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Green Energy in Ukraine: State, Public Demands, and Trends

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Abstract: The main purpose of this paper is to analyze and address the challenges of implementing green energy in Ukraine, in particular, to identify its advantages and disadvantages. The implementation of solar renewable sources—stations, panels, and batteries—is emphasized. The results of sociological surveys of Ukrainian public opinion on environmental issues, in particular, energy issues, are presented. The existence of public demand for renewable energy and the readiness of the population to use renewable energy sources are identified. A strategy for strengthening the country's energy independence in the face of new globalization challenges is defined. General scientific methods as well as special methods were used in this paper: statistical analysis, secondary analysis of data from sociological studies of public institutions, and desk analysis of documents and reports from public services. In this paper, it is concluded that Ukraine is geographically and territorially attractive for green energy development and investment. It is important that there is a public and state demand in the country to strengthen the country's energy security, in particular, through the introduction of renewable energy sources. Therefore, despite drawbacks and obstacles, green energy in Ukraine has great prospects.

Keywords: renewable energy sources; green energy; environmental safety; environmental independence; environmental awareness; environmental problems

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1. Introduction

One of the most pressing contemporary challenges is the preservation of energy resources and the search for and use of alternative energy sources. This problem is especially urgent for Ukraine, since it has energy-intensive production, which requires significant expenditures of natural energy sources. However, a number of changes have taken place in recent years. Firstly, the volume of natural energy sources has significantly decreased due to the military conflict in the east of Ukraine (including 2013), where most of the coal needed to meet the needs of the country was mined. Secondly, amendments have been made to the legislation of Ukraine, which bring its integration into the European Union. Thirdly, Ukraine has joined the implementation of the global doctrine of sustainable development. After all, we are talking not only and not so much about changing the energy supply of industrial production with alternative types of energy and fuel, but first of all, about preserving natural resources and the health of people, in particular, the younger generation. As Ukrainian expert D. Yermolayev points out, the global COVID-19 pandemic in 2020 has accelerated the processes of historic change in the global energy sector, which has long accumulated its internal potential for full systemic implementation. "The energy sector has been waiting for a long time for an unambiguous signal that can show long-term guarantees of a new "green" market and an ideologically unquestioning demand for new technologies and new qualities of capital Organization for the future fundamental restructuring of this industry; the demand for development through transformation is both a priority energy recovery method (including infrastructure for its implementation), and business models for capital behavior, directions and areas of its redistribution" [1].

That is, we are talking about the need for radical changes in the energy market, because the level of oil consumption exceeds reasonable limits, leading to environmental pollution, greenhouse effect and, of course, air deterioration.

Consequently, the world is moving towards "green energy" as an alternative form of traditional fuel resource [2–13]. New methods of energy management and implementation of technological innovations are being developed, as well as shaping ecological awareness through green marketing [14–20]. According to S. Singer, one of the founders of the idea of 100% global renewable energy, now chief energy policy advisor to the Climate Action Network (CAN) secretariat, some significant changes in policy, support schemes, financial incentives, education, skills, and training of workers are needed now in order to introduce renewable energy as quickly as possible [21].

An analysis of the introduction of renewable sources in Ukraine shows that it ranks last in this indicator in comparison with European countries, whose common energy space it seeks to join (Table 1).

Table 1. The share of renewable energy sources in electricity production in the Ukraine and in the EU countries 2000–2020 [22].

Countries/Year	2000	2005	2010	2015	2020
Ukraine	6.7%	6.7%	7.1%	5.3%	8.4%
EU countries					
France	13.7%	10.6%	14.6%	16.7%	24.3%
Germany	6.9%	11.3%	17.6%	30.0%	44.5%
Spain	16.9%	15.9%	33.5%	35.7%	43.9%
Italy	20.8%	18.2%	26.6%	39.0%	42.0%
Belgium	2.7%	3.9%	8.2%	22.4%	27.2%
United Kingdom	3.4%	5.0%	7.7%	25.6%	43.7%
Poland	3.0%	3.5%	7.3%	14.1%	16.7%
Romania	28.5%	34.0%	33.9%	40.1%	44.2%
Czech Republic	3.9%	4.6%	7.6%	12.8%	14.3%
Sweden	57.3%	51.3%	55.3%	64.3%	68.4%

The top three countries in implementing renewable energy sources among European countries are Sweden, Germany, and Romania. In 2020, Ukraine had an extremely low (2–6 times lower) compared to EU countries level of introduction of renewable energy sources (Table 1). According to the State Agency for Energy Efficiency, in 2019, the energy capacity of Ukraine's GDP was one of the highest in the world, 2.7 times higher than in Poland and 3.3 times higher than in German, which, in recent years, has topped the ratings of the introduction of renewable energy sources [23]. Total primary energy consumption in Ukraine in 2019 is 93.5 million toe (Figure 1).

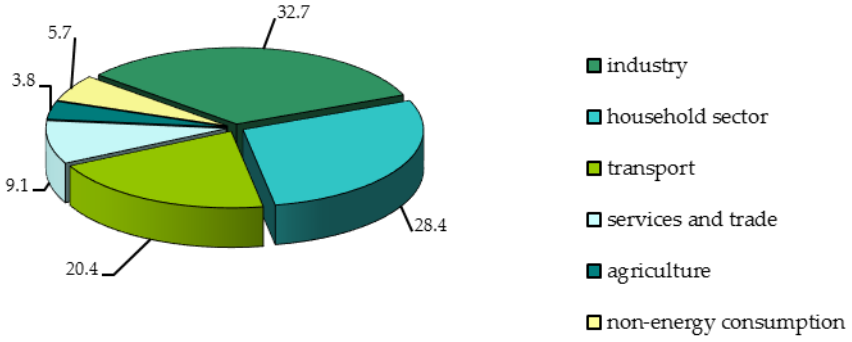

Figure 1. The structure of final energy consumption in 2019 in Ukraine, % of total energy consumption [24].

According to the German Federal Statistical Office, in the first quarter of 2020, renewable energy accounted for 51.2% of all electricity produced in Germany—the first time this has ever happened overall, the market share of green energy increased by 14.9% compared to the first quarter of 2019. Nuclear power is also showing a downward trend as a result of Germany's plans to abandon nuclear power plants by 2022 [23].

In the EU countries in 2020, the share of wind and solar power increased substantially against a background of increased electricity generation from renewable sources, while electricity generation from thermal sources, especially from coal combustion, and from nuclear power plants declined. Offshore wind power generation has increased in the UK, Germany, and Belgium. Wind and solar power are actively developed in EU countries, but their share in the overall energy balance remains low. In Ukraine, the share of wind and solar energy compared to 2015 has increased three times, while it is almost four times lower than, for example, in Poland, and five times lower than in Romania (Table 2).

Table 2. The share of wind and solar energy sources in electricity production in the EU countries and in the Ukraine 2000–2020 [22].

Countries/Year	2000	2005	2010	2015	2020
Ukraine	-	-	-	1.0%	3.1%
EU countries					
t France	0.1%	0.3%	2.0%	5.3%	10.3%
Germany	1.6%	5.1%	8.3%	18.7%	32.1%
Spain.	2.1%	8.9%	17.1%	22.6%	29.1%
Italy	2.2%	2.9%	5.7%	15.7%	18.3%
Belgium	-	0.3%	1.9%	12.4%	20.0%
United Kingdom	0.3%	0.7%	2.7%	14.1%	28.3%
Poland	-	0.2%	1.1%	6.6%	11.2%
Romania	-	-	0.5%	13.6%	15.5%
Czech Republic	-	-	1.2%	3.5%	3.7%
Sweden	-	-	-	-	-

In Poland, where the energy sector is predominantly based on coal combustion, a clean coal technology sector is indeed developing. Green energy is also supported by national legislation—according to the Polish energy policy, until 2030, the share of renewables in final energy consumption should rise to at least 15%.

The positive trend is that Ukraine has actively embraced renewable energy, as it has large natural locations that make the best use of it. In December 2003, the Institute of Renewable Energy was established at the National Academy of Sciences of Ukraine with the aim of further developing and coordinating research in the field of renewable energy. It includes six scientific departments, the Intersectoral Scientific and Technical Center for Energy Saving and Renewable Energy, as well as a branch of the Department of Renewable Energy of the National Technical University of Ukraine "Kiev Polytechnic Institute" [25]. According to SAEE, between 2014 and 2020, the capacity of solar energy facilities increased almost 14-fold and wind energy facilities 3-fold (Table 3). Renewable energy is being actively promoted in the electricity sector (Table 4).

Table 3. Installed capacity of renewable energy facilities in Ukraine 2014–2020 [24].

Installed Capacity of the Facility, MW/Year	2014	2015	2016	2017	2018	2019	2020
Solar power plants	411	432	531	742	1388	4925	6094
Solar power plants for households	0	2	17	51	157	553	779
Wind power plants	426	426	438	465	533	1170	1314
Small hydro power plants	80	87	90	95	99	114	117
Biomass	35	35	39	39	51	95	109
Biogas	15	17	20	34	46	86	103
Total	967	999	1135	1426	2274	6943	8516
Increase over previous years	-	32	136	291	848	4669	1574

Table 4. Actual values of renewable energy facilities in Ukraine 2014–2020 [24].

Percentage of Renewable Energy Sources in Some Industries/Year	2014	2015	2016	2017	2018	2019	2020
Electricity	7.4%	7.9%	7.9%	8.6%	8.9%	10.9%	13.5%
Heating and cooling systems	3.5%	4.7%	6.3%	7.7%	8.0%	9.0%	-
Transport sector	2.0%	2.1%	2.1%	2.4%	2.2%	3.1%	-

In 2015, Ukrainian scientists were convinced that "Ukraine has sufficient potential for renewable energy sources, the effective use of which until 2035 will provide 50% of the total consumption of energy resources from renewable energy sources" [25].

Meanwhile, 6 years after Ukrainian scientists identified the prospects for the development of renewable energy, target indicators in this area have not been reached. In addition, the joint requests of Ukrainians for the use of renewable energy sources remain poorly studied.

During the period 2014–2020, the real indicators of the share of the use of renewable energy sources almost correspond to the planned indicators (Figure 2). The number of solar installations in households increased almost 1500 times, and the total investment in this area amounted to EUR 600 million (Figure 3).

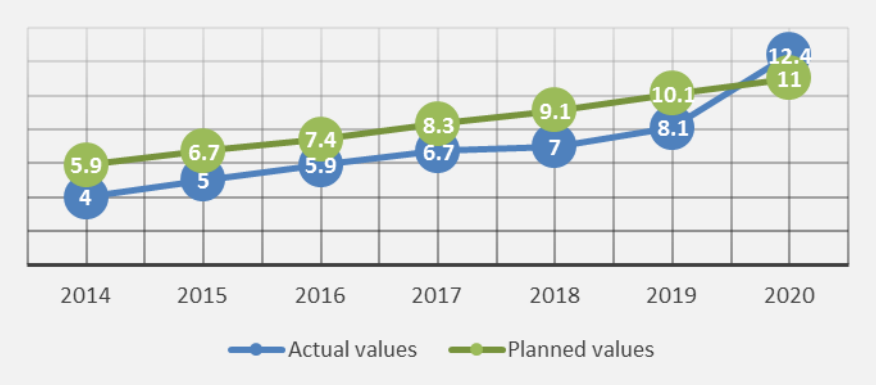

Figure 2. The actual and planned indicators of the share of renewable energy sources in Ukraine in 2014–2020, % of total energy consumption [24].

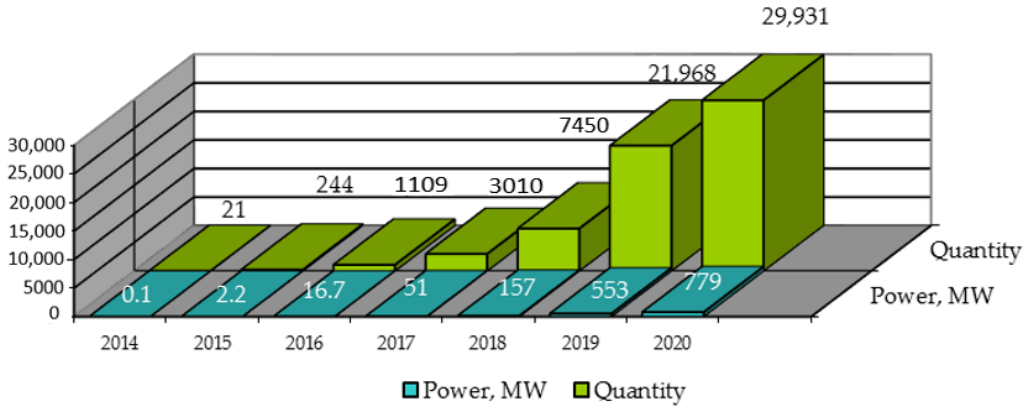

Figure 3. Dynamics of increate in the number and power of solar electrical installations in households in Ukraine 2014–2020 [24].

Ukraine produced more than 9.5 billion kWh in the first 10 months of 2020, according to Reform Energy with reference to the Ministry of energy. This is 110% more than last year—in 2019, 4.5 billion kWh were generated over the same period. Meanwhile, renewable energy accounts for only 8% of Ukraine's total energy sector, but in 2019, it was half that, namely 3.6% [26].

However, as experts point out, for the Ukrainian renewable energy sector, 2020 can be called a year of survival and struggle amid total non-payment for supplied green electricity and quarantine due to the COVID-19 pandemic. This year can still be marked by the stalling of investment in Ukraine and the loss of confidence of international and domestic investors [27].

Therefore, this paper aims to explore the status and challenges of green energy deployment in Ukraine, identifying the public demand for renewable energy and the trends that dominate government strategic plans and programs and the demands of the population and consumers.

To achieve this goal, it is necessary, firstly, to analyze the state and features of the development of "green" energy in Ukraine and to clarify the political, economic, technological, environmental, and legal aspects of this process; secondly, to analyze the state and problems of solar energy in Ukraine; thirdly, on the basis of empirical research to identify and present public requests for the introduction of "green energy" in Ukraine; fourthly, to identify the reasons for the retardation of the process of the introduction of renewable energy sources in Ukraine from European countries; and fifthly, to outline the main trends in the introduction of "green energy" in Ukraine. This research is important not only for the Ukrainian scientific community, political establishment, and entrepreneurs in terms of optimizing approaches to the development of renewable energy sources, but also for European Union countries cooperating with Ukraine in the energy sector, including European energy companies and businessmen, who invest or plan to invest their finances in the Ukrainian energy system, in particular, in renewable energy sources.

2. Materials and Methods

The design of the research on the state of "green energy" in Ukraine was based on the application of a mixed methodology, i.e., a combination of general scientific and special, quantitative, and qualitative methods, the choice of which was determined by the goals and objectives of this research.

In this paper, the authors used general scientific methods. In particular, the authors used traditional and critical analysis, synthesis, induction, deduction, the comparative historical method, the method of statistical analysis, desk analysis of documents, and reports of public services for analytical understanding of the state and features of the implementation of "green energy" in Ukraine. To identify the problems existing in the implementation of "green energy", as well as the reasons that hinder its development, was

used method of critical analysis and analysis of opinions of leading Ukrainian experts in the energy industry. To study public requests for the introduction of "green energy", the method of analysis of secondary data was used—the results of sociological research conducted in Ukraine by leading scientific sociological centers that study environmental problems. The use of forecasting and scenario planning methods made it possible to determine the main trends in the implementation of "green energy" in Ukraine.

3. Results

3.1. Features of Green Energy Development in Ukraine

As it is known, renewable "green" energy is electricity obtained not from fossil fuels, but from renewable energy sources. It is divided into solar, wind, bioenergy, hydropower, geothermal, and environmental energy. Solar energy among all sources is the most profitable and promising for use, because the energy of the sun is inexhaustible for the next 6 billion years, and its extraction is free.

The development of green energy in Ukraine began in the early 2000s for political rather than economic reasons. It is pertinent to recall that, as of 2008, there were a rather small number of solar power plants in Ukraine, 90% of which were owned by A. Klyuyev, MP and member of the Party of Regions, who served as the Head of former President Viktor Yanukovych's Administration. A. Klyuyev was one of the most active initiators of the introduction of a feed-in tariff for electricity from renewable sources in Ukraine. In addition, A. Klyuyev made efforts to become a monopolist and be the only recipient of the feed-in tariff in Ukraine. To this end, a requirement was approved at his initiative that allowed electricity to be sold at a feed-in tariff only to power plants comprising Ukrainian components, and the only plant «Kremniypolymer», which produced Ukrainian cells for solar panels, was also owned by A. Klyuyev. Thus, at the initiative of influential Ukrainian politicians, the highest Feed-in-Tariff Europe were introduced in Ukraine, and with restrictions that allowed for monopolisation of this market segment. Due to this situation, the green energy sector in Ukraine developed slowly for quite a long time, and only privileged politicians or businessmen close to the government enjoyed the benefits of the feed-in tariff [28].

In 2014, the National Action Plan on renewable energy for the period up to 2020 was adopted. It laid down a clear annual plan for the development of renewable energy facilities [29].

In 2017, the Energy Strategy of Ukraine was adopted, according to which Ukraine plans to increase the share of renewable energy in its energy balance to 25% by 2035. In 2018, Ukraine became a full member of the International Renewable Energy Agency (IRENA), and therefore, there is access to the knowledge base on the development of renewable energy, the best world experience in the implementation of renewable energy sources. Additionally, Ukraine had the opportunity to participate in specialized studies conducted by IRENA, aimed at finding effective ways to reduce the dependence of the countries of the world on fossil energy sources. As of the end of 2020, Ukraine has about 8% green generation in its overall balance sheet. However, the national action plan calls for this figure to reach 11%. About 26% is spent on RES. The sole buyer of green energy, the state-owned "Guaranteed Buyer" enterprise as of April 2020, has a debt to producers of renewable energy exceeding 7 billion UAH (about EUR 233 million). According to analysts, at the beginning of July 2020, the debt of this state-owned enterprise for green energy amounted to about 16 billion UAH (about EUR 533 million). Experts see the main reasons for such a large debt: a significant excess of the "green" tariff (Feed-In-Tariff) over the prices of the "day ahead" market by more than 2.5 times and the absence of adequate compensators for such a difference; a huge number of preliminary contracts for the sale and purchase of electricity, which could be implemented at still quite high Feed-In-Tariff (approximately 11 eurocents/kWh for the sun and 9 eurocents/kWh for wind); a delaying the transition to "green" auctions; a lack of responsibility of producers from renewable energy sources for imbalances [30].

3.2. Solar Electricity as a Modern Trend in Ukraine: Advantages and Challenges of Development

The energy crisis that Ukraine has been experiencing since 2014 in the context of the military conflict in the east, the annexation of the Crimea by the Russian Federation, forced the authorities and the population to look for a way out of this situation through the development of "green energy", in particular, solar electricity.

This is how large solar power plants appeared in the steppes, in private homes, and many wind farms on the coast of the Azov and Black Seas. This led to a "green boom" in the energy sector of the country.

Despite the existing positive shifts in the development of solar energy, Ukraine today is still at the stage typical of Europe in the early 2010s. At the same time, Ukraine has an investment structure for the development of this industry, which is much more attractive than in Europe. After all, in recent years, a number of favorable conditions have been created: allocation of resources and land plots, establishment of preferential tariffs, and development of state support programs and targeted energy strategies, which envisage reaching 25% of net energy production of the total energy production by the country by 2035. As a result, interest in the development of renewable energy technologies in Ukraine continues to grow, and according to the government, within the coming years, the total investment in "green" energy could amount to more than USD 18 billion [31].

In spite of the fact that, in Ukraine, since 2009, there was a "green" tariff (feed-in-tariff) for schemes to support renewable energy sources, the intensification of the development of solar energy took place only in 2018–2019. Thus, in 2018, the indicators of the overall solar photovoltaic capacity reached 1545 MW. The maximum positive shifts were recorded in 2019, when the installed capacity increased by 3.5 times compared to 2018. In 2020, the solar energy sector in Ukraine produced 1169 MW of commercial solar photovoltaic capacity and 226 MW in the private sector. As of 1 January 2021, Ukraine produced about 6873 MW of solar energy, with 11% being produced by private home photovoltaic plants up to 30 kW (NPPs).

The main prerequisite for the development of solar energy in Ukraine was the introduction of a scheme to support a "green" tariff (feed-in-tariff), which applied to all solar, wind, and biogeneration plants. "Green" tariffs in Ukraine are protected by the laws "On the Electricity Market" and "On Alternative Energy Sources" and guarantee the payback of new solar systems in 5.5–7 years after launching. The introduction of this tariff has contributed to the development of solar energy and significantly reduced equipment costs over the past two or three years [32].

The main factors contributing to the development of solar energy in Ukraine are the following:

(1) Ukraine has an extremely advantageous geographical location and a favorable climate for the active introduction of solar power plants. In particular, the level of insolation (the amount of solar radiation per square meter of the Earth's surface) in most regions of Ukraine is significantly higher than in Germany, which is a world leader in the implementation of solar energy. High levels of insolation make the territory of Ukraine attractive for the development of clean energy technologies, and the feed-in tariff makes it profitable. The most attractive regions for installing solar plants are Zaporizhzhya, Odessa, Mykolaiv, Kherson, and Dnipropetrovsk regions due the highest solar activity there. However, not only in the South of Ukraine, but also in the North and East, there is a significant potential for the installation of solar power plants.

(2) An appropriate regulatory framework has been created in Ukraine, which attracts investors who are ready to develop "green" energy. The "green" tariff in Ukraine is one of the highest in Europe. In 2019, the law on green auctions was ratified. According to this law, since 2020, participation in the auctions will be mandatory for solar (capacity over 1 MW) and wind (capacity over 5 MW) projects. Under the terms of the auction, the lowest bidder will be able to sell "net" electricity to the state. The introduction of such auctions will prevent the development of monopolies

in the market of renewable energy sources in Ukraine. It is a transparent selection of suppliers of "green" energy, which is carried out through the electronic trading system ProZorro twice a year, in autumn and spring. The introduction of auctions will also help reduce green energy tariffs due to increasing competition in the market for renewable energy sources and eliminating the monopoly.

(3) Facilitating the inflow of investments into the alternative energy sector of Ukraine is an extremely favorable circumstance, given the available resource and human capital needed for the development and implementation of innovative commercial technologies in this sector.

(4) The constant increase in the cost of electricity fully justifies the investment in the development of renewable electricity. Speaking about the cost price, we can already talk about the price parity between the alternative and traditional electricity [31].

Meanwhile, the new industry has not only positive phenomena, but also certain challenges have been faced by investors in Ukraine.

Firstly, investor distrust of government actions in the green energy sector, large debts for purchased electricity, existing international litigation to reduce the "green" tariff, and the possibility of introducing an additional excise tax on renewable energy sources at the end of 2021.

Secondly, the impact of the pandemic on the Ukrainian economy and extremely high lending rates for private photovoltaics significantly hinder investment processes, particularly in the field of renewable energy sources.

Thirdly, due to the uncertainty over auctions, the flow of investment for the purchase and installation of new photovoltaic plants decreased significantly in 2020 compared to 2019. For this reason, the problem of job losses appeared in the solar energy sector—more than 5000 workers lost their jobs.

Fourthly, tough quarantine sanctions complicated the situation, as foreign investors were restricted in their freedom of movement and were not able to settle a number of issues related to the development of their business in Ukraine following the introduction of new legal norms [32].

Fifthly, the state did not pay the "feed-in" tariff to electricity producers in full. As of the end of 2020, 47.7% of project participants received payments [33].

This led to a decrease in the popularity of the tariff itself and the freezing or cancellation of a number of "green" projects [34].

After the launch of the green auction support scheme, the next phase of industrial solar power growth is expected, but not before 2022–2025. Further development of BESS (battery energy storage system) is also necessary to achieve the ambitious goal of 25% renewable energy by 2035 and to further develop renewable energy sources. The relevant law to address this issue has still been pended in the Energy Committee of the Ukrainian Parliament from 2019.

The development of all new renewable energy sources in Ukraine is expected to slow down in the coming years unless the government improves the framework conditions for new investments in the photovoltaic industry sector. Considering global trends, it is necessary to be more ambitious when it comes to the development of solar energy. Active political support for the implementation of better management solutions and tools will allow solar energy to reach its full potential [32].

3.3. Public Demand for Green Energy Implementation in Ukraine: Empirical Analysis

Of course, the introduction of renewable energy should be a vital necessity for both businesses and the population. As I. Honcharuk rightly notes, energy is the "resource key" to the formation of an additional product, social well-being, etc. [35]. Therefore, environmental protection and the introduction of green energy must become a priority, not only in the activities of state authorities and business structures, but also in the everyday life of the population as a whole. Therefore, various social institutions and public foundations in Ukraine are actively studying public opinion and public demands for strengthening envi-

ronmental conservation measures and introducing renewable energy sources, in particular, solar power plants, panels, and batteries.

For example, a study conducted by the sociological agency «Fama» in cooperation with the Society and Environment Resource and Analysis Centre showed that, overall, 86.6% of citizens, regardless of their region of residence, are genuinely concerned about the rate of environmental pollution and believe that they can personally play a role in protecting the environment [34].

The most important environmental problems that concern Ukrainians are the following (Table 5).

Table 5. The most important environmental issues chosen by the respondents, % of the total number of respondents, multiple choice [34].

Answers to Questions	Ukraine	West	North	East	South	Centre
Population reduction or extinction of species, extinction of ecosystems, forests, and fertile soils	34.8	49.2	23.9	23.5	38.2	39.3
Lack of drinking water	30.0	25.2	17.0	29.6	46.9	30.4
Frequent droughts or floods	40.3	37.0	30.1	44.6	46.6	42.9
Pollution of rivers, lakes and of soil water	30.2	37.5	33.7	28.4	15.9	35.8
Pollution of the seas	24.0	13.5	21.8	24.3	39.5	20.1
Air pollution	35.8	41.4	31.1	29.3	33.8	42.8
Sound pollution	17.8	21.8	13.5	20.6	16.0	17.9
Climate changes	16.3	19.6	14.6	18.3	15.1	14.4
Waste amount growth	37.4	52.2	40.6	32.6	24.8	38.1
Agricultural pollution due to use of pesticides, fertilizers and soil degradation	30.4	24.0	22.9	35.5	36.3	33.1
Other	1.4	3.2	2.5	1.4	0.2	0
None of the above	0.4	0.3	0.4	1.2	0.2	0
It's hard to answer	1.3	0.8	2.6	1.5	0.3	1.3

The survey results show that the majority of residents surveyed are seriously concerned about the state of the environment, especially soil, water area, air pollution, droughts, and heavy rains. It is no coincidence that Ukrainians are beginning to implement economical environmental practices. The priority ones are the following: reduced energy consumption—43.5% of respondents; sorting most of the garbage for recycling—36%; use of environmentally friendly transport—29%; refusal to buy single-use plastic products—29%; reducing domestic water consumption—23% [34].

Energy conservation as a priority environmental practice, prevalent in the everyday life of almost half of the Ukrainians surveyed, indicates their awareness of the need to conserve energy sources and the need to find new alternatives to existing ones. According to sociological research conducted in August 2021 by specialists of the Friedrich Ebert Foundation, the following was revealed: 55.2% of respondents consider alternative energy to be the most promising for Ukraine; 25.7%—nuclear power; 24.9%—hydropower; 11.0%—thermal energy; 19.7% of respondents had difficulty in answering this question.

The majority of respondents (60.5%) support the idea of increasing tariffs for the sake of switching Ukraine to green energy sources; a quarter of those surveyed (26.2%) do not support such a transition, while 13.3% chose the answer "Difficult to answer". Most of the supporters of the country's gradual transition to green energy sources, even if utility tariffs increase, live in the central part of Ukraine (73.2%). Most of those who do not support such a transition are residents of the South (35.4%) [36].

Fuel issues are present today not only in Ukraine, but also in Europe, in economic and political terms, as the needs of both businesses and the population are constantly growing, despite the strong promotion of the sustainable development doctrine and the proposals to reduce energy-intensive industries. The debate on whether to close thermal and nuclear

plants has been going on for years, but it is not realistic under current conditions, as closing them altogether would deepen economic problems considerably.

Meanwhile, Ukrainian public opinion shows that almost a third of the respondents (38.5%) think that coal-fired thermal power plants should be closed down ("definitely yes"—11.4%, "rather yes"—27.1%), while 43.1% are against it ("definitely no"—15.7%, "rather no"—27.4%). Every fifth respondent (18.4%) could not determine their opinion on this issue. Additionally, 44.0% of citizens oppose the closure of all nuclear power plants in Ukraine; 40.1% of respondents support this idea. Every sixth respondent (15.9%) could not give an answer to this question. Turning to the focus group discussions, those Ukrainians who believe nuclear power should be used and developed in the country give the following arguments: it is the cheapest and gives more power, and it is also more environmentally friendly [36].

4. Discussion

Of course, the public enquiries that appear in the diagnosis of public opinion in a democratic society are an indicator of public consciousness and public dispositions regarding behavioral practices in various fields of activity, including the environment. Therefore, the orientation of public opinion in Ukraine towards an understanding of the importance and no alternative to the transition to renewable energy sources, in particular, solar energy as the most efficient one, indicates a positive change in environmental awareness and environmental behavior among Ukrainians.

However, the energy independence and energy security of the country is a very important component to be considered in this aspect, as the desire for change must be guided, firstly, by the availability of human, natural, labor, and financial resources, and secondly, by ensuring the economic development of the state without losing its energy independence and security. According to G. Lopanchuk, the energy independence of a country is "the ability of the state, represented by its governing bodies, to provide end-users with energy resources in the required volumes and of appropriate quality" and is measured by "the level of independence of the country's leadership in formulating and implementing policies, independent of external and internal influences and pressure", while the level of energy security is determined by "the potential of the national fuel and energy complex" [37].

A broader definition of energy independence is provided by I. Honcharuk, defining it as "an organizational, economic and resource-based aggregate energy potential formed from its own sources to meet the energy needs of the state, industry based on the principles of sustainable development, environmental friendliness and innovation" [35].

A. Shydlovsky and M. Kovalko present a generalized definition of energy independence, considering it one of the most important components of the economic security of the country. On the one hand, it can be viewed as a basis for providing the country with fuel and energy reserves for its full-fledged life, and on the other hand, as a prerequisite for the proper functioning of the entire energy complex of the country [38].

A logical question arises: does Ukraine have energy independence, because only its existence can contribute to an effective transition to green energy? Studies by experts show that the problem of providing the Ukrainian economy and social sphere with energy resources of sufficient quantity and quality is one of the most important issues for the state. Since independence, this problem has dominated every government and Ukrainian politics in general and goes far beyond the economic levers of solution. The situation is affected by three significant aspects: critical dependence on energy imports, the presence of excessive transit capacity, and the energy intensity of gross domestic product (hereinafter referred to as GDP) [39]. Ukraine's dependence on the import of primary energy resources today is approximately 61%. The structure of primary energy consumption is dominated by natural gas—approximately 40%. The share of oil consumption is 20%, coal—20%, nuclear fuel—almost 15%, and the share of renewable sources remains 4–5% as of thermal energy.

It was stressed that state control of nuclear power plants in Ukraine needs to be significantly strengthened.

The share of oil consumption is 20%, coal—20%, nuclear fuel—almost 15%, and the share of renewable sources remains 4–5% [40]. High gas consumption (on average, twice as high as in the European Union (EU)) also poses the most serious problems for Ukraine's energy independence. The gas issue has long gone from the economic plane to the political one. The use of primary energy per unit value of GDP in Ukraine in general is disastrous: about 0.6 kg of fuel equivalent per 1 UAH of GDP. This exceeds the global average by 2.6 times and the European average by 3.3 times. According to A. Ilyenko, the main reason for the high GDP energy intensity is a significant technological lag in both energy production and transit, as well as in use. Currently, none of the sectors of the national economy meets international energy saving standards [39].

Another important threat to Ukraine's energy independence in the current environment is the construction of Nord Stream 2 by Gazprom of the Russian Federation, which has provoked strong reactions around the world. However, experts differ on the threats it poses to Ukraine's energy independence. For example, European Parliament member A. Kubilius stressed that the Russian Nord Stream 2 pipeline is not economically viable and carries risks both for the EU and Ukraine, as well as for Germany itself. "First of all, this project brings with it many geopolitical dangers for Ukraine, starting with the loss of financial revenues, which are significant for the still rather vulnerable Ukrainian economy. Secondly, if Ukraine's gas infrastructure is not needed to transport gas to Europe after Nord Stream 2 is launched, Russia could act even more aggressively against Ukraine than in 2014, during the occupation of territories in eastern Ukraine" [41].

H. Ryabtsev, a member of the expert council at the Ministry of Energy of Ukraine, does not see any particular risks in the construction of Nord Stream-2, noting that "Ukraine has a contract on gas transit until 2024, according to which 40 bn cu. m. should be pumped through the territory of Ukraine this year and next year. Gas is supplied to Europe under long-term contracts, meaning that it has already been paid for until 2024. Therefore, today, there are no risks for Ukraine. They may arise from 2025, when new contracts will be signed, and Gazprom will say that it does not need 40 billion cubic meters but only 20 billion" [42]. One can hardly agree with this point of view, as the postponement of risks does not mean their absence. Therefore, this problem exists, and it is this that actualizes the emergence of new balanced political decisions, legislative initiatives and real state programs for the development of the renewable energy sector in order to strengthen the energy independence of Ukraine.

5. Conclusions

The globalization challenges of climate change, the depletion of natural resources, and environmental pollution are forcing all countries in the world, including Ukraine, whose production is too energy-intensive, to seek out new renewable energy sources and to increase "green energy". As Ukraine is territorially located on the European continent, the state of pollution of its environment with traditional energy sources significantly affects the ecological state of European countries, especially those bordering it in the west: Poland, Hungary, Slovakia, and Romania. It is worth mentioning the devastating consequences of the Chernobyl disaster (1986), not only for Ukraine and Belarus, but also for European countries. Therefore, analytical understanding of the state and problems of the introduction of renewable energy sources in Ukraine as an alternative to thermal and nuclear power plants, identifying the causes of inhibition of these processes is of particular importance for energy and environmental security of Ukraine and the European Union. Important steps in this direction have already been taken: in 2014, the National Action Plan on renewable energy for the period up to 2020 was adopted; and in 2017, the "Energy Strategy of Ukraine", according to which, by 2035, Ukraine plans have to increased the share of renewable energy in its energy balance to 25%. However, according to experts, national strategic plans are not being fully implemented. Thus, as of the end of 2020, only about

8% of green energy in the total balance in Ukraine does not contribute to the strengthening of the energy security of the country and does not reduce the energy dependence on imports of primary energy resources, which is approximately 61% of natural gas and oil. This is due to a number of problems, including the low level of forecasting the generation of renewable energy sources and the lack of highly mobile and storage capacities in the unified energy system of Ukraine, which jeopardizes the further stable development of renewable energy sources and the functioning of the unified energy system as a whole.

On 21 July 2020, the government of Ukraine adopted the law "On improving the conditions for supporting the production of electricity from alternative energy sources" No. 810-IX. This law came into force on 1 August 2020 and introduced significant changes in the system of state support for the renewable energy sector, which are designed to reduce the financial deficit of the state enterprise "Guaranteed Buyer", for timely payment of their current obligations, to provide certain steps towards the repayment of previously accumulated debts to the RES sector, and to reduce green tariffs by setting reducing factors for its calculation by the regulator, depending on the energy source, the date of commissioning of the RES facility, and the installed capacity [30]. At the end of 2020, Ukraine has about 8% of "green" generation in the total balance, which does not contribute to the country's energy security or reduce energy dependence on imports of primary energy resources making about 61% of natural gas and oil. Therefore, there is no alternative to the implementation of renewable energy sources, in particular, solar energy, in Ukraine in order to strengthen energy independence.

Therefore, the Energy Strategy of Ukraine up to 2035, "Safety, energy efficiency, competitiveness" [43], according to A. Ilyenko, envisages a transition from an outdated functioning model dominated by large producers, fossil fuels, inefficient networks, and uncivilized competition in energy markets to a new model with a developed competitive environment and equal opportunities to develop all types of energy production, sources, and supply routes for fuel and energy resources. This model is characterized by a predominance of low-carbon sources and high energy conversion efficiency technologies; smart energy implementation of mitigation and adaptation measures within the framework of the Paris Agreement [39].

These changes, as well as Ukraine's desire to join the European Union put before the country and society, pose new economic and technological challenges for Ukraine, namely the improvement of government policy in the area of energy balance optimization, the active use of low-carbon sources and technologies with high energy conversion ratios, as well as renewable energy sources. The national energy sector must take into account globalization challenges and societal demands and shape its development trends to ensure the implementation of sustainable development as a global eco-economic doctrine. In the field of sustainable development, scientific advice for politicians is important. Germany has positive practices in this [44].

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