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FOSTERING ENERGY SECTOR "GREEN" TRANSITION BASED ON RENEWABLE ENERGY IN UKRAINE IN TERMS OF WAR

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Abstract. This article presents the updated state of the renewable energy sector development in the European Union countries and in Ukraine. Due to obligatory international frameworks of the sustainable development and climate change policies introduction in the EU and Ukraine, it is important to track the transition period and its supportive mechanisms. The authors provide a comparison of the tendencies of the renewable energy development and "green" transition with emphasis on solar energy in Ukraine and EU before the full-scale war. The object of the research is the complex of introduced mechanisms that support and promote energy transition to RES in Ukraine taking into consideration the conditions of operationg in full-scale war. It is defined that in Ukraine, during wartime, state regulation of renewable energy development is carried out comprehensively – through legislation, financial instruments, market mechanisms, and advanced technical support for critical infrastructure. The primary research target of the article centers on the need for fostering energy transition based on renewable energy in Ukraine in times of war. Framed within this context, our research analyses how economic policy for the transition to renewable energy in Ukraine is optimized for achieving national goals in increasing renewable energy share in energy production and how the state is coping with rebuilding energy infrastructure on the bases of "green" transition during the full-scale war. It is concluded that the new changes in legislation can be effective when applied with the necessary economic and regulative mechanisms. The example of Ukraine shows how the new challenges and mechanisms to tackle with all risks involved are implied in the country during the war. A profound analysis of legislation changes, new financial mechanisms, energy market instruments modernization, construction of distributed energy system in Ukraine during the war with the simultaneous EU integration is made. It is emphasized that Ukraine has a great potential in transition of its energy sector to renewable energy sector. Its evidence is the statistic data of the rapid growth of installed capacities of renewable energy objects in Ukraine before the full-scale war. That's why it is obvious to make a prediction that in after war period the recovery of Ukraine will be based on "green" energy as well.

Keywords: renewable energy, sustainable development, state policy, green transition.

JEL Classification: L50, Q01, Q28

1. Introduction

Energy transition from fossil fuels to renewable energy sources (RES) has started globally long ago before the full-scale war in Ukraine. It can be explained by adoption of international climate policies, such as the Paris Agreement (United Nations, 2015) European Green Deal (European Green Deal, 2022) on one hand and high tech innovations in renewable energy on the other hand. Additionally, the Energy Policy Institute's report (Global Energy and Climate Outlook, 2021) highlighted that the increasing partnerships between academic institutions and the energy industry have played a crucial role in stimulating research efforts. It has to be emphasized that the renewable energy development both in EU and Ukraine was a pilar of energy policy before Russia started the full-scale war against Ukraine.

Therewith, in 2022, the total renewable energy capacity increased to 3371,79 gigawatts (GW), the largest expansion in renewable power capacity in history (International Renewable Energy Agency, 2023).

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2024 was an extremely successful year for the development of renewable energy in the world, according to an IRENA report (International Renewable Energy Agency, 2025).

Global results are impressive:

– total installed RES capacity reaches 4,448 GW with +585 GW of new RES capacity (+15.1%) in 2024;
– Renewables account for 46% of total global installed electricity capacity: Solar power – +452 GW and wind power – +113 GW.

But it is important to note that growth has been uneven across regions:

China, US, EU – accounted for over 83% of the increase.

To meet COP28 targets and triple RES by 2030, the world needs to add over 1,120 GW every year – twice as much as in 2024.

But a rapid growth of renewable energy capacities in the world after February 2022 we bind with the collapse of the world order caused by Russian war against Ukraine and geopolitical instability in Europe as a result as well.

The ongoing war in Ukraine has prompted a significant shift in transition to renewable energy, rising ecological consciousness of population, speeding policy changes for the promotion of renewable energy development in Ukraine, neighboring countries and across Europe.

The EU bases its energy landscape and planning on four policy packages:

– Energy Union Strategy, 2015;
– Clean Energy for all Europeans, 2016;
– European Green Deal, 2019;
– Fit for 55, 2021.

These energy packages focus on the energy transition by encouraging the reduction in emissions through decreasing the use of fossil fuels, deploying renewable energies, and increasing energy efficiency. As a respond to the disruption caused in the energy market of the EU by Russia's invasion of Ukraine, a new policy package was announced in February 2022: REPowerEU (REPower EU Plan, 2022). This package is a response aims at diversifying the energy supply, moving away from Russian dependence and modifying the transition path depicted before the energy crisis, also enhancing a stronger deployment of alternative energy sources (REPower EU Plan, 2022). The main energy proposals that appear in REPowerEU are:

– Natural gas supply diversification: To analyse the possibility to import more gas from other countries and evaluate new gas alliances as well as coordinate with other gas buyers.
– Boosting renewable energies: A new proposal for increasing the renewable energies target to 45%. Special focus on solar PV to install new 320 GW by 2025, creating an EU Solar Strategy and a European Solar Rooftop Initiative. Also, the EU will study the declaration of 'go-to' areas for a fast approval process for renewables deployment.
– Hydrogen promotion: A proposal for a target production of 10 million tonnes of domestic renewable hydrogen by 2030 and the creation of a European hydrogen bank.
– Biomethane: An initiative to boost sustainable biomethane production to 35 bcm by 2030.

Increase the binding target in the Energy Efficiency Directive to 13%.

The effectiveness of introduced policy can be measured by the amount of new installed capacities of RES in EU.

Since 2022, the EU generated more electricity from wind and solar than from gas and in 2023, wind alone produced more electricity than gas. In 2024, for the first time solar energy accounted for a larger share of electricity generation in the EU than coal. With almost 66 GW of new solar energy capacity installed in 2024 (according to SolarPower Europe, 2025), the EU has set yet another record from the additional 63 GW installed in 2023. As for wind power, 13 GW of new capacity was installed in the EU in 2024, amounting to a total 231 GW, up from 188 GW in 2021 (REPowerEU Plan – 3 years on, 2025).

2. Object and Subject of Research

The Ukrainian supportive policy of renewable energy development has to include both important pillars: first, it is security, provision of stable energy supply even during Russian attacks on energy infrastructure; secondly, it is about promoting renewable energy projects, attracting new investments as the industry was developing extremely fast in the country before the war. Between 2018 and 2020 the solar photovoltaic capacity in Ukraine more than tripled and exceeded 7,000MW (7GW) at the end of 2020, making Ukraine one of the fastest-growing photovoltaic markets in the world.

Due to official IRENA data (International Renewable Energy Agency statistics, 2025) in 2024 the capacity of operating renewable energy in Ukraine decreased from 14,287 MW to 7,150 MW. Solar energy suffered the most – minus more than 7 GW (a drop of more than 60%). At the same time, it is important to consider that the data for 2023 probably included: capacity in temporarily occupied territories; facilities that were physically destroyed but remained in the registers.

For a comparison of solar energy development trends in EU countries and Ukraine, the graph was constructed (Fig. 1). The graph shows data of total installed solar energy capacities in MW at the beginning of 2022, when the full-scale war started in Ukraine, and data available at the end of 2024 (Fig. 1). It is important to mention that the graph illustrates

the total installed solar energy capacities that are producing energy, because in the case of Ukraine there are many solar power plants at hostility and occupied territories that are damaged or totally destroyed. Such solar power plants are registered as installed in Ukraine, but in fact they don't produce any energy for now. The figure also illustrates the great difference between Ukraine suffering from daily Russian attacks and EU countries where solar energy capacities are sharply increasing.

Despite the unprecedented challenges caused by the war, Ukraine is consistently implementing an energy transition and developing new areas of renewable energy such as bioenergy. In February 2023, a Memorandum of Understanding on Strategic Partnership in the Fields of Biomethane, Hydrogen and Synthetic Gases was signed between Ukraine and the European Commission.

Ukraine has removed all obstacles to the entry of biomethane into the EU market – it has unblocked the export of biomethane, and has determined a temporary (until the full launch of the Ukrainian biomethane registry) procedure for the export of this renewable gas to the EU.

3. Literature Analysis

A comprehensive meta-analysis conducted on a review of literature based on 699 documents related to renewable power systems, as indexed in the Scopus database has highlighted significant growth in renewable energy capacity globally, with an unprecedented increase in solar and wind energy installations. These results affirm the global shift toward renewable energy, underscored by both technological advancements and policy support. (Kwilinski, Lyulyov, 2024)

The war in Ukraine has been identified as a critical factor influencing energy policies in Europe, particularly in the context of the EU's reliance on Russian energy supplies. Korosteleva notes that the Russian invasion of Ukraine in 2022 has served as a catalyst for accelerating Europe's transition to greener energy alternatives, as the war has highlighted the vulnerabilities associated with excess dependence on fossil fuels (Korosteleva, 2022). This sentiment is echoed by Janasz, who argues that the war has created a unique opportunity for the implementation of new climate and energy policies focused on renewable energy technologies (Janasz, 2022). The urgency of the situation has prompted both policymakers and the public to reconsider their energy strategies, leading to a surge in interest and investment in renewable energy sources.

Furthermore, the war has intensified discussions surrounding energy security and climate change, as highlighted by Brown, who emphasizes the dual challenges of energy security and climate action exacerbated by the war (Brown, 2023). The need for energy independence has become paramount, pushing nations to explore renewable energy options more vigorously. This shift is not only a response to immediate energy needs but also reflects a broader recognition of the importance of sustainable practices in tackling climate change. The implications of this transition are significant, as they may lead to a more robust and resilient energy infrastructure in the post-war period. The impact of the war on renewable energy markets has been profound.

Iwaszczuk highlights the favorable conditions for the development of photovoltaics in Ukraine, suggesting that the post-war period could see significant advancements in solar energy technologies (Iwaszczuk, 2023). The geographical advantages and existing scientific capabilities position Ukraine as a potential leader in renewable energy development, provided that the necessary investments and policy frameworks are established. This potential for growth aligns with the broader European trend towards renewable energy,

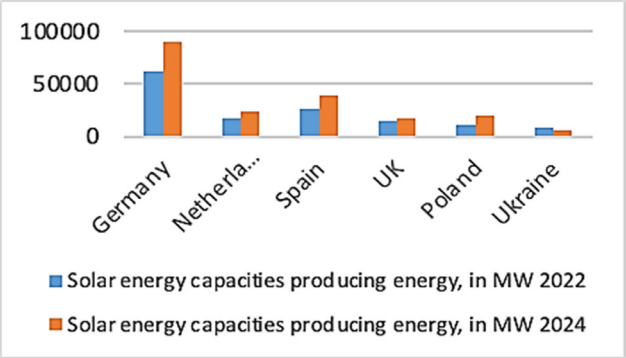

Figure 1. Solar energy development trends in EU countries and Ukraine in 2022 and in 2024

Source: made by authors based on IRENA data (Renewable Capacity Statistics, 2025)

as nations seek to diversify their energy portfolios and reduce reliance on fossil fuels. Moreover, the war has prompted a reevaluation of energy policies and strategies at both national and international levels.

Kurbatova discusses the challenges faced by Ukraine in integrating renewable energy into its grid, emphasizing the need for substantial reforms to accommodate the growing share of renewables (Kurbatova, 2024). The war has disrupted existing energy infrastructure, but it has also created a unique opportunity for innovation and reform in the energy sector. The push for a decentralized energy model, as proposed by Sokhatska and Panasyuk, reflects a growing recognition of the importance of sustainable and resilient energy systems in the face of geopolitical challenges (Sokhatska, Panasyuk, 2022).

Kudrya and group of Ukrainian researchers analyze the possibility of forming local electric power systems (LES) based on renewable energy sources (RES) as balancing groups in the electric power system (EPS), which can maintain their performance and provide offline power supply to consumers. Power grids are designed in such a way that they can operate autonomously in both normal and wartime conditions. The sources of electricity in the transmission system are small hydroelectric power plants (SHPPs), photovoltaic power plants (PVPPs) and wind power plants (WPPs), whose electricity generation is unstable due to dependence on natural conditions. Therefore, the structure of the RES power plant includes an energy storage system with sufficient reserves to compensate for the instability of generation and balancing (Kudrya, 2024).

Another group of Ukrainian researchers analyze the publications of scientists from two countries – Ukraine and Poland in the field of "thermoelectricity," "photoelectricity," and "bioenergy" to find regularities in each state and to determine the prospects for joint research. Ukraine and Poland share a common border and have similar climatic conditions and historical heritage, but Poland is a member of the EU, and its legislation in the field of renewable energy complies with the regulations of the European Community. Ukraine is making every effort to develop renewable energy. Comparison of the state of research in these countries is also an example of the analysis of the situation at the borders of EU countries and may answer questions related to sustainable development, the mass transition to renewable energy, and the refusal to use fossil fuels and nuclear power plants. The analysis is based on the results of data published in the international scientific databases Web of Science and Scopus (Nykyruy, 2020).

Maneejuk research reveals notable differences in renewable and fossil energy price cycles. The renewable price cycle exhibits greater persistence, indicating a limited response to the conflict shock. In contrast, the fossil energy price cycle exhibits more significant and enduring adjustments in high- and low-volatility regimes. These findings highlight the heterogeneous impacts of the Ukraine-Russia war on the fossil energy market, indicating potential disruptions in supply chains and market sensitivities. Notably, fossil energy prices demonstrate higher responsiveness to the Ukraine-Russia war across market conditions (Maneejuk, 2024).

4. Results and Discussions

The main driver of fostering energy transition to RES in a country is an effective stimulating state policy. State policy in the field of renewable energy is a certain strategic direction of energy development, which is determined by state authorities, and which is aimed at overcoming existing problems and achieving set goals. It consists in creating legal foundations for the production, storage, transportation and consumption of renewable energy, setting tariffs, exercising control over the safety of infrastructure energy facilities, "green" recovery of damaged energy facilities, stimulating scientific research in the field of renewable energy in order to ensure its further effective development.

The institutional basis of the state policy in the field of renewable energy in Ukraine is made up of executive bodies that develop, coordinate and implement strategies, programs and regulatory legal acts aimed at the development of renewable energy sources (Table 1). These include: the Ministry of Energy, the Ministry of Environmental Protection and Natural Resources, the State Agency for Energy Efficiency and Energy Saving, the State Inspectorate for Energy Supervision, the National Commission for State Regulation in the Fields of Energy and Utilities as shown in Table 1.

The state, being the most resourceful subject, has the opportunity to manage the entire institutional cycle of economic policy transition to renewable energy, including creating conditions for access to data and their analysis, ensuring participation in the development of a "green" course of stakeholders and political dialogue, creating legislation and setting standards. During the war the state's task is also to assure insurance mechanisms for investors (Table 1).

Traditionally, a scientific community plays an important role in the formation of directions and effective mechanisms of renewable energy growth, and the development of general theoretical and applied aspects of the implementation of a "green" growth policy.

The role of business in the economic policy of the transition to renewable energy, is fundamentally different from the passive role that business structures played within the framework of the implementation of traditional environmental policies. In fact, business

Table 1
Structural components of economic policy for the transition to renewable energy in Ukraine

Green economy policy actors	Functions	Resources
State	Integration of the "green" agenda into the national public discourse, definition of strategic priorities in the field of energy, economic policies of transition to RES, formation of regulatory and legal framework, development of plans, programs for its implementation, coordination and integration of the activities of all subjects, cooperation of resources.	Administrative, budgetary and financial, informational and discursive, regulatory
Scientific and research institutions	Aggregation and analytical generalization of scientific data, generation of knowledge for strategic directions of RES and green economy, formation of human resources potential to ensure structural development of the economy, expert and consulting support	Expert, intellectual, personnel, material and technical, information
Business entities	Formation of investment demand for "green technologies", goods and services, formation of markets for environmental goods and services, participation in the development of regulatory frameworks and implementation of "green" norms and standards, ecological modernization of production processes, "green" growth policies, formation of a new quality of business ethics	Investment and financial, logistical, lobbying, innovative
NGOs	Creating a public demand for ESG principles in political decision-making, forming and promoting a "green" discourse in the public sphere, businesses, forming and mobilizing public opinion, cooperation networks at the international, national and regional levels, monitoring and public assessment of environmentally significant state and corporate decisions	Expert, lobbying network, symbolic and image, information
Communities	Formation of public demand for the benefits associated with RES development, lobbying "green" projects at the local level, scaling up successful "green" practices, involvement of local work force to RES projects.	Investment, social, workforce, lobbying, network, innovation, material
Political parties	Political representation of the interests of communities in the development of the green economy, promotion of the "green course" at the legislative level, influence on the political, social and media agenda	Lobbying, network, information and discursive

is turning, on the one hand, into one of the main recipients of the results of the "green" development policy, and on the other, into one of the main recipients of the risks associated with this process, especially in a country in war.

However, there are general trends related to the implicit features of the green economy model that contribute to the inclusion of a wide range of business structures in the implementation of the "green" agenda. First of all, the economic policy of transition to renewable energy can create attractive opportunities for growth, sustainability and strengthening of competitive advantages of corporate players. Enterprises focused exclusively on traditional developed markets miss significant opportunities for growth in emerging markets in the times of the world's transition to sustainable development. In addition, the limited natural resources, which are becoming increasingly obvious, accelerating the prices of fossil fuels, create increased risk for investors and shareholders and force leading companies to focus on diversifying energy sources, investing in "green" technologies and projects.

The innovative material and technical resource of the business is very important in the formation and implementation of the economic policy of transition to renewable energy. At the same time, many innovations produced by business go beyond technology, reflect changes in business models, management processes, and are cross-cutting in nature, covering various industries and areas of innovation, industrial, and trade policy.

Public organizations, local communities, and "green" political parties are also important actors in the economic policy of transition to renewable energy, reflecting the interests of communities focused not only on solving global and national environmental problems, but also on promoting the "green course" at the local level.

The main instruments of state economic policy regulations include several important issues to be analyzed below.

1. **Legislation changes** with the purpose of maintaining stability in RES industry in wartime with simultaneous eurointegration process.

The main document adopted during the war in Ukraine is National RES Plan (approved by the government in August 2024) – to achieve 27% of RES in consumption by 2030, including 12.2 GW of solar (5 GW – distributed), 6.2GW of onshore wind, 100 MW of offshore, 876 MW of bioenergy, 40 MW of geothermal.

Law No. 3220-IX of June 30, 2023, "On Amendments to Certain Laws of Ukraine on the Restoration and Green Transformation of the Energy System of Ukraine" is aimed at improving the conditions for supporting producers of electricity from RES. It provides changes in the regulation of "green" auctions, guarantees of origin of electricity, contracts for difference and also introduces new support mechanisms, such as market premium and self-production. It introduces changes in the regulation of RES market:

– the market premium mechanism for energy producers from RES creates an opportunity for a producer, for whom a "green" tariff is established, to sell electricity in organized market segments, as well as in the market of bilateral contracts, but at the same time to receive the difference between the amount of the "green" tariff or auction price, taking into account the surcharge to it and the calculated price, determined in accordance with the Law of Ukraine "On the Electricity Market" (Law of Ukraine "On the Electricity Market", 2017). At the same time, if the amount of the calculated market price in the established period exceeds the amount of the auction price, taking into account the surcharge to it, the business entity producing electricity pays the Guaranteed Buyer the cost of the service under the market premium mechanism for the electricity sold. A strengthening factor for the conclusion of such contracts are amendments to Article 66 of the Law of Ukraine "On the Electricity Market", which establishes the voluntary principle of participation in auctions for the sale of electricity for all producers from RES;

– conditions for forming the financial balance of the Guaranteed Buyer, which provides for receiving additional income from the sale of "guarantees of origin" and the possibility of attracting financing to cover the service of ensuring an increase in the share of electricity production from alternative energy sources from the state budget. Thus, for the first time at the legislative level, the Guaranteed Buyer and the Producer are granted the right, in the event of mutual homogeneous debt, to offset counter homogeneous claims. It is also determined that the condition for joining the balancing group of the Guaranteed Buyer for a producer who has a "green" tariff is the presence of a load reduction agreement with the transmission system operator;

– the work of an active consumer, including under the self-production mechanism. The law creates the possibility of selling generation facilities, in particular from RES with their connection to the consumer's internal networks. Requirements for connecting electrical installations are determined by the current codes of the transmission and distribution system. Another feature determined by the Law is the possibility of selling surplus of generated electricity to the electricity supplier at contractual prices. The capacity of the generating installation of an active consumer is determined by the nominal capacity of the inverter equipment of such a generating installation, which ensures parallel operation of the generating installation with the power system. In turn, the readiness for operation of the generating installation must be confirmed by the authorized body in the field of construction;

– the work of a new market participant, a licensee – the Aggregator. A new type of activity in the electricity market – aggregation, will allow to ensure the management of distributed generation facilities and/or energy storage facilities connected to the internal networks of the consumer or to the networks of system operators with a capacity of up to 20 MW. It is assumed that the aggregator will carry out dispatching of the facilities of the aggregated unit to provide balancing services and auxiliary services for the transmission system operator. Also, the Aggregator will be the party responsible for the balance in relation to the aggregated objects;

– the mechanism of operation of the system of guarantees of origin of electricity. A guarantee of origin of electricity generated from RES is an electronic document that confirms that a certain amount of electricity is generated from renewable energy sources, confirms its environmental value and certifies the rights associated with the positive effect of generating electricity from renewable energy sources. This is about the environmental value of electricity generated from renewable energy sources – the amount of greenhouse gas emissions that were avoided due to the production of 1 MWh of "clean" electricity. The law also determines the procedure for the circulation of guarantees of origin and the functioning of the electronic platform and its operator;

– the work of a new market participant, a licensee – a small distribution system operator, which will create electricity networks and provide connection and distribution services for participants in industrial parks. The possibility of implementing a common small distribution system for several industrial parks located on adjacent land plots is envisaged. The possibility of connecting renewable energy objects and energy storage facilities to the networks of the small distribution system has been determined.

The newly adopted Law has created conditions for the implementation of new projects in the sector of renewable energy and balancing capacities, in particular those connected to consumer networks. The Law also outlines changes to the operating conditions of already implemented RES facilities regarding the possibility of selling electricity on market terms.

Law No. 3141-IX (Law of Ukraine on Amendments to Certain Laws of Ukraine on Prevention of Abuse in Wholesale Energy Markets, 2023) amends the

legislation on preventing abuse in wholesale energy markets by adapting the European rules on wholesale energy market transparency and integrity (REMIT). It also defines energy market abuse and sanctions for its violation.

The Law aims to adapt Ukrainian energy legislation to European standards, as it implements Regulation (EU) No. 1227/2011 (Regulation EU No. 1227/2011, 2025) on wholesale energy market integrity and transparency.

The Law defines the concept of energy market abuse and establishes sanctions for its commission.

Thanks to the new legislation, among other things, MPs introduced Net billing in Ukraine – a mechanism for accounting and calculating for "green" electricity.

According to the parliamentarians, such a system is designed to stimulate the development of renewable energy in Ukraine. The law also introduces the concept of an "active consumer".

Net billing is a mechanism for net metering and calculating for electricity. It works in a number of countries, but is new for Ukraine.

The system clearly regulates the interaction between consumers and electricity producers. For example, a household owns a solar power plant on its roof, depending on the season, it generates a different amount of electricity. Accordingly, there may be a surplus of electricity in summer and in winter the situation is the opposite and the household will need additional electricity.

In the event of a surplus of electricity, the supplier buys this electricity for money at the market price. And credits these funds to the consumer's personal account. And in the opposite case: when there are insufficient volumes of generation from their own solar installation, the consumer can use these funds to pay for the electricity supplied to them from the grid by the supplier.

The new law introduces the new concept of "active consumers" in Ukraine. This category can include both household and non-household owners of generation plants: these are households and municipal institutions (schools, hospitals, etc.), as well as businesses. The main condition is that consumers must not just be buyers of electricity, but most importantly they have to generate it too.

The new law does not cancel the "green" tariff. It will be valid until 2030, as provided for by the legislation. Net billing will operate in parallel. The cardinal difference between the two is simple: the "green" tariff cannot exist without subsidies from the budget. The state covers the difference between the real cost of producing electricity from renewable energy sources and the price at which it is sold. The right to use the "green" tariff will now be available to new owners of generation plants only under certain conditions. The main one is to use part of the generated electricity for their own needs. And the surplus, accordingly, is possible to sell to the network. State policy is reasonable that all entities must follow the path of self-provision of energy.

All the new adopted legislation is aimed at restoring and greening the energy system of Ukraine.

2. Financial Mechanisms. Decarbonization and Energy Efficient Transformation Fund of Ukraine (State Agency for Energy Saving and Energy Efficiency of Ukraine, 2024) was created in 2024 in order to promote Ukraine's transition to a low-carbon economy, reducing dependence on fossil fuels, increasing energy security, and improving the environmental situation during the war and in post-war recovery.

Its main sources of financing are:

– environmental tax on carbon dioxide emissions from stationary installations;
– state borrowings aimed at supporting energy efficiency and reducing carbon dioxide emissions.

The Fund provides preferential loans in Ukrainian hryvnia with the rate of 9% per annum from 1 to 10 years. For a national manufacturer to implement the President's Program "Made in Ukraine" the rate is 7%. The loan amount is from 120 thousand to 25 million UAH. The loan can be provided to:

– local governments (schools, hospitals, kindergartens);
– municipal enterprises (primarily heat and power and water utilities);
– industrial enterprises;
– small and medium-sized businesses.

The first loan was issued in 2024, when the project was financed (UAH 18 million) for the street lighting network in Voznesensk, Mykolaiv region. The results will be savings for local budgets, reduced heat and electricity consumption and reduced carbon dioxide emissions.

European Union launched Ukraine investment framework in 2024 as well. Developing sustainable energy solutions, including renewable energy projects and modernization of existing energy infrastructure are among the priority areas of the Strategic orientations of the Ukraine Investment Framework, which outline key economic priority sectors requiring Foreign direct investment to support Ukraine's socio-economic recovery.

3. Market Instruments Modernization. The day-ahead market for energy producers from RES is the segment of the energy market that allows participants to buy and sell electricity the day before it is actually consumed. For producers and traders, this is an opportunity to effectively plan operations, reduce costs, and ensure stability in supply. The main feature of the market is transparent pricing, as the price is determined by demand. In the day-ahead market, the price is formed according to the principle of marginal

pricing, which means that the final price is set at the level of the offer of the participant with the highest price among those whose volumes are necessary to meet demand.

Intraday electricity market is a segment of the electricity market in which the purchase and sale of electricity is carried out continuously after the end of trading on the day-ahead market and during the day of physical supply of electricity. It allows market participants to adjust their electricity production and consumption plans in real time, in particular, taking into account fluctuations in renewable energy production, which depends on weather conditions. Renewable energy producers, in particular solar and wind power plants, are active participants of the Intraday electricity market, as they need to balance their production with actual electricity demand.

Temporarily, for the period of martial law in Ukraine, the National Commission for State Regulation in the Energy and Utilities Sectors allows temporary connection of RES which is accelerated and simplified to ensure energy security and the possibility of restoring damaged facilities.

Ukraine has begun the process of issuing licenses for energy storage activities in 2023. This is a landmark event, as energy storage is very important and beneficial for the energy system during the war. The operation of electrical energy storage facilities or energy accumulation systems significantly contributes to balancing the operation of the energy system and increasing the stability of electricity supply for consumers.

4. Distributed Generation as Protection Against Military Risks. Ukraine is developing distributed generation – thousands of solar panels on roofs of private houses, small solar power plants and storage batteries on social facilities (schools, hospitals).

Regional authorities are adopting local programs for preferential loans, tax/customs benefits for installing solar panels and batteries in households and hospitals. Solar energy makes it possible to build new generation capacities as soon as possible. Now communities and municipalities in all regions of Ukraine are trying to implement solar power plant projects or to find investments for them. When the centralized network does not work, then in communities where there are solar plants, electricity is autonomous. In addition, the use of solar collectors for water heating will be more cost-effective especially in summer. Green energy is a new energy reality in a country in war.

Big energy companies like DTEK continue working on projects of large-scale wind farms on the left bank of Dnipro river even close to the hostilities regions. Company "ECO-Optima" is building new large-scale solar and wind power plants in the west of Ukraine.

During the full-scale war Ukrainian energy system has already withstood hundreds of missile and drone strikes and experienced the first blackout in its history, when all the country's nuclear reactors stopped. In general, about 50% of the country's energy infrastructure has been damaged or destroyed. Renewable energy is no exception, because its share in the production structure before the full-scale war was over 13%. Capacities of RES were increasing rapidly, especially solar energy. Moreover, in 2019, Ukraine was in the top ten countries in terms of the pace of development of "green" energy. In 2020, it was in the top five countries in Europe in terms of development of solar energy.

At the beginning of 2022, the total capacity of renewable energy facilities in Ukraine reached 9,656 MW (the National Renewable Energy Action Plan, 2024). But already in the fall 2022, almost 90% of wind power plants and about half of the solar ones were forcibly decommissioned due to their location in or close to hostility regions. As a result, the share of renewable sources in the energy balance fell more than twice. According to the assessment of the Ministry of Energy of Ukraine, by the end of October 2022, 45-50% of solar power plants had to be decommissioned.

Therefore, we believe that part of the recorded drop in 2024 reflects not only new losses, but also an adjustment of statistics in accordance with the actual availability of generating capacity in the conditions of war over the past two years.

5. Conclusions

Renewable energy in Ukraine has been actively developing since the end of 2008 with the adoption of a "green" tariff at the legislative level, which made financially attractive investments in industrial grid solar and wind power plants.

The full-scale invasion of Ukraine by Russia in 2022 has catalyzed a heightened awareness of ecological issues and has accelerated the transition from fossil fuels towards renewable energy sources as building a distributed generation network.

Ukraine is the only country in the world that is going through the procedure of euro integration while fighting for its existence in the full-scale war with russsian federation. It means the double loading on the policy makers, budget, authorities on all levels and society at whole.

The Ukrainian authorities during the war combine different mechanisms in order to support energy transition to renewable energy. Ukraine has adopted energy transition planning until 2050 with ambitious RES development goals.

First of all, Ukraine is adapting legislation to European Union norms (green certificates, FiP, auctions, net-billing). Secondly, there is a financial support for early-stage projects of renewable energy through state and EU funds. Decentralization of generation, technical advances in connection, licensing, new technologies

(biomethane, storage) help to achieve energy sustainability.

This multi-vector policy ensures energy security and recovery even under attacks. We concluded that the best option of rebuilding Ukrainian energy infrastructure is "green" rebuilding with a shift to renewable energy.

Prospects for further research development. Our future research will continue in investigating the regional differences in renewable energy development trends in Ukraine during the war and effective combination of issues of sustainable development and economics with high tech solutions in post war "green" recovery planning in different regions of Ukraine.

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