energies

MDPI

Review

Review of Selected Aspects of Wind Energy Market Development in Poland and Lithuania in the Face of Current Challenges

Ewa Chomać-Pierzecka [1,*], Hubert Gąsiński [2], Joanna Rogozińska-Mitrut [3], Dariusz Soboń [1] and Sebastian Zupok [4]

[1] The Jacob of Paradies Academy in Gorzów Wielkopolski, 66-400 Gorzów Wielkopolski, Poland
[2] The WSB University in Warszawa, 03-204 Warszawa, Poland
[3] Higher School of Justice in Warszawa, 02-520 Warszawa, Poland
[4] WSB National Louis University in Nowy Sącz, 03-300 Nowy Sącz, Poland
* Correspondence: echomac-pierzecka@ajp.edu.pl

Abstract: The disruption of fossil fuel supply chains due to the war in Ukraine has resulted in the need for an urgent reorganisation of the energy supply system, the cost of which has created a substantial increase in electricity prices in many markets. In light of the above, the need for the development of a renewable energy market has become stronger than ever; hence, the authors of this study have oriented their efforts towards investigating the development of the renewable energy market in countries bordering the line of armed conflict in Ukraine, i.e., Poland—strongly dependent on traditional forms of energy production—and Lithuania. The primary objective of the paper is to review the literature on wind energy, which is necessary to establish the current role of this energy dimension in the renewable energy market in the energy systems of Poland and Lithuania. Therefore, this review paper is oriented towards a review and evaluation of the available thematic literature and industry studies, as well as conclusions related to the number and direction of research topics in the area of the explored issues. The basic finding of this review is that the reviewed literature and studies are most strongly oriented towards a general assessment of the ongoing energy transition in the world, in which the thread of the assessment of the energy situation in Poland and Lithuania, including the thread of the analysis of wind energy, is part of broader assessments, most often regarding EU countries. The wind energy of the countries included in the scope of the review is not discussed comprehensively. The gap identified in this respect relates in particular to the aspect of wind energy development potential concerning solutions targeted at the individual consumer. In quantitative terms, studies addressing wind energy in Lithuania represent a lower percentage of the thematic literature acquired for the review. In the area of noted niches, the need for research and analysis is recommended to increase the information supply for developing the renewable energy market in Poland and Lithuania. In doing so, it is important to explore the technical and technological solutions (with a focus on the individual customer) and the economic aspects of wind installations from a micro and macro perspective. In addition, there is a lack of sufficient studies revealing the position of public opinion regarding the development of this dimension of the RES market and the direction of its changes. This is an important problem—particularly in Poland, where the so-called distance law constantly blocks the development of this dimension of RES and where the need to develop energy from renewable sources is particularly urgent.

Keywords: energy markets; energy securities; green energy; sustainable development

Citation: Chomać-Pierzecka, E.; Gąsiński, H.; Rogozińska-Mitrut, J.; Soboń, D.; Zupok, S. Review of Selected Aspects of Wind Energy Market Development in Poland and Lithuania in the Face of Current Challenges. *Energies* **2023**, *16*, 473. https://doi.org/10.3390/en16010473

Academic Editors: Tetyana Pimonenko, Oleksii Lyulyov and Henryk Dźwigoł

Received: 30 November 2022
Revised: 16 December 2022
Accepted: 19 December 2022
Published: 1 January 2023

1. Introduction

Contemporary functioning is subject to many challenges. These relate to the need for sustainable management at the level of countries, economic activities [1], or communities and are most strongly linked to the need to protect the environment and the associated reduction of the carbon footprint of human activities to reduce the drivers of climate change.

Pro-environmental action is currently a priority in the development strategies of the world's economies. Environmental protection has set an acceptable framework for development, in line with the concept of the sustainable approach, which concerns a number of dimensions of socio-economic life, strongly affecting, among others, the energy industry.

Activities to protect non-renewable resources (fossil fuels), combined with the gradual reduction of conventional energy production systems with substantial negative environmental impacts (discharges, emissions), have been supported by activities to develop renewable energy. These are important aspects of caring for the planet's life, counteracting the progressive disruption of water management due to the overexploitation of natural resources and the destruction of ecosystem functioning. The energy transition of the world's economies is an important topical issue, anchoring the choice of the review topic.

The need to promote the development of energy markets towards renewable energy is motivated by environmental considerations and the economic conditions created against this background. The scarcity of natural resources determines an increase in the cost of acquiring non-renewable energy resources. The cost of carbon dioxide emission allowances in connection with conventional energy production is also rising, creating high energy purchase prices on the market. The outbreak of war in Ukraine reinforced the growing energy crisis. There has been a dramatic increase in energy prices in countries dependent on fossil fuels. The importance of green sources of energy supply has gained momentum. The orientation towards sustainability and sourcing energy from renewable sources has become a focal point of modern energy policies. This is particularly true for the countries bordering the Ukrainian war line, which inspired an effort to undertake a literature review of green energy issues in Poland and Lithuania, informing the development of the renewable energy market in these countries.

This literature review will highlight the role of renewable energy sources with a focus on wind energy in the energy security of Poland and Lithuania, as well as outline the importance of this energy source in transforming energy markets in these countries. The above addresses the identified gap in the RES market development considerations in Poland and Lithuania with respect to this country combination. This will reveal the directions for additions to the literature on the areas most in need of strengthening the potential for pro-development activities in this sphere in the process of moving away from conventional—harmful and uneconomic—energy production in these countries.

An introduction, a main body of the review and conclusions structure the paper. The explored arrangement of neighbouring countries with similar economic conditions determines the scope of this review. The main review module contains a literature review outlining the background of the energy transition to the changes taking place in the world, which gives this section an introductory character to the topic. This is followed by a review of the literature exploring the theme of wind energy in the transformation of the energy systems of the countries adopted for the review, regarding the thesis adopted for the review.

The concept of the review is based on a critical appraisal of the available literature, including industry reports and statistical materials relating to the energy market in Poland and Lithuania. Literature resources were obtained by searching databases including Scopus, Google Scholar, Web of Science, and Eurostat, among others, using a compilation of a set of keywords including: "energy transition in Poland and Lithuania", "RES energy in Poland and Lithuania",, "energy security in Poland and Lithuania", "RES development in Poland and Lithuania", "wind potential in the RES market in Poland and Lithuania", "wind energy in Poland and Lithuania", with the term "Poland and Lithuania" used individually for each country in the search process, i.e., "Poland" and "Lithuania".

The literature review involved selection in determining the relevance of the selection in relation to the adopted evaluation objective. The above is to assess the available literature resources to identify the needs for the further penetration of the RES market in Poland and Lithuania to reduce the diagnosed information gap in relation to the adopted country layout. With the above in mind, a literature review was carried out according to the thematic areas related to the countries adopted for the review:

x_1—energy transition—essence, determinants, objectives, regulations,

x_2—renewable energy sources in the energy system of countries—share of RES in the energy mix, orientation towards RES,

x_3—wind energy in the energy system of countries,

x_4—onshore wind energy in the energy system of countries,

x_5—offshore hydropower in the energy system of states,

x_6—wind energy—solutions for the energy industry,

x_7—wind power—solutions for small individual investors,

x_8—economic conditions of renewable energy development in countries,

x_9—environmental and social aspects of renewable energy development in countries.

The next stage of the assessment of the available literature was related to the dimension of problem clarification:

H—high (comprehensive) level of explanation of the problem,

M—average (medium) level of explanation of the problem,

L—low (basic) level of problem discussion.

The categorisation of the level of problem elucidation reveals niches in the body of literature that can inspire further legitimate research challenges.

An overview of the results is discussed in the conclusion.

The combinations of words used in the literature search and the literature adopted for the evaluation, as well as the arrangement of the countries, created limitations on the review, giving it a general character in order to develop general conclusions in the area of needs and potential for additions.

2. Poland and Lithuania in the Light of Renewable Energy Development—Literature Review

2.1. The Energy Market in Light of Contemporary Environmental and Economic Challenges—Introductory Literature Review

Uninterrupted access to energy is a key determinant of the efficiency of societies and economies, as pointed out by M. Palonkorpi, S. Bigerna et al., or A. Mazur et al. [2–4], as well as a leading determinant of the development of markets, as highlighted by M. Ben Jebli et al., F. Amri, or A. Menegaki et al. [5–10]. However, energy security, considered an essential criterion for the effective existence of states, is raised most strongly in the literature, as emphasised by C. Flaherty et al., P. D. Williams, C. Winzer, or F. Hedenus, among others, treating its maintenance as an absolute necessity [11–14]. The environmental dimension is also important, as pointed out by J. Woźniak et al., D. F. Burchart-Karol, or H. Brauers, among others [15–18]. The above, through the prism of the need to reduce discharges and emissions due to the conventional formula of electricity production, contributes to the reduction of traditional forms of energy generation and the search for alternatives in the sphere of deriving energy from renewable sources, as emphasised by A. Rehmann et al. [19] among others. Hence the strong orientation of the world's economies towards renewable sources of energy supply in energy systems, as pointed out by M. Panait et al. or A. Apostu [20,21]. This orientation is expected to contribute to lower energy prices (cheap, green energy) and, through uninterrupted access to diversified, renewable sources, increase the energy security of economies relying on these solutions. A not inconsiderable argument in this measure is the low carbon intensity of production, of key importance for the environment, as emphasised by S. Baskutis et al. [22].

The benefits associated with obtaining energy from renewable sources convince the world to take up the challenge of transforming existing energy systems [23] in this direction. The energy policies of economies are being revised, and environmental targets, oriented towards decarbonising the energy sector—motivated by increasing environmental charges from emission allowances—are prompting increased action.

The trend towards RES is presented by a number of regulations addressing the issue of sustainable development, including, for example, those relating to United Nations member states (e.g., The 2030 Agenda for Sustainable Development [24]) or European Union member states (e.g., Directive 2009/28/EC of the European Parliament and of the

Council of 23 April 2009 on the promotion of the use of energy from renewable sources [25]). The shape of the challenges faced was determined by successive directives setting targets for creating a RES share in the energy mix, correlated with environmental targets oriented towards reducing emissions. The aim of such a policy is sustainable development [26], in which the decarbonisation of electricity systems plays a key role and increasing the share of RES sources increases their flexibility, security [27–29], and economic efficiency [30], as well as increases the possibility of energy cooperation between economies [31]. The aspects of modernity, sustainability, reliability, and low price of renewable energy are highlighted in the literature, as emphasised by, among others, B. Surya et al. [32], with A. Cherp et al. [33] linking low price to energy security and G. Bahgat seeing RES as having the potential to strengthen the energy self-sufficiency of economies while improving environmental performance [34]. W. E. Rees and I. Overland, on the other hand, point out that the development of a market for energy derived from renewable sources contributes to strengthening the competitiveness of the actors in this market [35], creating, as a result, the attractiveness of economies [36].

Moreover, the social dimension of this activity is important [37], referring to the political, economic, social, and technological aspects captured in the PEST assessment [38, 39]. It should be emphasised that the economic, environmental, and social dimensions form the backdrop for sustainable economic development [40], an integral part of which is the sustainable development of the energy market. Herein, economic growth grows against a background of ecologically responsible action in the processes of creating social progress [41] (low carbon, resource efficiency) [42], creating, as L. Aldieri notes, a new quality of life, based on conscious social expectations [43], creating a new dimension of values. Energy sustainability has become a common challenge in the world.

2.2. Poland and Lithuania in the Light of Sustainable Development Policy

Revisions to the legal regulations in the sphere of energy production in the European Union marked the orientation towards renewable energy sources. On 27 September 2001, Directive 2001/77/EC of the European Parliament and the Council on the promotion of electricity produced from renewable energy sources in the energy market of the European Union came into force [44]. Regulations affecting a number of areas of the economy were also amended, including, among other things, in the area of transport—Directive 2003/30/EC of the European Parliament and of the Council of 8 May 2003 concerning the use of biofuels or alternative renewable fuels for transport [45]. Activities aimed at the promotion of renewable sources resulted in the establishment of a target in 2009 of 20% shares of energy from renewable sources in the energy mix of EU countries by 2020, under Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of renewable energy sources [25]. A new look at renewable energy sources has initiated a current of change.

The review of the adopted EU energy policy points to the strategic objective of strengthening the member countries' energy security and enhancing the innovation, integration, and efficiency of the internal energy system by orienting it towards RES sources on the way to its decarbonisation [27]. These objectives are captured in the EU Energy Strategy established on 25 February 2015, orienting energy generation at competitive prices towards a sustainable energy market [28,46], a future consequence of which was the adoption of the Clean Energy for All Europeans programme [47].

The European Union's formal and legal framework in the sphere of energy policy is subject to periodic revisions. In 2018, the promotion of renewables was strengthened (Directive 2018/2001 of the European Parliament and the Council (EU) [48]), and the targets related to the share of RES sources in energy production in 2030 in at the Member State level were increased to 32% [49]. 2019 resulted in the establishment of the 'European Green Deal' [50], and, in 2021, it resulted in another higher target of 40% for the share of RES in countries' energy mixes by 2030 [46], as well as a target of 55% emission reductions by 2030 relative to 1990 performance [51].

Formal and legal regulations at the European Union level constitute the source of law at the level of economies creating the community market. The objectives arising from sustainable energy development set the directions for modelling national energy policies, to which EU Member States are obliged to follow. Poland and Lithuania, the countries accepted for this review, are obliged to implement the guidelines for developing energy systems at the national level. Supporting initiatives in the area in question is the EU Renewable Energy Financing Mechanism, among other things, under Commission Implementing Regulation (EU) 2020/1294 of 15 September 2020) [52]. K. Krūminš et al. [53] point out that Poland and Lithuania are applying to the EU for increased funding to protect against the financial impact of the policy in the form of increased energy prices for citizens.

The EU's sustainable development policy has created major transformational challenges for Poland, as the reliance of energy production on coal is rooted in the country's history [54]. As recently as 1960 to 2008, coal powered more than 90% of the energy system, only to break even in 2010, reaching a slightly lower level [55]. In 2016, the importance of coal for modern development was still strongly emphasised, and it was pointed out that it should be maintained as the main source of energy supply in Poland until 2050 [56].

M. Kuchler et al. pointed out that, in 2011, reserves of hard coal (of increasingly lower quality) in operating mines in Poland were estimated to last until 2035; hence, the need to remodel Poland's energy system has become a more urgent domestic need for the country [56]. J. G. Schiavo et al. drew attention to the fact that Polish coal is characterised by a high sulphur content, which, in conjunction with the classic infrastructure, generates emissions that strongly shape poor air quality [57]; hence for years, there has been strong pressure to reduce this source of energy supply [58], which, as indicated by W. Budzianowski et al. was declared to reach a level of approximately 60% by 2030 [59]. This is motivated by EU restrictions related to the CO_2 emission limit, wherein—according to the 'Clean Energy for All Europeans' initiative—its limit was set at 550 kg/MWh, which determines the eligibility for subsidies or grants [60]. Among other things, due to severe environmental pollution, progress in the implementation of the declaration of reducing the scale of energy production from coal in Poland is of interest to the international community, evident, for example, in the considerations of T. Zhao et al. [61].

Changing the energy system according to the current standards requires an orientation towards the practical implementation of carbon capture and storage technology, reducing Co_2 emissions in coal-fired power generation [62] by 90%, through its absorption and storage, as well as an opening to solutions from the area of low-carbon nuclear energy and energy based on renewable sources, increasing the capacity and energy efficiency of the system [63]. In this regard, Poland has made declarations to implement by the end of 2020 a 15% share of RES in the energy mix—with the possibility of purchasing CO_2 emission allowances from countries with a surplus of green energy vis-à-vis EU targets—and to increase the share of biofuels in the fuel market to 10% [64]. Subsequent revisions of EU regulations resulted in the EU ETS blocking the possibility of supporting Polish mines with funds from the Modernisation Fund [65]. Opening up to renewable energy has become an absolute necessity, which is more clearly emphasised in energy policy by, among others, A. Michalak [66].

The direction for developing renewable energy was pursued by orienting efforts towards investments in wind power plants and solar energy installations—explored among others by J. Jurasz et al. [67]—as well as hydroelectric power plants. In addition, the Polish renewable energy market has seen the launch of power plants deriving energy from biomass, discussed by A. Jezierska-Thöle et al. [68], biogas plants and geothermal installations. Substantial attention was paid to the aspect of the creation of a formal and legal framework towards the construction of power plants deriving energy from the potential of the Baltic Sea (offshore wind farms), as well as the investment conditions for RES development at the institutional and consumer level [69]. These aspects were supported by funding sources, obtained from the European Union, and national instruments oriented towards financing RES solutions, considering environmental protection measures. The

tax policy aspect, offering a tax rate reduction or exemptions from this burden, was not without significance. The fundamental aim of such action was to orient towards increasing the degree of energy self-sufficiency and creating energy security, combined with environmental protection and improved quality of life [69]. In addition, the motivation for the development of this field of energy has been the declaration of price guarantees for renewable energy tariffs [70–72].

Lithuania's sustainable energy development objectives fully correspond to the European Union's energy strategy; hence, the main challenges were identified as: [73]

- increasing the country's energy security in connection with the process of phasing out fuel imports from Russia—among other things, through the exclusion of the "Brell" energy hub and energy integration, in connection with the synchronisation of the national grid with the community transmission network by 2025,
- increasing energy security through the dispersal of energy supply sources, with particular attention to increasing RES sources in the national energy balance and increasing the country's energy efficiency,
- reducing traditional forms of energy generation in connection with environmental protection,
- energy innovation through an orientation towards new technologies in the energy industry, increasing the level of the environmental safety of energy production and optimising the cost of generation.

An intense energy transition process has increased energy self-sufficiency in Lithuania, allowing commercial energy production to support the energy systems of neighbouring countries (Poland, Finland). This is an important achievement as, for several years, domestic production covered only 5% of consumption.

The energy transition towards renewable energy sources and innovative generation technologies is expensive. Major investments relate to the technical and technological dimension, enabling the efficient and effective functioning of the energy market in Lithuania, where the grid's capacity (determining the supply chain capacity) creates the country's energy security.

The energy transition process in Lithuania is 75 per cent supported by European Union funding for this purpose, with an allocation of EUR 564.4 million for the period 2014–2020, with the cost of network synchronisation representing an investment of approximately EUR 1.5 billion [74]. The modernisation of Lithuania's energy system infrastructure by 2027 places an investment burden of approximately EUR 2.1 billion on the main grid and pipeline operator; hence, the main objectives are [74]:

- raising the share of RES in Lithuania's final energy consumption to 45% by 2030 and 80% by 2050,
- increasing the share of RES in Lithuania's energy production to 70% by 2030 and 100% by 2015.

The interest in Lithuanian energy imports strongly motivates the deepening of RES development activities. One dimension of this activity is wind energy, implemented, for example, in an international arrangement in cooperation with Poland.

There are many directions for developing renewable energy [75–80]. Among the most popular is wind energy [81], mentioned just after solar energy [82]; the recognition of the status of development in Poland and Lithuania will be further reviewed within the framework of this study.

2.3. Wind Energy on the Renewable Energy Market in Poland in Light of Literature Findings

Energy extraction from wind is not a new topic [83]. The orientation towards the search for renewable energy sources in relation to the need for environmental protection has contributed to the development of this field of the energy industry—particularly strong in the period 1999–2006 and 2016–2020, with steady growth observed over these periods [84]. With the development of wind power, the environmental advantages of such solutions have been strongly emphasised in the literature. For example, W. M. Lewandowski highlighted

the aspect of emission reductions (5500 Mg of sulphur dioxide, 4222 Mg of nitrogen oxide, 700,000 Mg of carbon dioxide and 49,000 Mg of a mixture of harmful dust) in connection with the production of 1 TWh of electricity [84], I. Soliński emphasised the economic significance of the high energy intensity of this power supply in energy production (3.5 MJ/kWh compared to 13.0 MJ/kWh of energy obtained from coal) [85]. The above as further studied by Y. Kumar et al. or M.D. Esteban [86,87]. The aspects indicated are extremely important, particularly for the Polish energy industry, which faces the problem of high levels of harmful emissions into the atmosphere, combined with high (and increasing) energy prices on the market. Improving solutions in the sphere of wind energy increases the interest in this dimension of RES [88,89] and strengthens the economic justification of such projects, as indicated by K. Talarek et al. citing the findings of the report: Wind Energy in Poland 4.0 2022, defining the outlay for acquiring 1 MW of installed capacity at a level oscillating around EUR 1.5 million—assuming the production capacity of the equipment for 20–30 years —and the position of the International Renewable Energy Agency in this regard [90,91]. The above justifies the development of the energy industry in the discussed direction [92], in connection with the implementation of the energy system transformation policy, wherein the total global installed wind power capacity exceeds 750 GW (with a strong offshore wind share of more than 50 GW). The leaders among European countries include Denmark (49.7%), Ireland (22.9%), Portugal (22.3%), and Spain (17.7%) [90].

M. Mana et al. emphasise the importance of adequate wind resources' availability in assessing the appropriateness of orienting the energy system of an economy towards wind power [93,94]. In this respect, Poland enjoys good resources to enable an energy transition towards RES development, including wind energy.

The development of wind energy in Poland has been progressing since 2000, with intensification since 2009 continuing (Figure 1) [95].

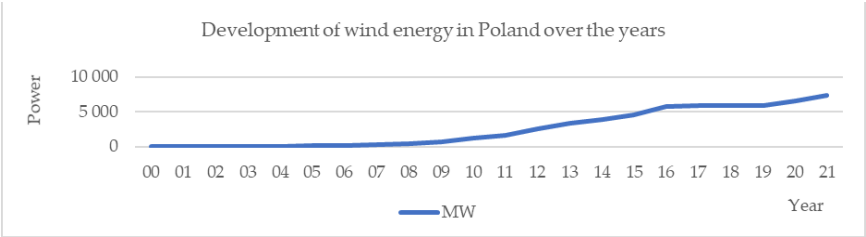

Figure 1. Development of wind energy in Poland.

According to the findings of P. Zhao et al. [94], the installed capacity of onshore wind installations in Poland amounted to 6.35 GW in 2020, and the share of wind energy in RES in 2021 amounted to 57.14% (16 TWh), with a 15% share of RES in Poland's overall energy supply volume. Referring to data from the Energy Market Agency, at the beginning of 2022, the installed capacity of wind farms in Poland oscillated around 7118 MW, indicating a nearly 11% year-on-year increase in the volume of connected capacity [96]. At the same time, it should be emphasised that the share of wind in Poland's energy supply sources is 11% and that the share of wind installations in the energy production structure in Poland in 2022 exceeds 9.3% [97].

The development of wind energy was disturbed by the establishment of regulations at the Polish level in the form of a distance law, limiting the siting of wind farm facilities to 10 times the distance from buildings concerning the height of the installation. As a consequence of the regulations in question, there has been a decline in the number of investments, translating into limited dynamics in the development of this market. The abandonment of these regulations was set for 2022, which, as of this study's date (November 2022), is still the subject of analysis and discussion in Poland.

A strong potential for the development of the wind energy sector is seen in the sphere of drawing on the wind resources created by the Baltic Sea—as signalled by K. Pronińska et al. [98], whose potential in this respect exceeds 90 GW, as pointed out

by A. Farkas et al. [99]. According to the Wind Europe Report "Offshore Wind in EU Maritime Spatial Plans" of 19.1.2022, Poland's share in the economic zone in the Baltic Sea is 12% (3600 km^2) with a power potential of 17.2 GW [100]. This direction of development is accentuated within the framework of the energy development policy until 2040, according to which the share of wind energy in RES in Poland is to be continuously increased through, among other things, investments in offshore wind farms, the commissioning of which is planned for 2024. [101]. By 2030, Poland plans to have offshore wind farms with a total capacity of 5.9 GW [102]. This dimension of energy development is supported by international cooperation, strongly reinforced during the energy crisis.

Wind energy development towards solutions dedicated to individual, small-scale investors is very underdeveloped in Poland. In light of the diagnosed interest in supporting the energy supply of individual consumers with wind energy solutions [81], it is worth strengthening this dimension of activities. In addition, literature additions are necessary to support systems for the development of this dimension of the market (regulations at the level of the national economy), as the discussion on this topic is extremely poor. The search for solutions and the argumentation for their application in practice should strengthen the interest in the topic, which, with an in-depth scientific discussion, could result in a more intense interest in the development of this sphere.

2.4. Wind Energy in the Energy Market in Lithuania Based on a Literature Review

The development of the renewable energy market in Lithuania is steadily progressing. The country's high share of RES in the EU energy mix is noteworthy, reaching 81.1% in 2019 [103]. Wind power plays an important role in Lithuania's energy system, exceeding a 45.5% share of renewable energy production in 2021 by supplying 1.3 TWh of energy, equivalent to about 11.5% of its total energy demand, with wind installations estimated to account for about 60% of RES sources in terms of installed capacity, with a capacity of 671 MW [104]. N. Blažauskas et al. and J. Jankeviciene et al. indicate that the Lithuanian energy industry is betting on wind [105,106]. The development of the wind energy industry in Lithuania has been progressing since 2003, with an increase since 2008 continuing (Figure 2) [107].

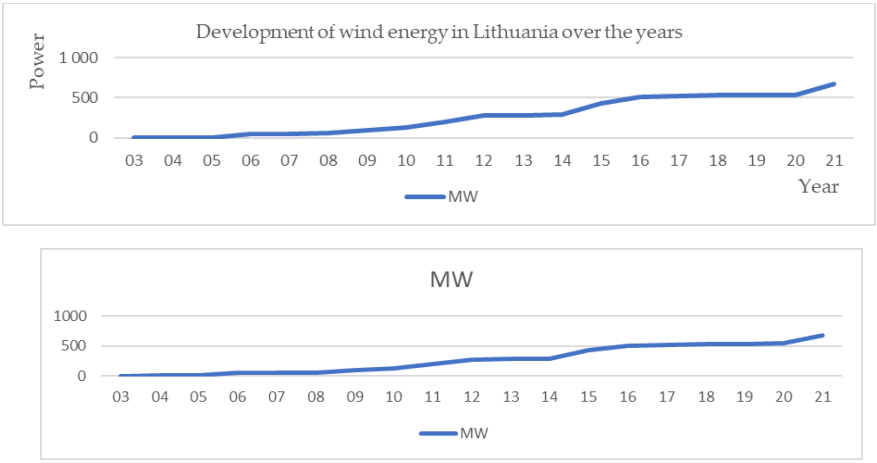

Figure 2. Development of wind energy in Lithuania.

According to the assumptions, a 300% increase in the share of wind power in the country's energy system is planned in a relatively short period (by 2030) in connection with the realisation of the goal of a full energy supply based on RES sources in 2050; hence, investment projects with a total capacity of more than 800 MW are being implemented in a number of regions in Lithuania [105]. In this regard, J. Jankeviciene et al. underline the target of a 21% RES share in Lithuania's total electricity production by 2030 [106, 107]. Tthe recently commissioned wind farm built 30 turbines with a total capacity of 73.5 MW [81].

Lithuania's greatest potential for wind energy development is seen in the wind resources generated in the Baltic Sea. According to the WindEurope Report 'Offshore Wind in EU Maritime Spatial Plants' of 19.1.2022, Lithuania's share of the economic zone in the Baltic Sea is 9.4%, (664 km^2), with a capacity potential of 2.4 GW [102]. According to the current regulations of the Lithuanian Parliament on offshore wind energy development of 31 March 2022, the first Lithuanian wind farm in the Baltic Sea is to be built by 2028 [108]. Investment in wind energy is the right direction for developing the country's energy system. Indeed, it should be emphasised that, in response to Lithuania's energy needs, the scale of energy imports until recently oscillated around 60% of the energy consumption level [109]. Hence, to increase the affectivity of the planned installations, numerous analyses of wind energy have been considered for years, especially those relevant to end consumers [110].

3. Discussion

Energy demand in the world is increasing. According to the contemporary strategy for developing Europe's energy system, a major part of the energy demand must be met from RES sources. B. Bepary et al. and M. Tsili et al. point out that a significant potential in this regard is created by wind energy [111,112]. Hence, numerous studies are being undertaken in the spheres of:

(a) technical (availability of wind resources),
(b) economic (economic justification of investment in wind energy),
(c) environmental (impact of wind installations on the environment),
(d) social (community assessment of wind energy development).

In the technical sphere, the potential of wind resources is examined in relation to existing or developing wind power installation solutions. In the case of Poland and Lithuania, the orientation towards offshore wind farms is assessed very positively from the perspective of the current and future energy potential offered by offshore wind in the area, which is forecast to grow continuously [113].

The location of wind farms is an important consideration. In addition to the availability of wind resources, an analysis of the eligibility of the land for this purpose and the exemptions associated with the investments is required, as pointed out by A. D. Sæþórsdóttir [114]. Another important factor is landscape changes, which create public opposition to the construction of wind farms to the greatest extent, as noted by E. Tumelienė [115]. Strong social resistance to wind installations is also accentuated by S. Eltham et al. [116], and it is created, among other things, by the noise generated by the operation of turbines—as emphasised by I. Van Kamp [117]. The objection is also created by the fear of the negative effects of magnetic fields and infrasound [118] on human and animal health, as emphasised by S. Smallwood et al., R. Drewitt et al., and J. Wyrobek et al. [119–121]. Available sources indicate the occupational risks of working around turbines (e.g., N. Karanikas et al.) [122]. J. S Chou et al., in turn, point to risks during construction and failures during turbine operation creating a bundle of risks [123]. The impact of turbine operation on the environment is continuously studied. Another dimension of the public discussion is the economic aspect related to the change in land values in the vicinity of wind installations—an above-average increase in land prices for wind investments and an equal decrease in prices for housing [117]. However, there are positive arguments to justify wind energy development and the legitimate trend of transforming energy systems towards RES. A fundamental consideration in favour of developing wind energy infrastructure is the economic benefits associated with the production of cheap, clean energy. Research by D. Štreimikiene reveals that only 10% of surveyed households in Lithuania use RES solutions in their homes. In contrast, most of the surveyed population would like to use green energy in everyday life [124]. In this respect, there is significant potential for solutions in wind installation for small individual users. In general terms (ideologically), the development of wind farms enjoys public interest and support. Wind micro-installations of 3–5 KW are assumed to be more efficient than the photovoltaics popular in Poland and Lithuania (+200–300%), while a combination of wind and solar (hybrid) may prove to be the most economically

viable solution [125]. The above is fully corroborated by a study revealing 71% interest among owners of PV micro-installations in further developing their solutions towards wind micro-installations to optimise electricity prices for individual consumption [81]. The lack of a sufficient discussion of the wind micro-installation strand in the literature and the lack of the adequate promotion of the solutions in question results in the low development of this strand of the energy market. By mid-2021, less than 80 micro-installations had been built in Poland; hence, Polish producers of the solutions in question were directed to promote them in neighbouring markets, e.g., in Lithuania, to unlock the development of this field [81].

Growing public support and interest in the RES dimension [37] motivates activity. Hence, challenges are undertaken to strengthen the activity to derive energy from wind for practical purposes, continuously improve the technology for its extraction, and to optimise the results obtained in this process, as mentioned by M. Rebe et al. [126]. In this sphere, directions for improving existing technologies are analysed—as emphasised by J. Ziegler et al. [127]—as is the dimension of the economic justification for maintaining older, less efficient farms [121]. In doing so, it is worth emphasising more strongly the need to develop wind energy on a micro level.

4. Conclusions

A review of the literature on the RES market in Poland and Lithuania—with particular emphasis on wind energy—reveals the achievements of the discussed economies in this sphere, giving rise to the following main conclusions:

1. Poland and Lithuania are strengthening the share of RES in the countries' energy mixes. The share of wind energy in RES sources in Poland reached 11% at the beginning of 2022, while in Lithuania, it reached 45.5%. The installed capacity of wind turbines in Poland has reached 671 MW with 2020/2021 y/y growth dynamics of 24.25% and 7.306 MW with 2020/2021 y/y growth dynamics of 10.46%.
2. The development of wind energy in both Poland and Lithuania is strongly concentrated around the wind resources of the Baltic Sea, whose capacity potential for Poland is 17.26 GW, with a 12% share in the economic zone, and for Lithuania is 2.4 GW, with a 9.4% share in the economic zone.
3. The Polish and Lithuanian wind energy market does not fully exploit the demand potential of micro wind installations for small-scale energy consumers. Increasing the share of RES sources through small-scale investors may create a noticeable increase in installed capacity—which is important from the point of view of meeting sustainability targets; moreover, it may significantly reduce the price of electricity for current consumption, which is the main motivation for acting in this field. However, this niche requires a more complete diagnosis, enabling an appropriate response (in the spheres of information, technical–technological and financial support), tailored to this group of consumers. Strengthening the literature in this area may increase the potential for changing attitudes among energy consumers, manifesting a higher openness to RES solutions.

The literature studies on wind energy in Poland and Lithuania strongly emphasise the analysis of trends in energy policy changes and strengthening the share of renewable sources in the energy systems of both economies. In this context, the general (overview) information in this field should be considered the most informatively attractive and, thus, the most fully developed.

An overall assessment of the available literature in wind energy in the established country system indicates the need for additions. The number of studies referring directly to wind energy in Poland or Lithuania is very modest. These issues are mostly addressed in broader analyses, and the information presented is very general. Therefore, in order to explore a given issue, it is necessary to rely on general findings in the field of wind energy, with the necessity of supplementing them regarding detailed data contained in industry reports published at the level of economies or, more broadly, of the European

Union and the world. The availability of general studies provides a basis for the creation of general conclusions, which reveals an important set of research challenges for filling the diagnosed information gap. A particularly challenging area of literature additions are aspects related to the analysis of wind energy solutions for small investors. These issues are addressed in only 1.52% of the reviewed literature. Also in need of additions is the area of the problematic impact of wind turbines on the environment, including a detailed and multifaceted risk analysis, as well as the analysis and evaluation of the public's stance on the construction of wind farms. Both strands (taken together) are addressed in less than 10% of the surveyed literature. These threads are closely connected, corresponding to the regulations adopted in Poland regarding conditions for the construction of wind farms (the Distance Law). In addition, the formal and legal framework—much discussed in the literature (45.80%)—should be expanded with studies touching upon the profitability of wind energy investments, considering resource and location conditions, in comparison to the current energy demand and price. Economic determinants of wind energy (in various dimensions and references) are addressed in the literature.

Relating the literature review to the aspects and scopes of assessment adopted in the introduction provided a basis for establishing the areas that the literature presents at a high level in terms of clarifying the problem at an average level or a low level (basic). The structure of the distribution of the variables, according to the criteria adopted in the introduction (x1–x9), together with the assignment to typological groups (according to the threads taken up; possibility of multiple assignment of the source to a category), has generated conclusions:

1. high level of discussion—grade H (score exceeding the 20% level) covers the issues of:
   - energy transition—essence, conditions, goals, regulations (x_1),
   - renewable energy sources in the energy system of countries—share of RES in the energy mix, orientation towards RES (x_2),
   - wind energy in the energy system of countries (x_3),
2. average level of discussion—grade M (score oscillating between 10–19%), covers the topics:
   - onshore wind energy in the energy system of countries (x_4),
3. low level of discussion—grade L (result oscillating within 0–9%), includes the topics:
   - offshore hydropower in the energy system of countries (x_5),
   - wind energy—solutions for the energy industry (x_6),
   - wind power—solutions for small individual investors (x_7),
   - economic conditions of renewable energy development in countries (x_8),
   - environmental and social aspects in relation to renewable energy development in the states (x_9).

A high level of discussion of the research thread indicates a high level of interest in the specific issue, giving grounds for considering it an important topic.

A low and average explanation of the problem reveals niches in the literature that may inspire further legitimate research challenges. The distribution of results is presented in the Figure 3.

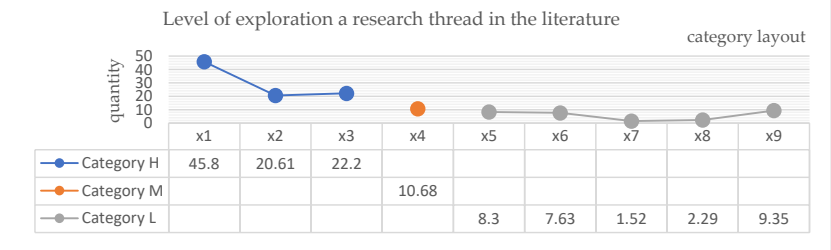

Figure 3. Level of exploration and research threads in the literature.

The review of the literature in wind energy in Poland and Lithuania confirms the thesis adopted in the introduction that there is a literature gap in this area. The outlined need for scientific recognition is important for strengthening the ongoing transformation of the energy market. Particularly important is the dimension of the analyses of the economic basis of wind turbine investments, analyses, and environmental assessments of aspects related to wind energy generation, combined with the assessment of public sentiment in this regard. In doing so, it is important to strengthen the literature recognition of the micro wind dimension, which is the main recommendation of this review.

The analysis and evaluation of the literature reveals that interest in the subject matter is growing. Literature items from the last 5 years constitute almost 63% of the total number of studies analysed (the analysis of the study periods is presented in Figure 4).

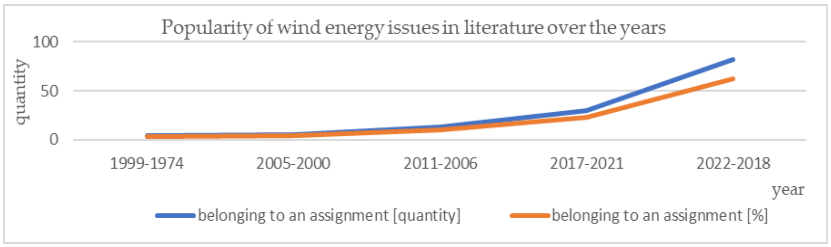

Figure 4. Popularity of wind energy issues in the literature over the years.

The above should be considered the right direction for scientific research. Wind resources are an important and promising direction for strengthening renewable energy sources in the energy market in Poland and Lithuania.

This review has revealed that, although the development of renewable energy markets in Poland and Lithuania is at an early stage, a strong policy framework and increased investments are necessary to ensure successful growth in the energy transition of the two countries. Furthermore, the compilation of information on energy market development in Poland and Lithuania can provide informative support in the process of reviewing adopted policies at the government level. In this respect, the importance of establishing precise dimensions of RES development as a basis for the creation of financial support programmes at the governmental levels, in the areas that most need it, is underlined.

Author Contributions: All authors have made significant contributions to this paper from the conception of the study through to the identification and selection of the research methodology and its conduct, the writing of the paper, and its editorial side. Conceptualisation, E.C.-P., H.G. and D.S.; methodology, E.C.-P., H.G. and S.Z.; validation, J.R.-M. and D.S.; formal analysis, E.C.-P.; resources, E.C.-P., J.R.-M., D.S. and S.Z.; writing—original draft preparation, E.C.-P. and J.R.-M.; writing—review and editing, E.C.-P. and J.R.-M.; visualisation, H.G. and S.Z.; supervision, J.R.-M. and D.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: Not applicable.

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

References

1. Azizzadeh, F.; Azizzadeh, S.; Hosseini, A.; Raut, Y. Co-opetition in COVID-19 era among organizations. *J. Contemp. Res. Bus. Adm. Econ. Sci.* **2022**, *1*, 63. [CrossRef]
2. Palonkorpi, M. *Energy Security and the Regional Security Complex Theory*; Reoprts in Education; University of Lapland: Rovaniemi, Finland, 2006; pp. 302–313.
3. Bigerna, S.; D'Errico, M.C.; Polinori, P. Dynamic forecast error variance decomposition as risk management proces for the Gulf Cooperation Council oil pertfolios. *Resour. Policy* **2022**, *78*, 102937. [CrossRef]
4. Mazur, A.; Rosa, E. Energy and Life-Style. *Science* **1974**, *186*, 607–610. [CrossRef] [PubMed]
5. Ben Jebli, M.; Ben Youssef, S. The Environmental Kuznets Curve, Economic Growth, Renewable and Non-Renewable Energy, and Trade in Tunisia. *Renew. Sustain. Energy Rev.* **2015**, *47*, 173–185. [CrossRef]

6. Amri, F. Intercourse across Economic Growth, Trade and Renewable Energy Consumption in Developing and Developed Countries. *Renew. Sustain. Energy Rev.* **2017**, *69*, 527–534. [CrossRef]
7. Menegaki, A.N.; Tugcu, C.T. Energy Consumption and Sustainable Economic Welfare in G7 Countries; A Comparison with the Conventional Nexus. *Renew. Sustain. Energy Rev.* **2017**, *69*, 892–901. [CrossRef]
8. Menegaki, A.; Tiwari, A. The Index of Sustainable Economic Welfare in the Energy-Growth Nexus for American Countries. *Ecol. Indic.* **2017**, *72*, 494–509. [CrossRef]
9. Kiran, M.S.; Özceylan, E.; Günfüz, M.; Paksoy, T. Swarm intelligence approaches to estimate electricity energy demand in Turkey. *Knowl.-Based Syst.* **2012**, *36*, 93–103. [CrossRef]
10. Toksan, M.D. Ant colony optimization approach to estimate energy demand of Turkey. *Energy Policy* **2007**, *35*, 3984–3990.
11. Winzer, C. Conceptualizing energy security. *Energy Policy* **2012**, *46*, 36–48. [CrossRef]
12. Williams, P.D.; MdDonald, M. (Eds.) *Energy Security*; Routledge: Oxfordshire, UK, 2018; pp. 483–496. [CrossRef]
13. Flaherty, C.; Filho, W.L. Energy Security as a Subset of National Security. In *Global Energy Policy and Security*; Springer: London, UK, 2013; pp. 11–25. [CrossRef]
14. Hedenus, F.; Azar, C.; Johansson, D.J. Energy security policies in EU-25—The expected cost of oil supply disruptions. *Energy Policy* **2010**, *38*, 1241–1250. [CrossRef]
15. Woźniak, J.; Krysa, Z.; Dudek, M. Concept of government subsidized energy prices for a group of individual consumers in Poland as a means to reduce smog. *Energy Policy* **2020**, *144*, 111620. [CrossRef]
16. Burchart-Karol, D.F.; Fugiel, A.; Czaplicka-Kolarz, A.; Turek, M. Model of environmental life cycle assessment for coal mining operations. *Sci. Total Environ.* **2016**, *562*, 61–72. [CrossRef] [PubMed]
17. Brauers, H.; Oei, P.-Y. The political economy of coal in Poland: Drivers and barriers for a shift away from fossil fuels. *Energy Policy* **2020**, *144*, 111621. [CrossRef]
18. Dzikić, M.; Piwowar, A. Ecological and economic aspects of electric energy production using the biomass co-firing method: The case of Poland. *Renew. Sustain. Energy Rev.* **2016**, *55*, 856–862. [CrossRef]
19. Rehman, A.; Radulescu, M.; Ma, H.; Dagar, V.; Hussain, I.; Khan, M.K. The impact of globalization, energy use, and trade on ecological footprint in Pakistan: Does environmental sustainability exist? *Energies* **2021**, *14*, 5234. [CrossRef]
20. Panait, M.; Janjua, L.R.; Apostu, S.A.; Mihăescu, C. Impact factors to reduce carbon emissions. Evidences from Latin America. *Kybernetes*, 2022; *ahead-of-print*. [CrossRef]
21. Apostu, S.A.; Panait, M.; Vasile, V. The energy transition in Europe—A solution for net zero carbon? *Environ. Sci. Pollut. Res.* **2022**, *29*, 71358–71379. [CrossRef]
22. Baskutis, S.; Baskutiene, J.; Navickas, V.; Bilan, Y.; Cieśliński, W. Perspectives and Problems of Using Renewable Energy Sources and Implementation of Local "Green" Initiatives: A Regional Assessment. *Energies* **2021**, *14*, 5888. [CrossRef]
23. OECD. *Applications of Complexity Science for Public Policy*; OECD: Paris, France, 2009.
24. Sachs, J.D. From millennium development goals to sustainable development goals. *Lancet* **2012**, *379*, 2206–2211. [CrossRef]
25. Eur-Lex. Available online: https://eur-lex.europa.eu/legal-content/PL/ALL/?uri=CELEX:32009L0028 (accessed on 10 June 2022).
26. Van Niekerk, A.J. Inclusive economic sustainability: SDGs and Global Inequality. *Sustainability* **2020**, *12*, 5427. [CrossRef]
27. Sustainable Development Report 2019. Transformations to Achieve the Sustainable Development Goals. Available online: https://s3.amazonaws.com/sustainabledevelopment.report/2019/2019_sustainable_development_report.pdf (accessed on 5 January 2021).
28. Eur-Lex. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2015:80:FIN (accessed on 10 June 2022).
29. International Energy Agency, World Energy Outlook 2016. Available online: https://www.iea.org/reports/world-energy-outlook-2016 (accessed on 4 September 2022).
30. 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. [CrossRef]
31. Lin, M.-X.; Liou, H.M.; Chou, K.T. National energy transition framework toward SDG7 with legal reforms and policy bundles:The case of Taiwan and its comparison with Japan. *Energies* **2020**, *13*, 1387. [CrossRef]
32. Surya, B.; Muhibuddin, A.; Suriani, S.; Rasyidi, E.S.; Baharuddin, B.; Fitriyah, A.T.; Abubakar, H. Economic Evaluation, Use of Renewable Energy, and Sustainable Urban Development Mamminasata Metropolitan, Indonesia. *Sustainability* **2021**, *13*, 1165. [CrossRef]
33. Cherp, A.; Jewell, J. The three perspectives on energy security: Intellectual history, disciplinary roots and the potential for integration. *Curr. Opin. Environ. Sustain.* **2011**, *3*, 202–212. [CrossRef]
34. Bahgat, G. Oil Security at the Turn of the Century: Economic and Strategic Implications. *Int. Relat.* **1999**, *14*, 41–52. [CrossRef]
35. Rybak, A.; Rybak, A. Possible strategies for hard coal mining in Poland as a result of production function analysis. *Resour. Policy* **2016**, *50*, 27–33. [CrossRef]
36. Rees, W.E. Globalization, trade and migration: Undermining sustainability. *Ecol. Econ.* **2006**, *59*, 220–225. [CrossRef]
37. Chomać-Pierzecka, E.; Sobczak, A.; Urbańczyk, E. RES Market Development and Public Awareness of the Economic and Environmental Dimension of the Energy Transformation in Poland and Lithuania. *Energies* **2022**, *15*, 5461. [CrossRef]

38. Racz, L.; Fozer, D.; Nagy, T.; Toth, A.J.; Haaz, E.; Tarjani, J.A.; Andre, A.; Selim, A.; Valentinyi, N.; Mika, L.T.; et al. Extensive comparison of biodiesel production alternatives with life cycle, PESTLE and multi-criteria decision analyses. *Clean Technol. Environ. Policy* **2018**, *20*, 2013–2024. [CrossRef]
39. Gupta, A. Environmental and PEST analysis: An approach to external business environment. *Int. J. Mod. Soc. Sci.* **2013**, *1*, 34–43. Available online: https://www.meritresearchjournals.org/assh/Content/2013/June/Gupta.pdf (accessed on 28 September 2022).
40. Toth, D.; Smutka, L.; Maitah, K.; Jarolínová, V. Income Differentiation as a Factor of Unsustainability in Forestry. *Sustainability* **2020**, *12*, 4749.
41. Dziekański, P.; Prus, P.; Sołtyk, P.; Wrońska, M.; Imbrea, F.; Smuleac, L.; Pascalau, R.; Błaszczyk, K. Spatial Disproportions of the Green Economy and the Financial Situation of Polish Voivodeships in 2010–2020. *Sustainability* **2022**, *14*, 13824. [CrossRef]
42. Ryszawska, B. Zielona gospodarka jako priorytet strategiczny Unii Europejskiej. *Logistyka Odzysku* **2013**, *4*, 18–21.
43. Aldieri, L.; Vinci, C.P. Green Economy and Sustainable Development: The Economic Impact of Innovation on Employment. *Sustainability* **2018**, *10*, 3541. [CrossRef]
44. Eur-Lex. Available online: https://eur-lex.europa.eu/legal-content/PL/TXT/?uri=CELEX:32001L0077 (accessed on 10 June 2022).
45. Eur-Lex. Available online: https://eur-lex.europa.eu/legal-content/PL/TXT/?uri=CELEX:32003L0030 (accessed on 10 June 2022).
46. Energy EC Europa. Available online: https://energy.ec.europa.eu/topics/energy-strategy/energy-union_en (accessed on 10 June 2022).
47. Eur-Lex. Available online: https://eur-lex.europa.eu/resource.html?uri=cellar:fa6ea15b-b7b0-11e6-9e3c-01aa75ed71a1.0001.02/DOC_1&format=PDF (accessed on 10 June 2022).
48. Eur-Lex. Available online: https://eur-lex.europa.eu/legal-content/PL/TXT/?uri=CELEX:32018L2001 (accessed on 10 June 2022).
49. Gao, M.-Z.A.; Fan, C.-T.; Liao, C.-N. Application of German energy transition in Taiwan: A critical review of unique electricity liberalisation as a core strategy to achieve renewable energy growth. *Energy Policy* **2018**, *120*, 644–654. [CrossRef]
50. Eur-Lex. Available online: https://eur-lex.europa.eu/legal-content/PL/TXT/?uri=CELEX:52019DC0640 (accessed on 10 June 2022).
51. EC Europa. Available online: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/delivering-european-green-deal_en (accessed on 10 June 2022).
52. Eur-Lex. Available online: https://eur-lex.europa.eu/legal-content/PL/TXT/PDF/?uri=CELEX:32020R1294&from=PL (accessed on 10 June 2022).
53. Krūminš, J.; Klavinš, M. The Baltic States' Move toward a Sustainable Energy Future. *Energies* **2022**, *15*, 8230. [CrossRef]
54. Glodek, A.; Pacyna, J.M. Mercury emission from coal-fired power plants in Poland. *Atmos. Environ.* **2009**, *43*, 5668–5673. [CrossRef]
55. Li, Y.; Zhang, H.; Kang, Y. Will Poland fulfill its coal commitment by 2030? An answer based on a novel time series prediction method. *Energy Rep.* **2020**, *6*, 1760–1767. [CrossRef]
56. Kuchler, M.; Bridge, G. Down the black hole: Sustaining national socio-technical imaginaries of coal in Poland. *Energy Res. Soc. Sci.* **2018**, *41*, 136–147. [CrossRef]
57. Schiavo, J.G.; Mendelsohn, R. The effect of domestic Air Pollution Mitigation and Fracking on Retirements of coal Power Plants. *Clim. Change Econ. (CCE)* **2019**, *10*, 1–21.
58. Johnson, C.; Boersma, T. Energy (in) security in Poland the case of shale gas. *Energy Policy* **2013**, *53*, 389–399. [CrossRef]
59. Budzianowski, W.; Gomes, J.F.P. Perspectives for low-carbon electricity production until 2030: Lessons learned from the comparison of local contexts in Poland and Portugal. *Energy Sources B* **2016**, *11*, 534–541. [CrossRef]
60. *Clean Energy for All Europeans–Unlocking Europe's Growth Potential*; European Commission: Brussels, Belgium, 2016. Available online: http://europa.eu/rapid/press-release_IP-16-4009_en.htm (accessed on 9 June 2022).
61. Zhao, T.; Hu, Y.; Zang, T.; Cheng, L. MRTFB regulates the expression of NOMO1 in colon. *Proc. Natl. Acad. Sci. USA* **2020**, *117*, 7568–7569. [CrossRef] [PubMed]
62. Brodny, J.; Tutak, M. Exposure to Harmful Dusts on fully Powered Longwall coal Mines in Poland. *Int. J. Environ. Res. Public Health* **2018**, *15*, 1846. [CrossRef] [PubMed]
63. Wagner, A.; Grobelski, T.; Harembski, M. Is energy policy a public issue? Nuclear power in Poland and implications for energy transitions in Central and East Europe. *Energy Res. Soc. Sci.* **2016**, *13*, 158–169. [CrossRef]
64. Poland's Energy Policy Until 2030. Ministry of Economy, Annex to the Resolution No. 202/2009 of the Council of Ministers of 10 November 2009. pp. 1–29. Available online: https://www.pigeor.pl/media/js/kcfinder/upload/files/Polityka-energetyczna-Polski-do-2030r.pdf (accessed on 10 June 2022).
65. Reform of the EU Emissions Trading System–Council Endorses Deal with European Parliament European Council, Brussels 2017. Available online: https://www.consilium.europa.eu/en/press/press-releases/2017/11/22/reform-of-the-eu-emissions-trading-system-council-endorses-deal-with-european-parliament/ (accessed on 9 November 2018).
66. Michalak, A.; Dziugiewicz, S. Development limitations and perspectives of Renewable Energy Sources in Poland. *Manag. Syst. Prod. Eng.* **2018**, *26*, 237–240. [CrossRef]

67. Jurasz, J.; Mikulik, J. Investigating theoretical PV energy generation patterns with their relation to the power load curve in Poland. *Int. J. Photoenergy* **2016**, *2016*, 3789840. [CrossRef]
68. Jezierska-Thöle, A.; Rudnicki, R.; Kluba, M. Development of energy crops cultivation for biomass production in Poland Renew. Sustain. *Energy Rev.* **2016**, *62*, 534–545.
69. Polish Energy Policy until 2030, Ministry of Economy, Annex to Resolution No. 202/2009 of the Council of Ministers of 10 November 2009. pp. 1–122. Available online: https://wfosigw.wroclaw.pl/files/download_pl/773_polityka-energetyczna-polski-do-2030.pdf (accessed on 9 November 2022).
70. Connolly, D.; Lund, H.; Mathiesen, B.V. Smart Energy Europe: The technical and economic impact of one potential 100% renewable energy scenario for the European Union. *Renew. Sustain. Energy Rev.* **2016**, *60*, 1634–1653. [CrossRef]
71. Bacenetti, J.; Fusi, A.; Azapagic, A. Environmental sustainability of integrating the organic Rankin cycle with anaerobic digestion and combined heat and power generation. *Sci. Total. Environ.* **2019**, *658*, 684–696. [CrossRef]
72. Fusi, A.; Bacenetti, J.; Proto, A.R.; Tedesco, D.E.A.; Pessina, D.; Facchinetti, D. Pellet Production from Miscanthus: Energy and Environmental Assessment. *Energies* **2021**, *14*, 73. [CrossRef]
73. Energy Policy of Lithuania 170 (1743), The Polish Institute of International Affairs. 2018. Available online: https://www.pism.pl/publikacje/Polityka_energetyczna_Litwy (accessed on 3 June 2022).
74. Consequences of the Energy Price Crisis in the Baltic StatesInstitute of Central Europe. Available online: https://ies.lublin.pl/komentarze/konsekwencje-kryzysu-cen-energii-energetycznej-w-panstwach-baltyckich/ (accessed on 14 June 2022).
75. Chomać-Pierzecka, E.; Sobczak, A.; Soboń, D. The Potential and Development of the Geothermal Energy Market in Poland and the Baltic States—Selected Aspects. *Energies* **2022**, *15*, 4142. [CrossRef]
76. Chomać-Pierzecka, E.; Kokiel, A.; Rogozińska-Mitrut, J.; Sobczak, A.; Soboń, D.; Stasiak, J. Hydropower in the Energy Market in Poland and the Baltic States in the Light of the Challenges of Sustainable Development-An Overview of the Current State and Development Potential. *Energies* **2022**, *15*, 7427. [CrossRef]
77. Sobczak, A.; Chomać-Pierzecka, E.; Kokiel, A.; Różycka, M.; Stasiak, J.; Soboń, D. Economic Conditions of Using Biodegradable Waste for Biogas Production, Using the Example of Poland and Germany. *Energies* **2022**, *15*, 5239. [CrossRef]
78. Alderucci, V.; Giordano, A.; Iovino, A.; Giordano, N.; Phillips, V.D. Potential biomass resources of Sicily for electric-power generation. *Appl. Energy* **1993**, *45*, 219–240. [CrossRef]
79. Chinnici, G.; D'Amico, M.; Rizzo, M.; Pecorino, B. Analysis of biomass availability for energy use in Sicily. *Renew. Sustain. Energy Rev.* **2015**, *52*, 1025–1030. [CrossRef]
80. Venturi, P.; Venturi, G. Analysis of energy comparison for crops in European agricultural systems. *Biomass Bioenergy* **2003**, *25*, 235–255. [CrossRef]
81. Chomać-Pierzecka, E.; Sobczak, A.; Sobon, D. Wind Energy Market in Poland in the Background of the Baltic Sea Bordering Countries in the Era of the COVID-19 Pandemic. *Energies* **2022**, *15*, 2470. [CrossRef]
82. Chomać-Pierzecka, E.; Kokiel, A.; Rogozińska-Mitrut, J.; Sobczak, A.; Soboń, D.; Stasiak, J. Analysis and Evaluation of the Photovoltaic Market in Poland and the Baltic States. *Energies* **2022**, *15*, 669. [CrossRef]
83. Fleming, P.D.; Probert, S.D. The evolution of wind-turbines: An historical review. *Appl. Energy* **1984**, *18*, 163–177. [CrossRef]
84. Lewandowski, W.M. *Pro-Ecological Sources of Renewable Energy*, 1st ed.; WNT: Warsaw, Poland, 2001.
85. Soliński, I. *Energy and Economical Aspects of Using Wind Energy*, 1st ed.; The Publishing House of the Mineral and Energy Economy Research Institute of PAN: Cracow, Poland, 1999.
86. Kumar, Y.; Ringenberg, J.; Depuru, S.S.; Devabhaktuni, V.K.; Lee, J.W.; Nikolaidis, E.; Andersen, B.; Afjeh, A. Wind Energy: Trends and Enabling Technologies. *Renew. Sustain. Energy Rev.* **2016**, *53*, 209–224. [CrossRef]
87. Esteban, M.D.; Diez, J.J.; López, J.S.; Negro, V. Why Offshore Wind Energy? *Renew. Energy* **2011**, *36*, 444–450. [CrossRef]
88. Gasset, N.; Landry, M.; Gagnon, Y. A Comparison of Wind Flow Models for Wind Resource Assessment in Wind Energy Applications. *Energies* **2012**, *5*, 4288–4322. [CrossRef]
89. Ochoa, G.V.; Alvarez, J.N.; Acevedo, C. Research Evolution on Renewable Energies Resources from 2007 to 2017: A Comparative Study on Solar, Geothermal, Wind and Biomass Energy. *Int. J. Energy Econ. Policy* **2019**, *9*, 242–253. [CrossRef]
90. Talarek, K.; Knitter Piątkowska, A.; Garbowski, T. Wind Parks in Poland—New Challenges and Perspectives. *Energies* **2022**, *15*, 7004. [CrossRef]
91. *Report: Wind Energy in Poland 4.0 2022*; TPA Poland: Katowice, Poland, 2022.
92. Carrillo, C.; Feijoo, A.E.; Cidras, J.; Gonzalez, J.A.G.J. Power fluctuations in an isolated wind plant. *IEEE Trans. Energy Convers.* **2004**, *19*, 217–221. [CrossRef]
93. Mana, M.; Burlando, M.; Meißner, C. Evaluation of two ANN approaches for the wind power forecast in a mountainous site. *Int. J. Renew. Energy Res.* **2017**, *7*, 1629–1638.
94. Zhao, P.; Wang, J.; Xia, J.; Dai, Y.; Sheng, Y.; Yue, J. Performance evaluation and accuracy enhancement of a day-ahead wind power forecasting system in China. *Renew. Energy* **2012**, *43*, 234–241. [CrossRef]
95. Wind power in Poand. Available online: https://pl.wikipedia.org/wiki/Energetyka_wiatrowa_w_Polsce (accessed on 4 November 2022).
96. Statistical Information on Electricity, Energy Market Agency. Available online: https://www.are.waw.pl/open-data/publication/ISoEE/table/5 (accessed on 30 August 2022).

97. Resulting Statistical Information. Available online: https://www.are.waw.pl/badania-statystyczne/wynikowe-informacje-statystyczne#2021-rok (accessed on 30 August 2022).
98. Pronińska, K.; Księzopolski, K. Baltic Offshore Wind Energy Development—Poland's Public PolicyTools Analysis and the Geostrategic Implications. *Energies* **2021**, *14*, 4883. [CrossRef]
99. Farkas, A.; Degiuli, N.; Martić, I. Assessment of OffshoreWave Energy Potential in the Croatian Part of the Adriatic Sea and Comparison with Wind Energy Potential. *Energies* **2019**, *12*, 2357. [CrossRef]
100. Wind Europe. Available online: https://balticwind.eu/pl/windeurope-morskie-plany-zagospodarowania-przestrzennego-panstw-ue-pozwola-na-220-gw-morskiej-energetyki-wiatrowej/#iLightbox[gallery20953]/0 (accessed on 11 November 2022).
101. Ministry of Climate and Environment. *Energy Policy of Poland Until 2040*; Ministry of Climate and Environment: Warsaw, Poland, 2021.
102. Wind Europe. Available online: https://windeurope.org/annual2022/networking/offshore-poland/ (accessed on 11 November 2022).
103. New Wind Farm in Lithuania. Available online: https://www.cire.pl/artykuly/serwis-informacyjny-cire-24/110019-nowa-elektrownia-wiatrowa-na-litwie (accessed on 10 February 2022).
104. Lithuanian Statisticsm. Available online: https://lvea.lt/en/statistics/lithuanian-statistics/ (accessed on 11 November 2020).
105. Blažauskas, N.; Wlodarski, M.; Paulauskas, S. *Perspectives for Offshore Wind Energy Development in the South-East Baltics*; Klaipeda University: Klaipeda, Lithuania, 2013; ISBN 978-9955-18-723-3.
106. Jankeviciene, J.; ˙Kanapickas, A. Projected NearSurface Wind Speed Trends in Lithuania. *Energies* **2021**, *14*, 5425. [CrossRef]
107. Wind Power in Lithuania. Available online: https://en.wikipedia.org/wiki/Wind_power_in_Lithuania (accessed on 11 November 2020).
108. Lithuanian Government Clears Path for First Offshore Wind Farm in 2028. Available online: https://www.offshorewind.biz/2022/04/01/lithuanian-government-clears-path-for-first-offshore-wind-farm-in-2028/ (accessed on 11 November 2020).
109. RES in Europe. Available online: https://magazynprzemyslowy.pl/artykuly/oze-w-europie-ktore-panstwa-sa-obecnie-najbardziej-zielone (accessed on 10 February 2022).
110. Tamašauskas, R.; Šadauskienė, J.; Bruzgevicius, P.; Krawczyk, D.A. Investigation and Evaluation of Primary Energy from Wind Turbines for a Nearly Zero Energy Building (nZEB). *Energies* **2019**, *12*, 2145. [CrossRef]
111. Bepary, B.; Kabi, G. Occupational Risk Assessment of Wind Turbines in Bangladesh. *Appl. Syst. Innov.* **2022**, *5*, 34. [CrossRef]
112. Tsili, M.; Papathanassiou, S. A review of grid code technical requirements for wind farms. *IET Renew. Power Gener.* **2009**, *3*, 308–332. [CrossRef]
113. Tobin, I.; Jerez, S.; Vautard, R.; Thais, F.; Van Meijgaard, E.; Prein, A.; Déqué, M.; Kotlarski, S.; Maule, C.F.; Nikulin, G.; et al. Climate change impacts on the power generation potential of a European mid-century wind farms scenario. *Environ. Res. Lett.* **2016**, *11*, 034013. [CrossRef]
114. Sæþórsdóttir, A.D.; Wendt, M.; Tverijonaite, E. Wealth of Wind and Visitors: Tourist Industry Attitudes towards Wind Energy Development in Iceland. *Land* **2021**, *10*, 693. [CrossRef]
115. Tumelienė, E.; Visockienė, J.S.; Maliene, V. Evaluating the Eligibility of Abandoned Agricultural Land for the Development of Wind Energy in Lithuania. *Sustainability* **2022**, *14*, 14569. [CrossRef]
116. Eltham, S.; Harrison, D.; Allen, G. Change in public attitudes towards a Cornish wind farm: Implications for planning. *Energy Policy* **2008**, *36*, 23–33. [CrossRef]
117. Van Kamp, I. Health Effects Related to Wind Turbine Sound, Including Low-Frequency Sound and Infrasound. *Acoust. Aust.* **2018**, *4*, 31–57. [CrossRef]
118. Castelo-Branco, M.; Alves-Pereira, N. Vibroacoustic Disease. *Noise Health* **2004**, *6*, 3–20.
119. Smallwood, S. Comparing bird and bat fatality-rate estimates among North American wind-energy projects. *Wildl. Soc. Bull.* **2013**, *37*, 19–33. [CrossRef]
120. Drewitt, R.; Langston, A. Assessing the impacts of wind farms on birds. *IBIS Int. J. Avian Sci.* **2006**, *148*, 29–42. [CrossRef]
121. Wyrobek, J.; Popławski, Ł.; Dzikuć, M. Analysis of Financial Problems of Wind Farms in Poland. *Energies* **2021**, *14*, 1239. [CrossRef]
122. Karanikas, N.; Steele, S.; Bruschi, K.; Robertson, C.; Kass, J.; Popovich, A.; MacFadyen, C. Occupational health hazards and risks in the wind industry. *Energy Rep.* **2021**, *7*, 3750–3759. [CrossRef]
123. Chou, J.S.; Liao, P.C.; Yeh, C.D. Risk Analysis and Management of Construction and Operations in Offshore Wind Power Project. *Sustainability* **2021**, *13*, 7473. [CrossRef]
124. Štreimikiene, D.; Lekavicius, V.; Stankuniene, G.; Pažeraite, A. Renewable Energy Acceptance by Households: Evidence from Lithuania. *Sustainability* **2022**, *14*, 8370. [CrossRef]
125. Babaremu, K.; Olumba, N.; Chris-Okoro, I.; Chuckwuma, K.; Jen, T.-C.; Oladijo, O.; Akinlabi, E. Overview of Solar–Wind Hybrid Products: Prominent Challenges and Possible Solutions. *Energies* **2022**, *15*, 6014. [CrossRef]

126. Rabe, M.; Streimikiene, D.; Bilan, Y. Model of Optimization of Wind Energy Production in the Light of Legal Changes in Poland. *Energies* **2020**, *13*, 1557. [CrossRef]
127. Ziegler, J.; Gonzales, L.; Rubert, E.; Smolka, T.; Melero, U. Lifetime extension of onshore wind turbines: A review covering Germany, Spain, Denmark, and the UK. *Renew. Sustain. Energy Rev.* **2018**, *82*, 1261–1271. [CrossRef]