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FINANCIAL AND ECONOMIC PROSPECTS FOR CREATING GREEN ENERGY PROJECTS IN THE UKRAINE-POLAND COLLABORATION

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ABSTRACT

This paper examines the economic and financial advantages of improving international collaboration between Ukraine and Poland in the development of alternative energy projects. It conducts a thorough evaluation of existing and forthcoming renewable energy generation technologies, using expert, Delphi, and methods based on statistics to identify the most promising and universally applicable solutions. The calculation of the payback period for small-scale green energy projects pays particular attention to the actual duration of the period in the case of small business ventures. The findings are summarized with a vision for the future Ukrainian-Polish cooperation in the scope of green energy cooperation and specific instruments and processes that could contribute to the success of the collaboration.

The article outlines the potential approach that involves the isolation of the cooperation between Ukraine and Poland in green energy relying on the creation of investment and venture funds, public support for the manufacturing of a renewable energy component, and the establishment of non-volatile industrial complexes. Additionally, measures such as independent small alternative power plants and the initiatives for the development of the Ukrainian-Polish joint network of alternative energy are mentioned.

The current war between Ukraine and Russia has drawn attention to the crucial need for energy security and diversification, making Ukraine-Poland collaboration on green energy projects all the more important. Ukraine may minimize its reliance on the Russian energy supply by focusing on renewable energy programs, while Poland can invest in sustainable energy to boost regional stability and economic progress. The article points out that the continuation and advancement of green energy initiatives require international cooperation. The paper offers detailed guidance on how the financial, economic, and technological opportunities and relations between Ukraine and Poland may be enhanced.

Keywords: energy, alternative energy, projects, international projects, sustainable development, international economic relations

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

INTRODUCTION

The war between Ukraine and Russia has highlighted the essential relevance of energy independence and security for Ukraine. The conflict has affected energy supply and infrastructure, emphasizing the critical need for resilient and sustainable energy systems. In this context, this research on the collaborative development of green energy projects between Ukraine and Poland becomes even more relevant, as it aims to improve energy sustainability, economic stability, and environmental benefits for both countries in the face of geopolitical problems.

Project activities in the energy sector are developing by leaps and bounds. Nuclear energy and green energy today are driving generation capabilities to meet the growing energy needs of humankind in the future. At the same time, today few countries have enough of their own resources to independently design, finance, build and maintain modern energy systems.

From this perspective, the future of energy lies in the collaboration of countries that can make a significant contribution to the planning and implementation of projects. First of all, in this article, we will explore the implementation of common projects in the field of green energy. This is due to the fact that today, at least nuclear power has a certain rate of development (a recent example is the memorandum between Ukraine and the United States on the construction of 5 power units at Ukrainian nuclear power plants (UNN, n.d.). At the same time, such projects are strategic not only in terms of energy development in the country but also in terms of national security. Therefore, their implementation is carried out at the initiative of the government and under its leadership.

At the same time, green energy projects do not require additional intercountry agreements, separate from those that already exist. In addition, wind, and solar energy, as well as biofuel-based energy generation, do not require colossal (in comparison with other types of energy - nuclear, thermal, hydropower) financial, scientific, and labour efforts for their implementation. From this point of view, such projects can be implemented between local governments of individual countries (both projects for international cooperation) as well as businesses independently.

In this aspect, we see special prospects for development in green energy projects between Ukraine and the Republic of Poland. Close historical ties, common European values, common border, and powerful scientific and technological potential are only a part of those aspects that can be used for the general development of alternative energy sources in both countries. Moreover, collaboration in alternative energy will create additional benefits: attracting investment flows, creating a base for further scientific and practical research, creating an innovative production base, and creating new jobs. All this, coupled with a positive effect on the environment, should become the basis for the formation of a socially responsible business, the electrical needs of which will be met by an independent, clean energy microsystem.

In addition, such a business development policy will stimulate not only the generation of energy to meet its own needs but also the development of a market for independent electricity suppliers for any enterprise. Moreover, such a practice will create opportunities for both trading surplus electricity and creating a new business that will specialize exclusively in the generation of green energy. In this aspect, it is worth noting the intercountry trade in green electricity, which will have a positive impact on the development of related industries such as the delivery of electricity. Today, unfortunately, the loss of electricity during its delivery through power lines remains significant and grows depending on the growth of voltage and cable cross-sections (LEG, n.d.).

All this requires not only sustainable generation of electrical energy but also responsible delivery to consumers.

Therefore, the solution to problems associated with the development of green energy, the search for ways to maximize its positive impact on related industries, as a solution to a number of social challenges should be implemented in an international scientific and practical collaboration between Ukraine and the Republic of Poland. This article is devoted to the study of the prospects for such a collaboration.

The purpose of the article is to study the financial and economic prospects for the collaborative development of green energy projects between Ukraine and the Republic of Poland, highlight the directions of such cooperation and substantiate its socially responsible effect.

The primary aim of this research is to explore the financial and economic prospects of developing green energy projects through a collaborative effort between Ukraine and Poland. The research seeks to identify the most effective technologies for renewable energy generation that can be feasibly implemented by small and medium-sized enterprises in both countries. By doing so, the study aims to propose a strategic framework for enhancing energy sustainability, economic development, and environmental benefits through bilateral cooperation. To achieve this aim, the research systematically reviews existing and emerging technologies for renewable energy generation, focusing on their applicability in the Ukraine-Poland context. It utilizes expert, Delphi, and statistical methods to identify and evaluate the most promising green energy technologies for small and medium-sized enterprises. A detailed financial analysis, including the calculation of payback periods for selected renewable energy projects, is conducted to determine their economic viability. Based on these evaluations, the research develops a strategic framework for the implementation of joint Ukrainian-Polish green energy initiatives, outlining specific tools and mechanisms for effective collaboration. Furthermore, it assesses the potential environmental, economic, and social impacts of the proposed green energy projects, ensuring they align with sustainable development goals.

This research work is driven by the following problem statement: essential energy resources today are still discovered from non-renewable energy sources and the environmental situation is becoming worse by the day as energy demand rises. Ukraine and Poland are individualistic in their approach, yet they are faced with several challenges in attempting to become sustainable and energy-independent nations primarily owing to inadequate resource endowment and emergent challenges in harnessing technology. Green energy partnership seems to fit the bill as a mutually beneficial model, with each country having relatively greater capabilities in areas where the other lacks them. Nevertheless, there is no vast body of literature discussing these issues in a steep and rigorous manner, comparing the financial and economic efficiency of such projects without focusing on particular aspects and giving guidelines for practice. In aiming to fill this gap of technology solutions towards realizing green energies, feasibility checks on the proposed solutions, and establishment of a cooperative model for green energy implementation with sustainability, this research brings a timely intervention in the two countries.

The structure of this article is organized as follows: first, it starts with a brief synoptic of the present condition and future prospects of the alternative energy technology especially focusing on the collaboration between Ukraine and Poland. Then, the article establishes an analysis based on expert, Delphi, and statistical means to outline the green energy technologies with the best small and medium enterprise prospects. This is succeeded with a financial assessment and calculation of the payback periods on the identified renewable energy undertakings. The article then revolves around an action plan or an agenda of how a constructively harmonious and viable joint Ukrainian–Polish green energy agenda may be forged, with an identification of relevant tools and mechanisms for implementation. Finally, the article accomplishes an argument on the broader implications of this collaboration for energy independence, environmental sustainability, and economic development in both countries.

LITERATURE REVIEW

The literature review provides a thorough examination of the existing research on the development and implementation of green energy projects, with a specific focus on the financial and economic aspects of international collaboration. It synthesizes findings from various studies that highlight the technological advancements, investment strategies, and policy frameworks necessary for the successful deployment of renewable energy technologies. By reviewing the best practices and lessons learned from previous initiatives, this literature review aims to establish a comprehensive understanding of the opportunities and challenges faced by Ukraine and Poland in their pursuit of sustainable energy solutions.

The profitability of companies in the renewable energy sector is evaluated by Prokopenko et al. (2023) in terms of investments and research and development (R&D) costs. This study provides insight with respect to the financial aspect of technological innovation and investment as well as can become a useful tool for the stakeholders of collaborative projects between Ukraine and Poland. Trypolska et al. (2022) examine the management perspectives of end-of-life equipment in the wind and solar power plants in Ukraine. The knowledge of the issues and possibilities related to decommissioning and disposal is fundamental for appropriate project planning. This study could contribute to the joint activities of Ukraine and Poland in managing renewable energy facilities.

Li et al. (2022) investigates the issue of energy poverty and energy efficiency in emerging economies, providing useful insights into socio-economic aspects that determine the access to and consumption of energy. Energy poverty dynamics should be understood in order to design inclusive and fair initiatives for green energy. This study adds value to the socio-economic aspect of collaboration initiatives between Ukraine and Poland.

Sotnyk et al. (2023a) focus on the advent of solar business prosumers in Ukraine and the impact they have on the energy canvas. The results give information about the functions of prosumers in the decentralized energy systems and potential participation in common projects of Ukraine and Poland. Kurbatova et al. (2023) introduce different strategies to improve the feed-in tariff policy to stimulate the use of renewable energy in households in Ukraine. Policy interventions are key in promoting investments and creating partnerships within the green energy industry. This research provides actionable recommendations for cross-border initiatives' policymakers and stakeholders.

A bibliometric analysis is conducted by Filatova et al. (2022) to investigate the role of public debt in the economic development policy of Ukraine both during the war and post-war periods. This paper addresses the economic aspects of debt management strategies, providing knowledge on fiscal policy choices and their effects on long-run development paths. Dynamics of public debt are the key to the development of a healthy economic policy and elasticity towards challenging geopolitical contexts.

Petlenko and Schehlyuk (2014) analyse the specifics of military technology marketing, accentuating that customized marketing approaches play an essential role in the promotion of defence-related products and services. The findings of this study have implications for the dynamics of defence industry markets and their relationship with general economic developments. Therefore, these findings can guide strategic spending in defence procurement and technology transfer programs with the dual goal of economic development and national security.

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Sopronenkov et al. (2023) deal with the influence of tax policies on business development and economic dynamics. This study emphasizes the interrelationships between fiscal regulations, entrepreneurial activities, and overall macroeconomic performance. The implications of tax policy changes are significant for both the policymakers and businesspeople who, in turn, determine the nature of investments, market attractiveness, and socio-economic effects.

Kuczabski et al. (2023) analyze the effectiveness of regional development management, highlighting the key role of integrated governance systems in promoting sustainable development. This study sheds some light on the importance of policy interventions, institutional arrangements, and stakeholder engagement mechanisms in promoting regional economic development. Knowledge from this study will assist in formulating approaches aimed at making use of resource allocation, improving competitiveness, and ensuring inclusive development at the regional level.

Redko et al. (2023) offer a comparative analysis of strategic directions of innovative development of the energy sector in Ukraine and the EU member countries. Through analysis of international cases and best practices, this study provides important information about policy frameworks, technological trends, and market dynamics influencing the energy transition. Utilizing comparative analysis can promote knowledge transfer and policy learning, which will enable the creation of locally applicable measures for sustainable energy transformation.

Masyk et al. (2023) study the indicators for evaluating the performance of governance institutions in relation to sustainable development assignments. This study highlights the role of governance structures, regulatory frameworks, and accountability mechanisms in achieving sustainable development objectives. Knowledge of the determinants of institutional effectiveness is important for ensuring good governance practices and developing comprehensive responses to sustainability challenges.

Sotnyk et al. (2023b) conducted a bibliometric study of the management of energy efficiency and renewable energy in the residential area. This study through synthesis of existing literature identifies the patterns, gaps and challenges for sustainable practices in energy. Findings from this study can guide collaborations towards energy efficiency and renewable integration in residential localities.

Bashynska et al. (2022) discuss the investment and innovation image of regions in Ukraine as regards sustainable developments. The study of regional development dynamics gives an understanding of the advantages and disadvantages of development, as well as potential activities for creating sustainable development. The findings from this research will be useful in the development of general and specific tactical and policy strategies that can enable the improvement of innovation systems and the attraction of capital to sustainable initiatives throughout the nation.

A study done by Dudek et al. (2023) suggests the appropriate procedure and measurement approach to determine the extent of participation of green energy projects in the green and inclusive energy sector of society was the feasibility study method. Considering the environmental, social and economic perspectives towards this scenario again unfolds the perfection of community efforts towards the progression of sustainable energy application. It is also important to flag this framework in general as it facilitates realizable universal com Touch and basic framework which can be applied to diverse collaboration and on this basis to follow the financial and economic perspective of green energy with respect to social return on investment.

The literature analysis proves the existence of a significant and credible scientific base that emphasizes the favourable financial and economic performance of green energy projects as well as highlights the importance of international collaboration in their implementation.

AIMS AND OBJECTIVES

This research aims to explore the financial and economic prospects of developing green energy projects through collaborative efforts between Ukraine and Poland. The study focuses on identifying effective renewable energy technologies suitable for implementation by small and medium-sized enterprises in both countries. By doing so, it seeks to propose a strategic framework that enhances energy sustainability, economic development, and environmental benefits through bilateral cooperation.

Objectives for this research:

1. Conduct a comprehensive review of existing and emerging renewable energy technologies applicable to SMEs in Ukraine and Poland. Employ expert, Delphi, and statistical methods to identify the most promising green energy technologies.

2. Perform detailed financial assessments of selected renewable energy projects. Calculate payback periods to determine their economic viability and attractiveness to potential investors.
3. Develop a cohesive strategic framework for the implementation of joint Ukrainian-Polish green energy initiatives. Outline specific tools and mechanisms that facilitate effective collaboration and mutual benefit.
4. Evaluate potential environmental, economic, and social impacts of proposed green energy projects. Ensure alignment with sustainable development goals and strategies for enhancing energy security and diversification.
5. Propose policies and initiatives to support the development and implementation of green energy projects. Identify roles for governments, private sectors, and international organizations in fostering collaborative efforts between Ukraine and Poland.
6. Recommend practical steps for creating investment and venture funds, establishing public support mechanisms, and initiating independent small alternative power plants. Advocate for the creation of a unified Ukrainian-Polish network for alternative energy to maximize efficiency and sustainability.

Through these objectives, the research aims to provide a comprehensive roadmap for leveraging Ukraine-Poland collaboration in the green energy sector. This collaboration is envisioned not only to drive technological innovation and economic growth but also to contribute significantly to environmental preservation and sustainable development in both countries.

METHODS

This research's approach allows for the exploration of the financial and economic viability of partnering with Poland to develop green energy projects since it employs both qualitative and quantitative methods. These components are the computation of financial values, statistical processing, and the use of questionnaires among other professionals. To obtain expert opinions on the promising green energy technology and potential cooperation between Poland and Ukraine, the authors applied the Delphi approach. It was a cyclical process to obtain the expert input, which was later modified based on the replies received from the group. The agreement on which basic standards and promising technology in the field of renewable energy should be achieved was the goal.

Thirty professionals made up the expert panel, which was further divided into three subgroups: Ten scholars with academic backgrounds in environment, international relations, and energetics. To embrace all facets of social, economic, and environmental aspects, faculty members from Sumy State University specializing in SD were purposively selected as the focus group. This technique eliminated chances of any one grouping to influence the results hence avoiding biases.

These experts were selected based on the number of works they have published on renewable energy, years of experience in the respective fields, and academic qualifications. Experts needed at least five years of experience and five papers/projects related to renewable energy. This survey procedure included two main rounds. Expert opinions for the first round in the case of small and medium enterprises in Poland and Ukraine, the most promising green energy solutions were to be selected. They evaluated various technologies based on hypothetical parameters such as feasibility, cost, scalability and sustainability. Written feedback collated from the first round was made anonymous. After that, the experts were invited to work on the evaluations and make improvements based on the composite score.

The quantitative data on green energy technologies including wind power, solar systems and biofuels as well as the forecast of future trends were obtained. Some of the sources of data included refereed research articles that have been published in scholarly journals, business and industry reports, as well as government publications.

The information received from the expert questionnaires was summarized in the form of descriptive statistics, defined as the arithmetic means, median, and standard deviations of the estimations provided by the experts about the particular technologies. Hence, a weighted-arithmetic mean was calculated to determine the score for each of the technologies, based on the identified weightage for each criterion as rated by the experts. With this approach, the outcome of the scoring for every technology will in fact mirror the importance and weight of the criteria.

Besides the questionnaires completed by the energy experts and statistical analysis, the works on the identification of different financial possibilities of various green energy systems required the usage of the financial computations. In the run of the analysis, we focused on the payback period of renewable energy investment with equal regard to the financial health of the firm. The initial cost of implementing the investment project, primary expenses, and expected benefits which may include the cost of renewable energy source usage were assessed.

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Compare payback time and costs of solar cells and independent wind generators to evaluate them consequently the electricity consumption of small businesses. The initial cost of the wind generators, solar panels, inverters, Controllers, installation and maintenance cost, cost savings due to energy conservation, and additional revenues by utilization of excess energy were taken into account in the cost analysis.

RESULTS

Alternative energy (green energy) in the literature is considered to be a complex of promising methods to provide energy generation, often from renewable sources, which has an additional purpose – to be environmentally friendly (TWI Global, n.d.). We see that this concept is very broad and not always "alternative energy" is the equivalent of "green energy". Alternative energy implies the use of non-traditional sources, methods and technologies for generating energy, including from renewable sources. Renewable energy, one that uses renewable or inexhaustible sources, is called "green" energy. At the same time, we do not set ourselves in the search for solving problems of systematizing terminology but identifying practical ways to ensure the energy independence of enterprises.

The presented types of alternative energy, as well as their offshoots, can potentially change the ideas of business structures about energy in the future. Today, there is still a problem of misunderstanding and rejection of the need to use green energy for production purposes. In this aspect, there are many influencing factors:

1. **Firstly,** not all types of energy can be realized in the country due to natural, legislative, and intellectual restrictions. Not all countries own technologies for the production of geothermal energy or cannot use them due to the peculiarities of their geographic location. For example, the Republic of Belarus has no access to the sea, therefore, purely marine types of alternative energy are not allowed there (tidal power plants, temperature gradient, etc.). If a country has weak forest resources, access to solid wood energy will also be limited.
2. **Secondly,** the country's specialization in a certain type of production also plays an important role. For example, in countries where agriculture is sufficiently developed, access to biogas and synthesis gas is sufficient in industrial volumes. In countries with a sufficiently developed industry and national technical potential, there is a possibility of using cryo-energy and synthesizing biodiesel.
3. **Thirdly,** external relations of the state can be rather narrow, which negatively affects the potential for the development of alternative energy sources. This forces such countries to either intensify the extraction of fossil fuels or limit consumption, which today cannot be considered either democratic or sustainable.
4. **Fourthly,** it is more profitable for countries to invest state budget funds in large energy infrastructure facilities, which are guaranteed to produce a significant amount of energy per unit of cost.
5. **Finally,** energy projects are often viewed by countries as objects of national energy security, therefore, attracting private investment in the construction of large power-generating enterprises is a difficult process.

Despite this, Ukraine already has experience of cooperation with foreign investors in the construction of energy facilities. Among them is the project for the construction of a new block at the Slavyanska TPP with the involvement of financial resources from the PRC in the amount of USD 600 million (Interfax-Ukraine, n.d.). Another project included the potential construction of a 220 MW power complex at the Lviv thermal power plant (Naftogaz, n.d.).

As we can see, Ukraine is interested in the implementation of new projects and the re-equipment of existing facilities. However, intergovernmental agreements mainly concern large energy facilities, which, unfortunately, concern more quantity than quality. At the same time, there are precedents for the construction of large solar stations. The latest of these projects is the creation of a 5 MW solar power plant on the territory of the Poltava mining plant (Ukrinform, n.d.). A feature of such a power plant is that its panels are installed on the dumps of open pits. That is those areas that are not used in any way begin to bring a useful effect.

The negative effect should also be noted. Today in Ukraine, the construction of alternative power plants is actively stimulated by the so-called "green" tariff (In English literature, the term "Feed-in tariff" is often used). According to the Law of Ukraine "On Electricity" №575 / 97-BP of 01.07.2019, a "green" tariff is a special tariff at which electricity is purchased, and produced at power facilities, including the commissioned queues of construction of electric stations (start-up complexes), from alternative energy sources (except for blast furnace and coke oven gases, and with the use of hydropower – produced only by micro-, mini- and small hydropower plants) (Verkhovna Rada of Ukraine, 2019). Today, this law has expired in Ukraine, but the current version looks quite interesting – the Law of Ukraine "On the Electricity Market" №2019-VIII of 29.08.2021, which does not provide any definition of "green" tariff (Verkhovna Rada of Ukraine, 2021).

In practice, such an incentive mechanism leads to the fact that enterprises or individuals invest in alternative energy in order to earn money by selling it to the state through the wholesale electricity market. Further, this electricity (along with the energy generated by nuclear, thermal and hydroelectric power plants) is sold to local energy sellers, who, in turn, sell it to consumers. In fact, the "green" tariff is paid by all consumers (even those who have nothing to do with energy) (Sagaydak, 2018).

In our research, we will focus on interstate projects between Ukraine and Poland aimed at increasing energy sustainability. In our opinion, sustainable energy should also be socially responsible. This means that companies should be stimulated in the development of "green" energy in other ways, without resorting to a "green" tariff, which is beneficial only for those, who generate such energy. This situation, in our opinion, does not correspond to the concept of sustainable development, which is the basis for the development of "green" energy. In other words, the introduction of motivational mechanisms, which essence is financial incentives for the "clean" energy generation, at the expense of the final consumer cannot be considered socially responsible**.**

Against this background, the document "Energy strategy of Ukraine for the period up to 2035" security, energy efficiency, competitiveness", which was approved by the Order of the Cabinet of Ministers of Ukraine №605-2017-r dated 18.08.2017, looks rather ambiguous (Verkhovna Rada of Ukraine, 2017).

Within the framework of this strategy, special emphasis is placed on: the modernization and re-equipment of existing electric power generation capacities;

- reduction of losses during transmission of energy through power lines (smart grid technology);
- improvement of technologies for the extraction of combustible minerals, the introduction of their digital accounting;
- decrease in the energy intensity of GDP.

Separately, it is worth noting the item of the Strategy "Ensuring sustainable development", which includes:

- improvement of tariff setting;
- the use of energy-efficient transport that consumes less fuel (apparently, this refers to public transport);
- transfer of heat energy consumers from centralized supplies; individual electric heating;
- improvement in the gas, coal and oil industries;
- bringing the share of alternative energy to the level of 25% of the total generation. Here the document assumes the introduction of new units at the hydroelectric power station; transfer of central heating to bioresources (incineration of household waste and bio-pallets); substitution of combustible fuels for alternative ones, but where it is economically feasible.

As we can see, the strategy does not imply the fundamental development of alternative energy in the fields of solar, wind, bioenergy, etc. Moreover, the vision of alternative sources in the energy sector of Ukraine, even after 15 years, can hardly be considered strategic.

Based on this, we concluded that for the speedy implementation of projects in the field of green energy, it is necessary to implement them without involving public authorities as direct participants**.**

In other words, the projects being implemented should relate to the activities of small and medium-sized businesses, since such a business is:

- very flexible - it can rebuild and adapt to changes and new challenges;
- is able to attract bank lending and international grants, since projects that can be implemented in small businesses require incommensurably lower costs;
- for the implementation of projects, it is possible to attract contractors who already have experience and can offer standardized solutions, which is cheaper than unique projects at the state level;
- it can be part of an international collaboration: co-production; supply chain, etc.

In order to find the most optimal opportunities for the implementation of interstate energy programs in small and medium-sized businesses, in our opinion, it is necessary to solve a number of problems:

1. Systematize the sources of obtaining green energy, possible nowadays.
2. Conduct a selection of criteria according to which possible alternative energy sources will be selected as candidates for international projects.

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3. Direct selection of alternative energy sources, which are most resealable for small and medium-sized businesses.

First problem. We systematized the most famous and potentially possible technologies of alternative (green) energy (Table 1). Technologies used in alternative energy are usually classified according to the source of generation of electrical energy.

Table 1. Used and promising branches of alternative electrical energy. *(Source: authors development based on (Muller, 2021; Morais, 2021; Acharya, 2014; Muratoglu, 2018; Nadarajah, 2016; Bhola, 2021; Gielen, 2019))*

Kinds of energetics	The branch of energetics	Characteristics
Alternative energy generation industries in use today		
Wind energetics	Autonomous wind generators	Wind turbines installed in production facilities remote from power lines
	Wind turbines connected to the grid	Wind turbines installed at industrial sites of enterprises and connected to the general energy network
Biofuel	Liquid: bioethanol, biodiesel	Using generators that work on biofuel: fatty acid ester blend (biodiesel); ordinary ethanol (bioethanol)
	Solid: wood waste and biomass	Burning wood waste (substandard forest; wood chips, husks, bio-pallets, etc.)
	Gaseous: synthesis gas, biogas	Gas synthesis by methanol or hydrous fermentation of green biomass (biogas); mixture of carbon monoxide and hydrogen (synthesis gas)
Solar energy	Solar collectors (including solar water heaters)	devices that generate electrical energy by collecting thermal energy from the sun
	Photovoltaic cells	use of vacuum or semiconductor photocells – solar panels
Alternative hydropower	Tidal power plants	in fact, they use the kinetic energy of the earth's rotation, but are based on the principle of transforming the energy of tides into electrical energy
	Wave power plants	stations that use the useful work of waves to generate electricity
	Mini and micro hydropower plants	hydroelectricity, installed on small rivers, streams, whose current allows the use of useful work of water
	Energy of the temperature gradient of seawater	energy, extraction based on temperature differences of ocean water at different depths
Geothermal energy	Thermal water power plants	heat exchange using groundwater temperature
	Ground heat exchangers	heat exchange using the temperature of the subsoil to heat the air
Cryoenergy	Cryoenergy power plants	obtaining excess energy in the process of oxygen liquefaction at a temperature of -182.96°C
Promising industries for the generation of alternative energy		
Solar energy	Energy tower	a promising device combining heat exchange processes between air and water, as well as wind energy
	Nanoantennas	devices operating on the principle of rectifying antennas and converting solar energy into electric power. Such antennas do not work in the radio range, as usual, but in the optical one
Alternative hydropower	Aero hydroelectric power plants	potential for energy production by condensation of water from the atmosphere and/or clouds
Thunderstorm energy	Thunderstorm power plants	the principle of operation is based on catching lightning and redirecting their energies to the power grid
Gravitational energy	Gravitational power plants	obtaining excess energy by accumulating potential energy under the influence of the Earth's gravitational field
Controlled thermonuclear fusion		the principle of obtaining energy by fusing heavier nuclei from lighter ones. Today, such a synthesis is considered to be the production of tritium (3H) from deuterium (2H), and in the future - the use of boron-11 (11B) or helium-3 (3He).
Hydrogen energy		promising technology using hydrogen fuel cells, engines, and biohydrogen. At the same time, to obtain energy from hydrogen today it is required to expend more energy than is generated from hydrogen. For these reasons, hydrogen-based fuel cells are used as energy storage rather than as a source
Space energy		Potential placement of any sources of alternative energy on space objects and/or in their orbit

As we can see from the systematized material, the nomenclature of possible alternative (including green) sources of energy generation is quite extensive. It contains examples from most modern types of energy (including thermal and nuclear). At

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the same time, we did not immediately take into account some of the "potential alternative" sources of nuclear power. For example, thermonuclear fusion using a toroidal chamber with magnetic coils (also known as Tokamak) or cold nuclear fusion (recognized by physicists as a utopia) are not only not used in practice, but at this stage are simply impossible for practical use. Therefore, we have collected only what actually works.

Second problem. Determination of criteria for the selection of energy projects. To identify the most relevant criteria for our study, we analysed specialized scientific sources and conducted a survey using the Delphi method. This technique includes three subgroups of experts: ten academic experts in energy, ten academic experts in ecology, and ten academic experts in international economics. The focus group, which included Sumy State University workers, was organized around sustainable development principles to provide a fair representation of economic, social, and environmental views. This strategy helps us reduce possible biases by preventing any single grouping from unnecessarily impacting the results.

Criteria for choosing sources of alternative (renewable energy) for implementation by small and medium-sized businesses

1. Possibility of project implementation without state participation
2. Possibility of implementation without complicated permitting procedures
3. Possibility of implementation without investing in know-how
4. The ability to attract bank loans or grants. Participation in venture funding programs
5. Placement versatility
6. Possibility to carry out placement on the industrial site of the enterprise
7. Community of interests of Ukraine and Poland in the development of certain types of alternative energy

Figure 1. Criteria for the selection of alternative (renewable) energy sources, possible for the implementation of small and medium-sized businesses.

It is necessary to provide an explanation of the logic based on which such the criteria for further research were selected:

1. The basis for the selection of criteria was simplicity (involving the smallest number of stakeholders) and safety (for citizens living in different settlements; employees of the enterprises, which are implementing such technologies).
2. We did not take the cost criterion initially. First, taking into account the specifics of individual examples from Table 1, cost may not be the most important factor. Some of these examples are generally impossible to implement for a business because of the complexity or danger. Secondly, in our opinion, it is advisable to conduct a financial assessment at the second stage of the study, when the primary selection has already been carried out. Thirdly, if only 1 option remains at the 2nd stage, the financial-economic assessment is more likely to be a factor in making a decision on expediency as such, and not as a selection criterion among a dozen options.
3. The first criterion means that common projects on alternative energy in the Ukraine-Poland collaboration should be implemented only within the framework of existing agreements on cooperation between Ukraine and the countries of the European Union in the energy sector (Linstone, 1975). In addition, such projects should be implemented at the expense of funds, grants (possibly interstate funds) and/or own funds of enterprises.
4. The second factor means that projects should be implemented without the involvement of state authorities, state energy companies (if possible) and without special permitting procedures. In other words, such projects should be implemented according to the principle "client in Ukraine - contractors - client in Poland". That is, it is necessary to shift licensing and licensing procedures to contractors. For example, the construction of thermal, and geothermal power plants will lead to mandatory environmental and geological expertise.

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5. Projects should be based on a universal, publicly available technology, which will make it possible to reduce the cost of purchasing the necessary components and reduce the cost of its maintenance. For example, an industrial plant for generating power from lightning is owned by Alternative Energy Holdings (Ministry of Foreign Affairs of Ukraine, n.d.).
6. Projects should be based on a universal, publicly available technology, which will make it possible to reduce the cost of purchasing the necessary components and reduce the cost of its maintenance. For example, an industrial plant for the generation of energy from lightning is owned by Alternative Energy Holdings (Mukherjee, 2019) or a startup for the production of cryogenic plants Dearman Engine (GW Blogs, 2020).
7. Projects should be relatively small; therefore, the cost of their implementation can be covered by the minimum number of lenders or grantors.
8. The territory of Ukraine and Poland is climatically, geo-physically, hydrologically rather heterogeneous. This suggests that only a limited set of options can be implemented throughout the countries. Wind, hydropower, etc. require special conditions for placement, which small and medium-sized businesses often do not have.
9. Energy projects should be located on the territory of enterprises - representatives of small and medium-sized businesses. Therefore, the construction of, for example, large wind turbines for such purposes is unacceptable.
10. Projects in international collaboration should correspond to the trends that exist in the energy sector of the countries nowadays. To determine the directions to develop such projects, we took data on the generation of electricity from various sources in Ukraine and Poland (Figure 2).

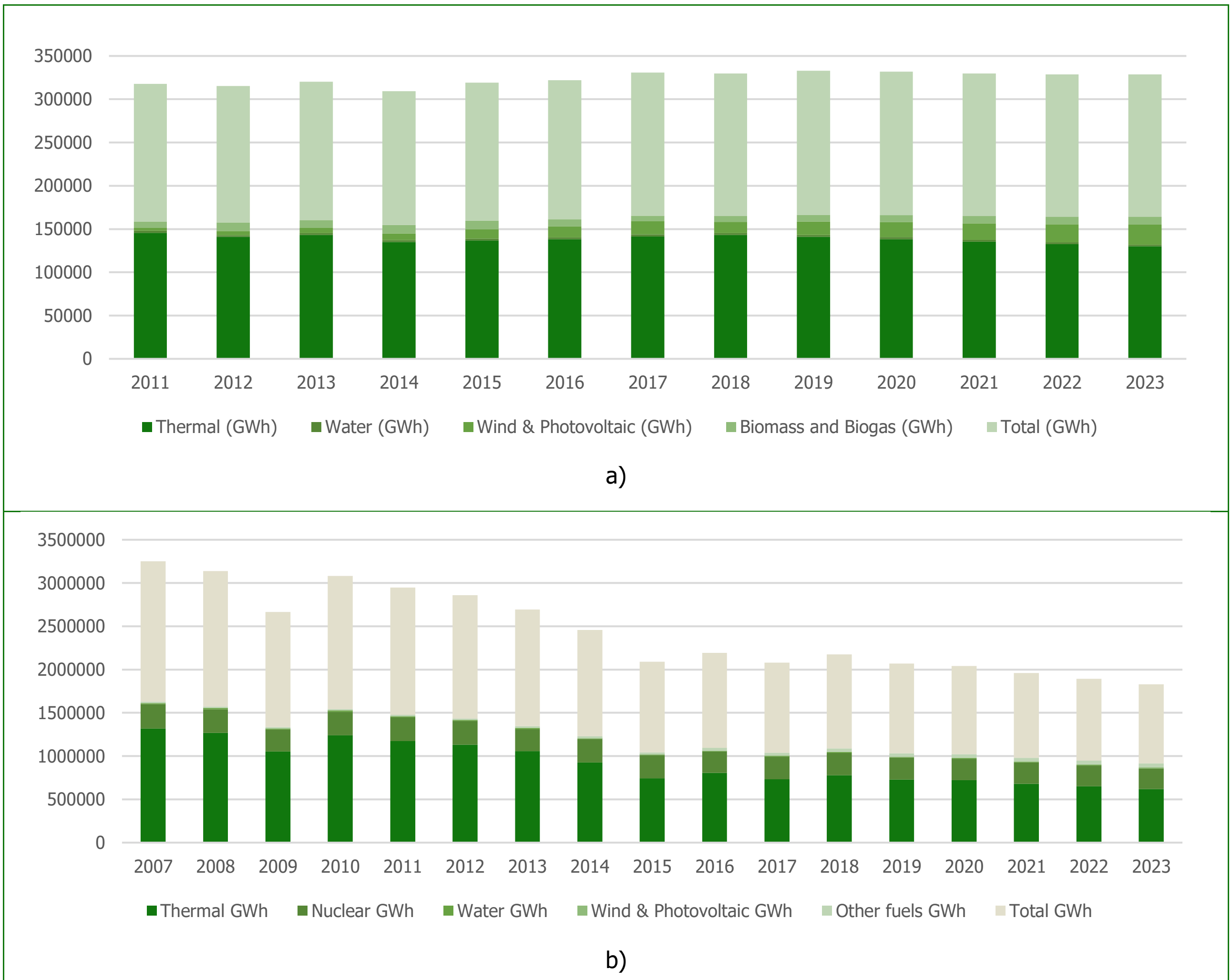

Figure 2. Dynamics of the structure of energy generation on alternative sources in the Republic of Poland. Note: a) Energy generation in Poland (2011-2023); b) Energy generation in Ukraine (2011-2023). *(Source: authors development based on (Central Statistical Office of Poland, n.d.; State Statistics Service of Ukraine, n.d.)).*

As we can see from the statistical data, the development of alternative sources based on the principles of wind and solar energy generation prevails in the Republic of Poland. In Ukraine, the situation is somewhat different - technologies based on the combustion of biogas, biofuel, and solid wood waste prevail. At the same time, we see that since 2016, Ukraine has seen a steady increase in the generation of solar energy and wind energy. From this, we conclude that the main directions in the field of international collaboration on projects of alternative (green energy) should be considered: a) solar and wind energy; b) biofuels.

Due to destroyed infrastructure and shattered supply networks, Ukraine's energy output significantly decreased after the war with Russia began in 2022, especially in the areas of thermal and nuclear power. Although at a slower pace than anticipated, wind and photovoltaic energy saw a moderate increase in Ukraine as attention turned to more decentralized and resilient energy sources. Although there was less of an immediate effect, Poland's adoption of renewable energy has been growing gradually overall. However, due to geopolitical concerns, investment and project implementation have slowed down slightly.

Third problem. Screening out sources of alternative energy. In fact, it is the second stage of the Delphi method. At this stage, we asked the experts to assign appropriate importance to each of the selected criteria. Further, each expert was asked to assign a rating to each of the sources in accordance with each of the criteria.

For clarification:

Significance of criteria, w. Experts had to assign weights to each criterion to two decimal places. In addition, the sum of all weights should not have exceeded 1 (100%).

Scoring of each of the sources, s. Further, the experts had to evaluate each of the sources in accordance with the criteria and assign an appropriate rating on a scale from 0 to 1. At the same time, 0 corresponded to a source that did not completely meet the criterion, and 1 - a source that fully corresponded to the criterion.

It is also worth noting that at the stages of weighting criteria (w) and source scores (s), we equalized the result using the PERT (Program (Project) Evaluation and Review Technique) method (Dovhan et al., 2017):

$$E = \frac{1}{6} \times (P + 4M + O) \quad (1)$$

where: E – estimation (result obtained); P – the most pessimistic assessment; M – the most likely estimate; O – the most optimistic assessment.

The results of expert estimates of the weights for the selected criteria are presented in Table 2.

Table 2. Expert assessment of weights for each of the selected criteria.

Experts	Criteria							Total
	Criteria 1	Criteria 2	Criteria 3	Criteria 4	Criteria 5	Criteria 6	Criteria 7	
Expert 1	0.15	0	0.1	0.05	0.25	0.15	0.3	1
Expert 2	0.1	0.1	0	0.35	0.2	0.05	0.2	1
Expert 3	0.1	0.05	0.1	0.2	0.1	0.15	0.3	1
Expert 4	0.1	0.1	0.05	0.2	0.3	0.1	0.15	1
Expert 5	0.1	0.1	0.2	0.1	0.15	0.15	0.2	1
Expert 6	0.15	0.1	0	0.2	0.25	0.1	0.2	1
Expert 7	0.05	0.1	0.1	0.2	0.25	0.1	0.2	1
Expert 8	0.05	0.1	0.1	0.2	0.25	0.1	0.2	1
Expert 9	0.05	0.1	0.15	0.25	0.15	0.15	0.15	1
Expert 10	0.15	0	0.1	0.15	0.25	0.15	0.2	1
Expert 11	0.1	0	0.1	0.2	0.25	0.15	0.2	1
Expert 12	0.1	0.05	0.05	0.2	0.3	0.05	0.25	1

(continued on next page)

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Table 2. Continued.

Experts	Criteria							Total
	Criteria 1	Criteria 2	Criteria 3	Criteria 4	Criteria 5	Criteria 6	Criteria 7	
Expert 13	0.15	0.1	0	0.1	0.2	0.25	0.2	1
Expert 14	0.05	0	0.1	0.35	0.25	0.05	0.2	1
Expert 15	0.1	0.1	0.1	0.2	0.1	0.15	0.25	1
Expert 16	0.15	0.1	0.15	0.1	0.15	0.15	0.2	1
Expert 17	0.1	0.05	0.1	0.1	0.25	0.1	0.3	1
Expert 18	0.1	0.05	0.1	0.2	0.25	0.15	0.15	1
Expert 19	0.1	0.1	0.25	0.1	0.15	0.1	0.2	1
Expert 20	0.15	0.05	0.1	0.2	0.25	0.05	0.2	1
Expert 21	0.1	0	0.15	0.15	0.25	0.1	0.25	1
Expert 22	0.1	0	0.1	0.2	0.25	0.05	0.3	1
Expert 23	0.1	0.1	0.1	0.2	0.15	0.15	0.2	1
Expert 24	0.15	0	0.1	0.1	0.25	0.15	0.25	1
Expert 25	0.1	0.1	0.1	0.35	0.1	0.05	0.2	1
Expert 26	0.1	0	0.1	0.2	0.25	0.15	0.2	1
Expert 27	0.1	0.1	0.1	0.2	0.1	0.15	0.25	1
Expert 28	0.15	0	0.15	0.1	0.25	0.15	0.2	1
Expert 29	0.1	0.1	0	0.2	0.25	0.15	0.2	1
Expert 30	0.1	0	0.1	0.15	0.3	0.15	0.2	1
Pessimistic assessment	**0.05**	**0**	**0**	**0.05**	**0.1**	**0.05**	**0.15**	**-**
Most likely	**0.1**	**0.05**	**0.1**	**0.2**	**0.25**	**0.15**	**0.2**	**-**
Optimistic	**0.15**	**0.1**	**0.25**	**0.35**	**0.3**	**0.25**	**0.3**	**-**
Total	**0.1**	**0.05**	**0.1**	**0.2**	**0.2**	**0.15**	**0.2**	**1**

Calculating the values for each source based on each expert's assessment cannot be easily represented in a two-dimensional table, as each expert evaluated each factor according to the selected criteria. To clarify this process, we will present the assessments given by Expert 12 as an example (Table 3).

Table 3. Scoring assessment of the strength of compliance of the source with the selected criteria, which was given by Expert 12.

Assessment of an expert 12	Criteria						
	Criteria 1	Criteria 2	Criteria 3	Criteria 4	Criteria 5	Criteria 6	Criteria 7
Autonomous wind generators	1	1	0,5	0,75	0, 25	1	1
Wind turbines connected to the grid	0.25	0.25	1	0.5	0.25	1	0
Liquid: bioethanol, biodiesel	1	1	0.5	0.75	0.75	0.75	1
Solid: wood waste and biomass	1	1	1	1	0.25	1	1
Gaseous: synthesis gas, biogas	1	1	0.25	1	0.25	0.75	1
Solar collectors (including solar water heaters)	1	1	1	1	0.25	1	1
Photovoltaic cells	1	1	1	1	1	1	1
Energy tower	0.25	0	0	0.25	0.5	0	0.5
Nanoantennas	1	0.5	0.25	0	0.25	0	0.5
Tidal power plants	0	0	0	0.25	0	0	0
Wave power plants	0	0	0	0	0	0	0
Mini and micro hydropower plants	0	0.25	0	0.5	0.5	0.5	0.5
Energy of the temperature gradient of seawater	0	0	0.25	0	0.25	0	0
Aero hydroelectric power plants	0.5	0.75	0	0	0.75	1	0.75
Thunderstorm power plants	0.5	0	0.5	0.25	0	0.75	1

In order to bring the weights and estimates obtained, we used the calculation of the weighted arithmetic mean (WAN). This method was chosen by analogy with the volume-weighted average price (VWAP) and the weighted average cost of capital (WACC) methods, widely used in the financial sphere. WAN was calculated using the current formula (Pyrozhkov et al., 2020):

$$WAN = \frac{\sum_{i=1}^{n} w_i \times s_i}{\sum_{i=1}^{n} w_i}, \quad (2)$$

where: WAN – weighted arithmetic means. Resulting indicator; w – factor i weight; s – source i score.

The results of the calculations obtained for each of the alternative energy sources selected for the study are presented in Table 4.

Table 4. Calculation of the WAN indicator for each of the alternative energy sources.

Kinds of energetics	The branch of energetics	Criteria for the selection of alternative (renewable) energy sources and their significance							
		Criteria 1	Criteria 2	Criteria 3	Criteria 4	Criteria 5	Criteria 6	Criteria 7	Total
		Significance of criteria							
	Significance coefficient, w	0.1	0.05	0.1	0.2	0.2	0.15	0.2	1
	Score	s^1	s^2	s^3	s^4	s^5	s^6	s^7	WAN
Wind energetics	Autonomous wind generators	1	1	1	1	0. 5	1	1	0.9
	Wind turbines connected to the grid	0.25	0	1	0.25	0.25	0	1	0.43
Biofuel	Liquid: bioethanol, biodiesel	1	1	0.5	0.75	0.75	1	1	0.85
	Solid: wood waste and biomass	1	1	1	1	0.25	1	1	0.85
	Gaseous: synthesis gas, biogas	1	1	0.25	1	0.25	1	1	0.78
Solar energy	Solar collectors (including solar water heaters)	1	1	1	1	0.25	1	1	0.85
	Photovoltaic cells	1	1	1	1	1	1	1	**1**
	Energy tower	0.25	0	0	0	0.5	0	0.5	0.23
	Nanoantennas	1	0.5	0	0	0.25	0	0.5	0.28
Alternative hydropower	Tidal power plants	0	0	0	0	0	0	0	0.00
	Wave power plants	0	0	0	0	0	0	0	0.00
	Mini and micro hydropower plants	0	0	0	0	0.5	0.5	0.5	0.28
	Energy of the temperature gradient of seawater	0	0	0	0	0	0	0	0.00
	Aero hydroelectric power plants	0.5	0.75	0	0	0.75	1	0.75	0.54
	Thunderstorm power plants	0.5	0	0	0	0	0	0	0.05

DISCUSSION

Based on the calculations, we concluded that the greatest potential for the implementation of alternative energy projects in small and medium-sized businesses is possessed by:

1. Wind power: Autonomous wind generators. Autonomous wind generators can be deployed on the territory of the enterprise. They are compact turbines of horizontal or vertical type, mounted on rooftops or on poles.

Among the general advantages of this technology are:

- the ability to work around the clock. When batteries are installed, they can be recharged automatically even at night;
- with an increase in wind speed, a sharp increase in the generation of electrical energy is possible;
- independence from the season and cloudiness.

Among the general disadvantages of this technology should be considered:

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- the need to install a wind generator at a distance from houses, since houses impede the free passage of the wind;
- dependence on wind speed. According to Global Wind Atlas (Global Wind Atlas, n.d.), the average wind speed in flat areas in Poland and Ukraine is 5-8 m/s, which in ideal conditions and an installation efficiency of about 90% can provide 800-1100 watts of energy generation with a voltage of 12-48 volts (Solar-Tech, n.d.). Using 12 Volt to 220 Volt inverters, it becomes possible only to power up of 2 computers with 500-Watt power supplies.

2. Solar energy: Photovoltaic cells. The panels can be deployed both on the territory of the enterprise (on freestanding installations) and on the roofs of industrial premises.

Among the general advantages of this technology are:

- independence from energy sources, except for the Sun;
- weak dependence on weather conditions (panels work even in cloudy weather);
- versatility. It is possible to place panels on any surfaces that have no other useful use. They can be placed near residential buildings (and even on them).

Among the general disadvantages of this technology should be considered:

- maximum efficiency only when the panels are clean;
- maximum efficiency only during the day with straight lines in sunny weather;
- low efficiency of one panel (about 20%) (Trina Solar, n.d.), which requires the installation of more panels in comparison with other sources. This means lower energy generation per unit of footprint. Also, it should be noted that the most powerful solar panels can deliver about 650 watts of energy.

After accumulating all these presented data, we decided to conduct a comparative analysis of the payback period between autonomous wind generators and solar panels, focusing on a power of about 1200 watts, which corresponds to the required consumption of 2 computers. The results of this analysis are presented in Table 5.

Table 5. Calculation of the payback period for an alternative energy project associated with the autonomous power supply of 2 computers. Note: * – Data taken from the Internet based on the proposals of equipment suppliers.

<table>
<tr><th colspan="5">Hourly electricity consumption of an average computer</th></tr>
<tr><td colspan="3">Power consumption of the power supply, Wh</td><td colspan="2">500</td></tr>
<tr><td colspan="3">Power consumption of monitor, Wh</td><td colspan="2">100</td></tr>
<tr><td colspan="3">Total consumption for 1 computer, Wh</td><td colspan="2">600</td></tr>
<tr><td colspan="3">Total consumption for 2 computers, Wh/2 computers</td><td colspan="2">1200*</td></tr>
<tr><th colspan="5">Office working hours</th></tr>
<tr><td colspan="3">Working days, days/month</td><td colspan="2">24</td></tr>
<tr><td colspan="3">Working hours, hours/day</td><td colspan="2">8</td></tr>
<tr><td colspan="3">Working hours, hours/month</td><td colspan="2">192</td></tr>
<tr><td colspan="3">Total consumption of electric power by 2 computers, kWh/month</td><td colspan="2">230.4</td></tr>
<tr><th colspan="5">Cost of running two computers on traditional power grids</th></tr>
<tr><td colspan="3" rowspan="2">Electricity tariff for corporate clients in the country, EUR/kWh (Global Petrol Prices, n.d.; National Energy and Utilities Regulatory Commission of Ukraine, 2021)</td><td>Ukraine</td><td>Republic of Poland</td></tr>
<tr><td>0.03</td><td>0.146</td></tr>
<tr><td colspan="3">The cost of electricity used by 2 computers per month, EUR/month</td><td>6.91</td><td>33.63</td></tr>
<tr><td colspan="3">The cost of electricity used by 2 computers per year, EUR/year</td><td>82.94</td><td>403.66</td></tr>
<tr><th colspan="5">Payback period of generating plants, taking into account electricity tariffs in Ukraine and the Republic of Poland</th></tr>
<tr><td>The price of equipment</td><td colspan="2">Autonomous wind generator (one unit) (Solar-Tech, n.d.)</td><td colspan="2">Photovoltaic cells (two cells with 655-Watt power each)</td></tr>
<tr><td>Generating unit power, Watt</td><td colspan="2">1200</td><td colspan="2">1300</td></tr>
<tr><td>Cost of equipment, EUR</td><td colspan="2">894.85</td><td colspan="2">423.25</td></tr>
<tr><td>Cost of controller, EUR</td><td colspan="2">239.69</td><td colspan="2">239.69</td></tr>
<tr><td>Cost of the inverter, EUR</td><td colspan="2">41.06</td><td colspan="2">123.28</td></tr>
<tr><td>Additional expenditures (wires, commissioning works etc.), EUR</td><td colspan="2">319.59</td><td colspan="2">319.59</td></tr>
<tr><td>Total price for unit, EUR</td><td colspan="2">1495.20</td><td colspan="2">1105.81</td></tr>
<tr><td rowspan="2">Payback period of the installation (Total price for unit / The cost of electricity used by 2 computers per year), years</td><td>Ukraine</td><td>Republic of Poland</td><td>Ukraine</td><td>Republic of Poland</td></tr>
<tr><td>18</td><td>3.7</td><td>13.3</td><td>2.7</td></tr>
</table>

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The results of calculations performed give us all opportunities to believe that:

- For ultra-low electricity needs, alternative sources are unreasonably expensive, even those that do not require additional purchase or production of biofuels. This is evidenced by the estimated payback period (Table 3). The situation in the Republic of Poland is somewhat more optimistic, but for such purposes as the power supply of office computers, such a project cannot be considered economically feasible.
- If there are no programs in the country to support projects in the field of alternative energy for business in the form of financing programs, concessional loans or purchases from such stations, then their independent (voluntary) implementation is impractical. For example, before January 1st 2019, imported equipment for the creation of alternative power plants in Ukraine was exempt from VAT (in the amount of 20%) (Verkhovna Rada of Ukraine, n.d.).
- If there are no financial possibilities to provide R&D as well as facilities to produce elements (parts, components) of alternative power units in the country, the cost of equipment also increases due to logistics and margins in the supply chain.

Based on the above information, calculations as well as on all intermediary conclusions made, we came to the general conclusions:

Firstly, it is very difficult for a separate country that does not specialize in the production of equipment used in the generation of alternative energy (which Ukraine and the Republic of Poland are) to create the necessary scientific, technical, and, most importantly, financial base.

Secondly, it is very difficult to ensure honesty and social responsibility for all stakeholders in the energy sector while manually stimulating its individual links. As a result: intermediary enterprises receive government support (for example, exemption from VAT on imported equipment); household consumers and legal entities must pay an increased tariff for the use of electricity (thereby offsetting the "green" tariff); enterprises-producers of alternative energy equipment, which still exist in countries, do not receive support at all.

Finally, international cooperation can become the basis for the exchange of invaluable experience. For example, we see that Ukraine has more experience in the use of alternative sources in the form of biofuels (basically this is based on the activities of the agro-industrial complex), and the Republic of Poland - on solar and wind energy. Generation statistics by country confirm this (Figure 2).

Thus, we see the prospects for the development of alternative energy in chosen countries only in financial, economic and technological collaboration. Moreover, such a collaboration should be based on the following instruments:

1. *Common and parity formation of investment and venture funds.* Venture funds should be directed to finance the development of small developments carried out by independent participants and their teams. The activities of common investment funds should be aimed at financing green energy projects in both countries. This collaboration will create the foundation for free indie development and help businesses get financing without the need for bank lending or government incentives.

2. *State support in the field of alternative energy exclusively for manufacturers of components used for the production of equipment (assemblies, parts) for alternative energy* (solar panels, wind generators, inverters, controllers, wires, fasteners). For example, enterprises providing a closed production cycle of such equipment (including common Ukrainian-Polish enterprises) should be exempted from VAT, and the income tax may be contracted at a reduced rate. This encourages manufacturers to create new production facilities. In turn, it will require the creation of new jobs, increase the prestige of higher and secondary specialized education and, which is very important, reduce the price of equipment on the market.

3. *Project for the creation of non-volatile industrial complexes.* Farming, manufacturing, and service industries can be involved in this process. For example, it is possible to locate land for growing crops in Ukraine, and the production of finished products in the Republic of Poland. All energy requirements of such complexes should be exclusively alternative. The incentive mechanism may also include reduced VAT and corporate tax rates. Thus, the cost of their products will decrease, but selling them at average market prices will allow such complexes to compensate for the expenditures of alternative energy.

4. *Introduction of independent small alternative power plants,* which in essence will be a new type of business. Enterprises with a design capacity of 500-1000 kW can be deployed near large cities, enterprises, in the border zone. Such plants will be alternative energy suppliers, which will lead to increased competition in the industry.

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5. *In perspective. United Ukrainian-Polish energy network for alternative energy.* In the future, this will mean the independence of small alternative power plants from their location. Such power plants can be located in any part of the Republic of Poland or Ukraine. Thus, over time, the need for traditional power grids will disappear.

Thus, financial and economic collaboration in the field of alternative energy is a complex, multifaceted issue. At the same time, it opens up incredible opportunities for joint development. Moreover, its correct implementation will have a powerful socially responsible effect and make alternative energy in Ukraine and Poland truly sustainable.

CONCLUSIONS

Alternative energy today, more than ever, is relevant for the development of mankind. Climatic changes that lead to multiple natural disasters and changes in ecosystems. This, in turn, changes the conditions for doing business (often making it impractical), and leads to the need to relocate citizens to more favourable places (which changes the concentration of markets). All this translates into higher prices for products in some places and their shortages in others.

The war between Russia and Ukraine has had a major effect on the energy industry, underscoring the pressing need for energy diversification and independence. Traditional energy supply channels have been disrupted by the fighting, underscoring the risk of depending too heavily on a small number of energy sources. This circumstance emphasizes how crucial it is to create and fund alternative energy alternatives in order to help impacted regions' resilience and economic stability in addition to enhancing energy security.

Alternative energy today, despite a rather long history of its development, is in its infancy (at least in matters of full-fledged transition from traditional sources). This means that exploring the prospects and looking for opportunities to intensify activities in this area is extremely important.

At the same time, our research showed that raising the problems associated with the development of alternative energy to the rank of state leads to the following: projects are being implemented for a rather long time (the development strategy itself is too long, and the results of its implementation can be considered not so significant); it is necessary to look for manual methods of incentives for producers of alternative energy, which makes it less socially responsible for other stakeholders.

Based on this, we came to the conclusion that such projects should be implemented at the level of small and medium-sized businesses, which is more flexible and can be financially supported without the involvement of the state.

Systematizing the most common sources of alternative energy (existing and potential) and taking into account the statistics of the generation of alternative energy in Ukraine and the Republic of Poland, we came to the conclusion that such projects should be implemented primarily in wind, solar and biofuel energy.

A combination of the expert method, the Delphi method and statistical analysis, we came to the conclusion that the most versatile technologies for obtaining alternative energy in small and medium-sized businesses are solar panels and autonomous wind generators.

At the same time, further calculations showed that it was completely inexpedient for small and medium-sized businesses to invest in alternative energy exclusively for their own needs. Investing in a micro-project for alternative energy, such as an autonomous wind generator or solar panel, worth USD 1100-1500 with an output capacity of 1200-1300 watts (sufficient to power two computers), has a payback period of up to 18 years in Ukrainian contexts and up to 4 years in Polish contexts. Considering the close historical, economic, and cultural ties between Ukraine and the Republic of Poland, alongside their common strategic financial and economic interests, we propose implementing alternative energy projects through the Ukraine-Poland collaboration.

This collaboration should be realized through the following initiatives: the common and parity formation of investment and venture funds; state support for the production of components used in alternative energy equipment; the creation of non-volatile industrial complexes; the introduction of independent small alternative power plants; and the establishment of a united Ukrainian-Polish energy network for alternative energy, identified as a strategic perspective tool.

Such a collaboration is envisioned not only as a powerful driver for development in the field of alternative energy but also as having a beneficial effect on the environmental development of both countries. By formulating this scientific and practical task, it is possible to achieve socially responsible energy generation in the future, ensuring that alternative energy sources are economically justified and sustainable. The implementation of each of these tools is a separate scientific and practical task. Our future research will be devoted to solving these problems.

ADDITIONAL INFORMATION

AUTHOR CONTRIBUTIONS

All authors have contributed equally.

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CONFLICT OF INTEREST

The Authors declare that there is no conflict of interest.

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ФІНАНСОВІ ТА ЕКОНОМІЧНІ ПЕРСПЕКТИВИ СТВОРЕННЯ ПРОЄКТІВ ЗЕЛЕНОЇ ЕНЕРГІЇ В СПІВПРАЦІ УКРАЇНИ ТА ПОЛЬЩІ

У цій статті розглянуто економічні та фінансові переваги покращення міжнародної співпраці між Україною та Польщею в розвитку проєктів альтернативної енергетики. Проведено ретельну оцінку існуючих і перспективних технологій генерації відновлюваної енергії, використовуючи експертні, Делфі й статистичні методи для визначення найперспективніших та універсально застосовуваних рішень. Особливу увагу приділено розрахункові терміну окупності для маломасштабних проєктів зеленої енергії, зокрема в контексті малих підприємств. Результати узагальнені з баченням майбутньої українсько-польської співпраці в царині зеленої енергії та конкретних інструментів і процесів, які можуть сприяти успіхові співпраці.

У статті окреслено потенційний підхід, що включає ізоляцію співпраці між Україною та Польщею в царині зеленої енергетики, спираючись на створення інвестиційних і венчурних фондів, державну підтримку виробництва компонентів відновлюваної енергії й створення стабільних промислових комплексів. Крім того, згадані такі заходи, як незалежні малі альтернативні електростанції та ініціативи щодо розвитку українсько-польської спільної мережі альтернативної енергії.

Поточна війна між Україною та росією привернула увагу до нагальної потреби в енергетичній безпеці й диверсифікації, що робить співпрацю України та Польщі в проєктах зеленої енергетики ще більш важливою. Україна може мінімізувати свою залежність від постачання російської енергії, зосередившись на програмах відновлюваної енергії, тоді як Польща може інвестувати в сталу енергетику для підвищення регіональної стабільності й економічного прогресу. У статті зазначено, що продовження та розвиток ініціатив зеленої енергетики вимагає міжнародної співпраці. Надані детальні рекомендації щодо покращення фінансових, економічних і технологічних можливостей і відносин між Україною та Польщею.

Ключові слова: енергія, альтернативна енергія, проєкти, міжнародні проєкти, сталий розвиток, міжнародні економічні відносини

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