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Green Energy as a Tool for Resilience and Recovery of Ukraine During the War and in the Post-War Period

Abstract. Introduction. *The Russian Federation's full-scale invasion of Ukraine has caused unprecedented destruction to the country's energy infrastructure, disrupting electricity supply chains, damaging centralized power systems, and exposing the inherent vulnerability of conventional energy models in the face of modern hybrid warfare. In this context, energy resilience becomes one of the key priorities for Ukraine's survival and recovery. The war has made it clear that Ukraine must shift its strategic focus from centralized, fossil-fuel-dependent systems to decentralized, renewable, and environmentally responsible energy solutions. Green energy – solar, wind, biomass, and small hydropower – offers significant advantages for both short-term survival and long-term post-war development. The intensifying global climate crisis and the rising cost of conventional fuels further reinforce the importance of transitioning to sustainable energy systems that not only ensure energy security but also contribute to Ukraine's integration into the European Green Deal and global sustainable development frameworks.*

This transition is not merely a response to destruction but an opportunity to rebuild Ukraine on a new foundation: one based on decarbonization, democratization of energy access, and innovative green technologies. As Ukraine enters the phase of post-war recovery, the government, civil society, and international partners must work in coordination to develop and implement energy strategies that will contribute to economic revitalization, social cohesion, environmental regeneration, and global climate goals. Learning from international experiences while relying on domestic resources and capacities will be critical in achieving these objectives.

Purpose. *The purpose of this article is to conduct a comprehensive investigation of the strategic role green energy can play in enhancing Ukraine's resilience during wartime and accelerating sustainable development during the post-war recovery period. Specifically, the article aims to (1) examine the current state of renewable energy development in Ukraine, (2) identify key challenges faced by the sector due to the war, (3) analyze policy responses and legislative developments, (4) explore best practices from international post-conflict reconstruction efforts, and (5) outline strategic directions for green energy integration into Ukraine's national recovery framework.*

The article also aims to demonstrate that renewable energy is not only a technological solution but also a socio-political and economic catalyst for change. It highlights how green energy can strengthen local governance, empower communities, reduce dependency on energy imports, and align Ukraine's development with global sustainability trends. Furthermore, the paper provides recommendations for creating a favorable investment climate, expanding decentralized energy systems, and ensuring policy coherence between national goals and international environmental commitments.

Results. *The findings of the study confirm that Ukraine's energy system has suffered extensive damage since the start of the war, with over 50% of its infrastructure affected. Many solar and wind facilities were destroyed, occupied, or disconnected, especially in southern and eastern regions. However, several projects – such as the restored Trifonivska Solar Power Plant (10 MW) and the operational phase of the Tiligulska Wind Farm (114 MW) – demonstrate that renewable energy can be quickly restored and scaled even under wartime conditions. These decentralized systems have proven vital in supplying electricity to essential services, including hospitals, water treatment plants, and municipal infrastructure.*

In addition, the article outlines key mechanisms that can facilitate the recovery and expansion of green energy in Ukraine. These include (1) contracts for difference (CFDs), which reduce market risks for producers by guaranteeing price stability; (2) the Net Billing mechanism, which allows small-scale producers to sell surplus energy back to the grid; and (3) origin certificates, which confirm the environmental value of renewable electricity and improve access to EU markets. International examples - from Germany's feed-in tariff system to Japan's microgrids - are analyzed to demonstrate practical applications that can be adapted to the Ukrainian context.

Moreover, the paper presents five practical Ukrainian case studies where renewable energy played a critical role in ensuring local resilience. These include household solar installations in Lviv region, a biomass-powered thermal station in Zhytomyr region, and a backup microgrid at a hospital in Chernivtsi. These projects not only provide energy but also generate economic savings, create jobs, reduce greenhouse gas emissions, and strengthen local capacities. The cumulative effect of these projects illustrates how green energy can be a cornerstone of a decentralized, inclusive, and future-oriented recovery process.

Conclusions. *The research concludes that green energy has the potential to become a cornerstone of Ukraine's war-time resilience and post-war transformation. The decentralized nature of renewable energy systems makes them more resistant to attacks and blackouts, while their clean and sustainable characteristics contribute to climate mitigation, environmental health, and public well-being. For Ukraine, which aspires to EU membership and global leadership in sustainability, green energy is not merely a policy choice - it is a necessity and an opportunity.*

Moving forward, Ukraine must prioritize (1) stable regulatory frameworks, (2) access to green financing, (3) integration with EU climate and energy policies, and (4) the development of local expertise and technologies. Active involvement of municipalities, businesses, and households will be crucial for building energy democracy and ensuring the long-term success of

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the transition. Importantly, investment in renewable energy must be coupled with energy efficiency programs, digital infrastructure, smart grids, and public awareness campaigns.

Ultimately, green energy provides a pathway not only to energy independence but to national renewal. It can drive economic recovery, reduce social inequalities, foster innovation, and make Ukraine more resilient to future crises - both military and environmental. The strategic integration of green energy into Ukraine's recovery policy is essential for rebuilding a sovereign, secure, and sustainable nation.

***Keywords**: green energy; resilience; post-war recovery; decentralization; renewable energy sources; Ukraine, sustainability; war impact; reconstruction policy; energy transition; international cooperation.*

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Зелена енергетика як інструмент стійкості та відновлення України під час війни та в післявоєнний період

***Анотація** У статті досліджено роль «зеленої» енергетики як ключового інструменту забезпечення стійкості енергетичної системи України в умовах війни та під час післявоєнної відбудови. Проаналізовано сучасний стан галузі відновлюваної енергетики, основні законодавчі ініціативи та напрями державної політики. Узагальнено міжнародний досвід впровадження біоенергетики, сонячних електростанцій, мікромереж і цифрових інструментів регулювання. Виокремлено стратегічні напрями трансформації енергетичного сектору, засновані на принципах децентралізації, екологічної безпеки та економічної ефективності. У результаті дослідження встановлено, що розвиток відновлюваної енергетики сприяє підвищенню енергетичної незалежності, створенню нових робочих місць, активізації місцевих громад та досягненню кліматичних цілей. Представлено українські кейси успішного застосування ВДЕ в умовах війни, які підтверджують їхню ефективність з погляду стійкості, екологічності та соціального впливу. Обґрунтовано необхідність формування стабільної інституційної бази, залучення міжнародної підтримки та інтеграції зеленої енергетики в стратегії відновлення України. Зроблено акцент на важливості розвитку фінансових механізмів підтримки ВДЕ, зокрема державно-приватного партнерства, Net Billing та контрактів на різницю. Окреслено перспективи використання «зеленої» енергетики як каталізатора сталого розвитку, енергетичної децентралізації та інтеграції України в європейський енергетичний простір.*

***Ключові слова:** зелена енергетика; стійкість; післявоєнне відновлення; децентралізація; відновлювані джерела енергії; Україна; сталий розвиток; вплив війни; політика відбудови; енергетичний перехід; міжнародне співробітництво.*

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Formulation of the problem. In the 21st century, the issues of energy security, environmental sustainability, and effective post-crisis recovery have acquired global significance. Ukraine, as a country experiencing full-scale war, faces multidimensional challenges encompassing not only the economic, social, and security spheres but also the critically important domain of energy. The war in Ukraine has caused significant damage to the country's energy infrastructure: power plants have been destroyed, grids damaged, and the stability of energy supply to both citizens and industry has been disrupted. In this context, there is an urgent need to reconsider the national energy model in line with the principles of decentralization, resilience, and environmental safety.

Green energy - based on the use of renewable energy sources such as solar, wind, and biomass – is considered one of the key directions for ensuring Ukraine's energy independence. The transition to such sources is not only a tool for mitigating the consequences of war but also a fundamental prerequisite for sustainable economic development in the post-war period. Global experience confirms that investments in green energy contribute to job creation, a reduction in dependence on imported fuels, improved environmental conditions, and the activation of local communities. In wartime, decentralized renewable energy systems are significantly less vulnerable to attacks than centralized thermal and nuclear power plants [7].

However, despite the evident advantages, the development of green energy in wartime conditions encounters numerous barriers: financial constraints, investor withdrawal, threats to critical infrastructure, logistical challenges, and regulatory instability. These factors hinder the implementation of new projects and slow down the integration of renewables into Ukraine's energy system. On the other hand, support for green energy sends an important signal to international partners regarding Ukraine's commitment to modernization, alignment with the principles of the European Green Deal, and engagement in the global climate change agenda. Thus, renewable energy is viewed not only as a technical solution but also as a strategic choice of the state.

Post-war reconstruction in Ukraine will require an integrated approach to the development of all economic sectors, with energy playing a system-forming role. Green technologies can serve as a key factor in ensuring the sustainability of new infrastructure, particularly in agriculture, transport, housing and communal services, and healthcare [2-3]. Special attention should be paid to the role of communities in restoring local energy autonomy. Energy cooperatives, municipal solar power stations, and small biogas facilities provide the

foundation for local economic activity, increased energy resilience, and the reduction of carbon footprints. The potential of green energy should also be considered in the context of psychological and social rehabilitation. Public participation in reconstruction efforts, the installation of solar panels, and modernization of energy systems create a sense of ownership in the recovery process and facilitate the return to peaceful life.

A key challenge remains the formation of an effective public policy that integrates security interests, climate commitments, economic needs, and principles of social justice. This requires reforming investment stimulation mechanisms, ensuring transparency in the renewable energy market, and actively cooperating with international financial institutions. The issue of green energy financing in conditions of limited resources also deserves particular attention. The implementation of blended financial models is necessary – comprising public support, loans from international organizations, tax incentives, and private capital mobilization. These mechanisms must be based on trust, transparency, and long-term planning.

At the same time, geopolitical and environmental risks must be considered. The accelerated deployment of renewable energy requires comprehensive assessments of its impact on biodiversity, land use, and water resources, as well as adherence to energy efficiency principles and integration with other economic sectors. Therefore, green energy emerges not only as a technological response to the energy challenges of wartime but also as an integral part of a broader paradigm of national recovery and transformation. It provides the foundation for a new economic model oriented toward sustainability, environmental stewardship, and decentralization.

Analysis of recent research and publications. The European Commission, in its "Europe 2020" strategy, emphasizes the necessity of smart, sustainable, and inclusive growth, which involves the integration of environmental principles into economic development [1]. V. Ye. Dankevych and his co-authors have presented a community-based approach to local development grounded in European legal standards [2-3]. International energy cooperation is reflected in the electricity import agreement between France and Germany, which illustrates the increasing interdependence in the energy market [4]. The European Environment Agency provides data on the share of renewable energy in gross final energy consumption, demonstrating the effectiveness of environmental policies in EU countries [5]. M. Yu. Haidai has explored the role of international organizations in promoting the development of the "green" economy at the global level [6]. I. V. Honcharuk and V. Yu. Vovk highlight the importance of introducing zero-waste technologies in the context of transitioning to a bioeconomy [7]. A critical assessment of Ukraine's current renewable energy support model is provided by M. Hrytsyshyna, who outlines the shortcomings of the "green" tariff [8]. The International Energy Agency has delivered a comprehensive global overview of energy balances [9], as well as statistics on the share of renewables in electricity generation in selected countries over recent years [10]. L. V. Kosharska, V. P. Brednova, and Yu. O. Nikiforov consider the development of green energy as an integral part of global energy redistribution policies [11]. The article by I. M. Kucheriava and N. L. Sorokina presents key global trends in the advancement of renewable energy sources [12]. The Kyoto Protocol to the United Nations Framework Convention on Climate Change remains a cornerstone of global climate policy [13]. Ukraine's Energy Strategy, developed by the Ministry of Energy, outlines national priorities in energy security and decarbonization [14]. T. Rooks analyzes Germany's prospects for regaining leadership in the field of solar energy [17]. O. Skydan, V. Dankevych, R. D. Garrett, and O. Nimko investigate the state of Ukraine's agricultural sector during the war, focusing on the resilience of farming enterprises [18]. O. V. Skydan, M. I. Yaremova, L. V. Tarasovych, V. Ye. Dankevych, and N. M. Kutsmus emphasize the global potential of sustainable development through the implementation of the bioeconomy concept [19]. M. Topalov provides a critical review of the current state of the green energy sector in Ukraine [20]. The National Power Company "Ukrenergo" offers statistical data on the installed capacity of Ukraine's energy system, which serves as a basis for infrastructure planning [21]. The United Nations Department of Economic and Social Affairs outlines strategic directions for sustainable development, particularly in the energy sector [22]. The Working Group on Renewable Energy Statistics in Germany presents national data on the development of renewables [23]. Despite the difficult conditions currently facing Ukraine, the transition to green energy may become the strategic vector that will enable the country not only to endure the crisis but also to emerge stronger, more modernized, and more deeply integrated into the European and global contexts. Consequently, a scientific and practical question arises: how can green energy become an effective tool for ensuring resilience and successful recovery in Ukraine during the war and post-war reconstruction, taking into account both national and global challenges?

Formulation of research goals. The objective of the article "Green Energy as a Tool for Ukraine's Resilience and Recovery During the War and in the Post-War Period" is to provide a scientific justification for the role and potential of renewable energy in ensuring energy security, economic resilience, and environmentally oriented reconstruction of Ukraine under martial law and in the context of post-war development. The article analyzes key directions for the development of green energy, explores both Ukrainian and international implementation practices, and offers recommendations for the effective integration of renewable energy into Ukraine's national recovery policy.

Outline of the main research material. The green energy sector in Ukraine has faced unprecedented challenges as a result of Russia's full-scale invasion. From the early days of the war, renewable energy facilities came under direct attack by Russian forces, leading to widespread destruction, occupation of several stations, loss of access to infrastructure, and a deep crisis in the national energy sector. The Ukrainian energy system withstood hundreds of strikes and, for the first time in its history, experienced a nationwide blackout – demonstrating the critical importance of distributed and resilient energy systems during wartime.

Prior to the outbreak of hostilities, the share of renewable energy sources (RES) in the electricity generation structure exceeded 13%. Installed RES capacity surpassed 10 GW, with a significant portion of facilities built during the period of elevated feed-in tariffs, which attracted considerable investment. Total investments in the sector exceeded $12 billion. However, by the autumn of 2022, nearly all wind power plants and approximately half of solar power stations were forced to cease operations. As a result, the share of RES in the energy mix dropped to 5–6%.

A large number of these facilities were located in frontline and temporarily occupied regions. Many were either destroyed by missile strikes, disconnected from the grid, or looted by occupying forces. For instance, the Solar Generation solar power plant in the Kharkiv region was destroyed by a missile attack. One of the most severe losses was experienced by the DTEK holding, which lost control of three major wind farms totaling 500 MW in occupied territories [1].

The Swedish company Windkraft Ukraine, which operates five wind farms in the Kherson region, lost access to 335 MW of generating capacity – accounting for one-fifth of all wind generation in the country. The sector has entered a deep crisis: in 2022, payment levels dropped by nearly half, while the total market debt exceeded UAH 18 billion. Among the key causes are insufficient electricity transmission tariffs, low efficiency in public procurement, export limitations, and rigid price caps. In response to these challenges, a package of legislative initiatives was developed and consolidated into a framework bill on the "green transformation" of the energy sector. This bill includes the introduction of guarantees of origin for green electricity. These certificates will enable consumers to verify the environmental origin of electricity and provide Ukrainian exporters with fiscal advantages when supplying goods to the EU. The draft law also proposes the introduction of Contracts for Difference (CfD), allowing RES producers to sell energy directly [5-6].

Another provision is the implementation of self-generation mechanisms: households and enterprises will be permitted to install their own RES units and sell excess energy to the market. Starting in 2030, this mechanism will be reserved exclusively for green generation, with certain exceptions for pre-existing installations. Net Billing is also envisioned as a key mechanism, allowing consumers to feed surplus electricity into the grid and pay only for the net difference between consumed and generated power. Furthermore, the legislation allows for local energy trading between enterprises at contractual rates, thereby reinforcing energy decentralization.

The state-owned enterprise "Guaranteed Buyer" will be authorized to export green electricity on market terms. This revenue can partially offset feed-in tariff obligations, reduce debt burdens, and improve market liquidity. Incentives for small-scale solar power producers will also remain in place through the end of 2023. The key directions for the development of green energy as a tool for Ukraine's resilience and recovery during the war and in the post-war period are summarized in Table 1.

The proposed table summarizes the key directions for the development of green energy, which are regarded as vital instruments for strengthening the resilience of Ukraine’s energy system during wartime and its reconstruction in the post-war period. Each direction carries strategic significance and possesses the potential for adaptation to national circumstances. It is crucial to note that the advancement of these directions requires simultaneous mobilization of financial resources, refinement of the regulatory framework, and alignment with international best practices.

Bioenergy represents a promising sector that combines energy production with the agricultural economy, allowing for the efficient utilization of biomass and organic waste to generate thermal and electric power. This contributes to the energy autonomy of regions and the creation of new value chains within rural communities. International experience, particularly within EU countries, demonstrates the effectiveness of bioenergy in district heating systems – an approach that could be adapted across Ukrainian municipalities. Local solar power plants (SPPs) are an important source of distributed generation. Their installation on the rooftops of private residences, educational institutions, and healthcare facilities reduces the load on the national grid, enhances energy security for critical infrastructure, and decreases electricity costs. Countries like Italy and Spain have achieved significant progress through state-supported rooftop solar programs, offering a replicable model for Ukraine’s community and residential energy policies.

Table 1 **Key Directions for the Development of Green Energy as a Tool for Ukraine's Resilience and Recovery During the War and in the Post-War Period**

Direction	Description	International Implementation Experience
Bioenergy	Utilization of biomass and agricultural or organic waste for energy generation; contributes to energy autonomy and rural development.	Germany, Sweden, and the Netherlands widely use bioenergy in centralized heating systems.
Local Solar Power Plants (PV)	Small-scale solar generation units installed on rooftops of households, institutions, and enterprises; reduce grid load and support localized consumption.	Italy and Spain have well-developed rooftop PV infrastructure supported by state incentive programs.
Microgrids (Energy Islands)	Autonomous local energy supply systems for critical infrastructure; ensure resilience during emergencies.	The USA, Canada, and Japan deploy microgrids to protect vital infrastructure from natural disasters and attacks.
Modernization of Electricity Grids (Smart Grids)	Integration of digital technologies into grid management; improves efficiency, flexibility, and reliability of energy supply.	France, Denmark, and South Korea actively invest in smart grid infrastructure.
Energy Origin Certificates	Certify the source of electricity generation; promote environmental responsibility and facilitate exports to the EU.	The EU has implemented a standardized system of energy origin guarantees, mandatory within the internal market.
Contracts for Difference (CfD)	Support mechanism that compensates the difference between market and fixed contractual prices; reduces investment risks.	The UK and France apply CfDs to support large-scale RES projects.
Net Billing Mechanism	Allows consumers to sell surplus energy to the grid; increases economic feasibility of small RES installations.	The USA and Germany have integrated Net Billing into support schemes for small renewable generators.
Institutional Support and Partnerships	Attracts private investment, fosters public-private partnerships, and engages in international financial initiatives.	Finland, Estonia, and Canada have experience with collaborative frameworks between state, business, and donors.

Source: [1, 10].

Microgrids, or energy islands, offer a solution to the vulnerabilities of centralized networks, particularly in conflict-affected areas. They ensure autonomous power supply for hospitals, command centers, and water systems. Global practice shows that such systems are being actively implemented in the USA, Japan, and Canada to safeguard critical infrastructure against disasters and attacks. In Ukraine, microgrids can play a pivotal role in guaranteeing uninterrupted electricity in high-risk zones.

Institutional mechanisms, such as energy origin certificates, Contracts for Difference (CfDs), and Net Billing systems, are key to building a transparent, stable, and attractive renewable energy market. These tools help reduce investment risks, support small businesses and households, and enable the integration of Ukraine's energy sector into the broader European space. The development of public-private partnerships, as successfully demonstrated in Finland and Canada, opens opportunities for attracting international funds, investments, and technical assistance to support Ukraine's green transformation [2-3].

Despite significant attention to legislative reforms in the renewable energy sector, certain provisions of the proposed legislation have prompted professional debate. Notably, there is an ongoing need to refine norms regarding the allocation of responsibility for commercial imbalances among market participants, the duration of technical conditions for renewable energy facilities impacted by warfare, and the terms of cooperation with the state-owned Guaranteed Buyer enterprise. There are also discussions concerning the investment incentive mechanism based on feed-in premium (FiP) payments. The current calculation algorithm is considered overly complex and potentially opaque, introducing additional risks for investors and reducing the attractiveness of renewable generation projects for both domestic and international capital. Nevertheless, market stakeholders generally express a constructive readiness to support legislative improvements. Over 500 amendments were submitted for the second reading of the legislative proposal, many of which are technical or repetitive. However, the core conceptual elements of the draft law had already been agreed upon during the first reading, suggesting a high likelihood of parliamentary approval during the final vote.

In the context of wartime, renewable energy has acquired new strategic importance. Decentralized energy sources enhance the resilience of the power grid, reduce dependency on vulnerable transmission lines, and create conditions for autonomous power supply in specific regions. This is particularly critical in light of infrastructure destruction caused by military actions.

In the post-war period, renewable energy can serve as a catalyst for economic growth. Investments in green technologies will foster job creation, stimulate innovative

industries, and strengthen Ukraine's energy independence. The development of this sector also aligns with the country's international commitments to climate policy and economic decarbonization. Special attention should be given to the development of sectors with high potential for scaling in Ukraine. First and foremost is bioenergy, based on the utilization of agricultural and household waste, which fosters the integration of energy systems with agriculture and supports the formation of regional energy clusters. Secondly, the expansion of local solar power, particularly small rooftop SPPs in households, public institutions, and businesses, will help alleviate the load on centralized infrastructure while cultivating a culture of energy responsibility among citizens [22].

Microgrids, or so-called "energy islands," represent another strategic direction by ensuring uninterrupted power supply to hospitals, schools, and water infrastructure in the event of network failures. These systems are especially valuable for rural territorial communities and border regions. The modernization of electricity supply infrastructure – especially through the deployment of smart grids – is essential for integrating new RES into the national energy system. This requires a reevaluation of load management, energy storage, and real-time frequency regulation practices.

It is also institutionally important to establish conditions conducive to attracting private investment. This includes mechanisms for public-private partnerships, transparent auctions, investment guarantees, and improved access to international climate funds. A stable regulatory environment will be key to ensuring sustained interest in the sector. Ukrainian case studies on the implementation of green energy as a resilience and recovery tool are presented in Table 2.

Table 2 **Ukrainian Case Studies of Green Energy Implementation as a Tool for Resilience and Recovery**

Practical Case	Digital Characteristics	Efficiency Description (with figures)
Triphonivska SPP, Kherson region	Capacity – 10 MW; resumed operations in January 2023 after de-occupation.	Provides electricity to over 3,000 households; reduces CO_2 emissions by 7,000 tons annually.
Tiligulska WPP, Mykolaiv region	Planned capacity – 114 MW; first stage commissioned in spring 2023.	Supplies power to over 100,000 households; avoids over 150,000 tons of CO_2 annually.
Households with rooftop SPPs, Lviv region	Average installed capacity – 10 kW; over 3,000 installations by end of 2023.	Electricity cost reduction up to 60%; annual savings exceed UAH 35 million.
Biomass-based BioCHP, Zhytomyr region	Thermal capacity – 5 MW; annual biomass usage – 25,000 tons.	Replaces 8 million m^3 of natural gas per year; reduces CO_2 emissions by over 12,000 tons.
Microgrid at hospital, Chernivtsi region	Backup generation capacity – 0.5 MW; power autonomy – up to 72 hours.	Ensures uninterrupted hospital operation during outages; serves energy needs of 4,000 patients annually.

Source: [1, 10].

Ukrainian case studies of green energy deployment clearly demonstrate the high potential of renewable energy sources as vital components of energy resilience under wartime conditions. A notable example is the Tryfonivska Solar Power Plant in Kherson Oblast, which was rapidly restored following de-occupation and currently supplies electricity to more than 3,000 households, reducing CO_2 emissions by approximately 7,000 tonnes annually. A larger-scale initiative is the Tyligulska Wind Power Plant in Mykolaiv Oblast, with a projected capacity of 114 MW, capable of providing energy to over 100,000 households and decreasing greenhouse gas emissions by over 150,000 tonnes each year [1].

At the household level, rooftop solar power stations have proven particularly impactful. In Lviv Oblast, over 3,000 such installations have been established, each with an average capacity of 10 kW. These systems allow households to reduce electricity expenses by up to 60%, resulting in total annual savings exceeding UAH 35 million. In parallel, Zhytomyr Oblast has implemented a successful bio-CHP (combined heat and power) project, which utilizes 25,000 tonnes of biomass per year to produce 5 MW of thermal energy. This initiative displaces up to 8 million m^3 of natural gas annually and cuts CO_2 emissions by more than 12,000 tonnes [22].

Another important case involves a microgrid solution implemented at a hospital in Chernivtsi Oblast. The facility includes a backup generation unit with a capacity of 0.5 MW, enabling autonomous operation for up to 72 hours. This setup ensures uninterrupted power supply to critical healthcare infrastructure, which is particularly crucial under wartime conditions and in the event of damage to central power lines. Collectively, these examples highlight the high efficiency of green energy as a tool for enhancing resilience, economic viability, and environmental responsibility.

Therefore, renewable energy in both wartime and the post-war context can – and must – serve as a fundamental pillar of national resilience, economic

diversification, and Ukraine's integration into the European energy landscape. Its advancement requires a systemic approach, cross-sectoral coordination, and a focus on delivering socio-economic benefits for all stakeholders in the energy transformation process.

Conclusions. The study has established that renewable energy plays a pivotal role in ensuring the energy resilience of Ukraine during wartime and in the post-war recovery phase. Its development enables the creation of a decentralized, secure, and adaptive energy system capable of functioning even under conditions of limited resource access and partial loss of centralized infrastructure.

The war has exposed the vulnerability of traditional energy systems to targeted attacks. Therefore, the decentralization of electricity production, which is inherent to green energy, holds strategic importance. It promotes energy autonomy for territorial communities, ensures the operation of critical infrastructure, and mitigates the risks of large-scale energy collapses. Ukrainian case studies – such as the Tryfonivska Solar Power Plant, Tyligulska Wind Power Plant, and the microgrid at the hospital in Chernivtsi Oblast – demonstrate the high effectiveness of this approach. Quantifiable indicators, including thousands of households supplied with electricity, millions of hryvnias saved, and significant reductions in CO_2 emissions, present a compelling case for the scaling-up of such solutions.

Institutional instruments such as Contracts for Difference, Net Billing, and Energy Origin Certificates must be implemented systematically to establish a predictable market and attract investment. These tools not only facilitate the commercialization of green energy but also lay the foundation for its integration into the European legal and market framework. In the post-war period, renewable energy may become one of the drivers of economic development, opening up new markets, employment opportunities, and technological niches. Local projects that combine energy, social, and environmental dimensions – such as small-scale solar plants, biogas units, and energy cooperatives – will have particular significance.

At the same time, the issue of financing green energy under conditions of a constrained budget requires close attention. It is necessary to activate mechanisms of public-private partnerships, attract funding from international donors and climate funds, and implement preferential taxation schemes to stimulate the growth of renewable energy. It is crucial to consider not only the energy-related but also the environmental parameters of renewable energy development – namely, the impact on biodiversity, water resources, and land use. Only an ecologically balanced green transition can ensure long-term sustainability.

The role of local governments and communities in the development of green energy is growing. It is at the local level that practices of energy independence, innovative resource use, and economic self-organization are being shaped. These initiatives should be supported through regional programs, grants, and concessional loans. The experience of EU countries, Canada, the United States, and others confirms the effectiveness of an integrated approach to renewable energy development that combines political will, financial incentives, technical assistance, and public participation. Ukraine can adapt these approaches to its unique wartime and economic context. Thus, green energy has all the prerequisites to become not only a response to the current challenges of war but also a long-term vector for Ukraine's ecologically oriented, decentralized, and competitive economy. Its integration into national security, economic, and social policies will ensure progress toward sustainable development and alignment with European standards.

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