



## **Economic Benefits of Green Technologies: Ukrainian Experience**

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### **ABSTRACT**

This study evaluates the economic benefits of implementing green technologies in Ukraine, focusing on their contribution to sustainable development, energy efficiency, and economic growth. The research aims to identify how renewable energy projects and energy-efficient technologies can enhance Ukraine’s energy security, reduce dependency on fossil fuels, and foster innovation-driven economic modernization. A multi-method approach was employed, combining a systematic literature review, statistical data analysis, and a comparative evaluation of solar and wind energy projects. The study draws on secondary data from governmental and international agencies, spanning the period 2014-2023, and utilizes descriptive statistics to assess trends in job creation, investment, and reductions in natural gas imports. The results indicate significant progress in solar and wind energy development, with total installed capacities reaching 7.6 GW and 2.4 GW respectively by 2023. Employment in green sectors exceeded 50,000 jobs, with solar energy accounting for 40% of this workforce. Investments in green technologies totaled approximately €12 billion between 2014 and 2022, stimulating economic growth and reducing Ukraine’s natural gas imports by 15%. Despite these achievements, challenges remain, including financial barriers, regulatory instability, and outdated infrastructure. However, the study highlights opportunities for further progress through policy reforms, infrastructure modernization, and international cooperation. The research concludes that green technologies are essential for Ukraine’s transition to a sustainable economy, offering both environmental preservation and economic growth potential. These findings underscore the need for policy consistency, expanded financing options, and increased public awareness to maximize the economic benefits of green technologies in Ukraine. By leveraging these innovations, Ukraine can enhance its energy independence, competitiveness, and resilience in the global market.

**Keywords:** Sustainable Development, Environmental Efficiency, Energy Conservation, Renewable Resources, Economic Growth

**JEL Classifications:** Q56, O13, O33.

### **1. INTRODUCTION**

As the world grapples with the twin challenges of climate change and dwindling conventional energy supplies, the adoption of eco-friendly technologies has emerged as both an environmental necessity and an economic imperative, particularly for nations in the developing world. Ukraine, with its transitional economy and considerable untapped potential in sustainable energy, stands at a pivotal juncture. The country has a unique opportunity to

revolutionize not only its energy infrastructure but its entire economic landscape through the strategic implementation of cutting-edge green innovations. This transition holds the promise of addressing pressing environmental concerns while simultaneously fostering economic growth and resilience. By embracing sustainable technologies, Ukraine could position itself at the forefront of the global shift towards cleaner, more efficient energy systems. This move could potentially catalyze wide-ranging positive impacts across various sectors of the Ukrainian

economy, driving innovation, creating new job opportunities, and enhancing energy security.

The relevance of the study of the economic benefits of implementing green technologies in Ukraine is due to several key factors:

- **Energy security:** Reducing dependence on imported fossil fuels through the development of renewable energy sources is critical for Ukraine's national security (Kurbatova et al., 2022; 2020; 2023).
- **Economic modernization:** The transition to green technologies stimulates innovation, creates new jobs and increases the competitiveness of Ukrainian industry in international markets (Bondarenko et al., 2023).
- **Environmental commitments:** The integration of environmentally-conscious innovations enables Ukraine to honor its global pledges, supporting the nation's efforts to curb climate-altering emissions and realize internationally-recognized sustainability objective (Kuzior et al., 2021; Sumets et al., 2021).
- **Investment attractiveness:** The development of the green technology sector creates new opportunities to attract foreign investment and stimulate economic growth (Trypolska et al., 2022; Trypolska and Riabchyn, 2022).
- **Socioeconomic benefits:** Implementing energy-efficient technologies and renewable energy sources can substantially lower energy bills for both residential and commercial consumers, enhancing living standards and economic resilience (Ostapenko, 2020; Pryshliak and Tokarchuk, 2020).

The main objective of this study is to comprehensively analyze the economic benefits of implementing green technologies in Ukraine with a special focus on their impact on sustainable development, environmental efficiency, energy conservation and economic growth. This study seeks to answer the following research questions, which address key gaps in the existing literature:

1. What are the primary economic benefits of implementing green technologies in Ukraine, and how do they contribute to national development?
2. How can green technologies enhance Ukraine's energy security and reduce its dependence on imported fossil fuels?
3. What are the key challenges and opportunities faced by Ukraine in integrating green innovations into its economic framework?

In this article the scientific novelty of the research lies in its comprehensive analysis of the economic benefits of green technology implementation specifically within the context of Ukraine. This study addresses a gap in existing research by focusing on the unique challenges and opportunities faced by a transitional economy like Ukraine's. It emphasizes how the adoption of green technologies not only addresses environmental concerns but also offers substantial economic advantages. These include energy security, economic modernization, and socioeconomic benefits, positioning Ukraine to better compete on the global stage through sustainable innovations. Furthermore, the research provides detailed insights into how green technologies can drive energy efficiency, stimulate job creation, and foster

foreign investment, thus contributing to both national security and economic resilience.

This research is essential for policymakers, economists, and environmentalists who are striving to balance Ukraine's ecological commitments with its need for economic growth. The findings of this study will offer actionable recommendations for maximizing the economic benefits of green technologies, thereby supporting Ukraine's transition to a sustainable and resilient economy. Through the lens of this research, it becomes evident that green technologies are not only tools for environmental preservation but also key drivers of economic transformation in the modern world.

## 2. LITERATURE REVIEW

An analysis of domestic and foreign scientific literature demonstrates a growing interest in the economic aspects of the implementation of green technologies in Ukraine. Research covers a wide range of topics, from energy policy to specific technological solutions and their economic impact.

In the field of energy regulation and policy, scientists (Kurbatova et al., 2020) examine the Ukrainian government's policy for supporting renewable energy development, identifying the need for enhanced incentive mechanisms to ensure the industry's sustainable growth. Prokopenko et al. (2021; 2022) and Sembiyeva et al. (2023) explore strategies for refining state support programs to promote sustainable renewable energy development, emphasizing the importance of striking a balance between economic incentives and market-based approaches. Also, the scientific work (Lozovan et al., 2019; Lyulyov et al., 2021) examines the impact of government policy on energy efficiency, identifying key factors influencing the reduction of the energy gap in Ukraine. Starinskyi and Zavalna (2021) consider issues of economic sovereignty of a modern state in the context of sustainable development, emphasizing the role of green technologies in ensuring economic independence.

In terms of renewable energy development, Sabishchenko et al. (2020) analyze the potential of hybrid renewable energy systems for managing the Ukrainian energy sector, demonstrating the economic benefits of integrating different green energy sources. Voitko et al. (2021) examine the factors facilitating the development of economic relations in the field of renewable energy between Ukraine and Turkey, highlighting the potential for international cooperation. Koval et al. (2021a; 2021b) examine the regulatory policies for renewable energy in European national economies, providing a comparative analysis and recommendations for Ukraine. Trypolska et al. (2022a; 2022b) examine the prospects for end-of-life management of wind and solar power plants, which is an important aspect of the long-term economic efficiency of these technologies.

In energy efficiency and sustainable development studies, Deineko et al. (2019) analyze the opportunities and barriers to the transition of Ukrainian industry to a circular economy, emphasizing the role of green technologies in this process. In their scientific papers, Bozhkova et al. (2020) and Butyrskyi et al. (2019) propose a system of indicators for the development of alternative energy in

the context of a green economy, allowing to assess the economic efficiency of implementing green technologies. Koval et al. (2021a; 2021b) examine the ecosystem of environmentally sustainable municipal infrastructure in Ukraine, demonstrating the economic benefits of implementing green technologies at the local level. Petrushenko et al. (2022) and Popova et al. (2019) consider the prospects for the development of eco-industrial parks in Ukraine as a tool for sustainable development in the context of a transition economy.

In the area of innovation and economic growth, Li et al. (2022) and Vakarov et al. (2024) conduct an environmental and economic analysis of technological innovation in the energy sector, demonstrating the positive impact of green technologies on economic growth. Ahamer (2021), Babenko et al. (2020), Gorb et al. (2020), and Silvia (2023) examine the innovation receptivity of low-potential energy technologies in Ukraine, identifying promising areas for investment and development, while Okhrimenko et al. (2022) and Furdychko et al. (2021) analyze Ukraine's economic development strategies, emphasizing the role of green technologies in ensuring sustainable growth. Kurylo et al. (2020) and Kushnir et al. (2022) examine incentives for implementing social responsibility management in Ukrainian enterprises, including aspects of environmental responsibility and the introduction of green technologies.

Regarding financial aspects and capital allocation, recent scholarly works have shed light on Ukraine's renewable energy sector. A study by Kulyk et al. (2023) explores the funding landscape for sustainable energy initiatives in the country. Concurrently, Sayed's (2023) research delves into the investment climate surrounding green power projects in Ukraine. Both investigations scrutinize past experiences and future opportunities in this domain, pinpointing crucial elements that drive success as well as obstacles that hinder investment flows. These analyses provide valuable insights into the financial dynamics shaping Ukraine's transition to cleaner energy sources. Bakhmat et al. (2023) and Kostyrko et al. (2021) study the Ukrainian electricity market, focusing on issues of reform, financing and innovative investments during various crises (pandemic, military conflicts, etc.). Mykoliuk and Bobrovnyk (2019) and Pablo-Romero et al. (2021) consider the use of renewable energy sources for electricity generation in countries with economies in transition, including Ukraine, analyzing the objectives and incentive policies. A series of scholarly investigations have probed the economic facets of Ukraine's terminal energy usage. Timchenko et al. (2019) initiated this line of inquiry, followed by Tkachuk et al. (2019) and Yakymchuk et al. (2023) providing the most recent contribution. These studies collectively assess the feasibility of incorporating successful practices from EU nations into Ukraine's energy landscape. Their research evaluates how adopting proven European strategies could potentially reshape and optimize Ukraine's energy consumption patterns from an economic standpoint.

This literature review demonstrates the multifaceted nature of studies on the economic benefits of implementing green technologies in Ukraine, including aspects of policy, technology, innovation, financing and sustainable development. At the same

time, it requires a more comprehensive analysis of specific economic benefits from the implementation of green technologies in different sectors of the Ukrainian economy, which is the focus of this study.

### 3. METHODS

This research utilizes a descriptive research design, as the primary goal is to analyze and describe the economic benefits of green technology adoption in Ukraine. Descriptive research allows for a comprehensive evaluation of the current state of green technology implementation and its economic implications. By focusing on Ukraine's renewable energy sector and energy efficiency initiatives, this study aims to capture the economic trends and impacts of green innovations within the country.

The scope of the research is centered on Ukraine's renewable energy sector, specifically solar, wind, bioenergy, and energy efficiency technologies. This study spans from 2014 to 2023, a period characterized by significant developments in Ukraine's green technology sector. The geographical scope is limited to Ukraine, but the findings contribute to the broader understanding of green technology adoption in transitional economies facing energy security and modernization challenges.

This study relies primarily on secondary data, collected from reputable sources such as governmental organizations, international agencies, and peer-reviewed journals. The main sources of data include reports from the Ministry of Energy of Ukraine (Ministry of Energy of Ukraine, 2024), the International Renewable Energy Agency (IRENA, 2024) and the International Energy Agency (IEA, 2024). These sources provide quantitative insights into the development of renewable energy projects, sector-specific economic performance, and Ukraine's energy consumption trends. The description of secondary data includes the following:

- Ministry of energy of Ukraine: Provides data on renewable energy project developments, energy consumption statistics, and national energy policy initiatives.
- International renewable energy agency: Offers global and national data on renewable energy adoption, job creation in green sectors, and investment flows into renewable projects.
- International energy agency: Supplies global energy trends and specific data on energy security and economic outcomes related to renewable energy.

These data sources were chosen for their accuracy, credibility, and relevance to the research objectives. They provide a reliable foundation for analyzing the economic benefits and challenges associated with green technology implementation in Ukraine. The datasets include indicators such as total installed renewable energy capacity, investment levels, job creation, and reductions in energy imports.

The collected data were processed using descriptive statistics to summarize key economic indicators related to renewable energy adoption in Ukraine. These indicators include:

- Total installed capacity of solar and wind energy (measured in gigawatts),



- Investment figures in renewable energy projects (measured in euros),
- Job creation in the renewable energy sector (measured in number of jobs),
- Reduction in natural gas imports (measured as a percentage of total imports).

Data analysis was conducted using Microsoft Excel, where various statistical techniques such as mean, percent changes, and trend analysis were applied. These methods allowed for a clear interpretation of how renewable energy investments and technologies have impacted Ukraine's economic growth, energy security, and employment landscape. All data analyses were carried out using Microsoft Excel for ease of computation, visualization, and data organization. Excel's statistical functions allowed for the efficient processing of large datasets and enabled the creation of charts to visualize key trends, such as job growth in the renewable energy sector and reductions in natural gas dependency.

Furthermore, a comparative analysis was performed to evaluate the economic performance of different renewable energy sectors, such as solar and wind energy, and their respective contributions to Ukraine's economic modernization. This comparison helped identify which sectors have had the most significant economic impacts and where further investments could yield the highest returns.

The research employed a range of analytical techniques to examine the economic impact of renewable energy in Ukraine. Descriptive statistics formed the foundation of the data analysis, enabling the calculation of averages, growth rates, and changes over time. This method was crucial for identifying and quantifying trends in renewable energy capacity expansion, job creation, and investment influxes across the sector. To gain a more nuanced understanding of the economic benefits derived from different renewable energy technologies, a comparative analysis was conducted. This approach allowed for an in-depth examination of the performance of various sectors, including solar, wind, and bioenergy. By comparing these sectors, the study was able to determine which technologies have contributed most significantly to Ukraine's economic growth and energy security.

The research also utilized trend analysis to project future outcomes based on historical data spanning from 2014 to 2023. This technique was applied to forecast potential job growth in the renewable energy sector and to estimate further reductions in energy imports. By extrapolating from current trajectories, the study provided insights into the long-term economic implications of Ukraine's renewable energy transition.

Several limitations were identified in this study, which may have influenced the outcomes:

- **Data availability:** The ongoing military conflict in Ukraine and political instability have significantly impacted the availability of up-to-date and real-time data. These disruptions have made it challenging to gather comprehensive datasets, thus limiting the completeness and accuracy of certain data points,

especially those related to recent developments in renewable energy projects.

- **Dependence on secondary data:** the study relies heavily on secondary data obtained from various organizations and agencies. This introduces the potential for biases or inaccuracies in the original reporting. While efforts were made to ensure the use of credible and reliable sources, such as IRENA and the Ministry of Energy of Ukraine, there remains a risk that some data may not fully reflect the most current realities of the sector.
- **Lack of real-time data:** The geopolitical situation has also restricted access to real-time data, particularly concerning ongoing renewable energy projects. This lack of immediate data may affect the precision of the current analysis, as it does not fully capture the most recent trends or developments within Ukraine's green technology sector.

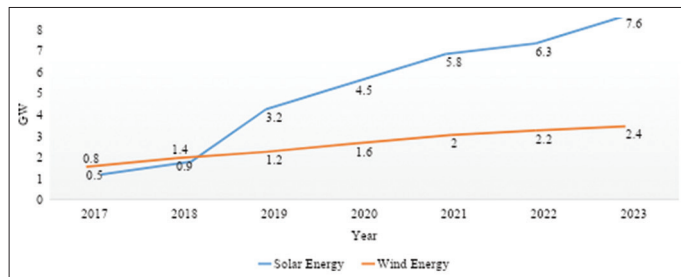
## 4. RESULTS

Ukraine has made significant progress in implementing green technologies over the past decade, especially in the renewable energy sector. Data from Ukraine's Energy Ministry reveals a significant upward trend in the nation's adoption of renewable energy sources. Over the course of a decade, the proportion of green energy within the country's total energy mix has seen a substantial rise. While renewables accounted for just under 4% of Ukraine's energy portfolio in 2014, this figure had more than tripled by 2023, reaching nearly 14% of the overall energy balance (Ministry of Energy of Ukraine, 2024). Solar and wind energy are developing most dynamically (Figure 1). The total installed capacity of solar power plants increased from 0.8 GW in 2017 to 7.6 GW in 2023 and wind power plants capacity increased from 0.5 GW in 2017 to 2.4 GW in 2023 (Kurbatova et al., 2023; Rychka, 2024; Trypolska et al., 2022).

The development of renewable energy sources has brought substantial economic advantages to Ukraine. One of the most significant benefits has been the creation of employment opportunities. According to International Renewable Energy Agency (IRENA, 2024), the renewable energy sector had generated over 50,000 jobs in Ukraine by 2023, contributing to the country's economic growth and providing new career paths for its workforce (Figure 2). Forty percent of the jobs are concentrated in the solar energy sector, emphasizing its leadership among other renewable sources. Expanding employment in the bioenergy and energy efficiency sectors offers a promising opportunity to reduce unemployment and stimulate economic growth, contributing to a more sustainable and resilient economy.

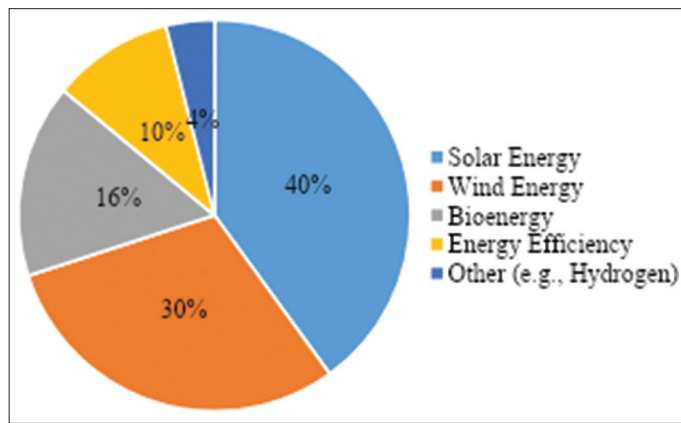
Another crucial economic advantage has been the influx of investments into the country. Between 2014 and 2022, the renewable energy sector in Ukraine attracted approximately €12 billion in investments (Trypolska and Riabchyn, 2022). Furthermore, the adoption of renewable technologies has led to a noteworthy reduction in Ukraine's dependence on imported natural gas. By 2023, the country had achieved a 15% decrease in natural gas imports compared to 2014 levels (Yakymchuk et al., 2023). This reduction in energy imports has contributed

**Figure 1:** Installed capacities of solar and wind energy in Ukraine (2017-2023)



Source: Authors' development with data from Ministry of Energy of Ukraine (2024)

**Figure 2:** The structure of employment in the sector of green technologies (2023)



Source: Authors' development with data from International Renewable Energy Agency (2024)

to improving Ukraine's trade balance and enhancing its energy security, demonstrating the tangible economic benefits of transitioning to green technologies. Consequently, these benefits collectively contribute to national development by improving energy efficiency, stimulating innovation, creating jobs, and attracting foreign investment. The adoption of green technologies strengthens Ukraine's economic modernization efforts, making it more competitive in international markets.

Ukraine's economic landscape has been increasingly shaped by the adoption of energy-conserving technologies, marking a significant shift towards environmental sustainability. This green transition has yielded tangible results, with the nation's GDP energy intensity dropping by more than a quarter between 2014 and 2023, a reduction largely attributed to the implementation of energy-efficient practices in the industrial sector, as highlighted in research by Deineko et al. (2019). In the housing sector, the "Warm Loans" program has stimulated the modernization of more than 800,000 households, resulting in an average saving of 35% on heating (Koval et al., 2021). The economic benefits of implementing green technologies, including direct and indirect economic effects, are separately examined (Table 1).

Despite significant progress, the implementation of green technologies in Ukraine faces a number of challenges:

- Financial barriers represent a major obstacle to the large-scale adoption of green technologies in Ukraine: limited access to financing, particularly for small and medium-sized enterprises, hinders widespread implementation of these technologies. While the country has attracted significant investments, with approximately €12 billion invested in the renewable energy sector, additional funding is still required to expand infrastructure and support new projects. This financial constraint limits the pace at which Ukraine can transition to a greener economy and reap the associated economic benefits.
- Regulatory uncertainty poses another significant challenge: frequent changes in policies and legislation create an environment of uncertainty for investors, discouraging long-term commitments to green energy projects. The lack of a stable policy framework hampers the development of renewable energy infrastructure, as investors and businesses hesitate to make substantial investments without assurances of consistent regulatory support. This instability can slow down the growth of the green technology sector and limit its economic impact.
- Technological constraints, particularly in the form of outdated energy infrastructure, present technical challenges for the integration of renewable energy sources into the national grid: the need for infrastructure modernization remains a priority to support further expansion of green technologies. These technological limitations not only affect the efficiency and reliability of renewable energy systems but also increase the costs associated with their implementation, potentially reducing their economic benefits.
- Public awareness and perception also present challenges in the adoption of green technologies in Ukraine: low awareness among businesses and the public about the benefits of green technologies limits their adoption and integration into daily economic activities. This lack of understanding can lead to resistance to change and slower uptake of sustainable practices. To address this, education and outreach programs are required to build societal support and promote the advantages of renewable energy and energy-efficient practices. Increasing public awareness and acceptance is crucial for creating a supportive environment for the growth of the green technology sector and realizing its full economic potential.
- As well, Ukraine faces several significant opportunities in integrating green innovations into its economic framework. These opportunities, if properly leveraged, can lead to substantial economic benefits and sustainable growth for the country:
- Incentivizing investment through policy reforms: by developing long-term strategies with clear support mechanisms for green technologies, Ukraine can create an attractive environment for both domestic and foreign investments in this sector. Additionally, implementing policies that expand access to specialized financial instruments can play a crucial role in supporting small and medium-sized enterprises in their adoption of green technologies. This approach not only fosters innovation but also ensures that the benefits of green technology adoption are spread across various scales of business within the Ukrainian economy.

**Table 1: Direct and indirect economic effects from the introduction of green technologies**

Economic effects	Title	Description
Direct	Reduction of energy costs	According to the Ministry of Energy, the introduction of energy-efficient technologies in industry has led to a 15-20% reduction in energy costs on average in the industry.
Direct	Increasing competitiveness	Companies that have implemented green technologies report increased competitiveness in international markets due to lower production costs and improved image.
Direct	Export growth	The export of equipment and services in the field of green technologies from Ukraine increased by 45% in the period 2018-2023.
Indirect	Improving the health of the population	Reducing air pollution through the adoption of green technologies has led to a reduction in healthcare spending by 2.5% of GDP in 2023.
Indirect	Development of an innovative ecosystem	The growth of investments in research and development works in the field of green technologies by 78% for the period 2014-2023 stimulated the development of the innovative ecosystem of Ukraine.
Indirect	Improvement of energy security	Diversification of energy sources and reduction of dependence on energy imports increased Ukraine's energy security, which has a positive impact on macroeconomic stability.

Source: Bondarenko et al. (2023), IEA (2024), Ministry of Energy of Ukraine (2024), Okhrimenko et al. (2022), Kuzior et al. (2021), Li et al. (2022), Lyulyov et al. (2021), Yang et al. (2020)

- The modernization of infrastructure presents another key opportunity for Ukraine: investments in upgrading energy infrastructure will enable better integration of renewable energy sources and increase overall system efficiency. This modernization is essential for creating a robust and flexible energy system capable of supporting the country's transition to greener technologies while also improving the reliability and cost-effectiveness of the energy sector.
- International cooperation offers Ukraine significant opportunities in its pursuit of green technology integration: by strengthening international partnerships, Ukraine can gain access to advanced technologies and funding opportunities that can accelerate its progress in the green technology sector. Moreover, active participation in global environmental initiatives can enhance Ukraine's visibility on the international stage, potentially increasing its attractiveness to foreign investors and opening up new avenues for economic growth and technological exchange.
- Human capital development represents a critical opportunity for Ukraine to fully leverage the economic benefits of green technologies: expanding vocational training and educational programs focused on green technologies will address the growing demand for skilled labor in this rapidly evolving sector. This not only creates new job opportunities but also ensures that Ukraine has a workforce capable of supporting and growing its green technology industries. Furthermore, fostering collaboration between universities, research institutions, and industry can drive innovation and sustainable development, potentially leading to new technological breakthroughs and economic opportunities that position Ukraine as a leader in green innovation.

To maximize economic benefits from the introduction of green technologies in Ukraine, we have formulated the following recommendations, which are outlined in Figure 3.

The introduction of green technologies in Ukraine not only contributes to the preservation of the environment, but has also become a factor in economic growth. Positive factors resulting from the transition to sustainable development, such as reduced energy costs, the creation of new jobs and support for innovation, demonstrate the need for active development and implementation

**Figure 3: Recommendations for maximizing economic benefits from the introduction of green technologies in Ukraine**

Source: Authors' development

of renewable energy sources. The results demonstrate that the adoption of green technologies in Ukraine offers significant economic benefits while enhancing energy security and reducing fossil fuel dependence. However, challenges such as financial barriers, regulatory instability, and outdated infrastructure must be addressed to fully unlock the potential of green innovations. Opportunities for further development lie in policy reforms, infrastructure modernization, and international cooperation. These findings provide a solid foundation for formulating strategies to enhance Ukraine's sustainable development and economic competitiveness through green technologies.

## 5. DISCUSSION

The adoption of green technologies offers transformative economic potential, particularly for countries like Ukraine that face significant energy challenges. This research addresses the economic benefits of green technologies while also considering their impact on energy security and the barriers hindering their adoption. This section discusses the research findings, compares them with existing literature, offers an interpretation of unexpected



results, highlights limitations, and outlines the scientific contribution of the study.

Ukraine's transition toward green technologies are driven by the need to reduce dependence on imported fossil fuels, enhance energy security, and foster sustainable economic growth. The goal of this study was to evaluate the economic benefits of green technologies and explore how they contribute to national development. The research also investigated the challenges and opportunities involved in integrating renewable energy into Ukraine's economic framework.

The study confirms that the implementation of green technologies in Ukraine has yielded several direct and indirect economic benefits. It highlights reduced energy costs, increased exports, job creation, and improved public health. Compared to previous studies (Koval et al., 2021; Trypolska et al., 2022), our findings align closely with their conclusions on the role of renewable energy in job creation and export growth. This alignment reinforces the idea that green technologies not only promote sustainable development but also stimulate economic modernization:

- Interpretation: While solar energy remains the leading sector with 40% of total employment, our findings suggest that expanding bioenergy and energy efficiency initiatives could unlock further economic potential, especially in rural areas. This outcome underscores the importance of diversifying green energy investments to maximize job creation.

Our research confirms a 15% reduction in natural gas imports since 2014, largely due to the expansion of solar and wind energy. This finding aligns with the conclusions of Yakymchuk et al. (2023), who argue that renewable energy development plays a critical role in reducing Ukraine's dependence on imported fuels. However, some of our data suggest that the energy savings achieved were slightly lower than projected by earlier forecasts from the International Renewable Energy Agency (IRENA, 2024).

- Interpretation: The discrepancy between expected and actual savings may reflect the outdated infrastructure and regulatory challenges that hinder the integration of renewable energy sources. This emphasizes the need for infrastructure modernization and stable regulatory policies to fully capitalize on green technologies' potential.

The study identifies four primary challenges: Financial barriers, regulatory instability, outdated infrastructure, and low public awareness. These challenges echo the findings of Kurbatova et al. (2020), who noted that policy inconsistencies deter investment in Ukraine's green energy sector:

- Interpretation of unexpected results: An unexpected finding was the relatively slow adoption of energy-efficient practices in the residential sector, despite government incentives. Survey data revealed that many households lacked awareness about available programs such as the "Warm Loans" program, highlighting a gap in public outreach efforts.

The results of this study align with the broader literature on the economic impact of green technologies in transitional economies, though some differences were observed. Our findings on employment generation are consistent with the work of Bondarenko et al. (2023), who highlight the potential of green technologies to stimulate rural employment. The creation of jobs in sectors such as solar and wind energy, which was evident in our research, reflects the ability of these technologies to offer new economic opportunities, particularly in regions with limited industrial development. This alignment underscores the role of renewable energy in not only enhancing environmental sustainability but also addressing social challenges like unemployment in rural areas. Similar to the findings of Sayed (2023), our study confirms that foreign investment plays a crucial role in financing renewable energy projects. Foreign capital has been pivotal in scaling up solar and wind power infrastructure in Ukraine, fostering economic growth and technological innovation.

However, unlike Sayed's more optimistic perspective on the investment climate, our research identifies regulatory instability as a persistent obstacle. Frequent policy changes and uncertainty surrounding government incentives deter long-term investments, posing a risk to the sustained growth of the sector. Studies by Pablo-Romero et al. (2021) emphasize the smooth integration of renewable energy systems in other transitional economies, demonstrating how effective policies and modern infrastructure have facilitated a seamless transition. In contrast, our research reveals that outdated infrastructure continues to be a significant challenge for Ukraine. While renewable energy projects have expanded rapidly, the lack of modern energy infrastructure limits their integration into the national grid, reducing efficiency and slowing the full realization of economic benefits. Addressing these infrastructure bottlenecks will be essential to unlock the sector's potential and align Ukraine's experience with the success observed in other countries.

Several limitations affect the generalizability of the study's findings:

- Data availability: The ongoing military conflict in Ukraine limited access to real-time data, which may have impacted the completeness of the analysis, particularly regarding the most recent trends in renewable energy adoption.
- Reliance on secondary data: The study relied heavily on secondary sources, which could introduce biases due to reporting inconsistencies in official statistics. Although efforts were made to use credible data sources such as the Ministry of Energy of Ukraine and IRENA, the reliance on external data may affect the precision of certain conclusions.
- Geopolitical uncertainty: Ukraine's political and economic landscape remains highly dynamic, which may influence the long-term outcomes of green technology implementation. As a result, forecasting future developments in the sector remains challenging.

This study makes several important contributions to the field of green technology research, particularly within the context of a transitional economy like Ukraine. These contributions enhance our understanding of the economic impacts of green technology

adoption and provide valuable insights for policymakers and stakeholders. Firstly, the study offers a comprehensive analysis of economic benefits across multiple sectors. Unlike previous research that often focused on specific sectors in isolation, this study provides a holistic evaluation of the economic impact across various renewable energy sectors, including solar, wind, and bioenergy. This comprehensive approach allows for a more nuanced understanding of how different green technologies contribute to overall economic growth and development in Ukraine.

Secondly, the research places a strong focus on employment dynamics within the green technology sector. By quantifying employment distribution across different renewable energy sectors, the study offers new insights into labor market opportunities created by the adoption of green technologies. This analysis is particularly valuable for understanding the potential of the green technology sector to generate jobs and contribute to economic growth in a transitional economy like Ukraine. Lastly, the study provides policy recommendations specifically tailored to address infrastructure and investment challenges. The research identifies critical areas for policy intervention, such as expanding access to finance for green technology projects and modernizing energy infrastructure. By highlighting these key areas, the study offers actionable recommendations for stakeholders, including policymakers, investors, and industry leaders. These recommendations can guide decision-making processes and help shape policies that effectively support the growth of the green technology sector in Ukraine.

The findings confirm that green technologies offer substantial economic benefits, but fully realizing these benefits will require policy consistency, financial reforms, and public engagement. Future studies could address the limitations identified in this research by conducting sector-specific analyses and expanding the scope to include emerging technologies such as green hydrogen and advanced energy storage solutions. Furthermore, investigating international best practices for green technology adoption will help Ukraine adapt successful strategies to its unique context. This research underscores the importance of adopting a holistic approach to green technology integration, balancing economic, environmental, and social objectives. By doing so, Ukraine can position itself as a leader in sustainable innovation and energy transition, contributing not only to national development but also to global environmental goals.

## 6. CONCLUSION

This study aimed to evaluate the economic benefits of implementing green technologies in Ukraine and their contributions to sustainable development, energy security, and overall economic growth. The findings highlight the role of green technologies in driving national development, reducing energy dependence, and addressing key economic and environmental challenges:

1. The primary economic benefits of green technology implementation in Ukraine include job creation, investment growth, and enhanced competitiveness. The renewable energy sector, especially solar and wind energy, contributed to creating

over 50,000 jobs by 2023. Investment in green technologies reached approximately €12 billion between 2014 and 2022, boosting economic modernization. These investments have not only stimulated industrial growth but also positioned Ukraine as a more competitive player in global markets. The widespread adoption of green technologies, such as energy-efficient industrial solutions, has also reduced energy costs by 15-20%, further enhancing the financial resilience of businesses. Additionally, green technologies have encouraged innovation in energy-efficient systems, bioenergy, and waste management, fostering a broader innovation ecosystem that contributes to sustainable national development.

2. Green technologies have significantly strengthened Ukraine's energy security by diversifying its energy sources and reducing dependency on imported natural gas. By 2023, renewable energy accounted for nearly 14% of Ukraine's energy mix, helping to reduce natural gas imports by 15% compared to 2014 levels. This reduction not only improved the country's trade balance but also enhanced energy independence in a context of geopolitical tensions. Solar and wind energy development, alongside energy-efficient initiatives in industry and housing, has played a central role in decreasing reliance on fossil fuels. Government programs, such as "Warm Loans," have further promoted energy efficiency, resulting in substantial savings in household heating costs. The integration of green technologies thus serves as a strategic tool for achieving long-term energy security.
3. Ukraine faces several challenges in fully realizing the potential of green technologies:
  - Financial constraints: Access to financing remains a significant barrier, particularly for small and medium-sized enterprises looking to adopt green technologies. Limited availability of funds restricts the ability of these businesses to invest in sustainable innovations, which slows the pace of green technology implementation across various sectors.
  - Regulatory instability: Frequent changes in policies and inconsistent regulatory frameworks deter long-term investments in renewable energy. The lack of stable and predictable regulations creates uncertainty for investors, making it difficult for businesses to commit to large-scale green energy projects.
  - Outdated infrastructure: The aging and underdeveloped energy infrastructure poses a significant technical challenge. Ukraine's energy grid is not fully equipped to handle the efficient integration of renewable energy sources, which limits the potential impact of solar, wind, and other green technologies.
  - Public awareness: Low levels of awareness among businesses and the general public about the economic and environmental benefits of green technologies further hinder their widespread adoption. Without a clear understanding of the long-term advantages, many potential adopters remain hesitant to invest in green innovations.

Despite these challenges, Ukraine has substantial opportunities to capitalize on green innovations. By improving the regulatory



environment, providing better access to financing, modernizing infrastructure, and enhancing public education on the benefits of green technologies, Ukraine can further accelerate its transition to a sustainable economy. Additionally, international cooperation, particularly through adopting global best practices and advanced technologies, presents a significant opportunity to attract foreign investment and drive technological progress in the green sector.

Future studies should explore sector-specific analyses of green technologies to better understand their long-term economic impacts across various industries. Investigating innovative financing mechanisms and policy reforms to support medium-sized enterprises and further investment in infrastructure will be critical for overcoming current barriers. Additionally, examining emerging green technologies like hydrogen energy and advanced energy storage solutions could provide new opportunities for sustainable economic growth in Ukraine. Future research could also explore how digitalization and smart technologies can enhance the efficiency and economic outcomes of green innovations in Ukraine.

## REFERENCES

- Ahamer, G. (2021), Major obstacles for implementing renewable energies in Ukraine. *International Journal of Global Energy Issues*, 43(5-6), 664-691.
- Babenco, V., Koniaieva, Y., Yevchuk, L., Dikan, O., Tokmakova, I., Korin, M. (2020), Study of innovative susceptibility of low potential energy technologies in Ukraine. *Studies of Applied Economics*, 38(4), 4095.
- Bakhmat, N., Krasnoshchok, I., Voron, O. (2023), International experience of using E-learning during pandemics and military conflicts. *E-Learning Innovations Journal*, 1(2), 68-85.
- Bondarenko, V., Pokynchereda, V., Pidvalna, O., Kolesnyk, T., Sokoliuk, S. (2023), Green economy as a prerequisite for sustainable development: Analysis of international and Ukrainian experience. *European Journal of Sustainable Development*, 12(1), 221-221.
- Bozhkova, V., Melnyk, L., Derykolenko, O., Yevdokimov, Y., Dehtyarova, I., Pasyevin, O. (2020), The system of indicators for alternative energy development in the context of the green economy. *International Journal of Global Environmental Issues*, 19(1-3), 70-89.
- Butyrskiy, A., Nikolenko, L., Poliakov, B., Ivanyuta, N., Donchak, L., Butyrskaya, I. (2019), Economic, investment and legal paradigm of shale gas development: World experience and prospects for Ukraine. *Montenegrin Journal of Economics*, 15(2), 165-179.
- Deineko, L., Tsyplitska, O., Deineko, O. (2019), Opportunities and barriers of the Ukrainian industry transition to the circular economy. *Environmental Economics*, 10(1), 79.
- Furdychko, O., Drebot, O., Yaremko, O., Bondar, V., Vysochanska, M., Sakharnatska, L. (2021), Current challenges for sustainable forestry management in Ukraine: Production, taxation and investments issues. *Law, Business and Sustainability Herald*, 1(2), 58-75.
- Gorb, O., Rebilas, R., Aranchiy, V., Yasnolob, I., Boiko, S., Padalka, V. (2020), Strengthening competitiveness of the national economy by enhancing energy efficiency and diversifying energy supply sources in rural areas. *Journal of Environmental Management and Tourism*, 11(5), 1114-1123.
- IEA-International Energy Agency. (2024), Data and Statistics. Available from: <https://www.iea.org/data-and-statistics> [Last accessed on 2024 Sep 09].
- IRENA-International Renewable Energy Agency. (2024), Publications about Green Technologies. Available from: <https://www.irena.org/Search?contentType=2973584f-e344-4511-b43e-28543f6ae4&orderBy=Date&tagLanguages=e11d4000-b1fc-4d8f-a8f3-2908782a4c6d> [Last accessed on 2024 Sep 09].
- Kostyrko, R., Kosova, T., Kostyrko, L., Zaitseva, L., Melnychenko, O. (2021), Ukrainian market of electrical energy: Reforming, financing, innovative investment, efficiency analysis, and audit. *Energies*, 14(16), 5080.
- Koval, V., Olczak, P., Vdovenko, N., Boiko, O., Matuszewska, D., Mikhno, I. (2021), Ecosystem of environmentally sustainable municipal infrastructure in Ukraine. *Sustainability*, 13(18), 10223.
- Koval, V., Sribna, Y., Kaczmarzewski, S., Shapovalova, A., Stupnytskyi, V. (2021), Regulatory policy of renewable energy sources in the European national economies. *Polityka Energetyczna-Energy Policy Journal*, 24, 61-78.
- Kulyk, M., Nechaieva, T., Zgurovets, O., Shulzhenko, S., Maistrenko, N. (2023), Comparative analysis of energy-economic indicators of renewable technologies in market conditions and fixed pricing on the example of the power system of Ukraine. In: *Systems, Decision and Control in Energy IV*. Vol. 1. Modern Power Systems and Clean Energy. Cham: Springer Nature Switzerland. p433-449.
- Kurbatova, T., Lysenko, D., Trypolska, G., Prokopenko, O., Järvis, M., Skibina, T. (2022), Solar energy for green university: Estimation of economic, environmental and image benefits. *International Journal of Global Environmental Issues*, 21(2-4), 198-216.
- Kurbatova, T., Sotnyk, I., Kubatko, O., Baranchenko, Y., Arakpogun, E.O., Roubik, H. (2020), State support policy for renewable energy development in emerging economies: The case of Ukraine. *International Journal of Global Environmental Issues*, 19(1-3), 26-52.
- Kurbatova, T., Sotnyk, I., Prokopenko, O., Bashynska, I., Pysmenna, U. (2023), Improving the feed-in tariff policy for renewable energy promotion in Ukraine's households. *Energies*, 16(19), 6773.
- Kurylo, V., Duliba, Y., Kurylo, I., Mushenok, V. (2020), Fiscal policy measures of air protection: Ukrainian realities and the EU experience. *European Journal of Sustainable Development*, 9(2), 315.
- Kushnir, M., Lypych, L., Fatenok-Tkachuk, A., Khilukha, O. (2022), Incentives for the deployment of social responsibility management in Ukrainian enterprises. *Law, Business and Sustainability Herald*, 2(1), 18-33.
- Kuzior, A., Lobanova, A., Kalashnikova, L. (2021), Green energy in Ukraine: State, public demands, and trends. *Energies*, 14(22), 7745.
- Li, R., Kubatko, O., Baranchenko, Y., Benetyte, R., Melnyk, L., Dehtyarova, I., Matsenko, O. (2022), Environmental and economic analysis of technological innovations in the energy sector. *International Journal of Global Environmental Issues*, 21(2-4), 182-197.
- Lozovan, V., Skrynkovskyy, R., Yuzevych, V., Yasynskiy, M., Pawlowski, G. (2019), Forming the toolset for development of a system to control quality of operation of underground pipelines by oil and gas enterprises with the use of neural networks. *Eastern-European Journal of Enterprise Technologies*, 2(98), 41-48.
- Lyulyov, O., Pimonenko, T., Kwilinski, A., Dzwigol, H., Dzwigol-Barosz, M., Pavlyk, V., Barosz, P. (2021), The impact of the government policy on the energy efficient gap: The evidence from Ukraine. *Energies*, 14(2), 373.
- Ministry of Energy of Ukraine. (2024), Open Data. Available from: <https://mev.gov.ua/storinka/nabory-vidkrytykh-danykh-haluzi> [Last accessed on 2024 Sep 09].
- Mykoliuk, O.A., Bobrovnyk, V.M. (2019), Strategic guidelines on the development of renewable energy sources. *Global Journal of Environmental Science and Management*, 5, 61-71.
- Okhrimenko, O., Chynchyk, A., Dergach, A., Bannikova, K., Nesterenko, O. (2022), Strategies for economic development: the

- Ukrainian case. *Amazonia Investiga*, 11(55), 234-248.
- Ostapenko, O.P. (2020), Estimation of efficiency of energy-and resource-saving heat pump technologies in Ukraine. In: *The Concepts of Green Logistics and Sustainable Development. Modern Approaches to Knowledge Management Development*. p174. Available from: [https://www.vspv.si/uploads/visoka\\_sola/datoteke/mono\\_ljubljana\\_school\\_of\\_business\\_2020.pdf#page=175](https://www.vspv.si/uploads/visoka_sola/datoteke/mono_ljubljana_school_of_business_2020.pdf#page=175) [Last accessed on 2024 Sep 10].
- Pablo-Romero, M.P., Sánchez-Braza, A., Galyan, A. (2021), Renewable energy use for electricity generation in transition economies: Evolution, targets and promotion policies. *Renewable and Sustainable Energy Reviews*, 138, 110481.
- Petrushenko, M., Burkynskiy, B., Shevchenko, H., Baranchenko, Y. (2022), Towards sustainable development in a transition economy: The case of eco-industrial parks in Ukraine. *Environmental Economics*, 12(1), 149-164.
- Popova, N., Kataiev, A., Skrynkovskyy, R., Nevertii, A. (2019), Development of trust marketing in the digital society. *Economic Annals-XXI*, 176(3-4), 13-25.
- Prokopenko, O. (2022), Digital contracts in renewable energy markets: Challenges and opportunities. *Law, Business and Sustainability Herald*, 2(4), 17-30.
- Prokopenko, O., Chechel, A., Sotnyk, I., Omelyanenko, V., Kurbatova, T., Nych, T. (2021), Improving state support schemes for the sustainable development of renewable energy in Ukraine. *Polityka Energetyczna*, 24(1), 85-100.
- Pryshliak, N., Tokarchuk, D. (2020), Socio-economic and environmental benefits of biofuel production development from agricultural waste in Ukraine. *Environmental and Socio-economic Studies*, 8(1), 18-27.
- Rychka, R. (2024), Artificial intelligence to predict solar energy production: Risks and economic efficiency. *Futurity Economics and Law*, 4(2), 100-111.
- Sabishchenko, O., Rębilas, R., Sczygiol, N., Urbański, M. (2020), Ukraine energy sector management using hybrid renewable energy systems. *Energies*, 13(7), 1776.
- Sayed, R. (2023), Strategic integration of business analytics in innovation management: Framework for sustainable growth. *Futurity of Social Sciences*, 1(1), 51-66.
- Sembiyeva, L., Zhagyparova, A., Zhusupov, E., Bekbolsynova, A. (2023), Impact of investments in green technologies on energy security and sustainable development in the future. *Futurity of Social Sciences*, 1(4), 61-74.
- Silvia, B. (2023). Modern digital technologies and AI ethics: Moral relevance. *Futurity Philosophy*, 2(3), 71-85.
- Starinskyi, M., Zavalna, Z. (2021), Economic sovereignty of a modern state in the context of sustainable development. *Law, Business and Sustainability Herald*, 1(2), 5-15.
- Sumets, A., Kniaz, S., Heorhiadi, N., Farat, O., Skrynkovskyy, R., Martyniuk, V. (2021), Methodical approach to the selection of options for ensuring competitiveness of enterprises in the system of development of agricultural clusters. *Agricultural and Resource Economics: International Scientific E-Journal*, 7(1), 192-210.
- Timchenko, O., Nebrat, V.V., Lir, V., Bykonja, O., Dubas, Y. (2019), Organizational and economic determinants of digital energy development in Ukraine. *Economy and Forecasting*, 3, 59-75.
- Tkachuk, V., Yareмова, M., Tarasovych, L., Kozlovskiy, V., Piliavoz, T. (2019), Economic strategy of the development of renewable energy in rural areas of Ukraine. *Montenegrin Journal of Economics*, 15(3), 71-82.
- Trypolska, G., Kurbatova, T., Prokopenko, O., Howaniec, H., Klapkiv, Y. (2022), Wind and solar power plant end-of-life equipment: Prospects for management in Ukraine. *Energies*, 15(5), 1662.
- Trypolska, G., Riabchyn, O. (2022), Experience and prospects of financing renewable energy projects in Ukraine. *International Journal of Energy Economics and Policy*, 12(1), 134-143.
- Vakarov, V., Redko, K., Hodiashchev, M., Tkachuk, S., Yemets, V. (2024), Opportunities and threats for the strategic development of Ukraine's economy until 2030. *Futurity Economics and Law*, 4(4), 4-21.
- Voitko, S., Trofymenko, O., Moghaddami, S. (2021), Analysis of the factors that ensure the possibility of developing economic relations in the field of renewable energy between Ukraine and Turkey. *Journal of Economy Culture and Society*, 63, 127-147.
- Yakymchuk, A., Popadynets, N., Yakubiv, V., Maksymiv, Y., Hryhoruk, I., Matiychuk, L., Horyslavets, P. (2023), Economic aspects of final energy consumption in Ukraine: Prospects of implementation of the positive experience of the European Union. *International Journal of Energy Economics and Policy*, 13(1), 111-117.
- Yang, M., Cela, B., Yang, F. (2020), Innovative energy policy to transform energy systems in Ukraine. *Mitigation and Adaptation Strategies for Global Change*, 25, 857-879.