energies

MDPI

Article

Energy Transition in Poland—Assessment of the Renewable Energy Sector

Michał Bernard Pietrzak [1,*], Bartłomiej Igliński [2], Wojciech Kujawski [2] and Paweł Iwański [2]

[1] Faculty of Economic Sciences and Management, Nicolaus Copernicus University in Toruń, Gagarina 11, 87-100 Toruń, Poland
[2] Faculty of Chemistry, Nicolaus Copernicus University in Toruń, Gagarina 11, 87-100 Toruń, Poland; iglinski@chem.umk.pl (B.I.); kujawski@chem.umk.pl (W.K.); piwanski@doktorant.umk.pl (P.I.)
* Correspondence: pietrzak.science@gmail.com

Abstract: The topic of the article considers the functioning of the renewable energy (RE) sector in Poland. This is really important in the context of the energy transition of the national economy because it influences the creation of modern technologies and increases the competitiveness and innovation of the country. Poland is in a process of energy transition where the RE sector has been developing for two decades. The authors aimed to research the RE sector improvement possibilities in Poland, including the influence of this sector on chosen social and economic aspects. Because of this research's aim a critical situation assessment of RE in Poland was conducted and a survey of a group of experts in this field was also involved. Legal, physical and mental determinants and their influence on RE sector were looked into. In the legal determinant context a necessity to simplify relevant legislation acts in Poland was found. Undoubtedly there is a need to improve several legal acts, including the Distance Act. In physical determinants it was found that solar, wind and biomass energy have the biggest chances for development. In the case of mental determinants the authors paid attention to the need of educating the public about using and obtaining energy. It is also important to make people aware how the RE sector influences the low emission economy positively. This will improve the creation of new jobs and reduce the emissions of harmful substances to the environment.

Keywords: energy transition; renewable energy sector; low-emission economy; decarbonization strategy; prosumers

Citation: Pietrzak, M.B.; Igliński, B.; Kujawski, W.; Iwański P. Energy Transition in Poland—Assessment of Renewable Energy Sector. *Energies* **2021**, *14*, 2046. https://doi.org/10.3390/en14082046

Academic Editor: Dario Padovan

Received: 10 March 2021
Accepted: 5 April 2021
Published: 7 April 2021

1. Introduction

The end of the twentieth century saw a dynamic development of globalization processes [1–3]. The changes caused by the progressing globalization mainly concern the increase in interdependence between economies, changes in the functioning of selected markets and institutional changes [4–8]. Undoubtedly, the globalization processes have led to systematic socio-economic development in most world economies, combined with a significant increase in the level of innovation, the level of investment outlays and the level of foreign direct investment [9–16]. Globalization processes have also contributed to the emergence of new lifestyles and consumption styles [17–20], which together with the increase in the wealth of the society and the level of innovation in enterprises contributed to the creation of the renewable energy (RE) sector, which is one of the fastest developing branches of the world economy [21–25]. Currently, there is a systematic increase in the RE sector in terms of production and research, which results in the increase of efficiency in sourcing RE and the decrease in the prices of RE sector installations, which simultaneously contributes to its further development. RE sector development is an impulse towards further research and introduction innovations.

The topics discussed in the article concern the energy transition in Poland, with

particular emphasis on the development of the RE sector. The subject is important from the point of view of Polish energy policy. In Poland, the current functioning of the energy sector is based on the use of coal. The functioning of the energy sector based on one dominant raw material in the form of coal is risky in many aspects. There is a threat of disruption to the supply of electricity from a technical point of view (black), there is a possibility of disruption to the raw material supply chain as a result of political and economic reasons in the world. There is also a probability that the use of this raw material in the energy sector will be negated by society because of its high health impact on the population and environmental degradation. This implies the need to carry out an energy transition in Poland towards building a strong RE sector and a transition to a low-carbon economy. In the case of energy transition processes, the issue of energy balance is important. Therefore, the country's energy policy should focus on the sustainable development of the RE sector in Poland. Actions should be taken to strengthen the development of different RE sources. In connection with geographical conditions in various regions of Poland, focus on the use of appropriate energy sources in such a way as to optimise the efficiency of their use. The inclusion of the energy balance issue in the energy policy also influences, through the sustainable development of renewable energy, a significantly higher level of investment, faster creation and transfer of innovations, faster commercialization of energy solutions and greater popularization of the RE idea in the society.

Poland is a country in which RE sector has been developing for a dozen or so years [26]. The wind power (aeroenergy) industry and combustion or joined co-combustion of solid biomass grew most rapidly till 2016. In 2016 the new law came into effect, limiting development of aeroenergy and co-combustion. Currently, photovoltaics (PV) is developing very fast. The number of energy prosumers is growing every month [27–31]. The total electrical installed capacity of all RE installations in Poland exceeds 9500 MW in 2020, however the distribution of these installations is not regular throughout the country. The highest power is generated by Zachodniopomorskie Voivodeship (1800 MW), and the lowest by Małopolskie Voivodeship (150 MW) (Figure 1) (according to the NUTS 2 classification, Poland is administratively divided into 16 voivodships).

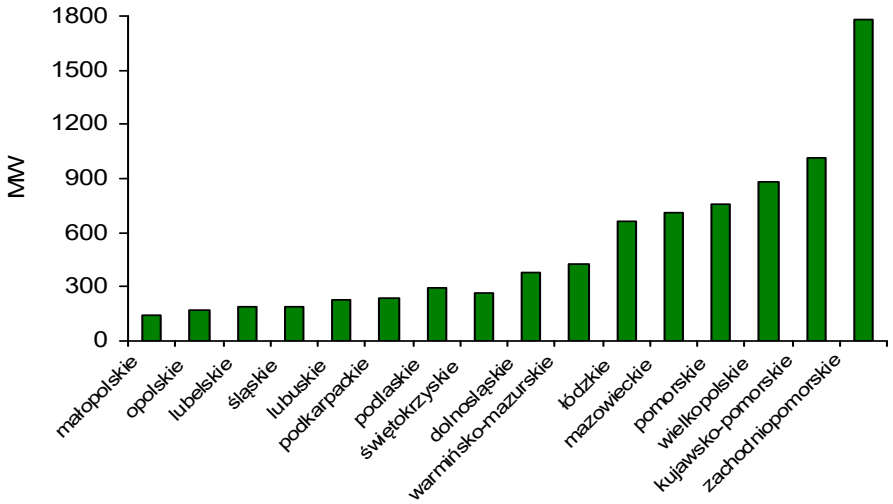

Figure 1. RE installations capacity in respective voivodships of Poland. Own elaboration based on data from [26].

Poland has high economic potential in RE, what is presented in Table 1 [32]. This means that there is a constant possibility for further development of this sector. It is worth emphasizing, that besides the RE production itself, an industry connected with RE is developing, which generates numerous economic advantages and job openings. Polish

investors, in spite of the bad legal conditions and the lack of investment support from the state and the complexity of the administrative process related to the launch and use of RE, present resourcefulness and engagement in building RE installations. Often their own ideas render the existing technology more efficiently. More and more investors develop two and more sources of RE, e.g., using biogas [32] and PV panels [33].

Table 1. Economic potential of RE sources in Poland [32].

Electricity Production	
Type of RE	**Economic potential**
Onshore wind energy	65 GW
Offshore wind energy	20 GW
Heat production	
Type of RE	**Economic potential**
Solar energy used for hot water storage	14,193 TJ
Deep geothermal energy	4200 TJ
Heat pumps	8167 TJ
Biomass use	
Type of RE	**Economic potential**
Solid biomass from plantations	5,918,052 tons
Straw	1,740,724 tons

The main goal of the article is to assess the possibilities of RE development in Poland, along with the potential of socio-economic consequences. The development of RE has three major determinants: physical, legal (institutional) and mental (society awareness). Mental determinant is derived from the society's assessment of RE in Poland. The physical determinant is created by geographical factors and the infrastructure that fosters RE sector made by society. Legal (institutional) determinant, in turn, comprises of two elements: the scope of the support of public and private institutions in the RE sector development and the extent to which administrative and legal regulations forester this development. In the article we will sequentially consider physical, legal and mental determinants according to their potential influence on RE sector development.

As part of this article, a survey was carried out among a group of experts in the field of RE in Poland. The survey was addressed to experts belonging to Facebook thematic groups related to the subject of RE. A significant part of the people who create expert groups on RE on Facebook are technical practitioners and work in the RE sector, as well as specialists in the field of RE installations and issues related to energy production and storage. Additionally, people belonging to expert thematic groups willingly engage in discussions among themselves, share their knowledge, observations and thoughts. In this way, experts broaden their knowledge of all possible factors for the development of the RE sector, including physical, institutional and social factors. The subsequent analysis of the experts' assessments obtained on the basis of the questionnaire survey made it possible to obtain knowledge about the state and prospects for the development of the RE sector in Poland, while taking into account institutional and social aspects.

The aim of the study was achieved on the basis of a critical analysis of literature studies on transition energy, an assessment of the current situation related to the functioning of the energy sector in Poland and an analysis of expert opinions on the development of the RE sector. As a result of the study, the possibilities for further development of the RE sector in Poland were assessed and which RE source has the greatest potential for development. The impact of the RE sector on the labor market and the development of low-emission economy in Poland were discussed. The main factors inhibiting the development of RE in Poland were also identified. It was also agreed what activities contribute to the development of the Polish renewable energy sector. In the case of selected inhibiting factors and activities, a detailed analysis of their potential impact on the de-

velopment of the RE sector was made, taking into account the institutional and social aspects.

2. The Results of a Surveys on the RE Sector—A Literature Overview

The results of surveys published in the research has been conducted on "a random" representative group. Social networking has not been used to carry such extended questionnaires concerning RE in Poland. In the presented survey a question has been posed concerning the actions that should be taken to boost the RE sector development together with place for respondents' comments and observations.

Bojnec and Papler [34] conducted surveys on the RE sector. The analysis showed that certain supplies of raw materials are very important in the RE technology. One should also not forget appropriate promotional activities that will increase the society's knowledge of the RE. Appropriate knowledge will allow for sustainable energy development. Education and promotion of RE is also very important in case of Poland. Education should be conducted from an early age, from kindergarten on. It is children who will influence adults' decisions. Educated children will demand the development of clean energy in the future.

The study by Hassan et al. [35] was aimed at assessing the attitudes of experts in the RE sector, and more specifically wood biomass in India. The operation and further development of a biomass power plant is associated with numerous problems both on a local and national scale. The further development of bio-power plants also means new opportunities for the further development of the RE sector [36]. The obtained results are a compendium of knowledge about RE in India. It can be used by energy engineers, politicians, as well as by parties interested in the development of RE in India and other countries. In Poland biomass is also a very important source of RE. Biomass was the first fuel used in Poland. It served and still serves as heating fuel, for cooking, as well as for the production of electricity. Forty eight (48) biomass power plants with a total capacity of 1364 MW are currently in operation in Poland. In addition, 33 power plants in Poland cofire solid biomass, and two power plants–biogas operate co-combustion with fossil fuels.

Shoaib and Ariaeatnam [37] examined whether the implementation of the RE programs leads to the improvement of the economic and social conditions of communities and ensures sustainable energy development [38]. The study presented by Alam et al. [39] examined the current state of RE in Malaysia, problems and further development prospects. One of the main problems is the lack of sufficient information on the RE, and the lack of knowledge is related to the reluctance towards RE. Another problem is the insufficient involvement of the private sector in the development of RE. Overcoming these problems will allow for the sustainable development of the RE. To this end, the government is launching small-scale projects that fail to raise public awareness. Education of the society is also important-for this purpose, universities introduce science about RE. Also in Poland, RE faces many barriers that need to be overcome in the near future.

Small hydropower (SHP) [40] makes it possible to meet the energy needs of the inhabitants of Nagqu in Tibet. In addition to the advantages, small hydropower also has disadvantages-power plants struggle with low use of installed power. Small hydropower also affects the local ecosystem. Small hydropower can be further developed in Tibet by meeting the appropriate environmental conditions, the need to implement an appropriate small hydropower sustainable development strategy. Due to numerous legislative and environmental conditions, small hydropower has developed rather poorly in Poland. The total capacity of the hydropower sector in Poland is 994 MW, and the number of small hydropowers is 746 [38].

The article by Muh et al. [41] presented that hydropower accounted for a large part of Cameroon's electricity needs. An "energy monopoly" situation has its drawbacks, as it reduces the country's energy security. Electricity outages are observed in rural areas and far away from power plants. The authors believe that a RE mix should be introduced in

Cameroon, i.e., not only hydropower, but also solar energy, wind energy and biomass. This will improve Cameroon's access to electricity. Also in Poland, the RE mix should be introduced and, additionally, energy storage.

Another study [42] analyzed the RE strategy in Pakistan. Much emphasis was placed on identifying solutions that would secure future energy supplies. four scenarios were analyzed. The first assumed "business as usual", the second the so-called "green Pakistan", the third one includes nuclear energy, while the fourth one is called "optimization". The result of the research is that RE technologies are the best solution, especially when operating costs are optimized.

Zyadin et al. [43] conducted a survey among farmers in two regions of Poland: in Silesia and in the Kuyavian-Pomeranian Voivodeship. The aim of the research was to determine whether there are surpluses of agricultural and forest biomass that could be used for energy purposes. The results of the surveys allowed for the preparation of GIS (Geographic Information System) maps of surplus biomass in the studied regions of Poland.

In Poland, in the IPSOS Group S.A. (IPSOS) survey conducted in 2014 [44], 80% of respondents considered the increase in RE production the best means to achieve energetic safety and independence of the country. A majority of Polish society (88%) considers the dependence on raw material imports from Russia a problem. The solution to the problem of energetic dependence on other countries is both the increase of energy production from renewable sources and the decrease in the consumption and energy losses (increasing the energy efficiency). Approximately 90% of Poles believe EU countries should set common binding aims to increase the participation in RE, and 89% believe it also to be true as far as the goals in decreasing consumption and wasting energy.

A survey titled "Poles on energy sources, energy policy and environment condition" [45] conducted by Centre for Public Opinion Research (CPOR) has shown that among all the energy sources, renewable sources of energy have gained the greatest trust (80%). Moreover, 89% of respondents believe that RE will allow to improve the natural environment condition, especially the air. As the CPOR has shown, those who declare the interest in investing in RE microinstallation for a house, are interested especially in generating energy for their own needs. Almost three quarters (72%) of them declare the need of generating heat, and 46% electric power. Every tenth person interested in prosument energy declared the intention of selling the energy to the network, at a "decent" price. As far as the heating source is concerned, those considering their own energy production decisively prefer solar collectors (76%), in the case of electric energy–PV installations selected (73%). 39% of respondents opt for the utilisation of both renewable and non-renewable sources of energy, while those supporting only conventional sources are a significant minority (5%).

In Poland, the subject of building a nuclear power plant has been brought up recently, with the Pomorskie Voivodeship to be one of the locations. For this reason, in 2016 Taylor Nelson Sofres has conducted a research: "The attitude of Pomorskie Voivodeship residents towards nuclear power" [46]. The respondents have been significantly seldom in favour of nuclear power development in Poland (18%), or energy technology based on hard and brown coal (12%). Almost three in four residents of Pomorskie Voivodeship (73%) believe that the energy policy based on raw materials and renewable sources should be especially developed in Poland. The need of energy and electric power conservation development lies second according to the respondents (40%).

3. Energy Policy of Poland

The Council of Ministers of the Polish government officially approved on 2 February 2021 the document "Poland's energy policy until 2040" [47], which is the formal basis for the development strategy for the fuel and energy sector.

The overriding goal of the country is to ensure energy security in such a way as to maintain the competitiveness of the economy. Important aspects are also: energy effi-

ciency and the lowest possible impact of energy on the natural environment. The energy transformation that will be carried out in Poland will be:

- just–will not leave anyone behind,
- participatory, carried locally, initiated from bottom up–everyone will be able to participate,
- focused on modernization and innovation–it is a plan for the future,
- stimulating economic development, efficiency and competitiveness–it will be the motor of economic development.

Poland's energy policy will be based on three main pillars: "Just transition", "zero-emission energy system" and "good air quality" [47]. In 2030, the share of coal in electricity production will not exceed 56%. In plans is increase in the share of RE in all sectors and technologies. In 2030, the share of RE in gross final energy consumption will be at least 23%—not less than 32% in electricity (mainly wind and PV)—28% in heating (increase by 1.1 pp per year)—14% in transport (with a large contribution of electromobility). Installed capacity of offshore wind energy will reach approximately 5.9 GW in 2030 and up to 11 GW in 2040. It is expected that the power of photovoltaics in Poland will reach 5–7 GW in 2030 and 10–16 GW in 2040. There will be energy efficiency, thanks to which primary energy consumption will decrease by 23%. Further fight against smog is planned-to this end, by 2040 individual customers will use the heat system or zero-emission heat sources.

The most anticipated energy technologies investment developments include:

- energy storage technologies
- smart metering and energy management systems
- electromobility and alternative fuels
- hydrogen technologies

The hydrogen market will be subject to development, supported by successive regulatory work and adjustment of support schemes for investment, research and development activities and the evolution of domestic technological resources [47].

4. Description of the Survey and the Group of Experts

In accordance with the adopted purpose of the article, a questionnaire study was first conducted, and then conclusions were drawn regarding the development of RE in Poland. For this aim, questionnaires were sent to specialists in the field of RE gathered in thematic groups on the Facebook platform. These are people who work in the RE, do research, or install the RE privately. Experts were asked to determine RE sector potential in Poland and assessment of development prospects of RE. The experts also pointed out what most inhibits the development of the RE sector in Poland. In the open part of the survey, experts sent their own suggestions about RE sector in Poland.

A survey research was carried from 1 May 2020 till 30 July 2020. The survey questionnaire was directed via Facebook at six thematic groups on RE subject:

- Group 1 "Renewable energy" [48];
- Group 2 "Renewable energy and energy efficiency" [49];
- Group 3 "100% renewable energy in Poland" [50];
- Group 4 "Passive house building" [51];
- Group 5 "Energetics and new technologies" [52];
- Group 6 "Fotovoltaics Hyde Park" [53].

Table 2 presents the questions from the survey questionnaire answered by the experts. The results of the survey were compiled using IBM SPSS Statistics, version 26 (IBM, New York, United States). Within the framework of the survey research 450 experts completed the questionnaire correctly. The experts have been asked whether they are employed in the RE sector (63.3% of people who answered stated that they were employed in the RE sector, whence for 38.5% it is the main employment, and for 24.8%

working in the RE sector is an additional workplace (Table 2, question 1 and Table 3). Additionally, 26.5% of answerers pointed out that they would like to work for the sector in the future.

Table 2. Questionnaire survey questions.

Questions	Description
Question 1	Do you work in the RE sector?
Question 2	Do you have a RE source in your household?
Question 3	Please indicate your gender.
Question 4	Please assess the size of RE resources in Poland.
Question 5	How do you assess the possibilities for further development of the RE sector in Poland?
Question 6	Which RE source has the greatest potential for development in Poland?
Question 7	Indicate the factors inhibiting the development of RE in Poland.
Question 8	How do you assess the impact of the RE sector on the labour market in Poland?
Question 9	How will the development of RE sector affect the development of a low-emission economy in Poland?
Question 10	Provide activities supporting the development of the renewable energy sector in Poland.
Question 11	What are your own observations about problems related to the RE sector in Poland?

Source: own elaboration.

High percentage of experts who own RE installations (46.2%) themselves or who intend to establish such installations in the future (38.4%) has been observed (Table 2, question 2 and Table 3). The gathered result show that the answerers not only have RE knowledge but also a considerable number of them is employed in RE sector, or even owns or plans to establish RE installations in their homes.

Table 3. Employment and possession of RE installations among the experts.

Employment in the RE Sector (Question 1)		Household Equipment with RE (Question 2)	
Answer	Percent	Answer	Percent
Yes	38.5	Yes	46.2
It is an additional job	24.8	I'm planning an installation in the near future	38.4
I am going to work in the RE sector	26.5	I'm not planning an installation in the near future	16.2

Source: own elaboration based on the conducted survey.

Among the participants of the study 58% were men and 42% women (Table 2, question 3). It has to be mentioned that the percentage of women is high. This means that women are equally interested in the subject of RE as men. For instance, on days of survey compilation in Group 3: "100% renewable energy in Poland" 47% of all Group members were women [50]. Additionally, it has to be pointed out that in Group 1: "Renewable energy" as much as 42% of women were employed in the RE sector. If we compare this to the mining sector, only 11% women are employed in the Polish mining industry. Additionally, women employed in mining work mainly at posts related with the mechanical processing of coal or administration. On the other hand, only 23.1% women work in conventional energetics [54]. This means that in the expert group with the knowledge of RE there is a higher percentage of women when compared with the conventional energetics sector. The authors of this paper believe that bearing the current world tendency in RE sector development the share of women may equal that of men. The RE sector is more

attractive to women than the conventional energy sector. Women are more sensitive to the environmental impact of energy, climate change and sustainable development. Women working in RE show independence and great creativity [55].

5. Results

5.1. Opportunities for the Development of the RE Sector in Poland

While Poland has great potential in RE, the question remains open about using this potential in the future and determining trends in RE development (Table 1). The experts commented on the opportunities for the development of RE sector in Poland. For this purpose, they assessed the potential RE sources, pointed out the main sources of RE, and enumerated the factors that hinder the further development of RE in Poland.

The experts assess the resources of RE in Poland as very large (26.5%), large (56.3%), and medium (15.7%) (Table 2, question 4 and Table 4). It should be emphasized that a small percentage of the experts specified the size of the resources of RE as small or very small (1.5%). Many countries have large potential of RE and think about energy transformation. Algeria, for example, is undergoing an energy transition. The area of the country has a significant potential of the RE, incl. solar energy, wind energy, geothermal energy, hydropower and bioenergy [56]. In Pakistan [57], attention was drawn to the possibility of obtaining waste biomass. For example, in 2018, the amount of only crop residues was as high as 40 million Mg. The estimated potential of bioenergy in Pakistan is 11 GW of capacity. This value is expected to increase to 16 GW in 2035. Australia is also striving to increase the share of RE in the energy mix. This is favored by the decreasing costs of RE installations, including distributed installations. In 2040, Australia wants to achieve a 94% share of RE in the energy mix. Nigiria [58], on the other hand, wants to achieve 100% RE thanks to solar farms and onshore wind farms.

Table 4. Resource assessment and possibilities for RE sector development RE sector in Poland.

Assessment of RE Resources in Poland (Question 4)		**Possibilities for RE Sector Development (Question 5)**	
Answer	Percent	Answer	Percent
Very large	26.5	Excellent	17.2
Large	56.3	Good	52.8
Medium	15.7	Average	14.1
Small	1.5	Poor	10.3
Very small	0	Very poor	5.6

Source: own elaboration based on the conducted survey.

Due to the high economic potential of RE in Poland, the experts then assessed the actual chances for this sector further development (see Table 2, question 5 and Table 4). As many as 70% of experts positively assess actual opportunities for the RE sector development in the near future (answers: excellent or good). Only 15.9% of people assess these possibilities as poor or very poor.

A survey "Poles on energy sources, energy policy and environment condition" [50] conducted by CPOR has shown that among all the energy sources, renewable sources of energy have gained the greatest trust (80%). Moreover, 89% of experts believe that RE will allow to improve the natural environment condition, especially the air.

The aim of the EU's efforts is to involve the local community in the energy transformation towards sustainable low-carbon energy. The authors [59] undertook the task of determining the participation of society in the energy transformation towards the RE in Europe. Surveys have shown that the society to a large extent is open to the energy transformation and wants to develop ecological energy sources. Moreover, the public is willing to co-finance RE investments. Co-financing of the RE by citizens will accelerate the energy transformation in Europe.

The experts have also assessed the actual development opportunities for selected RE sources in Poland according to them solar energy (60.6%), wind power (32.1%) and solid biomass processing (24.4%) have the greatest chances for development (see Table 2, question 6 and Table 5).

Table 5. RE sector development in Poland according to the experts.

Development Opportunities for Selected Resources of RE (Question 6)		Factors Hampering the RE Sector Development (Question 7)	
Answer	**Percent**	**Answer**	**Percent**
Solar energy	60.6	Strong lobby of conventional energy	55.5
Wind power	32.1	Complicated legal regulations	45.8
Solid biomass processing	24.4	High investment costs	33.9
Geothermal energy	12.8	Little public knowledge about RE	22.2
Hydropower	8.3	Low and variable price of green certificates	15.4
Energy mix	1.8	Disapproval of local authorities	2.4

Source: own elaboration based on the conducted survey (more than 1 answer was possible).

The views of experts are reflected in reality. The Polish PV sector is experiencing a real boom (Figure 2) [60,61]. Data for September 2020 indicate that the total PV power in Poland exceeded 3 GW [62]. Experts believe that by the end of 2021 this number will even double.

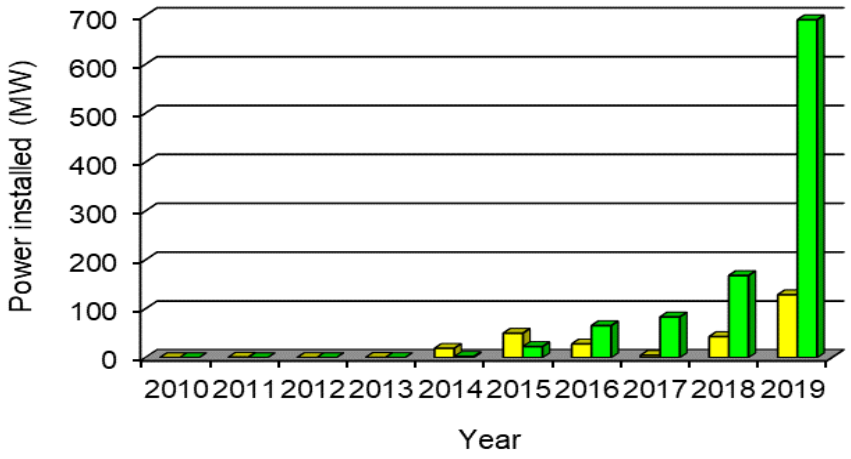

Figure 2. Power installed in a given year, light yellow colour–installations over 50 kW, green colour–micro installations. Own elaboration based on data from [61].

Helioenergy engineering, including PV in particular, is the fastest growing industry in the world (Figure 3) [63,64]. In 2019 alone, a 12% increase was achieved–115 GW of new capacity was installed. Total PV power is 627 GW. In 2019, as many as 18 countries installed at least 1 GW of new capacity. The greatest aggregate power can be found in China (over 200 GW), followed by the USA (almost 80 GW), Japan (over 60 GW) and Germany (50 GW).

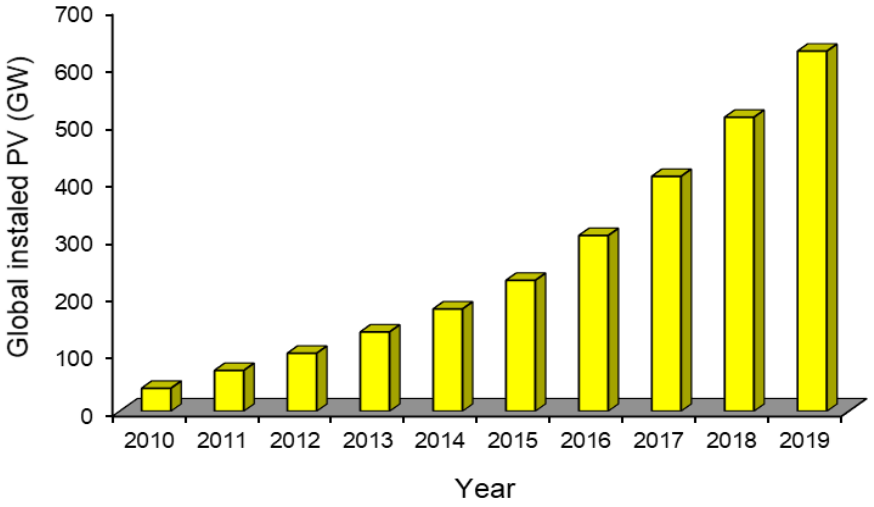

Figure 3. Global installed solar cell capacity (GW) in 2009–2019. Own elaboration based on data from [63].

For other RE sources, experts forecast much lower development chances (see Table 2, question 6 and Table 5). About 12.8% of experts indicated great chances for the development of geothermal energy, 8.3% of them for hydropower development, and 1.8% for the development of the energy mix based on RE sources. According to the experts, each type of RE should be developed in a sustainable way. In authors opinion, the world's RE has been developing in a sustainable manner for some time (Figure 4) [65]. For many years, hydropower was dominant, but recently wind and solar energy have played an increasingly important role.

Authors suggest that the choice of a given type of RE should be determined by local geographic conditions, investment budget, and spatial development plans. It should be emphasized that there are no genuine impediments in developing many types of RE in a given region at the same time. Table 6 shows the potential (energy mix) calculated for the Warmińsko-Mazurskie Voivodeship in Poland [66]. In 2019, 4 TWh of electricity and 12 PJ of heat were used in this Voivodeship. The calculated technical potential indicates that the Voivodeship could store excess electricity in energy storage facilities and electric cars. Warmińsko-Mazurskie Voivodeship may become a net exporter of electricity/energy carriers, such as hydrogen, in the near future.

The development of many types of energy can even trigger a synergy effect (e.g., solar farm-heat pump) and contribute to an even faster development of RE in a given region. Sustainable development of RE in Poland will certainly affect the energy security through diversification and decentralization of electricity production. In Poland, electricity is produced by several very large power plants [67]. In the event of failure of one of them, several hundred thousand houses may be deprived of electricity.

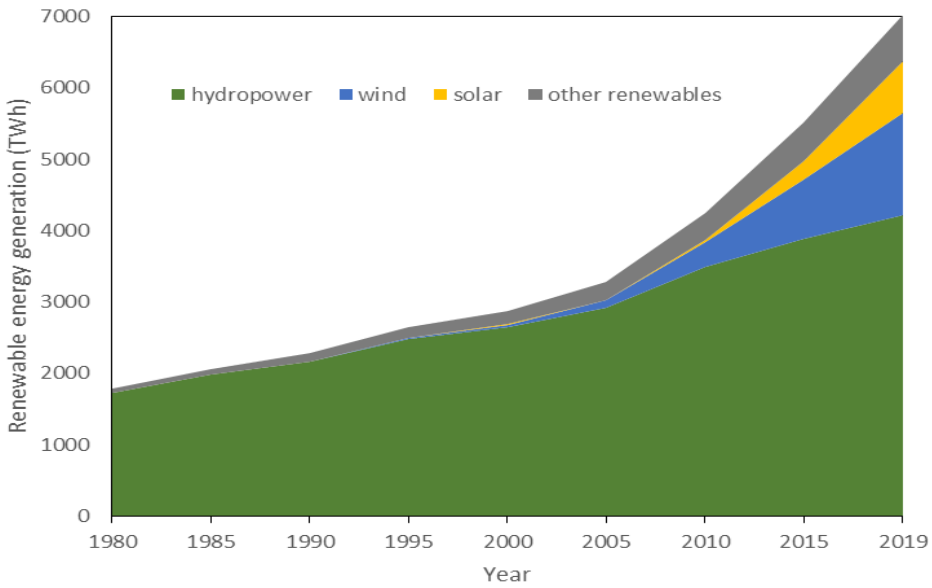

Figure 4. RE generation in the world. Own elaboration based on data from [64].

Table 6. The amounts of electricity and heat that can be obtained annually from RE in the Warmińsko-Mazurskie Voivodeship [65].

Resources of RE	The Amount of Electricity (TWh/year)	The Amount of Heat (PJ/year)
Bioenergy	2.54	14.99
Hydroenergy	0.14	
Aeroenergy	2.05	
Helioenergy	2.20	
Heat pumps		0.85
Total	6.93	15.84

Due to sudden atmospheric phenomena, resulting from climate change, blackouts are occurring more often in Poland. A similar failure of several wind farms (or another RE source) would not disturb the operation of the power system. Together with PV, biogas plants and biomass CHP plants form a dense "network" that provides greater energy security than a few large coal-fired power plants.

Following the experts' assessment of RE sources in Poland and the opportunities for its development, the experts were also asked about the main factors hampering the development of RE (see Table 2, question 7 and Table 5). Most experts indicated a negative impact from the conventional energy lobby (55.5%). Then, 45.8% of experts pointed to complicated legal regulations as a factor hampering the development of RE in Poland, 33.9% mentioned high investment costs, 22.2% indicated low public knowledge about RE and 15.4% mentioned the low and variable price of green certificates. The smallest number of experts pointed out to the local communities' protests as the hindering factor (2.4%). To sum up, experts share the view that RE resources in Poland are significant and there are great opportunities for further development of this sector.

In order for this to happen, it is first necessary to first limit the negative impact of the conventional energy lobby, whose influence can be seen in various subareas related to the development of RE. Many countries in the world have problems with coal and oil lobbies. There is also a strong coal lobby in other countries. For example, coal plays an important role in India's energy generation [68], despite the knowledge that burning fossil fuels has negative environmental and climate impacts. In India, as in Poland, there is an ongoing political debate about the withdrawal of coal from the energy sector and its effect on the energy transformation.

Experts think that regulations should also be simplified in Poland to a large extent. The law should be investor-friendly. RE regulations should be transparent and investor-friendly, not only in Poland, but also around the world. Many countries struggle with complex regulations. For example, in Ghana [69] it is considered that for the RE sector to thrive, major legal changes must be made to the RE sector.

Investment costs are also always too high for potential investors. It is necessary to introduce financial programs supporting investments in RE and tax remissions for RE investors in Poland. One of the forms of tax facilitation is the possibility of deduction of amounts invested in RE sources from the Personal Income Tax (PIT) by the investor. For example, in Spain [70] it has been shown that energy efficiency in homes can be "promoted" fiscally. The provisions on tax credits, real estate tax, tax on construction and infrastructure works should also be changed.

The experts emphasize that the favorable attitude of the local authorities towards RE investments is one of the conditions for the success of such an undertaking. In Poland, the acceptance of investments in RE sources at the level of municipal authorities is high. This is especially true of municipalities where similar investments already exist. Local authorities have a positive attitude to investments in RE, seeing them as opportunities for the economics and economic development of municipalities.

5.2. Impact of RE Sector on the Labor Market

The development of RE has undoubtedly a large impact on the labor market and the creation of new jobs [71–75]. It is estimated that about 50,000 people currently work in RE in Poland. In the world, this number has already exceeded 11.5 million (Figure 5) [75]. Moreover, 251 companies produce equipment for RE (Table 7) [76]. According to forecasts, in 2030 from 70,000 people [77] to up to 230,000 people [78] will be working in the RE sector in Poland.

In the conducted study, experts spoke about the impact of the of the sector development on the labor market in Poland (see Table 2, question 8 and Table 8). The vast majority of experts (86.2%) believe that the development of RE will positively affect new jobs in Poland. Only 11.5% of experts believe that the development of the RE sector will not affect the growth of new jobs and 2.3% are convinced of its negative impact on the labor market.

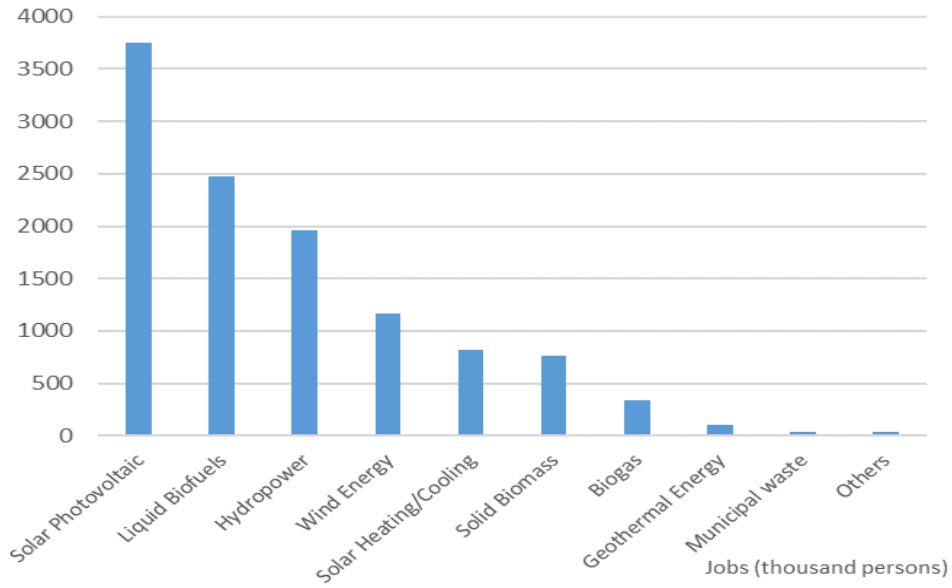

Figure 5. RE employment by technology in the world. Own elaboration based on data from [75].

Table 7. Number of enterprises producing RE equipment in Poland. Own elaboration based on data from [76].

RE Sector	Numbers of Firms
Biogas	123
Wind energy	40
Solar energy	36
Solid biomass	24
Liquid biofuels	11
Small hydropower	7
Heat pumps	6
PV	4
TOTAL	251

Table 8. Impact of RE development on the labor market and on a low-carbon economy in Poland.

Impact on the Labor Market (Question 8)		Impact on Development of a Low-Carbon Economy (Question 9)	
Answer	Percent	Answer	Percent
Very positive	14.6	Very positive	41.8
Positive	71.6	Positive	54.1
Neutral	11.5	Neutral	3.5
Negative	2.3	Negative	0.6

Source: own elaboration based on the conducted survey.

The development of RE technologies means new, well-paid jobs. A wind turbine technician in Poland can count on earnings of 150–200 PLN (1 Euro = 4.55 PLN) per hour. On the other hand, the field consultant or solar module salesman earns from 3000 to even 8000 PLN net per month. In the case of a RE installation designers, these can, depending on the complexity of the projects, earn as much as 5000, or even 10,000 PLN. However, the work is not easy. It is associated with frequent trips to the field, non-standard working hours, the need for continuous training and arduous creation of your own brand on the market [79,80]. This development also contributes to the creation of new jobs in sectors related to the RE. It is estimated that per 1 employee in the RE there are 2–3 places in related sectors: mainly industry, but also construction, services, etc. [81–85]. Experts believe that the development of RE industry is a great opportunity for Polish economy. If Poland will "sleep this period over", then in a few dozen of years we will have to import devices from other countries. When a favorable law is created (or at least not interfering) to low-energy constructions, prosumers, energy cooperatives and other future technologies; new companies will be created rapidly–providing well-paid jobs, and subsequently supplying their products and providing services to international markets [84]. According to the report of the International Renewable Energy Agency (IRENA) [75], 11.5 million people found employment in the global sector of RE sources in 2019. Many countries view RE sector as new, well-paid jobs. For example, in the Netherlands [85] finds that biomass and waste energy processing offer the highest employment per MWh, which benefits employment in (economically fragile) rural areas.

While analyzing the situation in other countries, the authors of the article [82] believe that the energy transformation towards the RE in the Netherlands will have a positive impact on the economy. It is estimated that several dozen new jobs will be created in the next decade. The energy transformation will ensure growth by 1% of gross domestic product. It is estimated that by 2050 the number of new jobs in the RE sector worldwide will triple. The energy transformation around the world will ensure energy security and dynamic development of the energy sector [83].

The experts also assessed the impact of RE development in Poland on the low-carbon economy (see Table 2, question 9 and Table 8). Most experts (95.9%) believe

that the development of RE will positively affect the development of a low-carbon economy in Poland, which will contribute to reduction of harmful emissions. Only 3.5% of experts believe that the development of RE will not affect the shape of the low-carbon economy. It should be noted that, in general, Polish society accepts the construction of a low-carbon economy. However, some Poles still believe that the RE is quite expensive, which may lead to an increase in energy prices, and thus an increase in the prices of consumer goods.

In other countries, it is believed as well that the development of RE will have a positive impact on the environment. RE will help to develop a low-emission economy that is environmentally friendly both in Poland and in the world. This is confirmed by Zeqiraj et al. [84]–stock market development fosters low carbon economy (LCE) through the channels of RE and technological innovation. To mitigate climate change, the EU implemented an energy policy strategy that encourages firms to implement sustainable, green energy systems. This could generate investment opportunities in energy efficiency and RE projects around the world for European mutual funds [85]. Research in the USA [85,86] reveals long-term cost and emission savings from bio-renewables, where the bulk of benefits are observed due to biofuels. Under a 40% CO_2 emissions reduction scenario over the next 40 years, penetration of bio-renewables promise up to 10 trillion USD savings in system costs (investments and operational).

5.3. Development of the RE Sector in Poland Factors

As part of the survey research, the experts also had the opportunity to present their opinions on the development of RE in Poland based on two open questions (see Table 2, question 10 and question 11). 351 experts responded to question 10 regarding actions to be taken for better RE sector development in Poland. The experts could name a few activities favoring the development of the RE. Additionally, 171 experts answered the question 11 regarding their own comments and insights concerning the development of RE in Poland. The share of participants of the study who answered open questions is high and amounts to 78% for the question 10 and 38% for the question 11, respectively. In the case of question 10, even though it was an open question, the experts' answers repeated in many ways. Therefore, the most frequently repeated types of responses were selected and along with the percentages are presented in the Table 9. In the case of question 11, the experts' responses were mainly descriptive. in this case, the authors referred critically to selected expert responses later in the text.

Table 9. Activities supporting the development of the RE sector in Poland.

Activities Supporting the Development of the RE (Question 10)	
Answer	**Percent**
Change of law in Poland	72.2
Educating the public about RE	42.4
Financial incentives and tax exemptions for RE investors in Poland	36.8
The necessity to develop prosumer energy	32.4
Dialogue with the coal lobby	30.6

Source: own elaboration based on the conducted survey. More than one answer was possible from the content of the open question.

Analyzing the answers to the question 10 on the measures to be taken to develop RE sector in Poland more, it can be said that 72.2% of experts are convinced that the laws in Poland should be changed. Some experts have admitted that they are willing to invest in RE, but are waiting for "normalization" of legal provisions.

Lots of experts (42.4%) indicated that society should be educated on RE. For many Poles, RE is still something new and unknown, so they approach it with respect or re-

luctance. In energy education, primary schools or even kindergartens play an important role. These educated pupils can then get very often the message across to their parents. People emphasize that the existing RE installations in Poland should also play an important role in educating the public. Most countries in the world struggle with the problem of developing the right political framework for the RE sector, as well as in terms of sustainable development. Seeing with one's own eyes how an agricultural biogas plant works will decrease the reluctance to accept this type of facilities. Moreover, several people believe that it is necessary to create "RE energy islands in Poland" that would have an educational function. In addition, experts have outlined the need to expand an educational offer for people who intend to work in the RE industry [87].

Also 36.8% of experts believe that there should be more financial incentives or tax exemptions for RE investors in Poland. Experts emphasize that it is not just about introducing very high subsidies, but rather about clear investment accounting principles, lack of problems with connecting to the electricity grid and access to the energy market. It is necessary to increase the propensity to invest in RE through the deduction of amounts invested in RE from PIT.

Many experts noticed the necessity of developing prosumer energy (32.4%). The popularity of prosumer energy, mainly PV, is constantly growing. Establishing an installation that exceeds their own needs, the prosumer should be able to resell energy. This would encourage households and small businesses to invest in RE.

Some 30.6% of experts point out that the strong coal lobby is an obstacle to the development of the RE sector in Poland. The coal lobby in Poland is openly opposed to the further development of the RE. The experts pointed out that the authorities should introduce a more restrictive policy towards energy waste and issuers of harmful substances. Coal mines should be gradually closed, while at the same time making it easier for miners to move to other professions (including the RE sector)

In the case of experts' answers to the open question 11 regarding their own observations about problems related to the RE sector in Poland (see Table 2, question 11). It should be stated that the most important problem for experts concerns improvement of legal regulations, including the act called "Distance Act" [88]. It is necessary to establish the actual distances from wind turbines, as current regulations are among the most restrictive in the world. The Act [88] is very restrictive-a wind turbine can be built at a distance of not less than 10 times its height from residential buildings, national parks, landscape parks or reserves. It should be emphasized that the location of a wind farm takes place only on the basis of a local spatial development plan, which significantly hampers their construction. In addition, taking into effect the "distance Act" in 2016 practically blocked the development of wind energy in Poland (Figure 6). So far, the aeroenergy increase amounted to 500–800 MW per year [26]. The record was broken in the first half of 2016, just before the distance Act took effect, when wind turbines with a total capacity of 1222 MW were erected. In turn, in 2018, the total power of wind turbines was only 6 MW. The experts state that, as a result of the "Distance Act" [88], they have observed the withdrawal of foreign RE investments. In other countries, for example in Germany [30,88], the distance between wind turbines and the so-called "sensitive" landscape elements, such as human settlements or bird nests is 1000 m.

Experts are confident that Poland should develop wind power at a much higher level offshore, where wind turbines work longer throughout the year and are far from residential buildings. At the end of 2018, the total capacity of offshore wind energy exceeded 23 GW. Northern Europe is in the lead, especially Germany and Great Britain. These two countries have the highest number of offshore wind turbines in operation. The largest wind farm, Hornsea Project One, with a capacity of over 1 GW, operates in Great Britain. At the initial investment stage, there is the Greater Changhua farm (2.4 GW) in Taiwan and the Dogger Bank one in Great Britain with a capacity of nearly 5 GW [89].

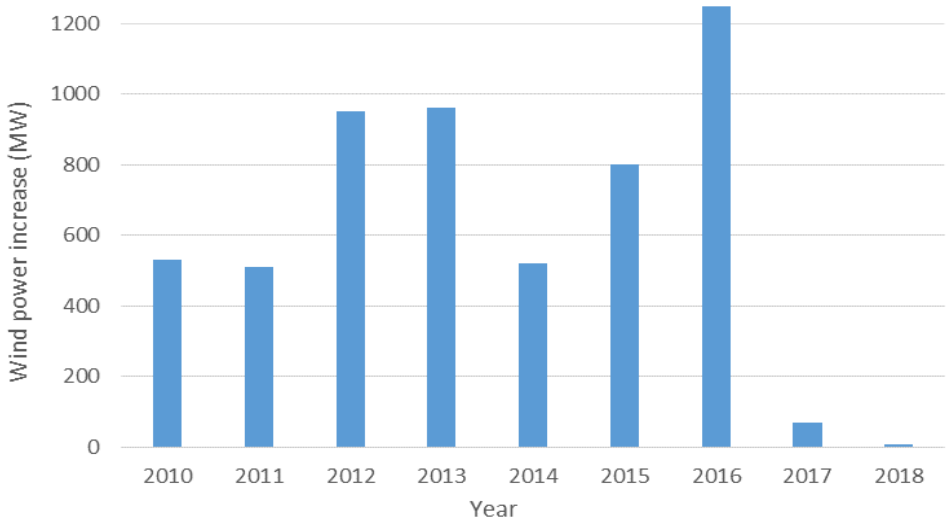

Figure 6. Aeroenergetics power increase in Poland. Own elaboration based on data from [26].

Experts also emphasize the problem of developing local, prosumer and municipal energy sources that are able to provide high-quality electricity, replacing central investments. A significant part of energy production (biogas, biomass, solar, etc.) will also be transferred to the agricultural areas, which will result in economic benefits [90–92]. Such energy production will also improve the quality of rural infrastructure and the quality of life. Poland as an agricultural country has a very high potential of waste biomass. These are waste from animal husbandry, food processing or expired food. This waste is an excellent substrate for methane fermentation in agricultural biogas plants. Sustainable development of the RE sector ensures energy security, as well as low energy prices, and thus consumer goods. Currently, there is a development of energy prosumers in Poland. It is influenced by lower and lower prices of RE installations, as well as increasing knowledge about climate change [93].

The experts also pointed that Poland has surpluses of unused energy at night and could this easily and in a relatively short time cause lower power consumption over time thanks to a change in the price tariff (the price should be lower than during the day, regardless of whether someone signed a night tariff contract, or not). In this respect, experts also show the problem of energy from renewable sources storage. It was emphasized that energy can be collected both in energy storage and electric cars. It is also possible to produce green hydrogen. For example, in study [94], hydrogen would also be produced at a much lower cost. RE produced by the prosumer allows you to achieve energy independence. The generated energy powers home appliances as well as the car. Such a system is beneficial for the environment as no greenhouse gases are emitted.

The experts think that the development of RE in Poland has a pejorative meaning according to a part of society. The RE sector should be combined with other sectors of economy, such as the construction, architectural or agricultural industries. The cooperation of RE-related activities with activities from these industries could result in a greater degree of promoting "green" solutions, which in turn will undoubtedly contribute to Poland's economic development. It is also necessary to intensify cooperation with other highly developed countries as part of RE development in Poland, which would significantly improve the current infrastructure associated with RE, as well as facilitate the introduction of new technologies in the future. Hybrid sources of RE are a continuation of the idea of a circular economy. RE devices should be made of recycled materials, which reduces the consumption of raw materials and generates less waste. It found that while such projects are initially expensive, they prove beneficial in the long run [95].

The experts also emphasize that educated and socially responsible citizens will create social pressure on political decision-makers who will create legal regulations beneficial not only for local communities, but also for global society, according to the motto: "act locally, think globally" [96].

The experts outlined the need to educate public about the negative impact of coal mining and coal burning on climate, natural environment and human health. Poland is at the forefront of Europe when it comes to air pollution and smog [97]. Smog is created mainly by burning of poor quality coal (sludge and coal fleets) in old furnaces [98].

6. Discussion and Recommendations

Poland is currently facing major challenges in the energy sector. This is due to the fact that the Polish economy is based on coal as the main energy source. At the same time, the electricity infrastructure is outdated and the use of coal-fired furnaces, which are widely used in heating, contributes to significant pollution and degradation of the natural environment. In the coming years, the Polish energy sector will have to undergo a real transformation towards a low-carbon economy, in which RE and energy efficiency will play a significant role. Mining regions are facing an energy transition. In the course of the energy transition, great emphasis must be placed on helping miners who work in coal mines-so that they can reorganise themselves and, for example, find work in the RE sector.

As highlighted earlier in this article, Poland is at the beginning of the energy transformation from coal energy to RE. Progress in the field of RE sources will have a positive impact on entrepreneurship and the competitiveness of the Polish economy. The increasing demand for equipment and installations will contribute to the development of local enterprises. These will be, to some extent, innovative products, which in turn will have a positive impact on the competitiveness of the Polish economy. Moreover, an increased inflow of foreign investments to the Polish market is possible, especially those related to the production of the necessary infrastructure and in the field of research and development. This, in turn, may contribute to the improvement of Poland's balance of payments thanks to the possibility of exporting devices to other countries.

It should be stressed that the energy transition processes in Poland are very strongly influenced by institutional factors, including legislation. As part of the issue of development of RE in Poland, the need should be indicated the simplification of regulations. Better regulation should contribute to greater economic efficiency of investments and reduce the level of current bureaucracy. Currently, the investor is struggling with many documents, permits, and in fact a significant part of them can be reduced or even eliminated. The law should be investor and prosumer-friendly. Moreover, officials should be competent and help in the implementation of investments. Additionally, the Act on RE sources [84] is very frquently amended, which has led to chaos in the RE market in Poland.

One of the main problems of related to the RE sector in Poland is development of the prosumer energy market**.** Prosumer energy is very important in process of energy transition, which has recently been developing in Poland. It is a very clean, ecological solution. In addition, the prospect of free electricity from solar energy, energy independence, but also additional income is very attractive. The number of prosumers using PV is constantly increasing (Figure 7). It is estimated that in 2019 the prosumer energy capacity in Poland exceeded 1 GW [99]. Each prosumer is part of the framework of low-emission energy, as if it is a "cell" of energy transformation. The prosumer also has measurable financial benefits-he has his own energy, and the surplus of it can be used to charge an electric car. An electric car is also an energy store [93] An important positive aspect of the new regulations is the introduction of prosumer definition in the RE Act [80]. This definition is intended to expand the group of entities that will be able to use the preferential billing system in the form of discounts, as well as additional administrative preferences at the investment and operational stage. Under the latest amendment to the Act [80],

prosumer preferences at the investment stage and the system of discounts provided can be used not only by households, but also by other types of entities, such as schools, churches, housing communities, etc. However, they must have a comprehensive contract, which in this case should be considered a disadvantage of the amendment. Moreover, currently the definition of a prosumer in Poland does not include entrepreneurs who would like to install a micro-installation in their company and use the discounts. The EU policy takes into account the RE prosumers in each member state. The authors [100] compared several European countries to reveal the main challenges and opportunities for prosumers. The most favorable conditions for prosumers exist in Great Britain, Germany, France and the Netherlands.

Wind energy is an important element of the energy transformation. However, poorly installed turbines have a negative impact on people, animals and the landscape. In Germany, the government plans to ban the placement of new wind farms within 1000 m of buildings. Introducing a clear boundary for the construction of new wind farms by indicating the distance of their location is to increase social acceptance for such installations.

It should be stressed that energy transition processes also have a very important social impact. The changes in the social dimension are related to many aspects. Energy availability has a direct impact on employment opportunities and poverty. As fossil fuels as a raw material in the economy become less and less profitable, holding on to them also results in negative phenomena in the labour sphere. This can be seen, for example, in the case of mines, which in many cases are no longer profitable. The lack of a good economic balance sheet often means job cuts in many sectors. In this context, a switch to alternative energy sources would stimulate the creation of many new jobs and the growth of the labour market in high-technology and high-performance industries. Investing in green RE technologies such as solar, wind, incineration or biocomposting of household and agricultural waste creates more jobs than comparable investments in the conventional energy sector.

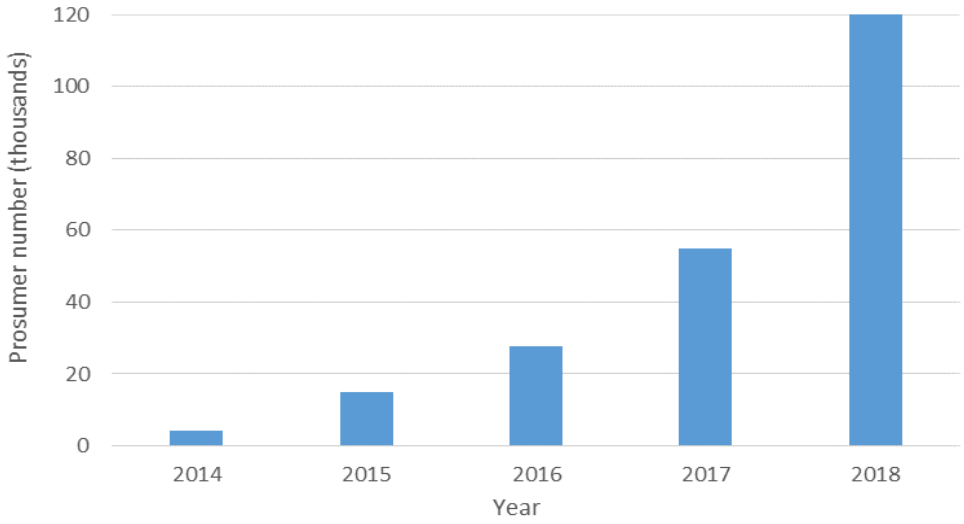

Figure 7. Number of prosumer PV installations in Poland 2012–2019. Own elaboration based on data from [101].

Based on the expert's assessment and available knowledge about RE in Poland the authors of the article postulate the following recommendations:

- Education of the public about RE starting at the kindergarten stage;

- Dialogue with politicians for faster development of the RE in the region and throughout Poland;
- Dialogue with the coal lobby;
- Ensuring job for miners from closed mines, eg in the RE sector in Poland;
- Simplification of the law, including the RE Act in Poland;
- Softening of the "Distance Act";
- Increased co-financing for RE installations as solutions enabling the fight against smog in Poland;
- Faster development of prosumer energy in Poland;
- Sustainable development of all types of RE in Poland;
- Supporting Polish companies in the RE sector.

7. Conclusions

The article deals with subject concerning the RE sector development in Poland. RE plays an increasingly important role in the Polish economy. That is why it is important to understand what is the current state of the RE market and what is the attitude of government authorities, local authorities, entrepreneurs and citizens towards RE. In connection with the subject, the condition of the RE sector in Poland was first discussed. In order to expand the current state of research, a survey was conducted which was directed at a targeted group of RE experts in Poland.

The conducted survey allows us to draw conclusions regarding the evaluation of the development of the RE sector in Poland. The experts pointed mainly to the fact that the potential of RE resources in Poland is large, which indicates actual opportunities for further development of RE sector. The experts have assessed the actual development opportunities for selected RE sources in Poland. According to them, solar energy, wind power and solid biomass processing have the greatest chances for development. The experts think that the coal lobby is the main reason for the slow development of RE in Poland. The vast majority of experts believe that the development of RE in Poland will positively affect low-carbon economy, which will translate into the creation of new jobs and the reduction of harmful substances to the environment.

As a hindrance in the development of RE in Poland experts mentioned four main factors: complicated legal regulations, high investment costs, and insufficient knowledge about RE among society and a negative impact of the conventional coal-based energy lobby. Education, including practical examples of RE installations, is necessary to overcome the obstacles faced by RE in Poland. Besides the low level of RE knowledge in Poland, the paper also emphasizes the pejorative meaning of the RE subject in the assessment of a part of society. Therefore, it is necessary to work social and decision-makers' mentality, so that the source of energy in harmony with nature and the long-term benefits of RE become a priority in energy development.

Experts indicate that prosumer energy has been growing rapidly in recent years in Poland. The capacity of PV micro installations in Poland in 2019 exceeded 1 GW. For prosumers in Poland, the prospect of free electricity from solar energy, energy independence, but also additional income is very attractive. Polish RE sector is being succesfully developed, mainly by prosumers. It is important for the professional power industry to develop the RE sector to a greater extent. The development of RE in Poland will protect the environment, less waste will be produced, and air quality will improve. The latter is particularly important because Poland has a big problem with smog, mainly during the heating period. The development of RE technology will allow the public to effectively fight smog in Poland.

Author Contributions: Conceptualization, M.B.P. and B.I.; methodology, M.B.P. and B.I.; software, M.B.P. and B.I.; validation, M.B.P. and B.I.; formal analysis, M.B.P. and B.I.; investigation, M.B.P., B.I., W.K., P.I.; resources, M.B.P., B.I., W.K., P.I.; data curation, M.B.P. and B.I.; writing—original draft preparation, M.B.P. and B.I.; writing—review and editing, M.B.P., B.I., W.K., P.I.; visualiza-

tion, M.B.P., B.I., W.K., P.I.; supervision, M.B.P. and B.I.; project administration M.B.P. and B.I. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data available on request due to restrictions. The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Dreher, A. Does globalization affect growth? Evidence from a new index of globalization. *Appl. Econ.* **2006**, *38*, 1091–1110, doi:10.1080/00036840500392078.
2. Sánchez-López, C.; Aceytuno, M.T.; De Paz-Bañez, M.A. Inequality and globalisation: Analysis of European countries. *Econ. Sociol.* **2019**, *12*, 84–100, doi:10.14254/2071-789X.2019/12-4/5.
3. Skare, M.; Porada-Rochoń, M. Financial and economic development link in transitional economies: A spectral Granger causality analysis 1991–2017. *Oecon. Copernic.* **2019**, *10*, 7–35, doi:10.24136/oc.2019.001.
4. Pietrzak, M.B.; Fałdziński, M.; Balcerzak, A.P.; Meluzín, T.; Zinecker, M. Short-term Shocks and Long-term Relationships of Interdependencies Among Central European Capital Markets. *Econ. Sociol.* **2017**, *10*, 61–77, doi:10.14254/2071-789X.2017/10-1/5.
5. Gygli, S.; Haelg, F.; Potrafke, N.; Sturm, J.E. The KOF globalisation index—Revisited. *Rev. Int. Organ.* **2019**, *14*, 543–574, doi:10.1007/s11558-019-09344-2.
6. Dias, R.; Teixeira, N.; Machova, V.; Pardal, P.; Horak, J.; Vochozka, M. Random walks and market efficiency tests: Evidence on US, Chinese and European capital markets within the context of the global Covid-19 pandemic. *Oecon. Copernic.* **2020**, *11*, 585–608, doi:10.24136/oc.2020.024.
7. Balcerzak, A.P.; Pietrzak, M.B. Quality of Institutions for Knowledge-based Economy within New Institutional Economics Framework. Multiple Criteria Decision Analysis for European Countries in the Years 2000–2013. *Econ. Sociol.* **2016**, *9*, 66–81, doi:10.14254/2071-789X.2016/9-4/4.
8. Balcerzak, A.P. Quality of institutions in the European Union countries. Application of TOPSIS based on entropy measure for objective weighting. *Acta Polytech. Hung.* **2020**, *17*, 101–122, doi:10.12700/aph.17.1.2020.1.6.
9. Cieślik, A.; Hien Tran, G. Determinants of outward FDI from emerging economies. *Equilib. Q. J. Econ. Econ. Policy* **2019**, *14*, 209–231, doi:10.24136/eq.2019.010.
10. Simionescu, M.; Lazányi, K.; Sopková, G.; Dobeš, K.; Balcerzak, A.P. Determinants of economic growth in V4 Countries and Romania. *J. Compet.* **2017**, *9*, 103–113, doi:10.7441/joc.2017.01.07.
11. Szopik-Depczyńska, K.; Kędzierska-Szczepaniak, A.; Szczepaniak, K.; Cheba, K.; Gajda, W.; Ioppolo, G. Innovation in sustainable development: An investigation of the EU context using 2030 agenda indicators. *Land Use Policy* **2018**, *79*, 251–262, doi:10.1016/j.landusepol.2018.08.004.
12. Szopik-Depczyńska, K.; Cheba, K.; Bąk, I.; Stajniak, M.; Simboli, A.; Ioppolo, G. The study of relationship in a hierarchical structure of EU sustainable development indicators. *Ecol. Indic.* **2018**, *90*, 120–131, doi:10.1016/j.ecolind.2018.03.002.
13. Thalassinos, E.; Cristea, M.; Noja, G.G. Measuring active ageing within the European Union: Implications on economic development. *Equilib. Q. J. Econ. Econ. Policy* **2019**, *14*, 591–609, doi:10.24136/eq.2019.028.
14. Kuc, M. Is the regional divergence a price for the international convergence? The case of Visegrad group. *J. Compet.* **2017**, *9*, 50–65.
15. Kijek, T.; Matras-Bolibok, A. The relationship between TFP and innovation performance: Evidence from EU regions. *Equilib. Q. J. Econ. Econ. Policy* **2019**, 14, 695–709, doi:10.24136/eq.2019.032.
16. Shkolnyk, I.; Kozmenko, S.; Kozmenko, O.; Mershchii, B. The impact of economy financialization on the level of economic development of the associate EU member states. *Econ. Sociol.* **2019**, *12*, 43–58, doi:10.14254/2071-789X.2019/12-4/2.
17. Kónya, I.; Ohashi, H. International Consumption Patterns among High-income Countries: Evidence from the OECD Data. *Rev. Int. Econ.* **2007**, *15*, 744–757, doi:10.1111/j.1467-9396.2007.00676.x.
18. Horáková, M. Consumer behavior of college students in the Czech Republic. *J. Compet.* **2015**, *7*, 68–85.
19. Razminiene, K. Circular economy in clusters' performance evaluation. *Equilib. Q. J. Econ. Econ. Policy* **2019**, *14*, 537–559, doi:10.24136/eq.2019.026.
20. Jankiewicz, M.; Pietrzak, M.B. Assessment of trends in the share of expenditure on services and food in the visegrad group member states. *Int. J. Bus. Soc.* **2020**, *21*, 977–996.
21. Piechota, G.; Igliński, B. Biomethane in Poland—Current Status, Potential, Perspective and Development. *Energies* **2021**, *14*, 1517, doi:10.3390/en14061517.
22. Igliński, B.; Piechota, G.; Iglińska, A.; Cichosz, M.; Buczkowski, R. The study on the SWOT analysis of renewable energy sector on the example of the Pomorskie Voivodeship (Poland). *Clean Technol. Environ. Policy* **2016**, *18*, 45–61, doi:10.1007/s10098-015-0989-7.

23. Filimonova, I.; Komarova, A.; Mishenin, M. Impact of the global green factor on the capitalization of oil companies in Russia. *Oecon. Copernic.* **2020**, *11*, 309–324, doi:10.24136/oc.2020.013.
24. Jonek-Kowalska, I. Transformation of energy balances with dominant coal consumption in European economies and Turkey in the years 1990–2017. *Oecon. Copernic.* **2019**, *10*, 627–647, doi:10.24136/oc.2019.030.
25. Chovancová, J.; Tej, J. Decoupling economic growth from greenhouse gas emissions: The case of the energy sector in V4 countries. *Equilib. Q. J. Econ. Econ. Policy* **2020**, *15*, 235–251, doi:10.24136/eq.2020.011.
26. The Energy Regulatory Authority. The Map of Renewable Energy Sources. Available online: www.ure.gov.pl/uremapoze/mapa.html (accessed on 14 August 2020).
27. Jurasz, J.K.; Dąbek, P.B. Campana PE. Can a city reach energy self-sufficiency by means of rooftop photovoltaics? Case study from Poland. *J. Clean. Prod.* **2020**, *245*, 118813, doi:10.1016/j.jclepro.2019.118813.
28. Sutopo, W.; Mardikaningsih, I.S.; Zakaria, R.; Ali, A. A model to improve the implementation standards of street lighting based on solar energy: A case study. *Energies* **2020**, *3*, 630, doi:10.3390/en13030630.
29. Zheng, X.; Zheng, H.; Lei, Y.; Li, Y.; Li, W. An offshore floating wind-solar-aquaculture system: Concept design and extreme response in survival conditions. *Energies* **2020**, *3*, 604, doi:10.3390/en13030604.
30. Igliński, B.; Iglińska, A.; Koziński, G.; Skrzatek, M.; Buczkowski, R. Wind energy in Poland—History, current state, surveys, Renewable Energy Sources Act, SWOT analysis. *Renew. Sustain. Energy Rev.* **2016**, *64*, 19–33, doi:10.1016/j.rser.2016.05.081.
31. Eurostat. Available online: https://ec.europa.eu/eurostat/web/nuts/background (accessed on 22 September 2020).
32. Wiśniewski, G. *Determination of the Energy Potential Polish Regions in terms of Renewable Sources of Energy—Lessons for Regional Operational Programmes for the Period 2014–2020 Programming Evaluation*; Publisher: Ministry of Regional Development: Warsaw, Poland, 2011.
33. Igliński, B.; Piechota, G.; Iwański, P.; Skrzatek, M.; Pilarski, G. 15 years of the Polish agricultural biogas plants: Their history, current status, biogas potential and perspectives. *Clean Technol. Environ. Policy* **2020**, *22*, 291–307, doi:10.1007/s10098-020-01812-3.
34. Bojnec, Š.; Papler, D. Efficient energy use and renewable sources of energy in Slovenia: A survey of public perception. *Agric. Econ.* **2011**, *57*, 484–492. Available online: www.agriculturejournals.cz/publicFiles/48732.pdf (accessed on 18 August 2020).
35. Hassan, M.K.; Natarajan, K.; Pelkonen, P.; Zyadin, A.; Pappinen, A. Perspectives of feedstock supply for biomass-based energy plant development in India: Views from expert survey. *Challenges* **2015**, *6*, 71–87, doi:10.3390/challe6010071.
36. Clancy, J.M.; Curtis, J.; Gallachóir, B.Ó. Modelling national policy making to promote bioenergy in heat, transport and electricity to 2030—Interactions, impacts and conflicts. *Energy Policy* **2018**, *123*, 579–593, doi:10.1016/j.enpol.2018.08.012.
37. Shoaib, A.; Ariaeatnam, S. A study of socioeconomic impacts of renewable energy projects of Afganistan. *Proc. Eng.* **2016**, *145*, 995–1003, doi:10.1016/j.proeng.2016.04.129.
38. Igliński, B. Hydro energy in Poland: The history, current state, potential, SWOT analysis, environmental aspects. *Int. J. Energy Water Resour.* **2019**, *5*, 61–72, doi:10.1007/s42108-019-00008-w.
39. Alam, S.S.; Nor, N.F.M.; Ahmad, M.; Hashim, N.H.N. A survey on renewable energy development in Malaysia: Current status, problems and prospects. *Environ. Clim. Technol.* **2016**, *17*, 5–17, doi:10.1515/rtuect-2016-0002.
40. Pang, M.; Zhang, L.; Bahaj, A.B.S.; Xu, K.; Hao, Y.; Wang, C. Small hydropower development in Tibet: Insight from a survey Nagqu Prefecture. *Renew. Sustain. Energy Rev.* **2018**, *81*, 3032–3040, doi:10.1016/j.rser.2017.06.115.
41. Muh, E.; Amara, S.; Tabet, F. Sustainable energy policies in Cameroon: A holistic overview. *Renew. Sustain. Energy Rev.* **2018**, *82*, 3420–3429, doi:10.1016/j.rser.2017.10.049.
42. Aized, T.; Shahid, M.; Bhatti, A.A.; Saleem, M.; Anandarajah, G. Energy security and renewable energy policy analysis of Pakistan. *Renew. Sustain. Energy Rev.* **2018**, 84,155–169, doi:10.1016/j.rser.2017.05.254.
43. Zyadin, A.; Natarajan, K.; LatvaKäyrä, P.; Igliński, B.; Iglińska, A.; Trishkin, M.; Pelkonen, P.; Pappinen, A. Estimation of surplus biomass potential in southern and central Poland using GIS applications. *Renew. Sustain. Energy Rev.* **2018**, *89*, 204–215, doi:10.1016/j.rser.2018.03.022.
44. IPSOS. *Energy Independence*; Ipsos: Warsaw, Poland, 2014.
45. Centre for Public Opinion Research. *Poles on Energy Sources, Energy Policy and Environment Condition*; Centre for Public Opinion Research: Warsaw, Poland, 2016. Available online: www.cbos.pl/PL/publikacje/diagnozy/034.pdf (accessed on 18 August 2020).
46. Sofres, T.N. *The Attitude of Pomorskie Voivodeship Residents Towards Nuclear Power*; Greenpeace Polska: Warsaw, Poland, 2016. Available online: http://m.greenpeace.org/poland/PageFiles/718686/Badania%20TNS_Raport_styczen_luty%202016_raport.pdf (accessed on 19 August 2020).
47. Ministry of Climate and Environment. *Energy Policy of Poland until 2024*; Ministry of Climate and Environment: Warsaw, Poland, 2021.
48. Group 1. "Renewable Energy". Available online: www.facebook.com/groups/1594502027467709 (accessed on 31 July 2020).
49. Group 2. "Renewable Energy and Energy Efficiency". Available online: www.facebook.com/groups/energia.odnawialna (accessed on 31 July 2020).
50. Group 3. "100% Renewable Energy in Poland". Available online: www.facebook.com/groups/1282786958420019 (accessed on 31 July 2020).
51. Group 4. "Passive House Building". Available online: www.facebook.com/groups/379613832410928 (accessed on 31 July 2020).

52. Group 5. "Energetics and New Technologies". Available online: www.facebook.com/groups/459839587876488 (accessed on 31 July 2020).
53. Group 6. "Fotovoltaics Hyde Park". Available online: www.facebook.com/groups/1118614851596997 (accessed on 31 July 2020).
54. Czarnik, S.; Kurek, K. *The Polish Labor Market—Professional Activity and the Structure of Education*; Polska Agencja Rozwoju Przedsiębiorczości: Warsaw, Poland, 2015.
55. IRENA. Renewable Energy and Jobs—Annual Review. 2018. Abu Dhabi, 2018. Available online: https://irena.org/-/media/Files/IRENA/Agency/Publication/2018/May/IRENA_RE_Jobs_Annual_Review_2018.pdf (accessed on 28 May 2020).
56. Bouraiou, A.; Necaibia, A.; Boutasseta, N.; Mekhilef, S.; Dabou, R.; Ziane, A.; Sahouane, N.; Attoui, I.; Mostefaoui, M.; Touaba, O. Status of renewable energy potential and utilization in Algeria. *J. Clean. Prod.* **2020**, *246*, 119011, doi:10.1016/j.jclepro.2019.119011.
57. Kashif, M.; Awan, M.B.; Nawaz, S.; Amjad, M.; Talib, B.; Farooq, M.; Nizami, A.S.; Rehan, M. Untapped renewable energy potential of crop residues in Pakistan: Challenges and future directions. *J. Environ. Manag.* **2020**, *15*, 109924, doi:10.1016/j.jenvman.2019.109924.
58. Tegina, I.T.; Dioha, M.O.; Failler, P. Renewable energy scenarios for sustainable electricity supply in Nigeria. *Energy Clim. Chang.* **2020**, *1*, 100017, doi:10.1016/j.egycc.2020.100017.
59. de Brauwer, C.P.S.; Cohen, J.J.; Analyzing the potential of citizen-financed community renewable energy to drive Europe's low-carbon energy transition. *Renew. Sustain. Energy Rev.* **2020**, *133*, 110300, doi:10.1016/j.rser.2020.110300.
60. Igliński, B.; Cichosz, M.; Kujawski, W.; Plaskacz-Dziuba, M.; Buczkowski. R. Helioenergy in Poland: Current state, surveys and prospects. *Renew. Sustain. Energy Rev.* **2016**, *58*, 862–870, doi:10.1016/j.rser.2015.12.244.
61. Instytut Energetyki Odnawialnej. Rynek Fotowoltaiki w Polsce'. 2019. Available online: https://ieo.pl/pl/projekty/raport-rynek-fotowoltaiki-w-polsce-2019 (accessed on 11 December 2020).
62. Wysokie Napięcie. Moc Fotowoltaiki w Polsce Przekroczyła 3 GW. Available online: https://wysokienapiecie.pl/33493-moc-fotowoltaiki-w-polsce-przekroczyla-3-gw (accessed on 30 September 2020).
63. Central Statistical Office. Energy Statistics in 2015 and 2016, Warsaw. 2017. Available online: https://stat.gov.pl/obszary-tematyczne/srodowisko-energia (accessed on 14 August 2020).
64. IEA. *World Energy Outlook 2020*; IEA: Paris, France, 2020.
65. Ritche, H.; Roser, M. Renewable Energy. Available online: https://ourworldindata.org/renewable-energy (accessed on 11 September 2020).
66. Igliński, B.; Skrzatek, M.; Iwański, P.; Krukowski, K. *Energia Odnawialna w Województwie Warmińsko-Mazurskim*; Nicolaus Copernicus University: Toruń, Poland, 2020.
67. Gram w Zielone. Available online: http://gramwzielone.pl/mapa-instalacji-oze/energia?fbclid=IwAR151rMMLNj4DPveNPfJ2UGTqxagaQbn5XWRY5J7iW8EzbgQx7H3GFqc9g (accessed on 16 August 2020).
68. Roy, B.; Schaffartzik, A. Talk renewables, walk coal: The paradox of India's energy transition. *Ecol. Econ.* **2021**, *180*, 106871, doi:10.1016/j.ecolecon.2020.106871.
69. Atuguba, R.A.; Tuokuu, F.X.D. Ghana's renewable energy agenda: Legislative drafting in search of policy paralysis. *Energy Res. Soc. Sci.* **2020**, *64*, 101453, doi:10.1016/j.erss.2020.101453.
70. Villca-Pozo, M.; Gonzales-Bustos, J.P. Tax incentives to modernize the energy efficiency of the housing in Spain. *Energy Policy* **2019**, *128*, 530–538, doi:10.1016/j.enpol.2019.01.031.
71. Chocholatá, M.; Furková, A. The analysis of employment rates in the context of spatial connectivity of the EU regions. *Equilib. Q. J. Econ. Econ. Policy* **2018**, *13*, 181–213, doi:10.24136/eq.2018.010.
72. Pietrzak, M.B.; Balcerzak, A.P.; Gajdos, A.; Arendt, Ł. Entrepreneurial environment at regional level: The case of Polish path towards sustainable socio-economic development. *Entrep. Sustain. Issues* **2017**, *5*, 190–203, doi:10.9770/jesi.2017.5.2(2).
73. Rollnik-Sadowska, E.; Dąbrowska, E. Cluster analysis of effectiveness of labour market policy in the European Union. *Oecon. Copernic.* **2018**, *9*, 143–158, doi:10.24136/oc.2018.008.
74. Gajdos, A.; Arendt, L.; Balcerzak, A.P.; Pietrzak, M.B. Future Trends of Labour Market Polarisation in Poland. The Perspective of 2025. *Transform. Bus. Econ.* **2020**, *19*, 114–135.
75. IRENA. Renewable Energy and Jobs, Annual Review. Available online: https://www.irena.org (accessed on 18 August 2020).
76. Institute for Renewable Energy. *Polish Industry for the Production of Equipment for Renewable Energy;* Institute for Renewable Energy: Warsaw, Poland, 2016.
77. Ministry of Economy. *The Energy Policy of Poland Until 2030*; Ministry of Economy: Warsaw, Poland, 2009. Available online: www.gov.pl/documents/33372/436746/DE_Polityka_energetyczna_ost_2030.pdf/78b689ec-62ec-af88-b0d7-decf95abdb70 (accessed on 18 August 2020).
78. Michalak, J.; Guzek, K. *Working for the Climate. Green Jobs in Poland*; Green Peace Polska: Warsaw, Poland, 2014. Available online: http://www.greenpeace.org/poland/PageFiles/351912/pracujac-dla-klimatu.pdf (accessed on 21 August 2020).
79. Szydłowski, K. Wymagająca, ale opłacalna praca w OZE. In Proceedings of the 6 Międzynarodowe Targi Energii Odnawialnej i Efektywności Energetycznej RENEXPO Poland, Warsaw, Poland, 19–21 October 2016.

80. *The RE Act of 20 February 2015 on Renewable Energy Sources*; Re Act: Warsaw, Poland, 2015. Available online: http://prawo.sejm.gov.pl/isap.nsf/download.xsp/WDU20150000478/U/D20150478Lj.pdf (accessed on 25 August 2020).
81. Dvořak, P.; Martinát, S.; Horsy, D.V.; Frantál, B.; Turečková, K. Renewable energy investment and job creation: A cross-sectoral assessment for Czech Republic with reference to EU benchmarks. *Renew. Sustain. Energy Rev.* **2017**, *69*, 360–368, doi:10.1016/j.rser.2016.11.158.
82. Bulavskaya, T.; Renkès, F. Job creation and economic impact of renewable energy in the Netherlands. *Renew. Energy* **2018**, *119*, 528–538, doi:10.1016/j.renene.2017.09.039.
83. Ram, M.; Aghahosseini, A.; Breyer, C. Job creation during the global energy transition towards 100% renewable power system by 2050. *Technol. Forecast. Soc. Chang.* **2020**, *151*, 119682, doi:10.1016/j.techfore.2019.06.008.
84. Zeqiraj, V.; Sohang, K.; Soytas, U. Stock market development and low-carbon economy: The role of innovation and renewable energy. *Energy Econ.* **2020**, *91*, 104908, doi:10.1016/j.eneco.2020.104908.
85. Martí-Ballester, C.P. Do European renewable energy mutual funds foster the transition to a low-carbon economy? *Renew. Energy* **2019**, *143*, 1299–1309, doi:10.1016/j.renene.2019.05.095.
86. Krishan, V.; McCalley, J.D. The role of bio-renewables in national energy and transportation systems portofolio planning for low carbon economy. *Renew. Energy* **2016**, *91*, 207–223, doi:10.1016/j.renene.2016.01.052.
87. Zafar, M.W.; Shahbaz, M.; Sinha, A.; Sengupta, T.; Qin, Q. How renewable energy consumption contribute to environmental quality? The role of education in OECD countries. *J. Clean. Prod.* **2020**, *268*, 122149, doi:10.1016/j.jclepro.2020.122149.
88. Distance Act: Law from 20 May 2016 About Investments in Wind Farms, Warsaw. 2016. Available online: http://prawo.sejm.gov.pl/isap.nsf/download.xsp/WDU20160000961/U/D20160961Lj.pdf (accessed on 13 August 2020).
89. Salomon, H.; Drechsler, M.; Reutter, F. Minimum distances for wind turbines: A robustness analysis of policies for a sustainable wind power development. *Energy Policy* **2020**, *140*, 111431, doi:10.1016/j.enpol.2020.111431.
90. Igliński, B.; Buczkowski, R.; Iglińska, A.; Cichosz, M.; Piechota, G.; Kujawski, W. Agricultural biogas plants in Poland: Investment process, economical and environmental aspects, biogas potential. *Renew. Sustain. Energy Rev.* **2012**, *16*, 4890–4900, doi:10.1016/j.rser.2012.04.037.
91. Biznes Alert. Available online: https://biznesalert.pl/sawicki-niemcy-energiewende-ustawa-odlegloscio wa-oze-energetyka (accessed on 13 August 2020).
92. Renewable Energy News. Available online: https://renews.biz/109422/orsted-clears-taiwan-hurdle (accessed on 16 August 2020).
93. Child, M.; Bogdanov, D.; Aghahosseini, A.; Breyer, C. The role of energy prosumers in the transition of the Finnish energy system towards 100% renewable energy by 2050. *Futures* **2020**, *124*, 102644, doi:10.1016/j.futures.2020.102644.
94. Turkdogan, S. Design and optimization of a solely renewable based hybrid energy system for residential electrical load and fuel cell electric vehicle. *Eng. Sci. Technol. Int. J.* **2020**, *24*, 397–404, doi:10.1016/j.jestch.2020.08.017.
95. Bist, N.; Sircar, A.; Yadav, K. Holistic review of hybrid renewable energy in circular economy for valorization and management. *Environ. Technol. Innov.* **2020**, *20*, 101054, doi:10.1016/j.eti.2020.101054.
96. Lucas, H.; Pinnington, S.; Cabeza, L.F. Education and training gaps in the renewable energy sector. *Sol. Energy* **2018**, *173*, 449–455, doi:10.1016/j.solener.2018.07.061.
97. Polish Smog Alarm. Available online: www.polskialarmsmogowy.pl (accessed on 5 September 2020).
98. Ji., X.; Yao, Y.; Long, X. What causes PM2,5 pollution? Cross-economy empirical analysis from socioeconomic perspective. *Energy Policy* **2018**, *119*, 458–472, doi:10.1016/j.enpol.2018.04.040.
99. Wysokie Napięcie. Mamy Pierwszy Gigawat Fotowoltaiki w Polsce. A to Dopiero Początek. Available online: https://wysokienapiecie.pl/23426-mamy-pierwszy-gigawat-fotowoltaiki-w-polsce-dopiero-poczatek/?fbclid=IwAR22ebG4y4zj twsY6d4JptNxCEo_93jBL37zCxN39HFkCxROiIpju1Asrzk (accessed on 15 December 2020).
100. Inês, C.; Guilherme, P.L.; Esther, M.-G.; Swantje, G.; Stephen, H.; Lars, H. Regulatory challenges and opportunities for collective renewable prosumers in the EU. *Energy Policy* **2020**, *138*, 111212, doi:10.1016/j.enpol.2019.111212.
101. Association of the Photovoltaic Industry. *Polish Photovoltaic Market in Numbers;* Association of the Photovoltaic Industry: Warsaw, Poland, 2019.