experiences of leading European countries indicates that green bonds are emerging as the most effective funding source for contemporary green projects. In Ukraine, the green and sustainable finance market has significant potential, yet it remains largely untapped. Most current market participants are just starting to show interest in innovative energy advancements, issuers are reassessing their objectives to align with sustainability goals, and investors are increasingly focusing on responsible investment practices.

This article employs a SWOT analysis to identify opportunities for the advancement of green technologies in Ukraine and clarify the obstacles hindering progress in this area. It demonstrates that while green technologies are beginning to capture investors' interest, there remains a lack of sustained enthusiasm for such projects, particularly considering the ongoing conflict in Ukraine. Consequently, the government is tasked with promoting financial instruments associated with green technologies.

Declaration of competing interest

The authors declare that they have no known financial or non-financial competing interests in any material discussed in this paper.

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Author contribution

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