DOI: 10.55643/fcaptp.2.55.2024.4299

FINANCING GREEN ENERGY FOR ENHANCING ENERGY SECURITY IN UKRAINE

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ABSTRACT

This paper examines the financing of green energy initiatives as a critical element in strengthening Ukraine's energy security, especially in the context of post-war reconstruction and the need for sustainable and resilient energy infrastructure. The study aims to assess the potential and challenges of investing in green energy in Ukraine, considering the destruction caused by Russian military actions in the winter of 2022-2023, and the need for recovery based on sustainable models. In this regard, the obtained results emphasize the importance of creating a reliable and decarbonized energy sector, driven by both domestic needs and international cooperation with the EU and other partners. The analysis shows that despite strong support for the green energy transition, the development of the sector is hindered by the high capital intensity required for green technologies, which are often not competitive without government subsidies. This requires a careful balance between innovation and commercial viability of green energy projects, highlighting the need for public and private investments in technologies that can compete with traditional sources of energy in the long term and developing new financing tools for Ukraine. The conclusions indicate that a multifaceted approach is needed to ensure Ukraine's energy future and minimize risks. Such an approach should include policy reforms, strategic investments in proven green technologies, and fostering partnerships to bridge the commercialization gap. Policymakers face the dual challenge of accelerating the energy transition while managing financial constraints exacerbated by military spending, highlighting the trade-off between rapid development and the risks associated with financing innovation. Overall, this study contributes to the understanding of how green energy financing mechanisms can enhance Ukraine's energy security, suggesting broader implications for policy, investment, and technological innovation in the context of Ukraine's post-war recovery and future resilience.

Keywords: energy transition, sustainability, decarbonization, energy infrastructure, green energy financing, Ukraine's post-war recovery

JEL Classification: Q42, Q48, O33, G28, P28

Received: 05/01/2024
Accepted: 16/04/2024
Published: 30/04/2024

INTRODUCTION

Given the recent surge in efforts to accelerate the imminent energy transition (Smil, 2016; York & Bell, 2019), driven by a growing public interest in environmental improvement and sustainable development paradigms (Stiglitz, 1998), there has been a noticeable emphasis on clean energy policies aimed at facilitating the decarbonization of the energy sector (Leal-Arcas et al., 2019). This imperative takes on even greater significance for Ukraine due to the added challenges posed by the overt and unwarranted intrusion of Russian military aggression, leading to substantial disruptions in the existing energy infrastructure (Rokicki et al., 2023) between 2022 and 2023, particularly pronounced during the heating season. The resultant electricity shortfall culminated in an exacerbated decline of the Gross Domestic Product (GDP) during the fourth quarter of 2022, achieving a notable annual contraction rate of 31.4% (Official website of the National Bank of Ukraine). The war in Ukraine has significantly influenced the global energy transition strategy by highlighting the vulnerabilities of reliance on fossil fuel imports (Zakeri et al., 2022), particularly from conflict regions (Tsangas et al., 2023). In response, many countries are accelerating their shift to renewable energy to enhance

energy security and independence. The conflict has especially spurred Europe to diversify energy sources (Rokicki et al., 2023), reduce dependency on Russian gas, and invest more aggressively in renewable energy infrastructure and technologies (Ateed, 2024). This has brought a renewed urgency to the global energy transition, emphasizing the importance of self-sufficiency and sustainability in energy policies. The reconstruction of the post-war energy infrastructure will serve as an impetus for investors to channel funds into projects guided by an emergent framework of infrastructure, buttressed by the tenets of sustainability and risk mitigation.

The trajectory of recuperation is poised to pivot upon Ukraine's onus to engage in close-knit collaboration and harmonious coordination with international entities and sympathetic nations, notably with the European Union at the forefront. Steadfastly adhering to its strategic compass, Ukraine has proficiently executed the Third Energy Package, effectively countering the deterioration of energy infrastructure through seamless amalgamation into the inner sanctum of the European Union's energy architecture, denominated as the ENTSO-E (European Network of Transmission System Operators for Electricity). This seamless integration has led to a congruence between Ukraine's energy policy and the benchmarked edicts of the European domain.

This study investigates the financing challenges and opportunities for Ukraine's energy sector as it transitions to 'green' energy and aligns with EU norms. We explore how these efforts are connected to broader socio-political and environmental aims to encourage sustainable development and resilience. By focusing on the shift to 'green' energy, we tackle fundamental issues in Ukraine's energy infrastructure, highlighting the need for new financial sources to fund innovative projects crucial for competing with conventional energy sources (Dresselhaus & Thomas, 2001). This is essential for improving Ukraine's energy security and establishing a sustainable (Liu et al., 2023; Revin, 2023), eco-friendly energy system through strategic investments and supportive policies.

LITERATURE REVIEW

The nexus between green energy financing (Petlenko & Pohribna, 2021; Sandri, Hussein & Alshyab, 2020; Hasan & Du, 2023) and energy security (Gorodnichenko et al., 2022; Wang, Sun & Iqbal, 2022) has been a focal point of academic inquiry and policy debates in recent years. Energy security (Yakymchuk et al., 2022) as defined by the International Energy Agency (IEA), encompasses "the uninterrupted availability of energy sources at an affordable price" (IEA, 2019). The role of green energy in achieving energy security has gained increasing recognition, particularly in the context of geopolitical tensions, price volatility of fossil fuels, and global commitments to mitigate climate change (Guo et al., 2023).

Several studies (Sachs et al., 2019; Rasoulinezhad & Taghizadeh-Hesary, 2022; Ainou et al., 2023) have explored the instruments available for financing green energy projects. These range from government subsidies and feed-in tariffs (FITs) to private investment, international financing, and innovative financial solutions such as green bonds and crowdfunding (Boufounou & Dellis, 2021; Rizzello, 2022). These financing mechanisms have been widely adopted across the globe to spur the development of renewable energy projects, which, in turn, contribute to energy security.

The relationship between green energy financing and energy security is multi-dimensional. On the one hand, investment in renewable energy projects contributes to diversifying the energy mix, reducing dependency on fossil fuels and foreign energy imports, and enhancing resilience against price shocks and supply disruptions (Prisecaru, 2022; Zakeri et al., 2022). On the other hand, green energy financing stimulates innovation, fosters competition, and drives down the costs of renewable technologies, making them more accessible and affordable (Ahmed et al., 2022; Skare et al., 2023).

Research has also highlighted the socioeconomic and environmental co-benefits of green energy financing. Investing in renewable energy projects (Prokopenko et al., 2023) creates jobs, fosters local economic development, and contributes to poverty alleviation, especially in rural and remote areas (Cheng et al., 2021; Qi et al., 2023). Additionally, green energy projects help reduce greenhouse gas emissions, mitigate climate change, and promote environmental sustainability (Sadiq et al., 2022; Ehigiamusoe & Dogan, 2022).

Despite the growing body of literature on green energy financing and its connection to energy security, several gaps and limitations remain. Firstly, much of the existing research has focused on developed countries with mature energy markets and stable regulatory environments (Jin et al., 2022). Few studies have examined the challenges and opportunities of green energy financing in countries with volatile political and economic contexts, such as Ukraine (Dogan et al., 2022).

Secondly, while several studies have explored the instruments and mechanisms for financing green energy projects, there is a dearth of research on their implications for energy security, particularly in the post-war context (Gorodnichenko et al., 2022; Borodina, 2022). This is particularly relevant for Ukraine, which has experienced geopolitical tensions, military aggression, and infrastructure destruction in recent years.

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Lastly, the unique circumstances and complexities of green energy financing in Ukraine have received limited attention in the literature. This includes the impact of international sanctions against Russia, the role of international financial institutions, and the interplay between government policies, private investment, and international financing (Li & Li, 2022).

Therefore, the current study aims to address these gaps by exploring the potential financing mechanisms for green energy in Ukraine and their implications for the nation's energy security in the post-war context. By focusing on the unique challenges and opportunities facing Ukraine, this study contributes to the literature on green energy financing and provides valuable insights for policymakers and stakeholders involved in the country's energy sector.

AIMS AND OBJECTIVES

The objectives of this study have been streamlined to Explore financing mechanisms for green energy in Ukraine, including government subsidies, private investment, and innovative financial solutions, to understand their impact on the country's energy transition.

Through this research, we aim to enhance our understanding of green energy financing in Ukraine's distinct post-war and geopolitical context. This study seeks to provide insights to guide policy and strategic decisions in Ukraine's energy sector as the nation progresses through post-war economic reconstruction, European integration, and towards a sustainable and climate-neutral future.

METHODS

Our research began with an open agenda to explore the implementation of financing strategies for green energy in Ukraine, with an initial focus on its legal framework and policy context. This led us to a comprehensive analysis of Ukraine's energy sector, particularly in the aftermath of recent geopolitical events that have reshaped its energy landscape. This study was a reflexive journey for us as researchers, considering our backgrounds in energy policy and finance, and our perspectives shaped by previous experiences in similar energy transition projects.

Our empirical research, set within the Ukrainian energy sector, was influenced by our interactions and observations within this space. The complexity of the Ukrainian energy sector, with its unique challenges and opportunities, required a nuanced approach that considered various aspects including policy, finance, technology, and social impacts.

Our methodology was designed to avoid epistemic biases and to embrace a holistic view of the energy transition. It was a guided approach to theorize from contextual observations and practical insights. The focus was on understanding the intricacies of financing green energy in Ukraine and its implications for energy security.

Data Sources: Our investigation commenced with a meticulous engagement with key stakeholders within the Ukrainian energy sector, encompassing policymakers, industry experts, and financial institutions. These preliminary discussions yielded profound insights into the prevailing landscape of green energy financing in Ukraine, laying the groundwork for our subsequent analyses. To augment our primary data, we leveraged secondary data sources, specifically drawing upon surveys conducted by the European Business Association (EBA). These surveys offered invaluable perspectives on the challenges and opportunities within the green energy financing sector, serving as a critical component of our research foundation.

Further deepening our inquiry, we engaged in semi-structured interviews with pivotal figures in the energy sector. These conversations were instrumental in distilling the nuanced perspectives of those at the forefront of green energy initiatives, thereby enriching our analysis with diverse viewpoints. Our field research extended to on-site visits to energy projects and interactions with local communities impacted by energy policies. This immersive approach enabled us to directly observe the socio-economic ramifications of green energy projects, ensuring a comprehensive understanding of the contextual realities.

Analysis: The crux of our analysis centred on the feasibility and implementation of green energy financing models within the unique socio-political and economic landscape of Ukraine. We scrutinised the compatibility of these models with the nation's objectives of energy security and the overarching goal of transitioning towards a sustainable energy paradigm. By systematically interpreting our findings through the prisms of energy policy, finance, and sustainability, we endeavoured to construct a multi-faceted understanding of the sector. The integration of insights derived from the European Business Association's surveys with our primary data collection efforts enabled a holistic assessment of the potential pathways and barriers to achieving a "green" energy future in Ukraine. This rigorous analytical process underscored the importance of

aligning financial mechanisms with sustainable energy policies, thereby facilitating a smoother transition towards environmentally friendly energy solutions. Our findings advocate for a strategic amalgamation of policy, finance, and technological innovation to drive the evolution of Ukraine's energy sector towards sustainability.

Establishing Trustworthiness: To ensure the credibility of our findings, we employed data triangulation, drawing from multiple sources including policy documents, financial reports, and empirical data. Our diverse backgrounds in energy policy and finance provided a comprehensive perspective for analysing the data.

Developing Core Concepts: Our analysis led to the development of key concepts related to green energy financing in Ukraine. We explored various financing models, their feasibility in the Ukrainian context, and their potential impacts on energy security and sustainability. These insights were integrated into a comprehensive framework for understanding and advancing green energy financing in Ukraine.

In conclusion, our research methodology was an organized combination of field observations, stakeholder interviews, and policy analysis. This approach enabled a thorough understanding of the challenges and opportunities in financing green energy in Ukraine, contributing valuable insights for policymakers and stakeholders in the energy sector.

RESULTS

Promoting Energy Security in Ukraine through Green Energy Financing: A Strategic Imperative

Ukraine faces the challenge of achieving energy security while adhering to environmental sustainability. This effort is hindered by a lack of emphasis on green financial mechanisms, essential for aligning with the Paris Climate Agreement and EU Climate Directives, which is crucial for Ukraine's post-war economic recovery. The country's economic revival efforts risk being compromised by overlooking ecological financing, especially when considering the restoration of major budget-contributing enterprises known for environmental harm. There's a tension between the urgent recovery of these enterprises for job creation and revenue, and their environmental impact, highlighting a conflict between rapid economic recovery and environmental responsibility.

Addressing this quandary there is a pronounced opportunity to attract foreign investments, primarily directed at the execution of "green" initiatives. The strategic focus of the EU towards Ukraine, accentuated by Ukraine's attainment of candidate status for EU membership on June 23, 2022 (Gözkaman, 2022), adds further impetus to this proposition. Consequently, adhering to ecological benchmarks to the maximum extent possible while Ukrainian economic reconstruction assumes paramount importance.

In the backdrop of Russia's military aggression against Ukraine commencing in February 2022, an escalating number of domestic and international scholars, as well as practitioners, are seeking cogent strategies to address the challenges of "green" financing within the context of war and the subsequent recuperation phase. However, an accord remains elusive regarding the financial revitalization of enterprises that were adversely affected by the Russian armed aggression, even though these entities were culpable of substantial greenhouse gas emissions before the war. In a broader context, it is imperative to establish guiding principles and operational mechanisms for "green" financing during Ukraine's recovery period, aligned with the recommendations of the EU. This alignment is accentuated by Ukraine's status as a prospective member of the European Union.

Ukraine’s energy landscape presents several multifaceted challenges, including:

1. *Energy Market Reforms and Security Amidst War*. The exigencies of the ongoing war have resulted in a deceleration of energy market reforms. The introduction of provisional measures to bolster energy supply security and safeguard consumer interests requires harmonization with EU protocols. Striking a balance between these short-term interventions and the long-term reform agenda assumes paramount significance.
2. *Strategic Planning and Implementation in the Energy Sector.* The imperative of updating strategic planning documents within the energy domain, such as the "Green" Bonds Market Concept and the Implementation of the "Smart Grids" Concept, cannot be understated. These documents chart a trajectory for sustainable development and the assimilation of innovative technologies, necessitating alignment with global best practices.

DOI: 10.55643/fcaptp.2.55.2024.4299

3. *Harmonization with EU Legislation and Expertise Shortfalls.* Persistent legislative endeavours are essential to harmonize Ukrainian regulatory frameworks with pertinent EU legislation. Mitigating inadequacies associated with decision-making processes, expertise deficits, and alignment with EU standards constitutes a paramount concern. Enhancing the transparency and quality of regulatory enactments is pivotal for seamless integration into the European energy landscape.
4. *Climate Diplomacy, Reforms, and Post-War Recovery.* Sustaining robust climate diplomacy efforts alongside fostering momentum for internal reforms within the ambit of climate policy and environmental protection is a conundrum. While external engagement is integral, a concurrent focus on advancing domestic policies aligned with international climate objectives is imperative.

Complementing these overarching challenges are additional pivotal dimensions:

1. Access to EU Financial Instruments and Emission Trading System (ETS) Sectors. Ensuring access to EU financial instruments, exemplified by the Programme for the Environment and Climate Action (LIFE), particularly in the context of Emission Trading System (ETS) sectors, is pivotal for underpinning sustainable development endeavours.
2. Initiating Post-War Recovery Strategy. Initiating a comprehensive strategy for post-war recovery in Ukraine, characterized by alignment with EU methodologies and the broader aspiration of EU membership, forms a pivotal aspect. This necessitates a judicious reconciliation of recovery priorities with the overarching trajectory of integration.

In response to these multifarious challenges, the Ukrainian government, in collaboration with expert panels, is diligently exploring avenues for transitioning towards renewable energy sources (RES) as a lynchpin measure to safeguard energy security and uphold ecological sustainability. A survey conducted by the European Business Association (EBA) divulged those disruptions in electricity supply, precipitated by Russian incursions, did not lead to widespread cessation of industrial activities. Among surveyed entities, 66% adapted operational schedules, 40% curtailed production or service capacities, while 12% shuttered specific operational units. Additionally, 9% suspended operations, with a mere 1% opting for complete cessation. Approximately 18% of enterprises remained minimally affected by power interruptions. A noteworthy observation, as underscored by 72% of respondents, is that an extended blackout would not compel them to exit the Ukrainian market.

In tandem with immediate tactical responses, a comprehensive, long-term strategy aimed at pre-empting systemic crises entails a prudent amalgamation of investments earmarked for infrastructure modernization, the implementation of energy-efficient protocols, and the amplification of RES's contribution to the overall energy matrix. Notwithstanding, the execution of this strategy within the Ukrainian context may encounter roadblocks due to the attrition or unavailability of extant RES sector capacities.

Simultaneously, decentralized RES generation stands as a viable albeit resource-intensive antidote. The execution of energy-efficient measures is also hindered by financial constraints. Moreover, the prevailing war has cast a pall over the national debt and the government's fiscal capability (Masyk et al., 2023) to underwrite such disbursements. Hence, there exists a compelling exigency to explore mechanisms that facilitate the transformation of a segment of Ukraine's debt into sustainable development and "green" reconstruction initiatives.

National Council for the Recovery of Ukraine from the War has formulated the Ukraine Recovery Plan, a project that underscores the "Ecological Security and Efficient Waste Management" sector as a strategic objective. This objective aims to instate a risk-oriented approach to ecological security, aligning with European Union (EU) legislation. This approach focuses on averting and mitigating environmental and human health harm, encompassing risk minimization for ecological security, addressing chemical and radiation safety, reducing, and preventing industrial pollution, and instituting the "polluter pays" principle, alongside efficient waste management (Ole et al., 2021).

In a broader context, scholars delineate three distinct approaches for achieving sustainable development: 1) a conservative approach maintaining the present model of global economic development and the supremacy of significant capital; 2) a modernization approach necessitating the transformation of social systems and institutions under ecological requisites without radical societal restructuring, with amplified state regulation; 3) a structuralist approach, acknowledging the perniciousness of industrial development itself and rejecting any attempts to modernize industry or enhance energy resource efficiency.

Notwithstanding the mandates of the Paris Climate Agreement, which delineates the strategic objective of expediting the shift towards a society and economy predicated on low-carbon technologies, the current paradigm of production and consumption casts doubt on the attainability of such targets within the forthcoming two to three decades (Ridderstrand & Tenfält, 2021). Complications in the commercialisation of eco-friendly technologies stem from substantial venture capital

prerequisites and the apprehension surrounding investment risks (Owen, 2021). Nonetheless, the progression of innovations within this domain is contingent upon considerable state backing (Gunningham, 2012) alongside the stimulation of private capital infusion. Policymakers are tasked with finding a balance between fast-tracking the energy transition and managing financial risks (Bohra & Anvari-Moghaddam, 2022), considering budget limitations intensified by military needs. In parallel, within the European Union, endeavours to amplify the penetration of green energy are also underway, as the current share of renewable sources in Europe's energy matrix hovers at a mere 22% (European Environment Agency 2023).

The significance of the green transition for Ukraine's post-war energy recovery is highlighted by the gradual shift towards renewable energy sources. Analysis of the data presented in Figure 1 and Figure 2, as well as in Table 1, indicates an annual increase in green energy production of 1.48% and a rise in the total volume of renewable energy by 8.79%.

Table 1. Total Energy Supply in Ukraine by Source 2000-2021. *(Source: IEA Data Services - https://www.iea.org/data-and-statistics/data-product/world-energy-statistics-and-balances)*

Year	Biofuels and Waste	Coal	Hydro	Natural Gas	Nuclear	Oil	Wind Solar Etc.	Energy Metrics by Emission Type (TJ)			
								Total Green Energy (TJ) =ΣColumns (2; 4; 6; 8)	**Total CO2 Emitting (TJ)** =ΣColumns (3; 5; 7)	**Total Renewable (TJ)** =ΣColumns (2; 4; 8)	**Total Non-Renewable (TJ)** =ΣColumns (3; 5 ;6; 7)
2000	10951	1613813	40586	2607079	843720	499956	21	895278	4720848	51558	5564568
2001	10951	1571224	43315	2607792	830934	561657	57	885257	4740673	54323	5571607
2002	10951	1581112	34657	2574841	850800	636707	79	896487	4792660	45687	5643460
2003	10951	1624891	33256	2660594	888065	694652	111	932383	4980137	44318	5868202
2004	10951	1543903	42310	2683034	949330	731541	118	1002709	4958478	53379	5907808
2005	10951	1561494	44506	2749269	968247	602225	136	1023840	4912988	55593	5881235
2006	34376	1678994	46389	2362500	984272	605292	126	1065163	4646786	80891	5631058
2007	63166	1787774	36932	2327944	1016090	637116	162	1116350	4752834	100260	5768924
2008	70745	1749792	41443	2211464	986485	601539	162	1098835	4562795	112350	5549280
2009	64874	1494746	42969	1708760	911037	582043	154	1019034	3785549	107997	4696586
2010	66862	1597194	47347	2313205	978980	551762	183	1093372	4462161	114392	5441141
2011	70427	1736964	39405	1961647	990926	521523	431	1101189	4220134	110263	5211060
2012	70987	1781261	37724	1801793	990117	486275	2235	1101063	4069329	110946	5059446
2013	78762	1742612	49683	1652150	914573	414318	4352	1047370	3809080	132797	4723653
2014	81036	1489536	30520	1400497	970808	445510	5612	1087976	3335543	117168	4306351
2015	88072	1260726	19429	1092043	962164	439801	5619	1075284	2792570	113120	3754734
2016	118635	1243889	27615	1071823	889429	466827	5201	1040880	2782539	151451	3671968
2017	125191	1078409	32202	1028015	939887	529302	6218	1103498	2635726	163611	3575613
2018	134349	1174595	37539	1077643	927182	555688	8234	1107304	2807926	180122	3735108
2019	140214	1091734	23429	978987	911525	564186	17830	1092998	2634907	181473	3546432
2020	177630	956561	27229	998296	837111	592118	33264	1075234	2546975	238123	3384086
2021	177720	873302	37197	1000885	946542	627226	33830	1195289	2501413	248747	3447955

DOI: 10.55643/fcaptp.2.55.2024.4299

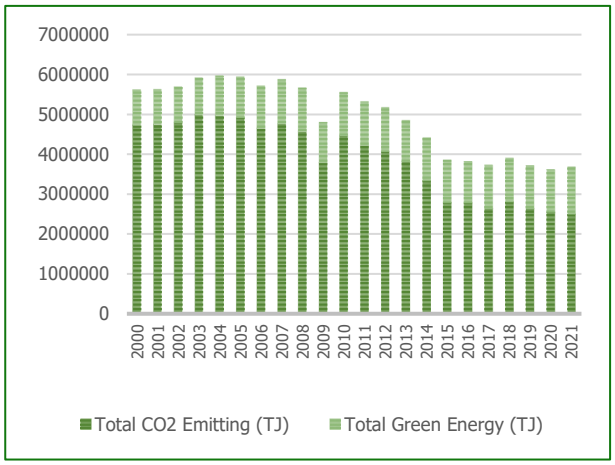

Figure 1. Total CO2 Emitting Energy Supply in Ukraine by Source 2000-2021. (*Source: author`s elaboration. Based on data from Table 1).*

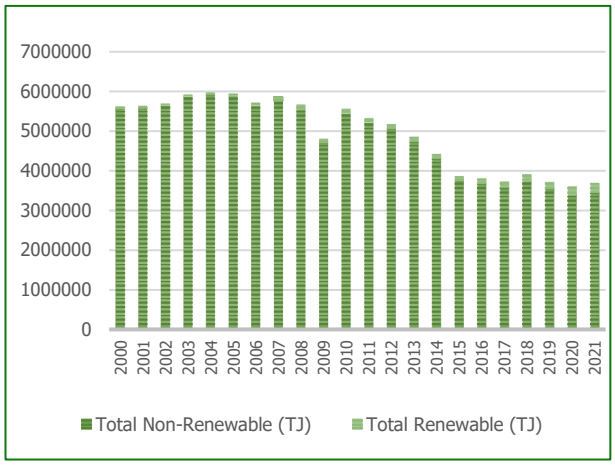

Figure 2. Total Energy Supply in Ukraine by Renewable and Non-Renewable Sources 2000-2021. *(Source: author`s elaboration. Based on data from Table 1)*

Concurrently, CO2 emissions and the use of non-renewable energy sources have declined by 2.70% and 2.05% annually, respectively. Although the overall growth in Ukraine's Total Energy Supply from Renewable sources was slight, the country, enduring its fifth year of war in the East, achieved the third-highest annual increase in renewable energy investments in Europe in 2019 (Figure 3). This achievement underscores Ukraine's commitment to aligning with the European objectives for a green energy transition by 2030. This demonstrates Ukraine's firm intentions to adhere to the broader European goals of a green energy transition by 2030. Therefore, Ukraine's full transition to renewable energy necessitates comprehensive modelling and further consideration of future policies, investments, and technological advancements.

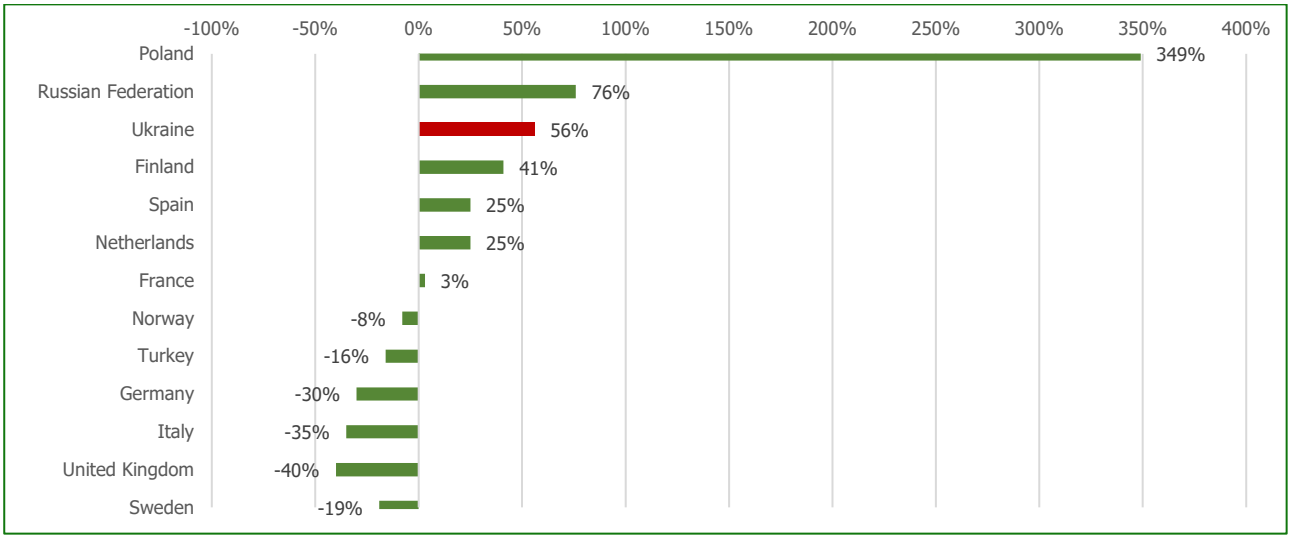

Figure 3. Total CO2 Emitting Energy Supply in Ukraine by Source 2000-2021. *(Source: author`s elaboration. Based on data from Europe: annual growth of renewable energy capacity investment by country 2019, 2022)*

The significant advancements in energy infrastructure and consumption prior to the full-scale invasion of Ukraine by Russia were dramatically set back by the ensuing widespread damage. This stark contrast highlights the critical need for more fortified strategies and stronger commitments towards the attainment of global sustainable development goals, alongside a concerted effort to mitigate the impacts of climate change effectively. In light of these events, the European Investment Bank's climate survey reveals a compelling perspective among Europeans, who perceive the war in Ukraine not only as a tragic event but also as a pivotal moment that necessitates a shift towards energy conservation and a reduction in reliance on fossil fuels. According to Chris Knight (2022), a substantial majority, 66% of the respondents, believe that the war's repercussions on oil and gas prices should serve as an impetus to accelerate the transition to cleaner energy sources. This sentiment underscores the interconnectedness of geopolitical events and the global energy landscape, propelling a consensus towards the urgent need for sustainable energy solutions.

The transition to green energy in Ukraine is more than a technological shift (Alvik, 2022; Kuzemko et al., 2022; Patrahau, 2023); it is a comprehensive change affecting the country's social, economic, and political landscape, requiring significant financial resources (Shipalana, 2020) and the development of new strategies (Ah-Voun et al., 2024) and financing mechanisms.

Developing a "green" financing system for Ukraine under contemporary circumstances necessitates adherence to the principles of "green" post-war recovery, as outlined by the environmental organization "Ecodia" (Shevchenko & Horiacheva, 2020).). These principles encompass 1) the sustainability and systemic nature of decision-making, characterized by quality, effectiveness, and long-term considerations; 2) transparency and public engagement, ensuring open access to public information for community participation in decision-making; 3) regulatory compliance through the implementation of EU legislation for utilizing the best available technologies and practices; 4) territorial balance in development, fostering sustainable development of cities and regions; 5) energy decarbonization and decentralization; 6) sustainable development of decentralized or regional agri-food systems; and 7) the preservation of ecosystems and Ukraine's natural wealth. Integrating these principles into the "green" financing system during the reconstruction of the Ukrainian economy is crucial.

During the reconstruction of Ukraine's economy, transitional mechanisms are pivotal for harmonizing the concepts of sustainable development and a "green" economy to achieve sustainable development objectives. One potential nexus between these concepts could be climate investments aimed at harmonizing human-nature relations. However, caution must be exercised to prevent the influx of "dirty investments," particularly in terms of climate, as Ukraine lacks both the requisite job opportunities for the unemployed and funds for innovative environmental projects. Prominent global powers and numerous international organizations have communicated their intent to financially aid Ukraine in overcoming the aftermath of the war with Russia, with the European Union (EU) leading the way (Gorodnichenko et al., 2022; Borodina, 2022). To capitalize on this support effectively, Ukraine must not only adhere to the highest ecological standards but also seek alignment with EU environmental requirements during the reconstruction of various industrial and infrastructural entities. Notably, leading Ukrainian investment experts propose the establishment of an observatory council comprising representatives from donor countries to manage foreign investments directed toward Ukraine's reconstruction. This initiative is designed to preclude potential corruption by Ukrainian officials (Gorodnichenko et al., 2022).

Green Energy Financing Mechanisms

The pursuit of green energy initiatives requires robust financing mechanisms (Figure 4) to support the transition to sustainable and environmentally friendly energy sources. In Ukraine, as in many other countries, several financing mechanisms are being investigated to facilitate the adoption of green energy. These mechanisms encompass a variety of approaches, each with its own strengths and challenges.

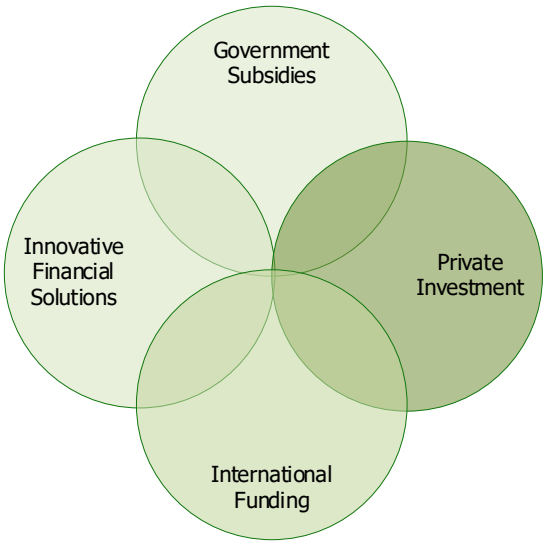

Figure 4. Sustainable Energy Financing Mechanisms.

The principal financing mechanisms under consideration for the advancement of green energy in Ukraine encompass governmental subsidies, private-sector investments, international financial support, and innovative fiscal strategies. The successful realization of a transition towards a green energy economy within Ukraine requires a coherent integration of these varied financing mechanisms, as detailed in Table 2.

DOI: 10.55643/fcaptp.2.55.2024.4299

Table 2. Sustainable Energy Financing Mechanisms Description.

Financing Mechanism	Description
Government Subsidies	Government subsidies play a vital role in stimulating the adoption of green energy technologies. These subsidies aim to reduce initial investment costs associated with renewable energy projects, making them financially attractive to investors. They can take the form of tax incentives, grants, or discounts, thus shortening the payback period and boosting demand.
Private Investment	Private investment is crucial for expanding green energy projects. Investors, from individuals to institutional investors and corporations, contribute capital to fund renewable energy initiatives. They expect competitive returns on their investments. Projects offering promising returns and aligning with environmental and financial goals attract private funding. Mechanisms like power purchase agreements (PPAs) and green bonds facilitate private investment by securing stable revenue streams and enhancing project viability.
International Funding	International organizations and financial agencies play a significant role in supporting green energy projects, especially in developing countries like Ukraine. Sources such as the World Bank, regional development banks, and climate funds provide financial resources for promoting sustainable energy practices. These funds support infrastructure development, capacity building, and technology transfer, contributing to the growth of the green energy sector.
Innovative Financial Solutions	Innovative hybrid financing solutions are emerging to address the unique challenges of financing green energy. These solutions include Green Credit Guarantee Corporations (CGCs), which enhance the creditworthiness of green projects without physical collateral or high credit ratings. CGCs act as guarantors, reducing perceived risk for lenders and attracting financing to environmentally beneficial projects. These mechanisms also address funding gaps for projects that offer significant environmental benefits but face barriers to traditional financing.

State subsidies wield the potential to propel the assimilation of renewable energy technologies, whilst private investment ensures an enduring and sustainable trajectory of growth. The infusion of international financing augments the resources required for the expansion of green initiatives, while pioneering financing solutions, exemplified by the CGC, adeptly tackle the distinct financial hurdles inherent to this domain. Given that Ukraine traverses through intricate phases of energy transition, the confluence of these mechanisms is poised to significantly contribute to the realization of green energy objectives, thereby engendering a future underscored by sustainability.

Both foreign and domestic experts underscore the imperative nature of facilitating a "green" resurgence in Ukraine, an endeavour necessitating the concerted efforts of a multitude of entities spanning multiple sectors. Integral to this journey is the decentralization of decision-making processes, fostering an environment conducive to "green" rejuvenation. Along this trajectory, the dismantling of prevailing impediments obstructing "green" investments assumes paramount significance.

To this end, the substitution of profligate direct and indirect price subsidies with more focused and consumption-independent subsidies targeted towards vulnerable segments of the populace emerges as a crucial step. It is within this context that the reconstruction program for Ukraine's economy should be meticulously structured, prioritizing the enduring efficacy of "green" technologies throughout their life cycles over initial financial investments (Borodina, 2022).

This transition emphasizes evaluating green technologies' life cycle performance over mere initial cost analysis, in line with Ukraine's Economic Recovery Concept and the European Green Deal. The strategy promotes sustainability by advancing new industrial capacities in metallurgy, food processing, and energy sectors, aiming at minimizing carbon footprints, reducing fossil fuel dependence, and fostering cleaner production practices. A pivotal element of this green shift is the financial and policy framework encouraging renewable energy adoption, exemplified by Ukraine's Green Tariff system, detailed in Table 3. Scheduled to last until January 2030, this tariff system incentivizes renewable energy production, including wind, solar, and biomass, with rates adjusted for the EUR/UAH exchange rate and local content contribution.

The implementation of this financial mechanism is instrumental in catalyzing the transition towards renewable energy, concurrently fostering the growth of local manufacturing and the creation of employment opportunities within the renewable energy sector. The State Agency on Energy Efficiency and Energy Savings of Ukraine acknowledges the multifaceted advantages of this strategy, which notably includes the bolstering of energy security and the promotion of economic expansion. This necessitates a judicious equilibrium between the innovation imperative and the commercial feasibility of green energy initiatives. It underscores the imperative for both public and private sector investments in technologies that are capable of rivalling traditional energy sources over the long haul. Moreover, it calls for the development of novel financing instruments specifically tailored for Ukraine, thereby ensuring a sustainable and economically viable energy future.

Table 3. Tariffs for Electricity Generated by Private Household Solar and Wind Installations in Ukraine. *(Source: author`s elaboration. Based on data from: https://dlf.ua/ua/znizheno-zeleni-tarifi-v-ukrayini/)*

Energy Type		Period	Price (kop, UA /kWh/year)
Solar energy from private Generating Units (GU)	up to 30 kW	01.04.2013 - 31.12.2014	1445.21
		01.01.2015 - 30.06.2015	1299.82
		01.07.2015 - 31.12.2015	807.24
		01.01.2016 - 31.12.2016	766.01
		01.01.2017 - 31.12.2019	729.12
		01.01.2020 - 31.12.2023	655.34
		01.01.2024 - 31.12.2024	590.24
	up to 50 kW (on rooftops and/or facades)	01.01.2019 - 31.12.2019	729.12
Wind energy from private GU	up to 30 kW	01.07.2015 - 31.12.2019	468.72
	up to 50 kW	01.01.2019 - 31.12.2019	468.72
		01.01.2020 - 31.12.2024	420.98
Energy from wind and solar on combined private GU up to 50 kW		01.01.2019 - 31.12.2019	659,68

Table 4 presents an overview of various subjects engaged in green energy financing within Ukraine's energy sector along with their corresponding descriptions and key instruments they utilize to promote and facilitate sustainable energy initiatives.

Table 4. The subject of Green Energy Financing in Ukraine. *(Source: author`s elaboration. Based on data from https://www.nefco.int/financing/municipalities-in-eastern-europe/green-recovery-ukraine/)*

	Financing Mechanism	Key Subject	Description
Government Subsidies	Government Institutions	▪ State Agency on Energy Efficiency and Energy Saving; ▪ National Bank of Ukraine's Green Finance Program; ▪ Energy Efficiency Fund; ▪ National Renewable Energy Action Plan and others.	National entities responsible for policy formulation and implementation related to green energy financing and energy security.
Private Investment	Commercial Banks	▪ Oschadbank's Green Loans; ▪ PrivatBank's Energy Efficiency Loans; ▪ Raiffeisen Bank Aval's Green Loans; ▪ ProCredit Bank's Renewable Energy Financing and others.	Private financial institutions providing loans, credits, and other financial products to facilitate green energy projects.
	Energy Companies	▪ DTEK Renewables; ▪ Naftogaz Group's Energy Efficiency Program; ▪ Ukrenergo's Grid Modernization Projects and others.	Entities engaged in energy production, distribution, and provision of energy services, incorporating green energy investments.
	Private Equity and Venture Capital	▪ Horizon Capital's Emerging Europe Growth Fund; ▪ Incofin Investment Management's Agriculture and Climate Resilience Fund; ▪ Astarta-Kyiv's Sustainable Energy Investment and others.	Investment firms and individuals funding early-stage and innovative green energy projects.
International Funding	International Financial Organizations	▪ Ukraine Relief, Recovery, Reconstruction and Reform Trust Fund (URTF); ▪ European Bank for Reconstruction and Development (EBRD); ▪ European Investment Bank (EIB); ▪ International Finance Corporation (IFC); ▪ World Bank Group and others.	Multilateral institutions offering financial support, technical assistance, and expertise to advance green energy initiatives.
	Foreign Direct Investors	▪ China National Complete Engineering Corporation (CCEC) investment in solar projects; ▪ Norwegian Investment Fund for Developing Countries (Norfund) investments in renewables and others.	Foreign entities and governments contributing capital to green energy projects in Ukraine.
	International Donor Organizations	▪ United Nations Development Programme (UNDP); ▪ Global Environment Facility (GEF); ▪ European Union's Neighbourhood Investment Facility.	Non-profit entities providing grants and financial aid to support sustainable energy initiatives in Ukraine.

DOI: 10.55643/fcaptp.2.55.2024.4299

This shift towards a sustainable economy is bolstered by the readiness of Western allies to supply considerable "green" investments, despite potential social risks associated with them (Ramirez & Böhm 2021) Concurrently, Ukraine's energy market sees significant domestic investment, with volumes exceeding EUR 250 million in 2020, as detailed in Table 5. These investments align with the financial needs of Ukraine's recovery strategy, emphasizing the enhancement of transparency and accountability (Järvis et al., 2016). This approach aims to regulate investment flows within ethical boundaries, acknowledging that not all investors see returns (Shkola et al., 2021), a challenge that urgently needs addressing.

Table 5. Potential Investors in the Energy Market of Ukraine with Activity Volume of EUR 250 million and above in 2020, EUR million.
(Source: author`s elaboration. Based on data from Dudek et al., 2023, p.6.)

N	Company	Activity	Profit	Loss
1	D.Trading LLC	Coal, electricity, natural gas	42.06	
2	Ukrgazvydobuvannya JSC	Gas production and production of petroleum products	131.48	
3	Ukrnafta PJSC	Oil and gas production	112.96	
4	TFIOC "Ukrnafta" PJSC	Production of petroleum products	21.96	
5	United Energy LLC	Resale of state-generated electricity	21.95	
6	YE Energy LLC	Gas trade	35.71	
7	West Petrol Market LLC	Import and sale of fuel	17.46	
8	Centernergo PJSC	Production of electricity	16.13	
9	VOG Trade Resource LLC	Import and sale of fuel	1.85	
10	Energotrade LLC	Import and sale of gas	22.75	
11	ERU Trading LLC	Sale of gas, electricity	12.96	
12	Alliance Energy Trade LLC	Import and sale of oil products	8.99	
13	Ukrhydroenergo PJSC	Production of electricity at hydroelectric stations	109.52	
14	Okko-Business Contract PP	Trading and sale of oil products	40.48	
15	Kyiv Energy Services LLC	Trade in electricity	83.86	
16	AV Metal Group LLC	Trade in electricity	7.67	
17	Dnipro Energy Services LLC	Trade in electricity	20.11	
18	DTEK Skhidenergo JSC	Production of electricity		79.37
19	DTEK Zahidenergo JSC	Production of electricity		64.55
20	DTEK Dniproenergo JSC	Production of electricity		55.56
21	Naftogaz of Ukraine JSC	Import and sale of natural gas		531.74
22	TEC Ukrenergo PJSC	Management of main power grids		727.51
23	SE “NNEGC "Energoatom"	Production of electricity		128.31
24	DTEK Pavlogradvugilya PJSC	Coal mining		159.78
25	Naftohimik Prykarpattia PJSC	Storage of oil products		35.19

The scrutiny of empirical data concerning the endeavours of prospective investors within the Ukrainian energy sector elucidates that, notwithstanding pronounced advocacy for a paradigm shift towards green energy, the proliferation of this domain is inextricably linked to the procurement of domestic financing avenues. However, as delineated in Table 5, entities such as DTEK Skhidenergo JSC, DTEK Zahidenergo JSC, DTEK Dniproenergo JSC, Naftogaz of Ukraine JSC, TEC Ukrenergo PJSC, SE "NNEGC "Energoatom", DTEK Pavlogradvugilya PJSC, and Naftohimik Prykarpattia PJSC, are observed to incur operational deficits, principally attributed to the substantial capital expenditures requisite for sustaining their operational viability and expansion, inclusive of investments in green technology infrastructure. These green technologies frequently manifest as non-viable in the absence of state-funded subsidies, thus underscoring a formidable impediment en route to achieving a sustainable energy paradigm. Consequently, the imperative of assimilating climate stipulations within the strategic reorganisation of extant Ukrainian enterprises, historically implicated in considerable emissions of greenhouse gases, alongside the pollution of aquatic and terrestrial environments and the accumulation of vast quantities of waste, emerges as a pressing challenge necessitating immediate redress. At this pivotal intersection, the proposition to forge collaborative enterprises with member states of the European Union, predicated upon a mutual commitment to stringent

environmental protocols, emerges as a strategic initiative of considerable promise for the revitalisation of these beleaguered entities.

Sustainability in green energy financing within Ukraine can be achieved through the deployment of an extensive array of innovative financial instruments, ensuring a harmonious blend of progress and preservation. Among these, the strategic use of an endowment fund stands out. This approach, which we have previously explored for its potential in public finance and education (Lyutiy et al., 2022; Petlenko et al., 2021; Kuznyetsova et al., 2017), is also highly applicable to innovation-driven research in the green energy sector. An endowment fund, typically sourced from private or corporate donors, can be invested to generate returns that finance ongoing green energy initiatives. This method ensures a consistent funding flow and aligns with the long-term sustainability goals of the energy sector. By investing in such a fund, stakeholders can make a lasting impact, supporting projects that range from renewable energy development to cutting-edge research in green technologies.

In conclusion, the entities involved in green energy financing in Ukraine are diverse and dynamic, encompassing governmental bodies, financial institutions, private enterprises, and international organizations. Through a variety of innovative instruments, these stakeholders collaborate to promote sustainable energy initiatives and propel Ukraine towards a greener and more secure energy future.

Challenges and Opportunities

In the endeavour to establish a green energy economy in Ukraine, brimming with potential, the landscape presents itself as a nuanced amalgamation of challenges and prospects. As Ukraine undertakes the intricate journey towards a more sustainable energy future, it becomes crucial to meticulously identify and analyse the intricate web of challenges that intertwine with the financing of green energy projects within the country. Simultaneously, an equally imperative task is to delve into the latent opportunities that reside within this realm, poised to amplify investments in green energy and thereby bolster energy security.

Challenges in Financing Green Energy Projects

The experiential insights garnered from numerous nations that have embarked on the ecological metamorphosis of their commercial undertakings underscore the formidable nature of this endeavour, one that rests substantially on governmental financial support. Evidently, enterprises navigating in isolation encounter substantial impediments in surmounting this challenge without the backing of the state. As the European Union (EU) charts its course towards the Green Deal, with a substantial allocation of over one trillion euros for forthcoming years, it underscores the realization that the autonomous European business domain falls short in meeting the prerequisites of this transformative trajectory. Within this context, Ukrainian enterprises seeking grants from EU funds must acknowledge the EU's prohibition on state financial assistance to individual firms, aimed at preserving competitive equilibrium within the organization. Nonetheless, EU legislation does permit state-backed financial aid to enterprises committed to environmental preservation endeavours. This pivotal aspect can be harnessed by Ukrainian businesses currently relocating to Western Ukraine, fostering collaborative ventures with their EU counterparts (Kuznetsova et al., 2020). This collaborative approach facilitates the assimilation of progressive ecological standards congruent with the European Green Deal.

Opportunities for Enhanced Investment in Green Energy

Survey findings by the European Business Association unveil a noteworthy alignment of Ukrainian businesses, for the most part, with the UN Sustainable Development Goals. However, a significant barrier arises when striving to direct increased investments towards these objectives, especially in ecological projects, where state-imposed regulatory barriers impede the full realization of their potential. Consequently, a prudent course of action for the Ukrainian government would be to cultivate an enabling environment that encourages domestic enterprises to amplify their fiscal dedication to sustainable development ventures, encompassing the purview of the "green" domain. Central to this endeavour is the refinement of the state's regulatory underpinning. Furthermore, extending state advisory and financial support to those Ukrainian enterprises yet to fully comprehend the significance of investing in sustainable development ventures, including the "green" economy, emerges as an imperative requirement. This recognition is poised to crystallize as these enterprises endeavour to export their goods to the EU, where a novel carbon tax on goods originating outside the EU will be instituted from 2023. Amidst the economic reconstruction of Ukraine, both the government and enterprises must factor in the EU Government's resolution of June 29, 2022, outlining strategies for curtailing greenhouse gas emissions. Collaborative undertakings within the EU are poised to collectively mitigate 310 million tons of CO2 equivalent from the atmosphere, primarily through the augmentation of natural carbon sinks like forests. Moreover, the cessation of internal combustion engine vehicle sales by

DOI: 10.55643/fcaptp.2.55.2024.4299

2035 and the implementation of carbon pricing for transportation and heating fuels signify further steps in this trajectory (Blanchard, Gollier & Tirole, 2022).

In this intricate interplay between challenges and opportunities, Ukraine finds itself at a pivotal juncture, equipped with the potential to embrace the evolution toward sustainable energy through inventive financing mechanisms and visionary policies. The ensuing sections undertake a detailed exploration of these dynamics, unravelling a comprehensive perspective on the course of green energy financing for fortified energy security.

Case Studies Highlighting Successful Green Energy Financing in Ukraine

One of the positive developments in the realm of state-regulated environmental funding by businesses in Ukraine is the enactment of Cabinet of Ministers of Ukraine Resolution No. 1060 on October 11, 2021. This resolution pertains to the approval of criteria for assessing the eligibility of state aid to economic entities for environmental conservation measures. As a result of this resolution, companies across various industries are now eligible to seek state assistance for capital investments, additional investment costs, concessional credits for the adoption of new environmental standards in production, and early adaptation to these standards. The quantum of state aid can extend up to 100% of the necessary funds. Notably, enterprises received UAH 10.8 billion of state aid in the year 2023 (Annual Action Plan in favour of Ukraine, 2023). However, it should be noted that instances are becoming more frequent where state aid, provided by authorities at both central and public levels, is deemed illegal. This situation makes businesses exercise caution when utilizing this instrument of state regulation. Furthermore, the criteria for evaluating the admissibility of state aid for business "green" modernization remain underdeveloped.

During the war with Russia, Ukraine's shift away from tender procedures in public procurement, deemed necessary for defence acquisitions, unfortunately, fostered the growth of shadow dealings and financial discrepancies, inflating costs. To mitigate such issues in the war and reconstruction periods, revising public procurement conditions—such as reducing procurement timelines to under two weeks, increasing the simplified procurement threshold to at least UAH 500.000, and raising fees for baseless tender complaints—is essential. Linking complaint fees to tender values may reduce delays. The "green" economic transition in Ukraine, aiming for EU compatibility, was estimated to cost hundreds of billions of dollars before the conflict, a figure likely to rise post-conflict. Thus, financing should come from public and Ukrainian private sources, alongside foreign investments, which require significant tax incentives. Enhancing state and public oversight over "green" projects is crucial to safeguard against corrupt practices within environmental agencies and to prevent harmful foreign investments in the reconstruction phase.

For Ukraine's economic revival, attracting investors from not just the EU, USA, and Great Britain but also China, Turkey, and Arab nations is crucial, particularly as businesses relocate westward due to Russian aggression. Chinese investors, deterred by EU sanctions on Russia and Belarus, are eyeing opportunities in Ukraine, notably in EU border projects where environmental compliance is key. Global conflicts, including over Russia's supply, escalate energy costs, urging a shift to renewables, though high food prices constrain this transition's funding. As developed nations subsidize household electricity, causing budget deficits, Ukraine seeks green financing and international aid to manage budget deficits and public debt surpassing EU limits. The National Bank of Ukraine's anti-inflationary policy, which involved raising the discount rate to 25% (NBU Raises Key Policy Rate to 25%), constrains private green project financing, peaking at 26.6%. However, by early 2024, the government has curtailed inflation, maintaining it at 5,8% (NBU Inflation Report, 2024).

In conclusion, as Ukraine navigates through the multifaceted challenges of its energy transition and post-war recovery, the utilization of diverse financing mechanisms and the involvement of international investors stand as crucial components. These financial instruments, alongside rigorous ecological oversight, are essential in shaping a sustainable future, marked by the fusion of energy security and environmental responsibility.

DISCUSSION

The transition towards "green" energy in Ukraine is precipitated by a confluence of economic and societal exigencies (Siddi, 2023), accentuated by the full-scale incursion by Russia. This situation is compounded by the absence of a cohesive state policy aimed at invigorating the post-war energy sector Copley, J. (2023). and a palpable deficit of financial mechanisms capable of facilitating the seamless integration of the green cluster into the economy (Khan et al, 2022). This is further exacerbated by a pronounced scarcity of public-private partnership experience in this sphere (Kuzior et al, 2023). Despite governmental endeavours to catalyse this transition through funding, incentives, or grants for green technology initiatives, these efforts, at their zenith, remain markedly lukewarm. As elucidated in our analytical deliberations, the domain of renewable energy in Ukraine is nascent, barely transcending its embryonic phase of development. This milieu necessitates

a profound recalibration of the green financing principles underpinning the post-war recuperation of the energy sector, aiming to ensure its autonomy from finite energy sources whilst accruing environmental dividends. This narrative finds resonance in the expansive discourse of Deb et al (2024) and is further nuanced in the seminal contributions of Adeoye et al (2024), who underscore the imperative of prioritising green finance within the energy sector. Such a paradigm epitomises socially responsible energy financing, strategically oriented towards ameliorating the anthropogenic impact on the environment.

Furthermore, this discourse navigates through the conceptual fragmentation observed amongst leading economists regarding the optimisation of financial instruments within the green energy development framework. Specific financial aspects are often tethered to a superficial exploration of their synergy with addressing socio-ecological challenges. This has impelled scholars like Taskin et al (2022) to scrutinise the interplay between traditional financial instruments and ecological benefits. The proposition of integrating ecological initiatives into the strategic and managerial fabric of the financial mechanism, as advocated in this discussion, heralds a visionary approach. It marries profit-oriented activities with the adoption of green technologies and tariffs, aligned with environmental conservation, as exemplified in the works of Sun & Sun (2021).

Amidst the backdrop of contemporary challenges, the urgency of engendering a global dialogue on harnessing "green" financing for the reconstruction and revitalisation of Ukraine's war-ravaged energy infrastructure ascends to the forefront. In particular, the utilisation of green bonds emerges as a viable strategy for facilitating the post-conflict resurgence of Ukraine’s energy infrastructure Versal & Sholoiko (2022), alongside initiatives by the European Investment Bank aimed at conceptualising short and long-term reconstruction frameworks. Despite these hurdles, the quest for a green economy should not necessitate an economic hiatus or overly burden Ukraine's public finance system. Addressing these challenges paves the way for future discourses on evolving strategies to integrate Environmental, Social, and Governance (ESG) factors into corporate and financial risk management. This underscores the unwavering commitment of the private sector to furnish the requisite resources for realising the Green Strategy for Ukraine, amalgamating economic viability with ecological stewardship to forge a resilient and sustainable future.

CONCLUSIONS

In the wake of our thorough exploration into green energy financing for energy security in Ukraine, a rich tapestry of insights and opportunities emerges, showcasing the transformative power of sustainable financial mechanisms. This conclusion encapsulates the key findings of our study, highlighting the critical role of green energy financing in strengthening Ukraine's energy security, while also acknowledging the unique characteristics and challenges that define the landscape of "green" economic revitalization. Our inquiry culminates in a convergence of insights that underscore the urgent need to advance green energy financing in Ukraine. We emphasize the pivotal role of diversified financing mechanisms, including government subsidies, private investments, and international collaborations, as essential pillars for a sustainable and resilient energy transition. Innovative models like the Credit Guarantee Corporation (CGC) further broaden the spectrum of financing avenues, offering tailored solutions to address sector-specific challenges. The importance of green energy financing for Ukraine's energy security cannot be overstated. As Ukraine navigates the complexities of energy transition, it stands at a pivotal juncture of opportunity and transformation. The symbiotic relationship between sustainable financing and energy security becomes increasingly evident as we strive for resilience and self-reliance, necessitating the infusion of capital, technology, and expertise. In this context, green energy financing emerges as the cornerstone upon which Ukraine's vision for a sustainable and secure energy landscape can be realized.

Our study not only unveils the current landscape but also illuminates promising avenues on the horizon. The active engagement of foreign investments from democratic nations and international financial institutions presents an opportunity to revitalize Ukraine's economy. However, stringent oversight is essential to curb corruption and ensure transparent utilization, especially in the realm of "green" investments. A comprehensive reconstruction program focusing on the long-term efficiency of "green" technologies, despite initial costs, is imperative. Additionally, adopting life cycle costing in tender procurements and reorienting the "green" tariff mechanism offer opportunities to optimize resource allocation and incentivize sustainable practices.

In conclusion, our study reveals a multifaceted landscape of green energy financing with transformative potential for Ukraine's energy security. It highlights the intertwined relationship between financial innovation and energy resilience, charting a path toward a more sustainable and secure future. By embracing diverse financing mechanisms and addressing prevailing challenges, Ukraine is poised to craft a compelling narrative of sustainable energy transition, reaffirming its commitment to a greener, more secure tomorrow.

DOI: 10.55643/fcaptp.2.55.2024.4299

Building upon the foundation of our comprehensive analysis, future research directions promise to expand the discourse on green energy financing's capacity to bolster Ukraine's energy security further. Delving into the efficacy of specific green financing models across Ukraine's varied regions will illuminate disparities in access and implementation, shedding light on potential strategies to democratize energy solutions. This granular exploration stands to refine our understanding of sustainable finance's geographical impact, setting the stage for targeted interventions that bridge regional gaps in green energy adoption. Moreover, probing the nexus between political stability, governance quality (Hansen, 2023), and the success of green energy initiatives will offer a nuanced perspective on the policy ecosystem's role in fostering or hindering sustainable energy financing. This line of inquiry will elucidate the critical interplay between governance frameworks and green financing efficacy, highlighting the indispensable role of political and institutional integrity in securing a sustainable energy future.

These proposed avenues for future research not only promise to augment our comprehension of green energy financing's pivotal role in enhancing Ukraine's energy security but also aim to chart a course for actionable insights and policy formulations. By delving deeper into these aspects, we can further untangle the complex web of factors influencing sustainable energy financing, paving the way for a comprehensive strategy that leverages financial innovation for energy resilience.

In essence, the journey of exploring green energy financing in Ukraine and beyond is far from complete. The insights garnered from our current study serve as a beacon, guiding us towards a broader understanding of how sustainable financial mechanisms can be optimized to achieve energy security. As we embark on these future research endeavours, the goal remains clear: to foster a sustainable, secure, and equitable energy future for Ukraine and similar transitioning economies, underpinned by robust, innovative financing models that address the unique challenges and opportunities of our time.

ADDITIONAL INFORMATION

ACKNOWLEDGMENT

I am deeply thankful to Hans Krause Hansen, Jacobo Ramirez, Albina Dioba, and Sergiy Prokopenko from Copenhagen Business School, for their support and discussions while I was writing this paper. A special thanks to Nataliya Drozd from Hochschule Mainz – University of Applied Sciences for her insightful comments on my research. I also appreciate Maria Urbaniec from Krakow University of Economics for helping organize the seminar on "Economic and Energy Transformation in the Context of the War in Ukraine" on September 8, 2023, in Krakow, which greatly expanded my knowledge of EU green financing. Additionally, I am grateful to two anonymous reviewers whose suggestions helped improve this paper.

FUNDING

The Author received no funding for this research.

CONFLICT OF INTEREST

The Author declares that there is no conflict of interest.

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ФІНАНСУВАННЯ ЗЕЛЕНОЇ ЕНЕРГЕТИКИ ДЛЯ ПОСИЛЕННЯ ЕНЕРГЕТИЧНОЇ БЕЗПЕКИ УКРАЇНИ

У цій статті розглядається фінансування ініціатив зеленої енергетики як критичного елемента зміцнення енергетичної безпеки України, особливо в контексті післявоєнної реконструкції та потреби в стійкій та витривалій енергетичній інфраструктурі. Дослідження має на меті оцінити потенціал і виклики інвестування в зелену енергетику в Україні, враховуючи руйнування, спричинені воєнними діями росії протягом 2022-2023 років, і необхідність відновлення на основі стійких моделей. У зв'язку з цим отримані результати підкреслюють важливість створення надійного та декарбонізованого енергетичного сектора, керованого й внутрішніми потребами, і міжнародною співпрацею з ЄС та іншими партнерами. Аналіз показує, що, незважаючи на сильну підтримку переходу на зелену енергетику, розвиткові сектора заважає висока капіталомісткість, необхідна для зелених технологій, які часто неконкурентоспроможні без державних субсидій. Це вимагає ретельного балансу між інноваціями та комерційною життєздатністю проєктів зеленої енергетики, підкреслюючи необхідність державних і приватних інвестицій у технології, які можуть конкурувати з традиційними джерелами енергії в довгостроковій перспективі, і розробки нових інструментів фінансування для України. Висновки вказують на те, що для забезпечення енергетичного майбутнього України та мінімізації ризиків потрібен багатогранний підхід. Такий підхід має включати політичні реформи, стратегічні інвестиції в перевірені зелені технології та сприяння партнерству для подолання розриву в комерціалізації. Політики стикаються з подвійним завданням: прискорити енергетичний перехід, водночас керуючи фінансовими обмеженнями, що посилюються військовими витратами, підкреслюючи компроміс між швидким розвитком і ризиками, пов'язаними з фінансуванням інновацій. Загалом це дослідження сприяє розумінню того, як механізми фінансування зеленої енергетики можуть підвищити енергетичну безпеку України, пропонуючи ширші наслідки для політики, інвестицій і технологічних інновацій у контексті післявоєнного відновлення та майбутньої стійкості України.

Ключові слова: енергетичний перехід, сталий розвиток, декарбонізація, енергетична інфраструктура, фінансування зеленої енергетики, повоєнне відновлення України

JEL Класифікація: Q42, Q48, O33, G28, P28