UDC 338.2:620.9

ENERGY SECURITY OF UKRAINE THROUGH THE LENS OF EUROPEAN UNION SUSTAINABLE DEVELOPMENT PRACTICES

DUMANSKA Ilona
Khmelnytskyi National University
https://orcid.org/0000-0001-8631-7268
e-mail: dumanskai@khmnu.edu.ua

This article explores the relationship between Ukraine's energy security and the sustainable development practices of the European Union, which define strategic directions for the energy transition in the context of acquiring EU membership status. Recognizing the importance of aligning national energy priorities with European standards, the study aims to provide practical recommendations for building a resilient energy sector model capable of ensuring long-term stability and compliance with membership criteria. Key areas of development are analyzed, including the expansion of renewable energy sources, the enhancement of energy efficiency, and the implementation of innovative technologies, all of which play a crucial role in strengthening energy security. Structural frameworks for defining strategic priorities in the energy sector and methodological parameters for integrating sustainable practices into national policy are substantiated, reflecting the requirements of EU member states. Furthermore, the publication examines the impact of the energy transition on economic resilience and illustrates how the combination of renewable technologies with international cooperation can safeguard the economy, population, and environment. The article also investigates the combined effect of energy efficiency measures and the EU accession process on resilience indicators such as productivity, profitability, and compliance with environmental standards. By evaluating contemporary energy security management strategies, the study emphasizes how Ukraine can leverage sustainable development tools and EU practices to enhance efficiency, adaptability, and long-term stability of its energy system.

Ключові слова: energy security, sustainable development, energy transition, EU, renewable energy sources, energy efficiency

https://doi.org/10.31891/mdes/2025-18-30

Стаття надійшла до редакції / Received 02.10.2025
Прийнята до друку / Accepted 18.11.2025

STATEMENT OF THE PROBLEM IN GENERAL AND ITS RELATIONSHIP WITH IMPORTANT SCIENTIFIC OR PRACTICAL TASKS

The problem of ensuring Ukraine's energy security has intensified in recent years due to the combined impact of war, globalization, and the urgent need for sustainable development. Russian attacks on energy infrastructure have caused severe damage: by mid-2023, assessments by the World Bank and UNDP estimated losses exceeding $10 billion in the energy sector, with more than 50% of power generation capacity affected [1]. In response, the European Union mobilized significant support, including €2 billion in energy security assistance since 2022, and in 2025 the European Bank for Reconstruction and Development signed a €500 million guarantee agreement to help Ukraine replenish gas reserves [2]. These figures highlight the scale of external support required to stabilize Ukraine's energy system.

From a scientific perspective, the problem is linked to the need for conceptual frameworks that integrate energy security with sustainable development theory. Ukraine's National Renewable Energy Action Plan (2024) set ambitious targets: 27% of electricity consumption from renewables by 2030, compared to only 14.3% in 2022 [3]. Current data show resilience in the renewable sector despite wartime challenges, with investment continuing in solar, wind, and biomass projects [4]. This transition requires interdisciplinary research combining economics, law, technology, and environmental studies to design effective governance models and risk-management strategies.

From a practical standpoint, the problem is directly tied to Ukraine's aspiration to acquire EU membership status. Compliance with EU standards demands modernization of energy infrastructure, diversification of generation, and adoption of energy efficiency measures. According to the State Agency on Energy Efficiency, Ukraine's energy intensity remains two to three times higher than the EU average, underscoring the urgent need for reforms [5]. Addressing these inefficiencies is critical for reducing dependence on imported fossil fuels, mitigating climate impacts, and meeting EU accession criteria.

The relationship between the general problem and practical tasks is evident: modernizing infrastructure, expanding renewables, and improving efficiency are not only scientific challenges but also essential steps toward economic resilience and EU membership. By aligning national energy priorities with European sustainable development practices, Ukraine can strengthen its independence, enhance environmental responsibility, and secure long-term stability. Thus, The aim of this article is to analyze the challenges and opportunities of strengthening Ukraine's energy security through the adoption of sustainable development practices of the European Union in the context of acquiring EU membership status. Specifically, the study seeks to: (1) identify strategic directions of Ukraine's energy transition in line

with EU membership requirements; (2) assess the role of renewable energy expansion, energy efficiency improvements, and technological innovation in enhancing resilience; (3) examine the impact of war and globalization on the stability of Ukraine's energy system; (4) provide practical recommendations for aligning national energy policies with EU sustainable development standards and accession criteria.

ANALYSIS OF LATEST RESEARCH AND PUBLICATIONS

This literature review synthesizes findings from recent studies to emphasize the necessity of integrating sustainable development (SD) practices of the European Union into Ukraine's energy security framework. The recent literature relevant to the topic of this publication highlights the significant role of renewable energy, energy efficiency, and institutional reforms in shaping Ukraine's energy transition, and its description is systematized in Table 1.

Table 1

Synthesis of modern research and studies in the field of energy security and SD

№	Author, source	Direction of research	Description of ideas	SD Impact in the study
1	Kogut, S. (2023) [6]	Global energy trends & Ukraine's security	Analyzes global energy development trends and their implications for Ukraine's energy security.	Emphasizes the need to align Ukraine's energy priorities with global sustainability standards.
2	Yakovyuk, I. V., & Tsvelikh, M. P. (2023) [7]	EU energy security under war conditions	Examines EU energy security challenges during Russian aggression and implications for Ukraine's accession.	Highlights EU solidarity and sustainable energy diversification as key for resilience.
3	Furman, I. (2024) [8]	Bioenergy development	Highlights bioenergy as a strategic tool for strengthening Ukraine's energy independence.	Promotes renewable bioenergy as a sustainable pathway to reduce fossil fuel dependence.
4	Polukhin, A. V., et al. (2023) [9]	Energy security processes	Discusses systemic issues and current challenges in Ukraine's energy security management.	Suggests integrating sustainable governance frameworks into national energy policy.
5	Tsulaia, H. Z. (2023) [10]	Energy security in state policy	Considers energy security as a central object of Ukraine's national policy framework.	Frames energy security as part of sustainable state development priorities.
6	Pazynich, Y. (2024) [11]	Energy security & socio-economic development	Links energy security to socio-economic resilience, outlining challenges and future prospects.	Connects sustainable energy reforms with long-term socio-economic stability.
7	Horbatenko, V. P., & Kukuruz, O. V. (2023) [12]	Conceptual approaches	Explores evolving approaches to understanding energy security in Ukraine.	Advocates for sustainability-oriented conceptual models of energy security.
8	Kuzo, N. J., & Kosar, N. S. (2023) [13]	Petroleum products market	Analyzes trends in Ukraine's petroleum products market and their impact on energy security.	Stresses the transition from fossil fuels to sustainable alternatives.
9	Kobielieva, T., & Pererva, P. (2023) [14]	Monitoring energy security indicators	Proposes methodological foundations for monitoring energy security in business structures.	Encourages sustainable monitoring practices to ensure efficiency and transparency.
10	Pshybelskyi, V. (2023) [15]	War impacts on energy security	Evaluates the challenges war poses to Ukraine's fuel and energy sector.	Notes that sustainable reconstruction is essential for post-war energy resilience.
11	Yara, O. S., et al. (2023) [16]	Alternative energy sources	Studies the role of renewables in ensuring Ukraine's energy security.	Demonstrates how renewables strengthen sustainability and reduce environmental risks.
12	Yakovets, I., & Ruda, I. (2023) [17]	Global energy supply stability	Discusses strategies for stable energy supply in global economic development.	Links global supply stability to sustainable energy diversification.
13	Bondarenko, S., & Korotchenko, O. (2023) [18]	Resilience concept	Introduces resilience as a new paradigm in energy security research.	Positions resilience as a sustainability-driven concept for energy systems.
14	Havrysh, O. A., & Vyžanov, O. S. (2025) [19]	Regional energy security	Conducts structural analysis of regional energy security and reducing fossil fuel dependence.	Promotes regional sustainability through reduced fossil fuel reliance.
15	Mazaraki, A., & Melnyk, T. (2024) [20]	National energy security	Provides a comprehensive overview of Ukraine's national energy security in the context of EU integration.	Aligns national energy security with EU sustainable development practices and membership criteria.

In conclusion, the reviewed literature underscores the crucial integration of renewable energy expansion, energy efficiency improvements, and EU sustainable development practices in enhancing Ukraine's energy security. The evidence suggests that technological innovation, combined with institutional reforms and EU membership criteria, can lead to significant improvements in resilience, sustainability, and economic stability. Future research is essential to explore the evolving landscape of Ukraine's energy transition, particularly focusing on the synthesis of EU policy frameworks, renewable energy deployment, and efficiency measures. As Ukraine advances toward EU membership, fostering a culture that prioritizes both sustainability and security will be imperative for long-term success in the energy sector.

HIGHLIGHTING THE PREVIOUSLY UNSOLVED PARTS OF THE GENERAL PROBLEM TO WHICH THE ARTICLE IS DEDICATED

Despite significant progress in Ukraine's energy transition, several critical aspects of the general problem remain unresolved. First, the country's high energy intensity - two to three times above the EU average - continues to hinder sustainable growth. Second, insufficient diversification of energy sources leaves Ukraine vulnerable to external shocks and geopolitical risks. Third, the integration of renewable energy into national grids faces technical, financial, and regulatory barriers. Finally, the alignment of Ukraine's energy policies with EU sustainable development standards is incomplete, requiring deeper institutional reforms. These unsolved issues form the core challenges to which this article is dedicated.

FORMULATING THE PURPOSE OF THE ARTICLE

The primary purpose of this research article is to critically examine the mechanisms of energy security in Ukraine, with an emphasis on identifying and analyzing sustainable development practices derived from the European Union that can enhance resilience and reduce vulnerability. This study aims to explore the interplay between renewable energy expansion, energy efficiency improvements, and institutional reforms in the context of Ukraine's integration into the EU energy framework. By addressing both scientific and practical dimensions, the article contributes to the existing body of knowledge on energy security, sustainability, and European integration, while offering policy-relevant insights for strengthening Ukraine's long-term energy independence.

PRESENTATION OF THE MAIN MATERIAL

Ukraine's energy security is undergoing a profound transformation under the dual influence of wartime challenges and the requirements of European Union sustainable development practices. The ongoing war has inflicted unprecedented damage on the country's energy infrastructure, while simultaneously accelerating the urgency of reforms that align Ukraine with the EU's Green Deal and broader sustainability agenda. The main material of this study is presented through a synthesis of statistical data, comparative analysis, and conceptual modeling, which together highlight both the vulnerabilities and opportunities facing Ukraine's energy system.

1. Current State of Ukraine's Energy Security. Ukraine's energy system remains vulnerable due to three interrelated factors: extensive war damage, persistently high energy intensity, and continued dependence on fossil fuels. Russian attacks on power plants, transmission lines, and fuel storage facilities have caused billions of dollars in losses, undermining the stability of electricity supply and forcing emergency reliance on imported energy. At the same time, Ukraine's energy intensity - measured as the amount of energy consumed per unit of GDP - remains approximately three times higher than the EU average. This inefficiency reflects outdated industrial processes, insufficient modernization of housing and public infrastructure, and limited adoption of energy-saving technologies.

Despite these challenges, Ukraine has demonstrated resilience by expanding renewable energy generation and securing financial and technical assistance from the European Union (Table 2). Solar, wind, and biomass projects continue to attract investment, even under wartime conditions, while EU institutions have mobilized billions of euros to support Ukraine's energy sector. This dual dynamic - vulnerability and resilience - defines the current state of Ukraine's energy security.

The data presented in Table 2 provides a clear picture of Ukraine's energy trajectory between 2022 and 2024 [1-5]:

1. Renewable Energy Growth: The share of renewables in electricity generation increased from 14.3% in 2022 to 18.2% in 2024. While this growth is encouraging, it remains significantly below the EU average of 32%. This gap underscores the need for accelerated investment in renewable technologies and integration into national grids.

2. Energy Intensity: Ukraine's energy intensity decreased modestly from 0.35 toe per $1,000 GDP in 2022 to 0.31 in 2024. However, the figure is still nearly three times higher than the EU average of 0.12. This inefficiency reflects structural weaknesses in industry and housing, where outdated technologies and poor insulation drive excessive energy consumption.

3. War-Related Losses: Infrastructure losses rose from $10 billion in 2022 to $14 billion in 2024. These figures highlight the destructive impact of war on energy resilience, with repeated attacks on power plants and transmission systems forcing costly repairs and emergency imports.

4. EU Financial Support: Assistance from the EU increased steadily from €1.5 billion in 2022 to €2.5 billion in 2024. This support has been critical in stabilizing Ukraine's energy system, funding emergency repairs, and enabling investment in renewable projects.

Table 2

Key Indicators of Ukraine's Energy Security (2022–2024)

Indicator	2022	2023	2024	EU Average (2023)	Analytical Note
Share of renewables in electricity generation (%)	14.3	16.5	18.2	32.0	Ukraine shows growth but remains below EU average.
Energy intensity (toe per $1,000 GDP)	0.35	0.33	0.31	0.12	Ukraine's energy intensity is ~3x higher than EU.
War-related infrastructure losses ($ billion)	10.0	12.5	14.0	–	Ongoing destruction undermines resilience.
EU financial support (€ billion)	1.5	2.0	2.5	–	EU assistance is steadily increasing.

* formed by the author based on [1-5]

Together, these indicators reveal a paradox: while Ukraine is making progress in renewable energy and efficiency, the pace of transformation is constrained by war damage and structural inefficiencies. Comparing Ukraine's energy security indicators with EU averages highlights the scale of the challenge. The EU has achieved significant progress in renewable energy integration, efficiency improvements, and diversification of supply. Ukraine, by contrast, remains heavily dependent on fossil fuels and vulnerable to external shocks.

The EU's Green Deal sets ambitious targets for climate neutrality by 2050, with intermediate goals of 45% renewable energy by 2030 [21]. Ukraine's target of 27% by 2030 is less ambitious, reflecting both wartime constraints and structural challenges. Similarly, while EU countries have steadily reduced energy intensity through modernization and efficiency programs, Ukraine's intensity remains among the highest in Europe [4].

This comparative perspective underscores the importance of EU assistance and integration. By adopting EU practices in renewable energy, efficiency, and governance, Ukraine can accelerate its transition and close the gap with European standards.

Ukraine's energy security transformation can be conceptualized as a dynamic interplay between three forces - war challenges, EU sustainable development practices, and national energy transition goals [6-20]:

1. War Challenges: Infrastructure destruction, fuel shortages, and reliance on emergency imports create immediate vulnerabilities.

2. EU Sustainable Development Practices: Renewable energy expansion, efficiency improvements, and governance reforms provide a framework for resilience.

3. National Energy Transition Goals: Ukraine's long-term objectives include independence from Russian energy, integration into the EU energy market, and alignment with sustainability standards.

This conceptual model highlights the dual pressures facing Ukraine: the need to repair and stabilize its energy system while simultaneously pursuing long-term reforms.

Despite the severity of wartime challenges, Ukraine has significant opportunities to strengthen its energy security through sustainable development practices [4]:

1. Renewable Energy Expansion: Continued investment in solar, wind, and biomass can reduce dependence on fossil fuels and enhance resilience.

2. Energy Efficiency Improvements: Modernizing industry, housing, and public infrastructure can lower energy intensity and align Ukraine with EU standards.

3. Governance Reforms: Adopting EU-style regulatory frameworks can improve transparency, attract investment, and facilitate integration into the European energy market.

4. EU Assistance: Financial and technical support from the EU provides critical resources for reconstruction and modernization.

These opportunities demonstrate that sustainable development is not only a long-term goal but also an immediate necessity for Ukraine's survival and resilience.

This findings carry several important strategic implications for Ukraine's energy security and its broader integration into the European Union. First, the accelerated integration of renewable energy must become a national priority. Expanding solar, wind, and biomass projects will not only help Ukraine close the gap with EU averages but also reduce its vulnerability to external shocks and geopolitical pressures. Second, efficiency must be treated as a cornerstone of energy policy. Lowering Ukraine's energy intensity is essential for enhancing economic competitiveness, reducing costs, and ensuring sustainability in line with European standards. Third, resilience can only be achieved through diversification. By broadening the mix of energy sources and supply routes, Ukraine can mitigate risks associated with war damage, supply disruptions, and geopolitical instability. Finally, alignment with EU sustainable development practices is critical. Harmonizing Ukraine's energy policies with EU frameworks will strengthen its membership aspirations, foster institutional reforms, and secure long-term stability. Together, these strategic directions form a roadmap for transforming Ukraine's energy sector into one that is resilient, efficient, and fully integrated with the European sustainable development model.6. Strategic Implications

Ukraine's energy security is defined by a complex interplay of vulnerability and resilience. War damage and structural inefficiencies create immediate challenges, while renewable energy development and EU assistance provide pathways to stability. The statistical data, comparative analysis, and conceptual modeling presented in this section highlight both the scale of the problem and the opportunities for transformation.

By embracing EU sustainable development practices, Ukraine can strengthen its independence, reduce vulnerability, and secure a sustainable energy future. The path forward requires not only reconstruction but also reform, ensuring that Ukraine's energy system evolves into one that is resilient, efficient, and aligned with European standards.The data presented in Table 2 provides a clear picture of Ukraine's energy trajectory between 2022 and 2024.

2. Integration with EU Sustainable Development Practices. Ukraine's energy transition is inseparably linked to its aspirations for European Union membership. Energy security is not only a technical or economic issue but also a political and institutional challenge that directly influences Ukraine's integration trajectory. The EU has established ambitious frameworks for sustainable development, most notably the European Green Deal, which sets binding targets for renewable energy expansion, efficiency improvements, and climate neutrality by 2050. For Ukraine, adopting these practices is both a necessity for resilience in wartime and a prerequisite for accession, as energy security and sustainability are central to the EU's integration criteria.

The EU's sustainable development agenda is built on three pillars: renewable energy expansion, energy efficiency, and governance reforms. These pillars are reinforced by infrastructure diversification and resilience measures, including interconnected electricity markets and smart grids. Ukraine's energy system, however, remains constrained by wartime destruction, outdated industrial processes, and fragmented governance. Bridging this gap requires not only reconstruction but also systemic reforms that align Ukraine with EU standards.

EU assistance has already played a critical role in stabilizing Ukraine's energy sector. Since 2022, the EU has mobilized billions of euros in financial support, technical expertise, and emergency equipment to repair damaged infrastructure and sustain electricity supply. At the same time, Ukraine has committed to renewable energy targets and efficiency improvements, but the pace of transformation remains slower than EU averages (Table 3). This comparative perspective highlights both the progress made and the challenges ahead.

Table 3

Comparative Analysis of Ukraine and EU Energy Security Practices

Dimension	Ukraine (2023–2024)	EU Practices	Gap/Challenge
Renewable energy targets	27% by 2030	45% by 2030	Ambitious but lower than EU.
Energy efficiency	2–3x higher intensity than EU	Continuous reduction	Requires modernization of industry and housing.
Governance & policy	Fragmented, wartime adjustments	Integrated EU Green Deal	Needs institutional reforms and alignment.
Infrastructure resilience	Damaged, under reconstruction	Diversified, interconnected	Requires EU-style diversification and smart grids.

* formed by the author based on [1-5]

Ukraine's target of 27% renewable electricity by 2030 reflects a significant commitment, especially under wartime conditions. However, it remains below the EU's collective target of 45% by 2030 [21]. This disparity underscores the need for accelerated investment in solar, wind, and biomass projects. EU integration would provide Ukraine access to funding mechanisms such as the European Investment Bank and EU Innovation Fund, which could help bridge this gap. Moreover, Ukraine's renewable sector faces regulatory and technical barriers, including grid integration challenges and limited incentives for private investors. Addressing these barriers is essential for scaling up renewable deployment.

Ukraine's energy intensity remains two to three times higher than the EU average. This inefficiency stems from outdated industrial processes, poor building insulation, and limited adoption of modern energy-saving technologies. In contrast, EU countries have achieved continuous reductions in energy intensity through large-scale modernization programs, efficiency standards, and incentives for households and businesses. For Ukraine, modernization of housing stock, industrial equipment, and district heating systems is critical to narrowing this gap. Aligning with EU directives on energy efficiency would also attract investment and reduce long-term costs [15].

Ukraine's energy governance remains fragmented, with wartime adjustments often replacing long-term strategic planning. By contrast, the EU operates under an integrated framework - the Green Deal - which coordinates energy, climate, and industrial policies [21]. For Ukraine, alignment requires institutional reforms, transparent regulation, and harmonization with EU directives on renewable energy, emissions trading, and energy efficiency. Without such reforms, Ukraine risks lagging behind in integration and losing investor confidence. Strengthening governance also means combating corruption, ensuring transparency in energy markets, and building institutions capable of implementing EU-style reforms.

Ukraine's energy infrastructure has suffered extensive damage from Russian attacks, with billions lost in destroyed power plants and transmission systems. Reconstruction efforts are ongoing but remain reactive. The EU, by contrast, has developed diversified and interconnected energy systems, including cross-border electricity markets and smart grids. For Ukraine, adopting EU-style diversification and smart grid technologies is essential to ensure resilience, reduce vulnerability to future shocks, and enable integration into the European energy market. This requires not only rebuilding damaged facilities but also rethinking infrastructure design to prioritize sustainability and resilience.

A deeper comparison with selected EU countries illustrates the scale of Ukraine's challenge [1-3]: (1) Germany has achieved over 50% renewable electricity generation, supported by strong policy frameworks and investment incentives; (2) Poland, despite its reliance on coal, has committed to EU targets and is rapidly expanding wind and solar capacity; (3) France combines nuclear power with renewables, ensuring both low emissions and resilience. Ukraine's reliance on fossil fuels and wartime vulnerabilities place it behind these benchmarks. However, EU integration offers a pathway to adopt best practices and accelerate reforms.

Despite the challenges, Ukraine has significant opportunities to strengthen its energy security through EU sustainable development practices [5]:

1. Access to EU Funding: Integration would provide Ukraine with access to EU financial instruments, enabling large-scale investment in renewables and efficiency.
2. Technology Transfer: Collaboration with EU partners would facilitate the adoption of advanced technologies, including smart grids and energy storage.
3. Market Integration: Joining the EU energy market would diversify Ukraine's supply routes and reduce dependence on Russian energy.
4. Policy Alignment: Harmonizing Ukraine's energy policies with EU directives would strengthen governance and attract foreign investment.

The comparative analysis demonstrates that Ukraine's energy transition is progressing but remains constrained by wartime realities and structural inefficiencies. The EU provides both a benchmark and a roadmap: higher renewable targets, continuous efficiency improvements, integrated governance, and resilient infrastructure. For Ukraine, closing these gaps is not only a technical challenge but also a political and institutional one. Successful integration requires a dual approach: immediate reconstruction to restore resilience and long-term reforms to align with EU sustainable development practices.

Ukraine's energy transition is at a crossroads. Wartime destruction has exposed vulnerabilities, but EU sustainable development practices offer a pathway to resilience and integration. By accelerating renewable energy deployment, improving efficiency, reforming governance, and rebuilding infrastructure with sustainability in mind, Ukraine can strengthen its independence and secure a sustainable energy future. The path forward requires not only reconstruction but also reform, ensuring that Ukraine's energy

system evolves into one that is resilient, efficient, and fully aligned with European standards.

3. Conceptual Scheme of Ukraine's Energy Security Transformation. Ukraine's energy security is undergoing a profound transformation under the dual influence of wartime challenges and the requirements of European Union sustainable development practices.

The conceptual scheme presented in Fig. 1 illustrates the dynamic interplay between three critical dimensions: the destructive impacts of war, the stabilizing and reformative role of EU sustainable development practices, and Ukraine's long-term energy transition goals. This framework provides a holistic view of how vulnerabilities can be converted into opportunities for resilience, independence, and integration into the European energy system.

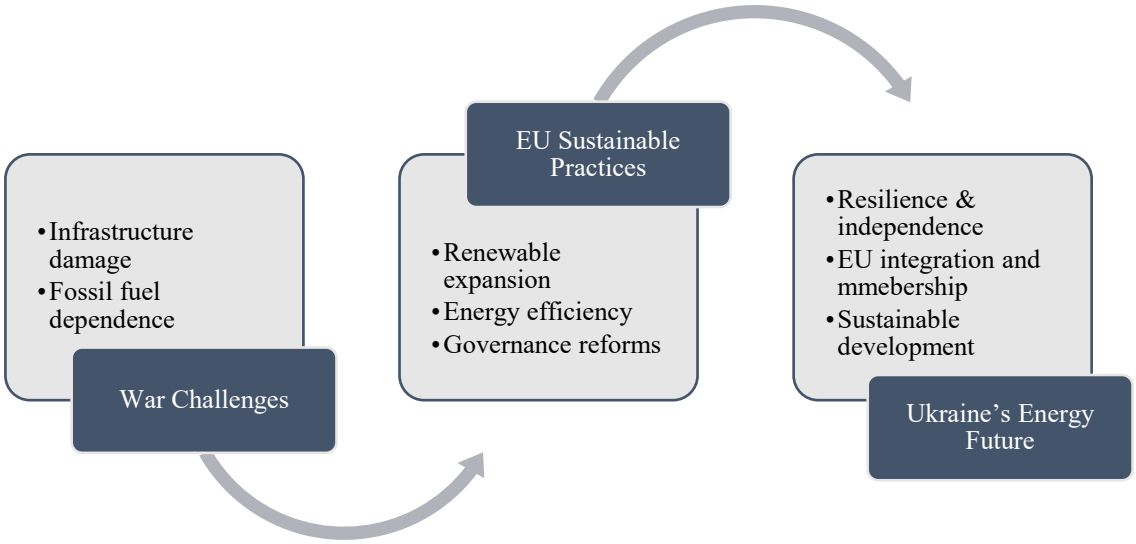

Fig. 1. Conceptual Scheme of Ukraine's Energy Security Transformation

* formed by the author based on [1-5, 18-23]

At the foundation of the scheme lies the reality of war challenges, which continue to shape Ukraine's energy landscape. Russian attacks on energy infrastructure have caused extensive damage, with billions of dollars in losses recorded between 2022 and 2024. Power plants, transmission lines, and fuel storage facilities have been repeatedly targeted, undermining the stability of electricity supply and forcing reliance on emergency imports.

Beyond physical destruction, the war has reinforced Ukraine's dependence on fossil fuels, particularly natural gas and coal, which remain vulnerable to supply disruptions and geopolitical manipulation. This dependence not only undermines resilience but also conflicts with global sustainability goals. High energy intensity - three times the EU average - further exacerbates vulnerability, reflecting outdated industrial processes and inefficient housing stock.

Thus, the war has created a multidimensional crisis: physical damage, structural inefficiency, and geopolitical dependence. These challenges form the starting point of the conceptual scheme, highlighting the urgent need for transformation.

The second stage of the scheme emphasizes the role of EU sustainable development practices as a pathway to resilience and modernization. The European Union has established ambitious frameworks for renewable energy expansion, efficiency improvements, and governance reforms, most notably through the European Green Deal.

For Ukraine, adopting these practices is both a necessity for survival and a prerequisite for EU membership:

1. Renewable Expansion: Ukraine has set a target of 27% renewable electricity by 2030, compared to the EU's 45% target. While progress has been made - renewable generation increased from 14.3% in 2022 to 18.2% in 2024 - the pace remains slower than EU averages. Accelerating renewable deployment is essential to reduce fossil fuel dependence and enhance resilience.
2. Energy Efficiency: Ukraine's energy intensity decreased modestly from 0.35 toe per $1,000 GDP in 2022 to 0.31 in 2024, but remains far above the EU average of 0.12. Modernization of industry, housing, and district heating systems is critical to narrowing this gap. EU practices provide a roadmap for continuous efficiency improvements.
3. Governance Reforms: Ukraine's energy governance remains fragmented, with wartime

adjustments often replacing long-term strategic planning. By contrast, the EU operates under an integrated framework that coordinates energy, climate, and industrial policies. Aligning with EU directives requires institutional reforms, transparent regulation, and harmonization with European standards.

EU assistance has already played a vital role, with financial support increasing from €1.5 billion in 2022 to €2.5 billion in 2024. This support has funded emergency repairs, renewable projects, and efficiency programs, demonstrating the transformative potential of EU practices.

The final stage of the scheme envisions Ukraine's energy future, characterized by resilience, independence, EU integration, and sustainable development. This outcome is contingent upon successfully navigating the pathway of EU practices and overcoming wartime challenges [1-5; 21]:

1. Resilience & Independence: By diversifying energy sources, expanding renewables, and modernizing infrastructure, Ukraine can reduce vulnerability to external shocks and achieve greater independence from Russian energy.
2. EU Integration: Aligning with EU sustainable development practices will strengthen Ukraine's membership aspirations, enabling integration into the European energy market and access to funding mechanisms.
3. Sustainable Development: A reformed energy system will contribute to broader sustainability goals, including reduced emissions, improved efficiency, and enhanced socio-economic stability.

The conceptual scheme highlights the multidimensional nature of Ukraine's energy security problem. War damage, high energy intensity, and insufficient diversification remain unresolved, creating immediate vulnerabilities. However, EU sustainable development practices - particularly renewable energy expansion, efficiency improvements, and governance reforms - offer a pathway to resilience and integration. The scheme demonstrates that Ukraine's energy transition is not linear but rather a dynamic process shaped by external shocks and internal reforms. Tables 1 and 2 complement this scheme by providing statistical evidence of current gaps and comparative analysis with EU practices.

Together, they underscore the strategic opportunities for Ukraine's energy future:

1. Accelerated Renewable Integration: Ukraine must prioritize renewable energy projects to close the gap with EU averages and reduce vulnerability to external shocks.
2. Efficiency as a Priority: Reducing energy intensity is essential for economic competitiveness and sustainability.
3. Resilience through Diversification: Diversifying energy sources and supply routes can mitigate risks associated with war and geopolitical instability.
4. EU Alignment: Aligning Ukraine's energy policies with EU sustainable development practices is critical for membership aspirations and long-term stability.

These opportunities form the strategic roadmap for Ukraine's energy transformation, linking immediate reconstruction with long-term reforms.

Ukraine's energy security transformation can be conceptualized as a journey from vulnerability to resilience, guided by EU sustainable development practices. The war has exposed critical weaknesses - physical damage, inefficiency, and dependence - but has also accelerated the urgency of reform. By embracing EU practices in renewable energy, efficiency, and governance, Ukraine can rebuild its energy system on a foundation of sustainability and independence.

CONCLUSIONS FROM THIS RESEARCH AND PROSPECTS FOR FURTHER RESEARCH IN THIS DIRECTION

This research has demonstrated that Ukraine's energy security is a multidimensional challenge shaped by the destructive impacts of war, structural inefficiencies, and the pressing need for alignment with European Union sustainable development practices. The synthesis of statistical data, comparative analysis, and conceptual modeling reveals several key findings.

First, war damage remains the most immediate and destabilizing factor. Repeated attacks on energy infrastructure have caused billions in losses, undermining electricity supply and forcing reliance on emergency imports. This destruction has highlighted the fragility of Ukraine's energy system and the urgent need for reconstruction strategies that prioritize resilience and sustainability. Second, Ukraine's energy intensity remains significantly higher than EU averages, reflecting outdated industrial processes, inefficient housing, and limited adoption of modern technologies. While modest improvements have been observed between 2022 and 2024, the pace of efficiency gains is insufficient to close the gap with European standards. Addressing this issue is critical not only for energy security but also for economic competitiveness and environmental sustainability. Third, renewable energy expansion offers a pathway to resilience, but current targets remain below EU ambitions. Ukraine's commitment to achieving 27%

renewable electricity by 2030 is commendable, yet it lags behind the EU's 45% target. Accelerating renewable deployment is essential to reduce dependence on fossil fuels, enhance independence from Russian energy, and align with global climate goals. Fourth, governance and policy fragmentation hinder progress. Wartime adjustments often replace long-term strategic planning, creating uncertainty for investors and slowing reforms. In contrast, the EU operates under an integrated framework - the Green Deal - that coordinates energy, climate, and industrial policies. Ukraine must strengthen governance, harmonize regulations, and adopt transparent practices to attract investment and facilitate integration. Finally, the conceptual scheme of Ukraine's energy security transformation illustrates that resilience and independence can be achieved through the adoption of EU sustainable development practices. Renewable expansion, efficiency improvements, and governance reforms form the pathway to a sustainable energy future, while EU assistance provides critical support for reconstruction and modernization.

While this study provides a comprehensive overview of Ukraine's energy security challenges and opportunities, several areas warrant further investigation: (1) regional energy security analysis; (2) comparative studies with EU Member States; (3) integration of Smart Grid Technologies; (4) socio-economic impacts of energy transition; (5) post-war reconstruction scenarios; (6) climate change and energy security nexus. Finally, further research should investigate the intersection of climate change and energy security in Ukraine. Rising temperatures, extreme weather events, and global climate policies will increasingly shape energy demand and supply. Understanding this nexus is essential for long-term planning.

The conclusions of this research underscore that Ukraine's energy security transformation is both a national imperative and a European integration requirement. The prospects for further research highlight the need for interdisciplinary approaches that combine economics, engineering, governance, and social sciences. By deepening analysis in these areas, scholars and policymakers can contribute to building an energy system that is resilient, efficient, and sustainable. Ultimately, Ukraine's path to energy independence and EU integration depends on its ability to transform wartime challenges into drivers of reform. Future research will play a crucial role in guiding this transformation, ensuring that Ukraine's energy future is not only secure but also aligned with the principles of sustainable development.

REFERENCES:

1. United Nations Development Programme (UNDP). (2023). *Towards a Green Transition in the Energy Sector of Ukraine*. UNDP Ukraine. Available at: Retrieved from https://www.undp.org/ukraine/publications/towards-green-transition-energy-sector-ukraine
2. European Commission. (2024). *EU Assistance to Ukraine: Supporting Ukraine's Resilience*. Brussels: European Commission. Available at: https://commission.europa.eu/topics/eu-solidarity-ukraine/eu-assistance-ukraine/support-ukraines-resilience_en
3. Energy Partnership Ukraine. (2025). *Snapshot: Renewables Market in Ukraine*. Berlin: German Energy Agency (dena). Available at: https://energypartnership-ukraine.org/fileadmin/ukraine/media_elements/250131_Snapshot_Renewables_Market_Ukraine.pdf
4. BDO Ukraine. (2025). *Renewable Energy in Ukraine 2025: Overview, Challenges, and Prospects*. Kyiv: BDO Ukraine. Available at: Retrieved from https://www.bdo.ua/en-gb/insights-1/information-materials/2025/renewable-energy-ukraine-2025-overview-challenges-prospects
5. State Agency on Energy Efficiency and Energy Saving of Ukraine (SAEE). (2025). *Official Website of the State Agency on Energy Efficiency and Energy Saving of Ukraine*. Kyiv: SAEE. Available at: https://saee.gov.ua/en
6. Kogut, S. (2023). Modern trends in the development of global energy and Ukraine's energy security. *Modeling the Development of Economic Systems*, (4), 75–83.
7. Yakovyuk, I. V., & Tsvelikh, M. P. (2023). Energy security of the European Union under Russian aggression against Ukraine. *Bulletin of Yaroslav Mudryi National Law University*, (170).
8. Furman, I. (2024). Development of bioenergy in the context of ensuring Ukraine's energy security. *Economy and Society*, (61).
9. Polukhin, A. V., Tkachova, N. M., Lukashevych, Ya. P., & Cherniavskyi, A. V. (2023). Current issues of Ukraine's energy security processes. *Academic Visions*, (18).
10. Tsulaia, H. Z. (2023). Energy security as an object of Ukraine's state policy. *Legal Novels*, (413).
11. Pazynich, Y. (2024). Energy security and socio-economic development: Challenges and prospects. *Scientific Bulletin of Ivano-Frankivsk National Technical University of Oil and Gas (Series: Economics and Management in the Oil and Gas Industry)*, 2(30), 34–51.
12. Horbatenko, V. P., & Kukuruz, O. V. (2023). Energy security: Changing approaches to understanding.
13. Kuzo, N. J., & Kosar, N. S. (2023). Trends in the Ukrainian light petroleum products market and prospects for energy security in this sector. *Economics and Law*, 2(69), 60–70.
14. Kobielieva, T., & Pererva, P. (2023). Methodological foundations for monitoring energy security indicators in business structures. *Energy Saving. Energy. Energy Audit*, 3(181), 33–42.
15. Pshybelskyi, V. (2023). War and energy security: Challenges for Ukraine's fuel and energy sector. In *Rebuild Ukraine: The Cause of the Civilized World*. Vezha-Druk.
16. Yara, O. S., Artemenko, O. V., Zhuravel, Ya. V., & Lytvyn, N. A. (2023). Ensuring Ukraine's energy security through alternative energy sources. *Academic Visions*, (17).
17. Yakovets, I., & Ruda, I. (2023). Energy security: How to ensure stability of energy supply for global economic development. *Theoretical and Applied Issues of State-Building*, (29), 439–441.

18. Bondarenko, S., & Korotchenko, O. (2023). Resilience as a new concept of energy security. *Social Development and Security*, 13(6), 215–240.

19. Havrysh, O. A., & Vyžanov, O. S. (2025). Structural analysis of regional energy security of Ukraine in the context of reducing dependence on fossil fuels. *Achievements of Economics: Prospects and Innovations*, (17).

20. Mazaraki, A., & Melnyk, T. (2024). Energy security of the country. *Foreign Trade: Economics, Finance, Law*, 133(2), 4–29.

21. European Commission. (2019). *The European Green Deal*. European Commission. Available at: Retrieved from https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

22. Bielenia, M., Marusic, E., & Dumanska, I. (2024). Rethinking the green strategies and environmental performance of ports for the global energy transition. *Energies, 17*(24), 6322. https://doi.org/10.3390/en17246322

23. Dumanska, I., Pavlova, O., & Khmelevskyi, O. (2024). Combating illicit energy trade in the strategic imperatives of diversifying import dependence. In M. Bezpartochnyi (Ed.), *Mechanisms of adaptation of socio-economic systems to global changes and challenges: Resource-efficient technologies, environmental protection, security, sustainable development* (pp. 217–230). Sofia, Bulgaria: VUZF University of Finance, Business and Entrepreneurship. https://doi.org/10.5281/zenodo.12158339

24. Dumanska, I. (2022). Europe's import dependence on Russia's energy resources through the prism of Maslow's pyramid in financing the aggressor. In *Proceedings of the International Scientific Conference "Economic, Political and Legal Issues of International Relations 2022"* (pp. 92–102). Bratislava, Slovakia.

ЕНЕРГЕТИЧНА БЕЗПЕКА УКРАЇНИ КРІЗЬ ПРИЗМУ ПРАКТИК СТАЛОГО РОЗВИТКУ ЄВРОПЕЙСЬКОГО СОЮЗУ

ДУМАНСЬКА Ілона
Хмельницький національний університет

У цій статті досліджується взаємозв'язок між енергетичною безпекою України та практиками сталого розвитку Європейського Союзу, які визначають стратегічні напрями енергетичного переходу в умовах набуття статусу члена ЄС. Визнаючи важливість узгодження національних енергетичних пріоритетів із європейськими стандартами, стаття має на меті надати практичні рекомендації щодо формування стійкої моделі енергетичного сектору, здатної забезпечувати довгострокову стабільність та відповідність критеріям членства. Аналізуються ключові напрями розвитку, такі як розширення використання відновлюваних джерел енергії, підвищення енергоефективності та впровадження інноваційних технологій, які демонструють свою важливу роль у зміцненні енергетичної безпеки. Обґрунтовано структурні рамки визначення стратегічних пріоритетів у сфері енергетики та параметри методичної інтеграції сталих практик у національну політику, що відповідає вимогам Європейського Союзу для країн-членів. Поміж іншого публікація містить розгляд впливу енергетичного переходу на економічну стійкість та ілюструє, як поєднання відновлюваних технологій із міжнародною співпрацею може забезпечити захист економіки, населення та навколишнього середовища. Додатково стаття досліджує комбінований ефект енергоефективних заходів та процесу набуття членства в ЄС на показники стійкості, такі як продуктивність, рентабельність та відповідність екологічним нормам. Оцінюючи сучасні стратегії управління енергетичною безпекою, дослідження підкреслює, як Україна може використовувати інструменти сталого розвитку та практики ЄС для підвищення ефективності, адаптивності та довгострокової стабільності енергетичної системи.

Ключові слова: енергетична безпека, сталий розвиток, енергетичний перехід, ЄС, відновлювані джерела енергії, енергоефективність.