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Renewable Energy Investments in Poland: Goals, Socio-Economic Benefits, and Development Directions

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Abstract: Renewable energy sources (RES) will play a key role in the transition to clean energy. Financial and socio-economic benefits determine the investment management in these energy sources. This article aims to indicate current energy policy goals, present socio-economic benefits resulting from renewable energy investments, and review further development directions in Poland. The research was carried out using desk research, case studies, and literature review methods to provide a broader economic context for RES investments. The scope of the research included both the Polish and the European Union contexts. The authors examined the Polish objectives of investment in renewable energy contained in strategic, planning, and other legal documents compared to EU targets, reviewed possible investments in renewable energy, and indicated wind farms and photovoltaic investments as the most effective ones from the point of view of further development which aims to meet the EU's goals by 2030. The authors also demonstrated a wide range of socio-economic benefits based on literature reviews, analysis of policy documents, and regulations regarding the energy sector, and examined a specific example of investment implementation and identified the ecosystem of beneficiaries and their benefits.

Keywords: RES; investment management; RES socio-economic benefits; sustainable development goals; case study

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1. Introduction

In 2015, the United Nations (UN) adopted a resolution entitled Transforming our World: the 2030 Agenda for Sustainable Development. The document announced 17 Sustainable Development Goals (SDG) and 169 targets to achieve development in three dimensions, economic, social, and environmental, in a sustainable and integrated manner [1]. The development agenda is intended to serve as a common standard that involves actors at all levels, including governments, society, and the private sector. The adopted resolution launched an intense debate on the role and importance of business in and for society. Never before has there been so much pressure on corporations to contribute to sustainable development in the world [2]. The Polish perspective on actions for sustainable economic development is provided by the Strategy for Responsible Development, the main objective of which is "*Creating the conditions for an increase in the income of the Polish population while increasing cohesion in the social, economic, environmental, and territorial dimensions.*" [3].

Among the Sustainable Development Goals related to energy are Goal 7 and Goal 13. Goal 7 is to ensure affordable access to modern, sustainable, and stable energy sources for all [1]. According to Goal 7, access to clean fuels and technologies should be increased, and the use of renewable energy sources in buildings, transport, and industry should be increased. The achievement of this goal depends on several factors. It seems important to

increase public and private investment in energy. Therefore, it is advocated that attention should be paid to regulatory frameworks and innovative business models in transforming world energy systems [4]. Goal 13, although only indirectly addressing energy aspects, appears to be equally relevant. It points to the need for urgent action to address climate change and its impacts [5].

Renewable energy sources will play a key role in the context of climate change through the transition to clean energy [6,7], which, according to the European Commission's communication, should involve consumers and bring them tangible benefits. The use of renewable energy can not only contribute to the reduction of greenhouse gas emissions but also allow for a diversification of energy supply, improved energy efficiency, and reduced dependence on fossil fuel markets [8].

Investment decision-making for renewable energy projects is a complex process. This is due to the multidimensional impact of these investments, both for the investor and for the environment. The analysis of investment profitability usually includes an analysis of the financial efficiency of the selected project based on purely financial values. The modern view of economic efficiency considers a much broader spectrum of analysis. Not only are financial data from financial statements analysed, but also other dimensions of efficiency, which may include social, environmental, legal, and technical aspects [9]. This approach seems more suitable for the cost-effectiveness analyses of RES project implementation. The analysis of economic efficiency, considering non-financial and qualitative aspects, is definitely more complicated due to the difficulty of measuring the selected effects/costs, especially if there is a need to express them in monetary terms. Although most projects do not require valuation of these effects in monetary units, it seems crucial to identify all effects relevant to the project in order to make the best investment decision.

Taking this into account, the main aim of this article was to indicate current energy policy goals, present socio-economic benefits resulting from renewable energy investments, and review further development directions in Poland.

In detail, the aim was to indicate current energy policy goals in Poland and show the socio-economic benefits of renewable energy investments in Poland, both at the general social level and with the example of a specific investment carried out in the north-eastern part of the Greater Poland Voivodeship and the local community within this investment. Further, we aimed to identify an ecosystem of beneficiaries of this investment. Moreover, another aim was to try to review current and possible further investments in renewable energy sources in the Polish market and to indicate the chosen directions of changes in the management of investments in renewable energy sources so as to be able to meet the goals set in the EU.

The obtained results may constitute a starting point for further scientific discussion in the field of renewable energy. They can also be successfully used in business practice by company management boards. Our considerations also fulfil the goal of providing information to companies that are making certain decisions to adapt to upcoming changes and providing some recommendations regarding the research problem.

The further material is divided into several sections. The Section 2 presents the materials and methods used in the publication. The Section 3 reviews the literature on the goals and possible investments in renewable energy in Poland. The Section 4 describes the socio-economic benefits of investing in renewable energy projects. Section 5 presents a case study of the installation of a wind farm in Margonin, which is an interesting renewable energy project for the local community. Section 6 presents the Polish government's plans for the coming years. The article ends with a discussion and conclusions.

2. Materials and Methods

A variety of research methods were required to achieve the goals of the study. The methods used at different stages of the study are shown in Figure 1.

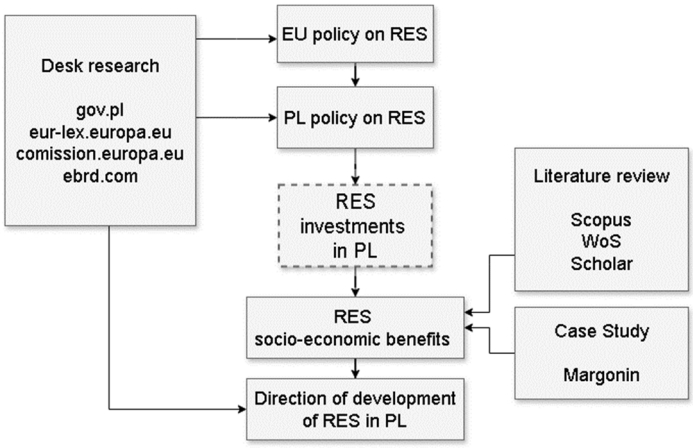

Figure 1. Research scheme.

The study used desk research, a literature review and a case study method. The desk research method was used to analyse the policy objectives for renewable energy sources at the Polish and European levels and to identify further directions for the development of renewable energy in Poland. It included a review of government documents, Eurostat statistics, scientific publications, national and international reports, and expert opinions from national and international institutions. Among the sites where policy documents, reports, and announcements are published, gov.pl, eur-lex.europa.eu, commission.europa.eu, and ebrd.eu were searched in the study. In addition, a narrative literature review was used to identify socio-economic benefits. The Scopus, WoS, and Google Scholar databases were used. The data and results obtained formed the basis for further considerations. The selected investment was analysed using the case study method. Investments were selected based on the criteria of investment value and completion.

The research results obtained using the case study method, although not based on quantitative predictions, may constitute an interesting starting point for future scientific discussion. The management boards of renewable energy investors, municipal and city authorities, and local communities can also use them. Our considerations also aim to provide information to businesses and households that need to make certain decisions well in advance to better adapt to upcoming changes.

3. Goals and Directions of Renewable Energy Investments in Poland

For many years, Poland has paid increasing attention to investments in renewable energy sources as an alternative to traditional ones that burn fossil fuels, which contribute to environmental pollution and climate change [10–13]. The future of renewable energy in Poland after 2020 seems promising due to the growing interest in this form of energy from both the state authorities, the public, and investors [14–16].

The basic directions of the Polish energy policy are: [17]:

(a) Energy efficiency improvement.
(b) Security of supply fuels and energy.
(c) Diversification of electricity generation by using nuclear energy.
(d) Renewable energy, including biofuels development.
(e) Competitive energy and fuel markets development.
(f) Influence of energy sector on environment limitation.

The main goals of the energy policy in the area of renewable energy are [17]:

(a) Increasing the use of renewable energy sources in final energy consumption.
(b) Increasing the share of biofuels and the use of second-generation biofuels.
(c) Protection of forests against over-exploitation for biomass production and sustainable exploitation of agricultural areas for the production of energy from renewable sources,

including biofuels, in order to avoid any competition between the production of renewable energy and agriculture, as well as to preserve environmental diversity.

(d) Use of existing government-owned weirs for hydropower production.

(e) Increasing the diversification of supply sources and creating favourable conditions for distributed electricity generation based on locally available resources.

The goal is to increase the share of energy from renewable sources in total energy production. In 2019, the share of energy from renewable sources was approximately 18% of the total energy production in Poland, and according to the Polish Energy Strategy, this share is expected to increase to 32% by 2040 [18]. The EU's ambitions were revised as part of the Fit for 55 regulatory packages [19]. The first proposal set a target of 40%. Finally, Directive 2023/2415/EU (RED III Directive) set the target for the share of renewable energy in gross final energy consumption in the EU at the level of 42.5% by 2030. Still, the implementation of RePowerEU [20] should contribute to increasing the share of renewable energy sources by an additional 2.5 percentage points, which is why the EU will strive for the level of 45%. The package aims to modernise existing legislation in line with the EU's 2030 climate target, which will help deliver the transformational changes needed in the economy, society, and industry to achieve climate neutrality by 2050 and, to support this, reduce net emissions by at least 55 per cent (compared to 1990) by 2030. To achieve this goal, it will be necessary to increase investments in wind farms, solar power plants, photovoltaic installations, hydroelectric power plants, biogas plants, biomass energy, and geothermal energy.

Investments in wind farms are crucial in achieving goals regarding the production of energy from renewable sources [21–25]. Wind is a clean and renewable energy source that can be used to produce electricity, especially in areas with high wind potential, such as coastal areas or mountainous regions. Currently, many wind farms operate in Poland, but there is potential for further development in this industry. New technologies allow the construction of increasingly larger wind turbines, which are more efficient and less harmful to the environment. The development of investments in wind farms contributes not only to increasing the production of energy from renewable sources but also to the creation of new jobs and the development of local communities. Investments in wind farm development in Poland face a challenging landscape leading up to 2050. Spatial constraints due to environmental objectives significantly impact the potential for wind farm siting, with environmental criteria and buffer zones affecting up to 99% of the country's area [26]. The current regulatory environment has resulted in a slowdown of onshore wind energy development, although there is an expectation for increased renewable energy production by 2030 [25]. Due to current regulations limiting the development of onshore wind farms in Poland, there will be an increased emphasis on using the wind energy potential in the Baltic Sea [27].

Investments in solar power plants and photovoltaic installations play an important role in the development of renewable energy in Poland [28–32]. The sun is an extremely abundant and free source of energy that can be converted into electricity using photovoltaic panels. Photovoltaic technology is constantly developing, becoming more and more effective and economical. Photovoltaic installations are installed both on a micro scale, e.g., on the roofs of private houses, and on a macro scale on large solar farms that occupy vast areas of land, most often located in rural areas. Increasing investment in solar power plants and photovoltaic installations allows for further reduction of CO_2 emissions and reduction of dependence on fossil fuels. Solar installations will play a significant role in the Polish energy mix, potentially covering approximately 26% of the country's demand for electricity at the currently calculated technical potential [33]. The developmental trend is anticipated to continue with the European Union's 2030 targets for renewable energy consumption and potentially beyond 2050 as part of low-carbon development strategies. Additionally, the grassroots development of photovoltaics driven by prosumer motivation and proactive investment in micro-installations has contributed to Poland's position as the fourth-fastest-growing PV market in Europe as of 2020 [31].

Hydroelectric power plants in Poland have theoretically great development potential [34–37]. There are many rivers and streams in the country that could potentially be used to produce electricity using hydroelectric power plants. Hydropower is clean, reliable and renewable, making hydropower an attractive alternative to traditional gas- or coal-fired power plants. In recent years, investments in hydropower plants in Poland have slowed down. This is primarily influenced by the legislative process and significant environmental restrictions. In addition to hydroelectric power plants, there are also pumped storage power plants that stabilise the operation of the power grid and supplement peak power. Pumped storage power plants have enormous potential, but they are not renewable energy sources. This infrastructure should be treated as an energy storage or grid stabiliser. Investments in hydropower in Poland could contribute to the use of the country's untapped technical potential, thus helping to achieve low-carbon energy goals and increasing energy security [38,39]. Investments in hydropower plants, including pumped storage plants, could mitigate the potential increase in energy prices due to the growing share of renewable energy sources [40].

Biogas plants producing biogas are a particularly interesting source of renewable energy [41–46]. After desulfurisation, biogas can be burned in cogeneration, generating electricity and heat. The advantage is the possibility of storing energy in biogas, which can be used for regulatory purposes and switching on cogeneration units during periods of peak energy load in the power grid. The main factors determining the small increase in installed capacity in biogas plants are high investment outlays and limitations, including the possible very long construction period of a biogas plant of up to 3 years. For this purpose, in July 2023, the Act on Facilitating the Preparation and Implementation of Investments in Agricultural Biogas plants, as well as their operation, was announced [47]. From an economic point of view, biogas offers additional added value because it enables the disposal of particularly harmful waste (e.g., animal excrement, landfill gas, and odours from sewage treatment plants). Depending on their location, biogas plants can provide electricity and heat (cogeneration process) and cold using absorption units. An alternative use of biogas is its purification into pure methane and subsequent injection into the gas network or liquefaction and its distribution in liquefied form (bioLNG) [48]. The potential for producing and using biogas in Poland is huge and interesting. The future of investments in biogas plants may be stimulated by new support programs, especially in the case of biogas production on a micro scale. The production and extensive use of agricultural biogas may constitute an important element of the energy transformation in Poland and be an important step towards achieving climate neutrality by the EU in 2050. For this to happen, appropriate legal opportunities and support systems must be created for agricultural biogas producers, as currently, Poland uses just over 4% of the estimated biogas production potential [49,50].

Biomass in Poland is used mainly in individual boilers in households for heating purposes and in large-scale systems mainly in cogeneration; it has the greatest potential to achieve the renewable energy goal in heating due to the availability of fuel and the technical and economic parameters of the installation [51–53]. From an economic point of view, the most advantageous use of biomass is in places of its high availability. The potential annual biomass and organic waste in Poland is estimated at approximately 245 PJ (5.9 Mtoe) [54]. From the perspective of 2030, the consumption of biomass for heat production must increase almost ten times [17].

The use of geothermal energy in Poland is still at a low level, although an upward trend is expected [55–58]. Currently, geothermal energy is most often used locally to supply heat to Aquaparks and several local heating networks. Determining the geothermal potential requires large financial outlays with a significant degree of uncertainty, but the use of this type of energy may have a positive impact on the development of renewable energy sources. It is possible that geothermal energy in Poland will become one of the stable renewable energy sources by 2050, especially taking into account the pressure from

the European Union in the field of renewable energy and the diversification of energy sources [17].

4. Socio-Economic Benefits of Investing in RES Projects

Climate change and the ever-increasing degradation of the environment require specific steps to reduce the impact of human activity in these areas. Sustainable ecological transformation is one of the significant challenges facing Europe. The European Union is pursuing measures for ecological transformation and sustainable development, inter alia, through the implementation of the European Green Deal (COM (2019) 640 final) [8]: a strategy that aims for Europe to achieve climate neutrality by 2050 boosting the economy through green technology and creating sustainable industry and transport (Figure 2).

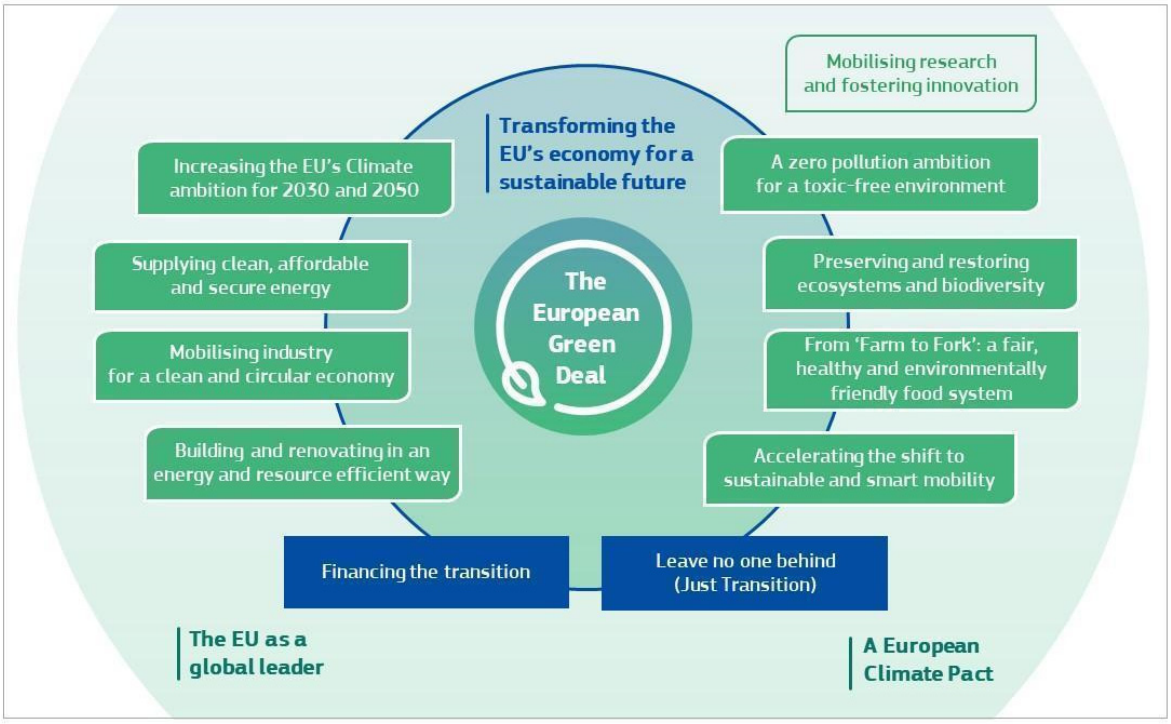

Figure 2. Key assumptions of the European Green Deal [8].

The basic elements of sustainability in energy policy are as follows: managing energy security, guaranteeing the continuity of energy supply, protecting the environment, guaranteeing the energy production potential and the use of domestic sources, energy efficiency, research and development, and supporting the development of renewable energy sources [59,60].

The economic, environmental, and social benefits of investments in renewable energy sources are underlined by a number of European Union (EU) directives, communications, and opinions. As an example of how important RES investments are for achieving climate goals and enhancing strategic energy autonomy, the European Economic and Social Committee (EESC) opinion "Renewable energy investments in the EU" is as follows: "*Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee, and the Committee of the Regions: An EU Strategy for Solar Energy*" (COM(2022) 221 final) [61] and "*Commission Recommendation on speeding up authorisation procedures for renewable energy projects and facilitating power purchase agreements*" (C(2022) 3219 final) [62] issued in October 2022. The EESC stresses that the EU should urgently increase the use of solar energy and European capacity in this field. It also points out that the environment for public and private investment should be improved and a business-friendly environment created, including adequate access to finance and a strong emphasis on research and innovation [61].

Numerous scientific studies [63,64] that present various aspects of renewable energy's role in socio-economic development confirm RES's importance and place in contemporary concepts of sustainable development of countries and regions. These studies confirm that the sustainable development model and its main assumptions will become a strategic element of the economic policy of the EU and its member states in the coming decades and that the greater use of renewable resources will improve both the quality of the environment and the quality of life of societies [65].

Many authors have attempted to identify socio-economic [66–69] and environmental benefits [70–72] using a variety of research methodologies. These studies mainly focus on the analysis of the multidimensional benefits of RES projects, most often associated with (1) CO_2 emission reductions, (2) fossil fuel savings, and (3) job creation.

For example, Ortega-Izquierdo and del Ri [73] applied an ex-post assessment of the benefits in terms of CO_2 emission reductions, fossil fuel avoidance, and job creation in the European Union between 2008 and 2016. They indicated that the benefits studied are significant and increased over the period studied. They also point out that the calculation of savings (in financial terms) on fossil fuels is twice as large as the benefits in terms of emission reductions CO_2 emission reductions. The significance of the benefits indicated varies from country to country.

In turn, Stigka et al. [74] conducted a literature review on the social acceptance of RES as a substitute for conventional fossil fuels in electricity generation and the use of the contingent valuation method (CVM) to assess social acceptance. The analysis yielded the following key findings: (1) the need for renewable energy production is emphasised by the simultaneous increase in energy demand and the harmful environmental impact of fossil fuels, (2) although renewable energy is becoming more widespread, it still represents a small fraction of the global energy mix, and (3) in areas facing economic challenges, investing in renewable energy could provide an economic boost. According to the authors, the use of renewable energy provides a balance between economic, technical, and environmental factors and promotes more sustainable development that will also benefit future generations. Similar conclusions are presented by Bhowmik et al. [75], who indicate that public acceptance is an important factor in the development of RES projects.

It should be noted that interest in RES solutions among energy consumers is growing [76,77]. This is exemplified by the results of the study by Chomać-Pierzecka et al. [78], according to which the high interest is due to increasing public awareness of energy sources and rising energy costs. As the authors point out, government policies supporting renewable energy can further strengthen this trend. Sestino [77], on the other hand, indicates that consumer interest in renewable energy solutions is growing due to environmental concerns, psychological benefits, and the willingness to pay more for green energy brands.

The benefits indicated are most often of an indirect nature for the investor, mainly affecting the environment and communities [79]. From an investor's point of view, the most important direct benefits of RES projects are the long-term savings resulting from the reduction of electricity costs due to the substitution of a specific energy source. High investment outlays can be partially compensated by various government support schemes, such as subsidies or tax breaks that reduce taxes for qualifying investors [80]. Such support allows for a faster return on investment, thus making it more profitable. In addition, the use of one's own energy source can reduce the risks associated with fluctuations in the prices of energy commodities such as coal, gas, or oil. By analysing the evolution of electricity prices in the domestic market, we can see how vulnerable they are to fluctuations (Figure 3).

The initial price increase in 2021 was due to the strong demand for electricity as a result of the recovery of the domestic economy. Natural gas supply disruptions in the EU caused a sharp price increase in the last quarter of 2021. In contrast, subsequent increases resulted from the Russian–Ukrainian war, increasing the average price for electricity in the Day-Ahead Market (DAM) market by 100% compared to 2021 prices [9]. Despite the fall in electricity market prices in 2023, end-user prices are not projected to return to pre-2022

levels, and further price increases are assumed over a multi-year horizon, which may have a positive impact on the profitability of RES projects.

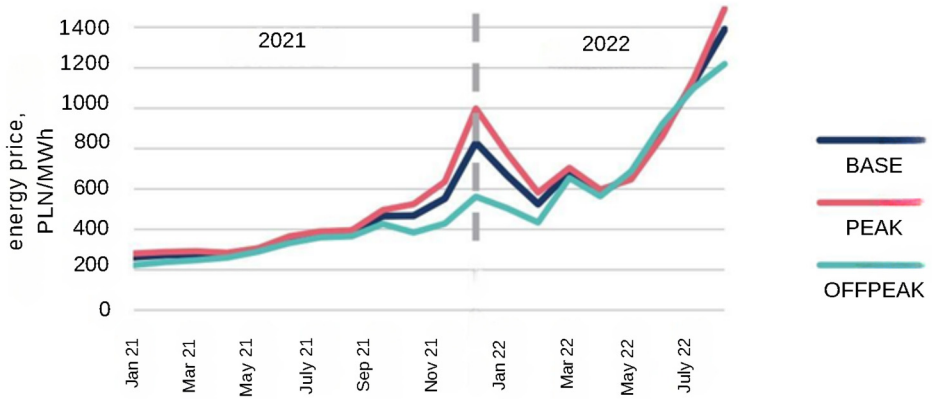

Figure 3. Average electricity prices on the DAM market, January 2021–August 2022 [81].

Further possible benefits for the investor resulting from RES investments are as follows [81]: (1) gain additional revenue in case of surplus energy produced, (2) increase energy efficiency, or (3) develop wasteland for investment.

In summary, the implementation of RES projects can have both a direct effect on the investor and an external effect that affects the investor's environment. The typical benefits are presented in Table 1.

Table 1. Typical benefits of RES projects.

Benefits	Type of Impact
Increasing and diversifying the energy supply to meet growing demand	Direct
Improving the security and reliability of the energy supply	Direct
Reduction in energy costs due to substitution of a specific energy source	Direct
Increasing energy efficiency	Direct
Possibility of developing a wasteland for investment	Direct
Changes in greenhouse gas emissions	External Effect
Changes in air pollutant emissions	External Effect
Creating a "green" image	External Effect

Source: Own elaboration based on [81,82].

In the next chapter, we will analyse an investment in renewable energy implemented in Poland, which is a wind farm with a total capacity of 120MW, and its effects on the local community. Further, the possibilities and directions for the development of renewable energy investments in Poland are described.

5. Case Study: Margonin Wind Farm

The analysed investment is the Margonin wind farm located in the north-eastern part of the Greater Poland Voivodeship, more precisely, in the Margonin commune. Construction of the farm began in 2009. The investor of the project is Relaks Wind Park Sp. z o. o., Warsaw, Poland, and the contractor and operator is EDP Renewables Polska Sp. z o. o., Warsaw, Poland. The power plant consists of a total of 60 wind turbines with a total capacity of 120 MW, which constitutes almost 50% of the capacity of wind farms operating in Poland. The power generated by the farm allows for the energy supply of 90,000 households [83].

The farm is divided into two areas where windmills are grouped. Each area covers an area of over 50 km^2. The Gamesa turbines installed at the Margonin power plant are placed on 100 m towers with 90 m-high blades. Each turbine has a total power of 2 MW. Assuming that the installation will operate 40% of the time during the year, energy production will amount to approximately 63,000 MWh, which will allow avoiding emissions of over

65,000 tons of CO_2 generated when generating the same amount of energy in a hard coal-fired installation.

The investment is valued at EUR 166 million. According to the tax website podatki.biz, the European Investment Bank has agreed to grant a loan of EUR 45 million. The remaining funds came from subsidies (including European Funds) and from the commune budget.

The Margonin wind farm is located outside the boundaries of nature and landscape protection areas, at a distance of over 6 km from the border of the "Natura 2000" bird habitat area.

As part of the pre-investment process, two series of ornithological observations were carried out in designated locations within the planned investment area and in its immediate vicinity. A total of 21 species of birds were observed on the Margonin Zachód wind farm, and 66 species on the Margonin Wschód wind farm. Most of these species were typical for other areas of Greater Poland. The most valuable ones observed were the common bittern (lxobrychus minutes), the white stork (ciconia ciconia) and the marsh harrier (cirrus aeruginosus). The results of the observations showed that the wind farm may affect two important habitats, namely Lake Oporzyńskie and Lake Margonińskie, as a result of which the investor modified the location of the wind farms to limit the negative impact of the investment on the bird population.

Similar observations were made in the context of bats present on the farm. Over 160 bats of the most characteristic species found in the Polish lowlands were observed then. Due to the fact that all species were classified as low risk in terms of population changes, there was no need to take significant conservation measures [83].

The project also has an impact on socio-economic issues in the Margonin commune. The construction of the Margonin wind farm did not require the displacement of people or enterprises. The land for the investment was acquired based on lease agreements signed with the owners of the area. Income tax saw a 10% increase in the commune's revenues due to the construction of the farm. The annual income of tenants and landowners also increased by approximately PLN 8000 per person per year. As part of the investment, the quality of local roads was improved by building and rebuilding a total of 10 km of roads. Moreover, the wind farm is a tourist attraction as one of the largest wind farms in Poland, which supports the development of the commune and creates new sources of income for its residents. Work related to the project also increased the security of the electricity supply to the commune, which created a more attractive environment for business development [83].

One of the biggest challenges faced when building a power plant is maintaining an acceptable level of noise emissions. The investor of the facility carried out an assessment of the noise levels emitted into the environment, which resulted in the creation of maps illustrating the acoustic climate of the power plant areas. The assessment results showed that the noise level did not exceed the level permitted for farm development areas, both during the day and at night.

Analysis of the Margonin wind farm shows that such investments can have a significant positive impact on various social, economic and environmental aspects, contributing both to increasing the share of renewable energy in the Polish energy mix and to promoting the sustainable development of local communities.

The investment not only contributed to the sustainable development of the energy industry in Poland but also had a significant impact on the socio-economic development of the region. Without the displacement of residents or companies, the investment generated profits for the commune, improved road infrastructure, and generated additional sources of income for local residents. Moreover, as one of the largest wind farms in Poland, it has become a tourist attraction, supporting the development of local businesses and contributing to the security of electricity supplies. The investment in the Margonin wind farm is an example of the successful integration of the development of energy infrastructure with environmental protection and support for the local community, which is a model for future renewable energy projects (Table 2).

Table 2. Selected effects of renewable energy investments based on the Margonin wind farm.

Element of the Renewable Energy Market	Source of Financing	Selected Effects of Renewable Energy Investment	Beneficiaries of Renewable Energy Investment
Margonin wind farm	European Investment Bank EU Funds Commune	Generated electricity for 243 thousand inhabitants Avoided emissions of over 65 thousand tons of CO_2—environmental improvement 10% increase in commune income due to income tax Increased income for leaseholders and landowners by c. PLN 8 k/year/person Improvement of the quality of approximately 10 km of local roads Tourist attraction—a new source of income for residents Security of energy supplies to the commune—increasing the attractiveness of the environment for business development Creation of acoustic climate maps for commune areas	Direct: Commune Indirect: Residents Entrepreneurs Tourists

Source: Own elaboration.

The results of the analysis indicate that investments in renewable energy sources not only built new facilities producing green energy, thus meeting the energy needs of many households and enterprises, but what is more, these investments contributed to the development of the local economy, tourism and road construction, which suggests that the investments create a kind of ecosystem of beneficiaries.

6. Directions of Development of Renewable Energy Investments in Poland Based on Document Updates to the National Energy and Climate Plan (NECP)

A very important document presenting the directions of the development of renewable energy investments in Poland is the "National Energy and Climate Plan (NECP)" (org. "Krajowy plan w dziedzinie energii i klimatu (KPEiK)") [84]. This is a key document both for the Polish energy sector and other sectors of the economy. Poland prepared a preliminary version of the NECP update, which was submitted to the European Commission on 1 March 2024 [85]. Broad consultations on the project will begin soon. The document submitted to the European Commission is a draft update of the National Energy and Climate Plan for 2021–2030 (National Energy and Climate Plan) from 2019 (the title "National Energy and Climate Plan until 2030" was used in the prepared update). This scenario reflects the current assessment of Poland's possible contribution to the implementation of the EU's climate and energy goals for 2030. The trajectory enabling Poland to achieve a greenhouse gas (GHG) emission reduction target at a level close to the EU level (i.e., 55%) will be presented in a more ambitious transformation scenario with additional measures (WAM), on which advanced work is underway at the Ministry of Climate and Environment. The target document containing two scenarios, base (WEM) and ambitious (WAM), will be

presented for full public consultations and sectoral arrangements, and then finalised at the turn of the second and third quarters of 2024.

After conducting forward-looking analyses, Poland declares to achieve a 29.8% share of renewable energy sources in gross final energy consumption by 2030, as a contribution to the implementation of the new EU-wide target for 2030. The implementation of this target will consist of the total consumption of renewable energy sources in the electricity, heating, and cooling sectors and for transport purposes. The share of renewable energy sources by 2030 is presented in Figures 4–7.

Most energy is used for heating purposes; therefore, the share of each percentage point of renewable energy in the power industry and transport in absolute terms constitutes a lower contribution to the overall goal. Forecasts indicate that the fastest changes will occur in the electricity sector, in which the share of renewable energy sources may reach 50.1% (8.3 Mtoe) in 2030 (Figure 8). The share of renewable energy in heating and cooling may amount to 32.1% (10.3 Mtoe), and in transport 17.7% (2.5 Mtoe).

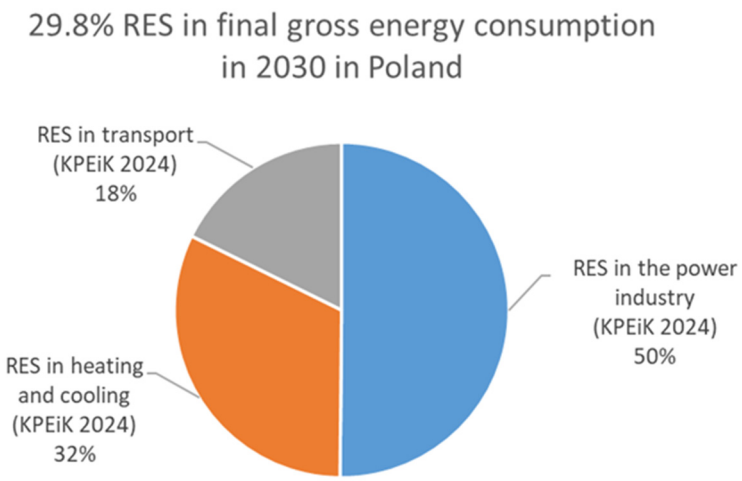

Figure 4. The share of renewable energy sources in final gross energy consumption in 2030 in Poland (based on [85]).

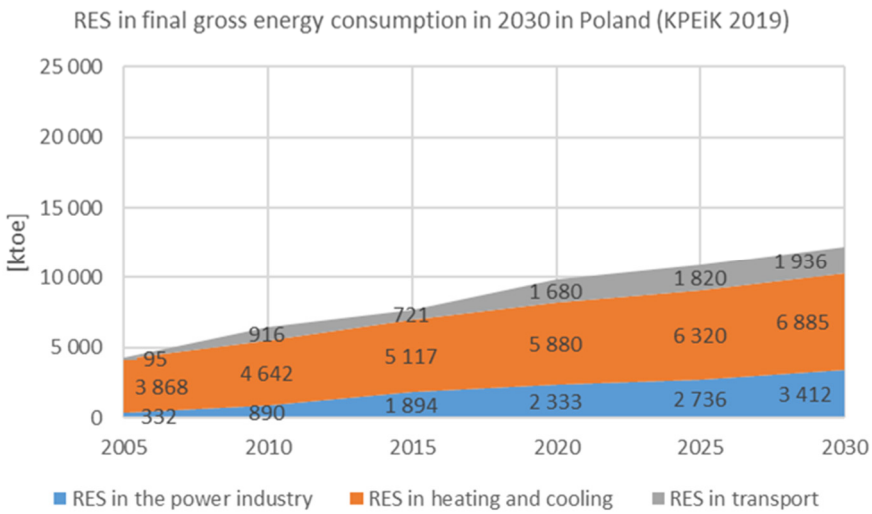

Figure 5. Renewable energy consumption in sectors and final energy consumption in Poland: KPEIK 2019 [85].

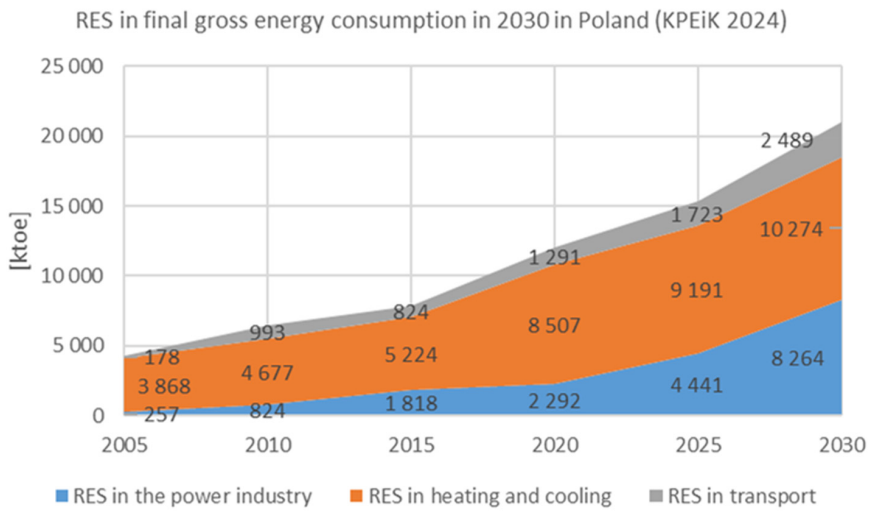

Figure 6. Renewable energy consumption in sectors and final energy consumption in Poland: KPEIK 2024 [85].

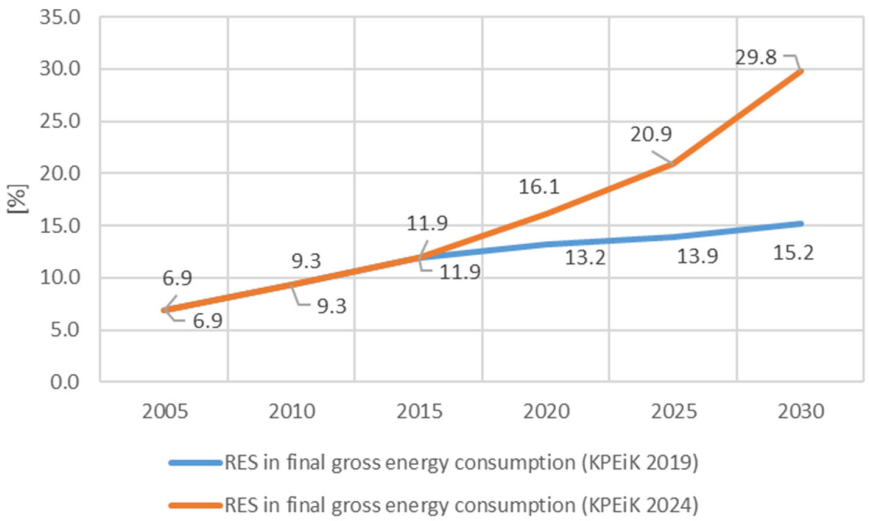

Figure 7. Renewable energy consumption in sectors and final energy consumption in Poland: KPEIK 2019, 2024 [85].

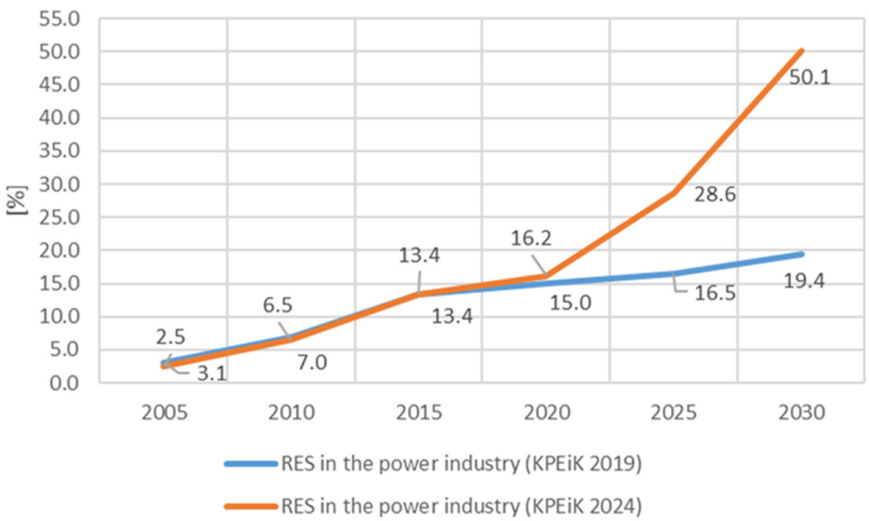

Figure 8. The share of renewable energy sources in energy consumption by 2030 [85].

In Poland, in the power sector in the years 2015–2023, there was an increase in renewable energy generation capacity from approximately 7.1 GW to over 28.8 GW, which accounted for approximately 90% of the newly installed capacity in the national power system (NPS). This is due to the growing popularity of solar and wind energy. Biomass and biogas power plants play a complementary role, and in the future, biomethane should constitute a large share. Biogas units could be an excellent complement to weather-dependent renewable energy sources, but they are characterised by high inputs and operating costs. Poland does not have significant hydrological potential that would allow for the significant role of run-of-river hydroelectric power plants. However, water energy can be used in pumped-storage power plants (they are not classified as renewable energy sources), which, while supporting the need to regulate the system in periods of favourable and unfavourable sunny and windy conditions, also constitute energy storage.

In Poland, by 2030, the increase in electricity production from renewable energy sources will be achieved to the greatest extent using wind farms located on land (with an installed capacity of approx. 15.8 GW) and at sea (approx. 5.9 GW) and using solar power plants (approx. 29.3 GW). Their launch is estimated for 2026. According to the plan, the increase in renewable energy in the power industry will be further increased thanks to biomass, biogas, and biomethane power plants, as well as hydroelectric power plants.

Heating and cooling accounts for around half of the energy consumption both at the EU level and in Poland. It covers a wide range of end-use applications and technologies in buildings, industry, and heating or cooling systems. The heating needs in Poland are largely covered by municipal heating systems, but also by individual installations. The main source of primary energy in both cases is hard coal. In 2021, Poland set the goal of phasing out coal from individual household heating by 2040 and in urban areas even by 2030. The goal is to ensure that by approximately 2040, all heating needs in the economy will be covered by system heat and low- and zero-emission individual sources. Poland has set a target for 2030 to achieve a 32.1% share of renewable energy in final energy consumption in heating and cooling (Figure 9).

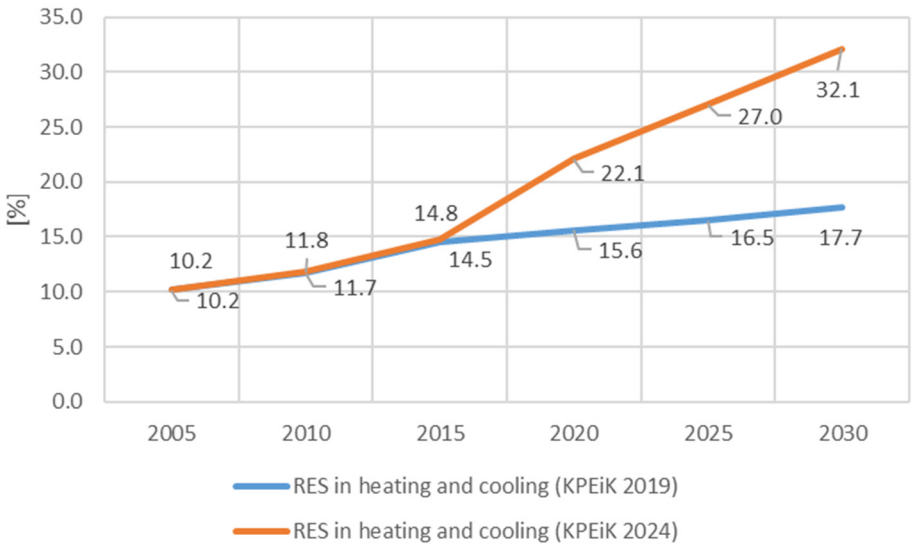

Figure 9. The share of renewable energy sources in energy consumption in heating and cooling by 2030 [85].

The transport sector (road passenger transport, road freight transport, maritime transport, air transport, and rail transport) currently uses mainly petroleum fuels. Due to the scale of use, the long life cycle of vehicles, and the need to provide appropriate infrastructure for introducing the energy carrier into the vehicle (e.g., electric charging or hydrogen refuelling), decarbonisation of transport is a big challenge.

The new targets set in RED III [86] oblige EU Member States to achieve a 29% share of renewable energy in final energy consumption in the transport sector or to reduce the greenhouse gas emission intensity of the transport sector by 14.5%. The implementation of decarbonisation goals in transport is to be achieved in particular by increasing the use of biofuels (especially second generation) and the development of alternative fuels (electromobility, hydrogen, and its derivatives, e.g., ammonia and synthetic fuels), as well as by increasing the efficiency of vehicles and increasing pedestrian and traffic cycling. According to forecasts, by 2030, the share of renewable energy sources in final energy consumption in transport may amount to 17.7% (Figure 10).

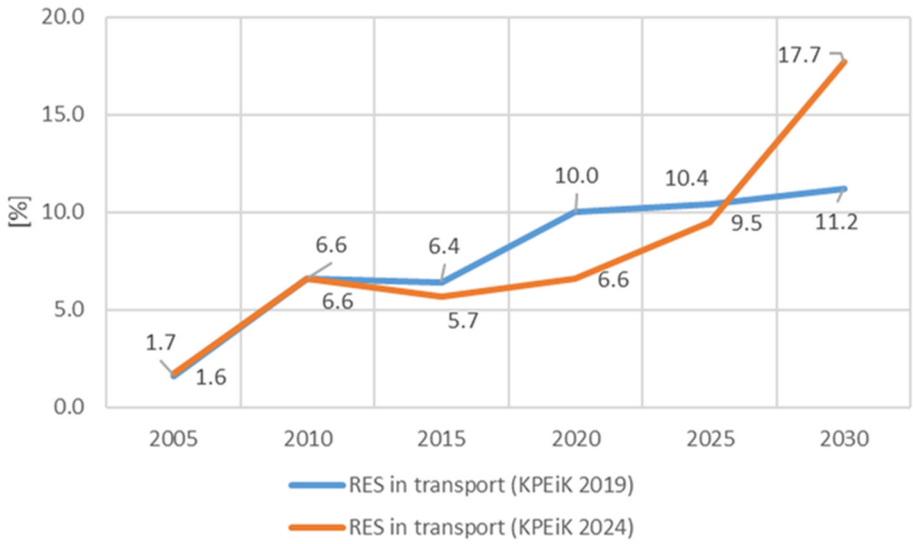

Figure 10. The share of renewable energy sources in transport energy consumption by 2030 [85].

Achieving the renewable energy target in transport, set at 29% in 2030, is assessed as impossible in Poland, and taking into account current statistics, it seems extremely difficult also in most EU countries.

7. Discussion

The goals of development for renewable energy investments in Poland are multifaceted, reflecting both the country's specific energy needs and the broader objectives set by the European Union. A key aspect of renewable energy utilisation in Poland involves achieving the EU energy policy targets. The European Commission determined in [87] that in recent years, investments related to the production of energy from renewable sources accounted for over 85% of all investments in electricity generation. This is a very large and decisive share. The introduction of further regulations should perpetuate this tendency. However, further support mechanisms will intensify this dependence.

In Poland, the enormous challenges facing the energy sector may be hindered by, among others, the increase in energy demand and insufficient and ageing energy infrastructure. However, a particularly interesting area for implementing renewable energy investments is the rural area, which accounts for over 90% of the country's area and is characterised by a significant degree of development diversification. The use of renewable energy sources in rural areas can contribute to reducing social differences, improving the level of economic development, and improving the quality of the natural environment [88–90].

An example of an investment in a rural area is the wind farm in Margonin, as analysed in this article. The investment contributed to the sustainable development of Poland but also had an impact on the socio-economic development of the region and the local community. Without the need to displace residents or companies, the investment contributed to an increase in the commune's income. Thanks to its implementation, road infrastructure was improved and residents' income sources were created. The wind farm has also become a

tourist attraction, supporting the development of local businesses. It contributed to the security of electricity supplies for enterprises while improving the quality of the business environment. We have shown, based on a specific examined example, who the direct and indirect beneficiaries of this investment are, we have named them, we have demonstrated these benefits in numbers, and we have shown that investments in renewable energy create an entire ecosystem of beneficiaries. These benefits, such as stable access to energy for entrepreneurs and enterprises, have a kind of multiplier effect because they create an attractive business environment and attract new investors to neighbouring communes. In turn, a wind farm as a tourist attraction attracts visitors and leads to the development of local businesses, e.g., gastronomy and other services. This investment is an example of a successful combination of energy infrastructure development with environmental protection and community support, which can serve as a model for similar projects in EU.

It should be noted that the effects of the selected RES solutions vary depending on the type of installation. When making investment decisions, it is important to consider all possible benefits of the chosen solutions, as well as the disadvantages and costs associated with the investment, including social costs. While small private investments mainly bring a number of benefits, other, especially larger investments, such as wind farms, may already be more controversial [91]. The effects of selected RES solutions may vary depending on the type of installation. Selected effects for solar and wind energy are shown in Table 3.

Table 3. Selected effects of wind and solar energy use.

Advantages	Disadvantages
Solar energy	
reduction in emissions—the ability to provide energy in the absence of emissions (or low levels) of air pollutants and greenhouse gases no waste ubiquity (possibility of local use) low operating costs improving energy self-sufficiency saving of fossil fuels no noise emissions no moving mechanical parts used for energy conversion easy integration of photovoltaics into the power system	diurnal and seasonal cyclicity of generated energy problems with storing more significant amounts of energy area intensity of the installation high cost of power equipment to ensure proper operation and cooperation of the installation with the grid
Wind energy	
no emissions no waste possibility to build on wasteland the cleanest and cheapest energy technology (taking into account the entire life cycle of equipment) saving of fossil fuels improving energy self-sufficiency possibility of installation throughout the country relatively short installation period	the need for suitable geographical conditions high investment high noise level threat to birds may affect the climate in their immediate region possible negative impact on tourist attractions of the area

Source: Based on [73,91–93].

As studies have shown, investments in RES can bring multidimensional direct and indirect benefits, creating an ecosystem of beneficiaries. Poland's set energy plans and targets may determine further RES development. However, there are still barriers that challenge the authorities. Currently, the following are indicated as the main barriers to renewable energy in Poland: limited possibilities for entrepreneurs to finance investments, legal support regulations, administrative and procedural difficulties, and problems with the functioning of transmission networks [94].

As shown in Section 6, the update of the government document entitled the "National Energy and Climate Plan (NECP)" [84] aims to further increase the amount and impor-

tance of investments in renewable energy in the near future. The goals and directions of development in renewable energy are updated on an ongoing basis, and the perspective is one-way—there is a significant increase in the share of renewable energy sources in the energy basket of the Polish economy. It is very encouraging that such decisions are made at the level of government policy. As shown in Section 3, the range of renewable energy investments in Poland is wide, and they are implemented on many levels.

8. Conclusions

To sum up, we can see the dynamic development of the renewable energy sector and the important role played by investments and financial support mechanisms, including the EU mechanism. Many institutions and enterprises are currently focusing on building renewable energy sources with significant capacities, which proves the growing interest in the topic in the country and society itself. However, the development of the market is not without challenges, such as competitiveness, changing regulations governing the activities of the renewable energy industry, and the need for a balanced approach to financing to avoid excessive dependence on external sources of support. In the context of development prospects, it is also important to take into account the environmental aspects of the renewable energy industry's activities and the need to ensure lasting and sustainable development of the sector, which is of key importance for achieving the goals of reducing greenhouse gas emissions and improving energy efficiency. Therefore, it is necessary to continue monitoring and analysing changes in the renewable energy market while striving to adopt development strategies that consider both the opportunities and challenges facing the renewable energy industry in Poland.

To summarise the above considerations, we can formulate the following research results:

1. Poland's goals are identical to the EU's goals.
2. Wind farm investments and photovoltaic investments are crucial; a mix of investments is needed to meet energy demand.
3. Pumped storage power plants have a regulatory function for the grid system, which is particularly important in the case of the use of wind and photovoltaic installations and the need to store surpluses of generated electricity during peak periods.
4. By analysing a specific example of a completed investment in renewable energy, it is possible to identify the entire ecosystem of beneficiaries of such an investment and their benefits.
5. Based on a not yet widely known document sent for approval to the European Commission on March 1, 2024, we present Polish assumptions and further plans to contribute to this European energy policy. These assumptions show that Poland declares to achieve a 29.8% share of renewable energy sources in gross final energy consumption by 2030 as a contribution to the implementation of the new EU-wide target for 2030. The most important element of this system will be wind farm energy sources.

This is why the results obtained by our research can serve as a starting point for further scientific discussion in the field of renewable energy. They can also be used in business practice by the management of enterprises considering investments in renewable energy. Our findings can also be used to provide information to companies and public authorities that are preparing to make certain decisions to adapt to the upcoming changes and to provide some recommendations on the subject.

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