Solutions Related to Wind Energy in EU Countries

Subjects: Business
Contributor: Radosław Wolniak , Bożena Skotnicka-Zasadzień

Energy security in EU (European Union) countries has become a priority, especially after the outbreak of the war in Ukraine. In addition to the EU becoming independent from oil and gas from Russia, another important factor influencing the development of alternative renewable energy sources is the increasingly visible climate change in the world and in Europe. One of the key actions that EU countries should undertake is the transition to a low-emission economy and the associated use of various renewable energy systems and placing these energy sources wherever the production of clean energy does not significantly change the landscape and society.

wind energy | wind resources | energy transformation | EU countries

1. Introduction

Renewable energy sources offer significant advantages over fossil fuels, as they are abundant, sustainable, and produce little-to-no greenhouse gas emissions during operation [1]. By harnessing these clean and renewable sources, EU countries can substantially reduce their reliance on fossil fuels, thereby decreasing their carbon footprint, contributing to global efforts to limit global warming, and mitigating climate change impacts [2]. The strategic placement of renewable energy systems is a critical consideration in the transition to a low-emission economy. By locating these energy sources where they do not significantly alter the landscape or disrupt communities, the social acceptability and environmental sustainability of such projects are enhanced [3].

The societies of individual countries that are observing increasingly unfavorable weather phenomena related to the production of energy from fossil fuels have become very much involved in the development of innovative clean technology solutions [4]. Unfavorable weather phenomena, such as heatwaves, droughts, floods, hurricanes, and wildfires, have become more frequent and severe due to climate change driven by greenhouse gas emissions from burning fossil fuels [5]. These extreme events have devastating effects on communities, ecosystems, and economies. As a result, there is a growing recognition among EU societies that relying heavily on fossil fuels is unsustainable and poses significant risks to their wellbeing and prosperity [6]. All social strata of a given country participate in the energy transformation conducted in this way [7]. Achieving a successful energy transition involves not only the active involvement of governments and businesses but also the engagement of citizens, communities, and civil society as a whole [8]. This inclusive approach is crucial for driving the adoption of renewable energy and ensuring its sustainable development [9].

In recent years, very intensive work on the use of renewable energy sources (RESs) has been observed in European Union countries [8][10]. By involving all social strata in the energy transformation, EU countries can harness the collective efforts and ideas of their citizens, businesses, and communities to accelerate the adoption of renewable energy technologies and achieve their renewable energy targets [11]. This comprehensive approach ensures a more balanced and resilient energy system while fostering a sense of shared responsibility and ownership among all stakeholders in shaping a greener future [12][13]. Thanks to these works, the share of renewable energy sources in energy production in the EU in 2017 reached 29.9% [14][15]. Wind energy and its solutions are of great importance among renewable energy sources in the EU [16]. In 2018, wind energy achieved the largest share among renewable energy sources in the EU for the first time. In EU countries, the amount of electricity produced by wind turbines reached 362.4 TWh [17][18][19], which was a 37.2% increase in relation to 2007. In 2018, the total capacity of wind farms accounted for 24% of the total installed capacity of all RES installations [20]. In EU countries, the best conditions for the development of wind energy are in the North Sea and the Baltic Sea and off the Atlantic coast [21]. Apart from changeable wind conditions, the development of wind power engineering is also influenced by the internal conditions of a given country. Wind farms in the EU are installed both on land and at sea [22][23]. The number of offshore wind farms depends on the length of the coastline in a given country. According to the analysis, wind farms in the EU are located primarily on land. Offshore wind farms account for merely 4.1% of the total capacity produced by installations using wind energy [24]. Historically, onshore wind farms have been more cost-effective to develop and operate compared to their offshore counterparts [25]. The initial investment for offshore wind projects can be significantly higher due to the complexities of constructing and maintaining turbines in marine environments [26]. The development of onshore wind farms began earlier and gained traction in many EU countries before offshore wind technology was widely deployed [26]. As a result, onshore wind farms have had a head start and established a stronger presence in the energy landscape [27]. In 2021, the largest share of wind power in the European Union was generated by Denmark (44%), followed by Portugal (26%), Spain (24%), and Germany (23%). Countries where these values ranged from 20% to 10% include Sweden (19%), Greece (18%), the Netherlands (15%), Belgium (13%), Croatia, Austria and Romania (11%), and Lithuania (10%). Less than 10% generation from wind power was generated in countries such as Estonia (9%), Poland (9%), France (8%), Italy (7%), Bulgaria (4%), Latvia (2%), Hungary (1%), the Czech Republic (1%), and Slovakia (0.04%) [27][28][29][30].

2. Solutions Related to Wind Energy

In the last fifteen years, many legal acts regarding the promotion of renewable energy sources have been introduced in the EU [31][32]. In 2009, the EU leaders set targets, according to which by 2020 approximately 20% of the energy consumed in the European Union should come from renewable sources [33]. This directive obligated all the EU countries to reach a level of a 10% share of fuels from renewable sources in the transport sector. Based on this directive, all the EU countries defined how they intended to achieve individual targets and presented action plans regarding the policy of using energy from renewable sources. Every two years, each EU country is required to submit a report on progress in this area on the basis of relevant indicators [34].

In July 2021, in the European Green Deal package, the Commission presented the Renewable Energy Directive, aiming to increase renewable energy sources to 40% by 2023 [35][36]. In May 2022, after the Russian invasion of Ukraine, the European Commission decided to accelerate the transition to clean energy and reduce dependence on Russian oil (RED III) (RED—Renewable Energy Directive) as part of the REPowerEU plan. On 9 November 2022, it was decided that power plants using renewable energy sources would be considered an overriding public objective (RED IV) [37]. This decision represents a significant step forward in the European Union's commitment to advancing renewable energy and combating climate change [38]. The RED IV directive builds upon the existing Renewable Energy Directive (RED) framework, which was first introduced in 2009 to set binding targets for renewable energy use across the EU member states [39]. The primary objective of RED IV is to further accelerate the transition towards a low-carbon and sustainable energy system by promoting the development and integration of renewable energy sources into the region's energy mix [40].

RED IV is expected to set even more ambitious targets for the share of renewable energy in the EU's overall energy consumption [41]. The directive is likely to call for higher percentages of renewable energy use by a specific timeline, encouraging member states to accelerate their renewable energy investments and deployments [42].

In July 2021, the European Commission published a legislative package entitled "Fit for 55: delivering the EU's 2030 climate target on the way to climate neutrality" [34]. The main targets included an increase in the use of renewable energy in buildings to 49% by 2023, a new benchmark of a 1.1 percentage point increase in the use of renewable energy in industry, an annual increase of 1.1 percentage points in the use of renewable energy sources for heating and cooling purposes in the member states, and an indicative annual increase of 2.1 percentage points in the use of renewable energy sources and waste-based heating and cooling processes [41][43]. After the EU decided to increase the use of renewable energy sources in individual EU countries, in September 2020, the European Commission established a mechanism for financing energy from renewable sources [44] based on Art. 33 of the Regulation [34] in the "Clean energy for all Europeans" package. This mechanism is still being implemented in EU countries [44]. Its main goal is to help the countries meet their individual and collective renewable energy targets. The energy generated owing to this financing mechanism will be included in the renewable energy targets of all the countries striving to achieve carbon neutrality by 2050 [39][45]. As part of the REPowerEU plan, the European Commission made important assumptions regarding the resources of individual types of renewable energy. The plan assumes that by 2025, the capacity of photovoltaic systems will have doubled to reach 320 GW, and by 2030, systems with a capacity of 600 GW will have been installed [37][46]. Regarding biomass and biofuels, the EU directive [47] assumes that by 2030, the share of advanced biofuels and biogas in the transport sector will have increased to 3.5% [46]. In the last three years, a very large development in wind power engineering, especially with regards to onshore wind energy, has been observed throughout Europe, including in the EU. In 2022, the most energy in the entire European Union was generated by wind and photovoltaic power plants. It is worth noting that for the first time in history, renewable energy sources outnumbered other power generation technologies [48][49]. Since 2020, the amount of wind energy in the European Union has been systematically increased in relation to the total amount of renewable energy produced in the EU. The European Parliament has been developing strategies and directives that assume an increase in the production of energy from wind farms [41]. Recognizing the urgent need to transition to renewable energy sources and combat climate change, the European Parliament has played a pivotal role in shaping the EU's energy policies and setting ambitious targets for the expansion of wind energy [50]. The European Parliament has consistently pushed for more ambitious renewable energy targets to be set at the EU level. These targets have provided a clear roadmap for member states to increase their share of renewable energy in their energy mix and have been a driving force behind the expansion of wind energy projects [51].

In November 2020, the Commission published a special EU strategy regarding offshore renewable energy [42]. According to this strategy, the production of electricity from offshore renewable sources is to reach 60 GW (gigawatts) by 2030 and 300 GW by 2050. In February 2022, the European Parliament adopted a resolution (2021/2012(INI)) (INI—own-initiative procedure) on the strategy for wind energy, which assumes that wind energy generation should range from 70 to 79 GW [52]. According to the report "Wind Energy in Europe: 2021 Statistics and the outlook for 2022–2026", onshore wind energy installations in EU countries generated 14 GW, whereas offshore installations generated merely 3.4 GW. This report assumes that in the years 2022–2026, 27 EU countries will build new wind farms with a capacity of ca. 18 GW. To achieve such a result, individual countries must provide 32 GW per year, which will result in a 40% share of wind energy in electricity generated by renewable sources in the EU. The increase in renewable energy resources is related to the economic efficiency of individual renewable energy generation technologies [53]. The economic efficiency of individual technologies in the EU countries has been specified in the document of the European Commission "Energy sources, production costs and operation of electricity generation technologies, heat production and transport" [54] as an attachment entitled "Second Strategic Energy Review". This document compares the costs and efficiency of different technologies used to produce energy from renewable sources. The following parameters were taken into account: capital expenditure, operating costs, and the total cost of energy production [55].

Onshore wind energy is the cheapest form of electricity generated from renewable energy sources. The investment costs in this case range from EUR 1000 to EUR 1370/kW, whereas electricity from offshore farms is more expensive, reaching EUR 1750 to EUR 2750/kW. Wind energy is also unrivalled when it comes to operating costs, which for onshore farms amount to EUR 33–42/kW, and in the case of offshore farms, costs range from EUR 71 to EUR 105/kW. Also, production costs are lower, reaching €50–93/kW [56]. Based on the above-presented information, the European Commission has concluded that the costs of producing wind power, especially onshore energy, in the years to come will be the lowest of all electricity generation technologies [57]. The wind power sector has witnessed remarkable technological advancements and innovations over the years. Improved turbine designs, enhanced manufacturing processes, and better materials have led to increased efficiency and reduced production costs. As technology continues to evolve, the efficiency and performance of wind turbines are expected to improve further, driving down the overall cost of wind energy production [58].

The development of wind power engineering must comply with the principle of sustainable socio-economic development, taking into account an increase in the quality of life and natural environment improvements [59]. It is important that solutions related to the production of wind energy should have a positive impact on the natural environment and should reduce greenhouse gas emissions into the atmosphere [60]. The development of wind power engineering and its technologies results in a significant reduction in so-called environmental costs, i.e., the costs involved in the production of energy using conventional power generation technologies [61]. The advantages of wind energy also include the fact that wind is a source of renewable energy that will never run out. Another benefit is the partial independence from electricity suppliers, especially in places where power outages occur [62]. Wind energy also can be produced not only on wind farms—there are modern innovative wind turbines that can be installed on the roofs of residential houses, office buildings, and production halls. An innovative solution that is currently gaining popularity is placing wind turbines in the structures of bridge carriers and in movable boards or advertising billboards [49].

Wind power engineering as a source of energy encounters many obstacles related to the implementation of new solutions, which makes the development of this cost-effective technology difficult [63].

Barriers related to the development of wind power engineering that are mentioned in the subject literature can be divided into the following groups: legal and financial barriers, educational barriers, and technical and ecological barriers [64].

In the European Union, there are no regulations applying to visual and noise encumbrance related to wind farm operations, whereas individual countries have legal instruments that allow citizens and NGOs (non-governmental organizations) to block the establishment of wind farms and the installation of wind turbines. The legal instruments that can be used to block the development of wind power engineering include the environmental impact assessment procedure. The process of assessing the environmental impact is usually time-consuming as it must be conducted whilst consulting with the local community. Moreover, it may generate economic losses for the investor in the event that permission to build a new turbine is not granted. In accordance with legal requirements in the EU [65], investors of large wind farms are forced to follow the environmental impact assessment strategy. In addition to legal and economic barriers, large wind farm investors frequently encounter social resistance, i.e., reluctance or fear of local residents. Sometimes, despite the conducted and positively completed environmental impact assessment procedure, wind farms are not built due to the strong opposition from residents and non-governmental organizations [66]. An example of this could be the construction of a wind energy test center in north-western Jutland, which was to consist of five to seven wind turbines located on land [48]. The opposition of non-governmental organizations and the local community was so great that the investment was not completed. Another barrier hindering the development of wind farms and the introduction of new innovative solutions is the lack of legal regulations regarding protected areas of cultural heritage as well as the resistance of ecologists [65]. The EU is introducing many amendments that regulate these issues. Any legal changes deriving from community law must be applied in accordance with the provisions of the legislation of the country concerned. Currently, the EU is working on procedures regulating, among others, issues related to cultural heritage, protected areas, and local spatial development plans. All these regulations should be useful in the implementation of wind energy projects [65].

An important obstacle is also the information and education barrier; therefore, it is necessary to get through to local communities by launching information campaigns, in which people are informed in a clear and comprehensible way about investments related to the construction of wind farms and development of wind power engineering. Both the advantages and disadvantages should be presented in order to prevent future investments from being blocked by local residents, such as non-governmental organizations [67][68]. The lack of knowledge about the benefits of using wind energy among the society is a significant problem in EU countries and affects the development of wind farms. Education should be conducted for all renewable energy sources [65]. Significant obstacles include technical barriers connected with limited access to new technologies and devices used in wind power engineering as well as difficulties in the planning and forecasting of the available capacity and volume of energy produced at wind farms [69]. The European Union continues to implement technical solutions that support the infrastructure necessary for large-scale wind energy production. One of the solutions is to connect offshore wind farms directly to the mainland via a radial connection. This is related to the concept of so-called hybrid projects regarding islands where wind turbines and onshore power hubs are located [42]. Another example of an innovative solution used in wind power engineering involves vertical-axis wind turbines—an alternative to horizontal-axis wind turbines used so far [70]. Other innovative solutions are so-called mini power plants, i.e., home wind farms that can be used extensively in single-family housing [65]. Such solutions can be found in Scandinavian countries. It should be noted, however, that a home wind turbine does not cover the full demand for electrical energy, but merely ca. 25% [6].

References

1. Percesila, M.; Burcea, S.G.; Colesca, S.E. Analysis of renewable energies in European Union. Renew. Sustain. Energy Rev. 2018, 56, 156–170.
2. Chudy-Laskowska, K.; Pisula, T.; Liana, M.; Vasa, L. Taxomic analysis of the diversity in the level of wind energy development in European Union Countries. Energies 2020, 13, 4371.
3. Wang, S.; Wang, S. Impacts of wind energy on environment: A review. Renew. Sustain. Energy Rev. 2015, 49, 437–443.
4. Rygg, B.J. Wind power—An assault on local landscapes or an opportunity for modernization? Energy Policy 2012, 48, 167–175.
5. Vázquez, A.; Izquierdo, U.; Enevyoldes, P.; Anderson, F.-H. A macroscale optimal substructure selection for Europe’s offshore wind farms. Sustain. Energy Technol. Assess. 2022, 53, 102768.
6. Otawa, A.; Skomudek, W. Innowacyjne rozwiązania w zakresie odnawialnej energii na wybranych przykładach. In Innowacje w Zarządzaniu i Inżynierii Produkcji; Knosala, R., Ed.; Politechnika Opolska: Opole, Poland, 2018; pp. 117–129.
7. Devine-Wright, P.; Howes, Y. Disruption to place attachment and the protection of restorative environments: A wind energy case study. J. Environ. Psychol. 2010, 30, 271–280.
8. Liebe, U.; Bartczak, A.; Meyerhoff, J. A turbine is not only a turbine: The role of social context and fairness characteristics for the local acceptance of wind power. Energy Policy 2017, 107, 300–308.
9. Hektus, P. Czynniki Lokalizacji Elektrowni Wiatrowych w Polsce. Ph.D. Thesis, Adam Mickiewicz University, Poznań, Poland, 2020; pp. 7–10.
10. Allen, M.L.; Allen, M.M.C.; Cumminig, D.; Johan, S. Compartive Capitalisms and Energy Transitions: Renewable Energy in the European Union. Brit. J. Manag. 2020, 32, 611–629.
11. Wood, G.; Finnegan, J.J.; Allen, M.L.; Allen, M.M.C.; Cumming, D.; Johan, S.; Nicklich, M.; Endo, T.; Lim, S.; Tanaka, S. The comparative institutional analysis of energy transitions. Socio-Econ. Rev. 2020, 18, 257–294.
12. Leiren, M.D.; Aakre, S.; Linnerud, K.; Julsrud, T.E.; Di Nucci, M.-R.; Krug, M. Community Acceptance of Wind Energy Developments: Experience from Wind Energy Scarce Regions in Europe. Sustainability 2020, 12, 1754.
13. Aasen, M.; Vatn, A. Public attitudes toward climate policies: The effect of institutional contexts and political values. Ecol. Econ. 2018, 146, 106–111.
14. Brożyna, J.; Mentel, G.; Ivanová, E.; Sorokin, G. Classification of Renewable Sources of Electricity in the Context of Sustainable Development of the New EU Member States. Energies 2019, 12, 2271.
15. Kasperowicz, R.; Pinczyński, M.; Khabdullin, A. Modeling the power of renewable energy sources in the context of classical electricity system transformation. J. Int. Stud. 2017, 10, 264–272.
16. 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.

17. IRENA. Renewable Energy Prospects for the European Union. Available online: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Feb/IRENA_REmap_EU_2018.pdf (accessed on 23 February 2023).
18. Wind Europe. Statistics. Available online: https://windeurope.org/intelligence-platform/statistics/ (accessed on 23 January 2023).
19. Eurostat. The EU in the World 2018 Edition. Available online: https://ec.europa.eu/eurostat/documents/3217494/9066251/KS-EX-18-001-EN-N.pdf/64b85130-5de2-4c9b-aa5a-8881bf6ca59b (accessed on 22 January 2023).
20. Eurostat. Energy Production and Imports. 2019. Available online: https://ec.europa.eu/eurostat/statistics-explained/index.php/Energy_production_and_imports (accessed on 23 January 2023).
21. BP. Statistical Review of World Energy. 2019. Available online: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2019-full-report.pdf (accessed on 17 April 2023).
22. Augutis, J.; Martišauskas, L.; Krikštolaitis, R. Energy mix optimization from an energy security perspective. Energy Convers. Manag. 2015, 90, 300–314.
23. Eurostat. Renewable Energy Statistics. Available online: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Renewable_energy_statistics (accessed on 23 January 2023).
24. Wind Europe. Wind Energy in Europe 2021. Statistics and the Outlook for 2022–2026. Available online: https://windeurope.org/intelligence-platform/product/wind-energy-in-europe-2021-statistics-and-the-outlook-for-2022-2026/ (accessed on 9 February 2023).
25. Wind Europe. Offshore Wind in Europe Key Trends and Statistics. 2020. Available online: https://windeurope.org/data-and-analysis/product/offshore-wind-in-europe-key-trends-and-statistics-2020 (accessed on 22 January 2023).
26. European Parliment. Fact Sheets on the European Union. Available online: www.europarl.europa.eu/factsheets/ (accessed on 9 February 2023).
27. IRENA. Wind Energy. Available online: https://www.irena.org/wind (accessed on 23 January 2023).
28. Majchrzak, H. Europejskie sieci przesyłowe na morzu. Czysta Energ. 2012, 11, 11–12.
29. Dawid, L. Perspectives on offshore wind farms development in chosen countries of European Union. J. Water Land Dev. 2018, 38, 27–34.
30. Wind Europe. Wind Energy in Europe 2022. Statistics and the Outlook for 2023–2027. Available online: https://windeurope.org/intelligence-platform/product/wind-energy-in-europe-2022-statistics-and-the-outlook-for-2023-2027/ (accessed on 10 February 2023).
31. Hansen, H.S. Bariery dla Rozowju Energetyki Wiatrowej Wyniki z Ustawodawstwa Unii Europejskiej. Available online: http://www.ptmew.pl/media/projekty/websr2/ustawodawstwo_ue_bariery.pdf (accessed on 10 February 2023).
32. Weichenhain, U.; Elsen, S.; Zorn, T.; Kern, S. Hybrid Projects: How to Reduce Costs and Space of Offshore Developments. Available online: https://op.europa.eu/en/publication-detail/-/publication/59165f6d-802e-11e9-9f05-01aa75ed71a1 (accessed on 10 January 2023).
33. 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 and Amending and Subsequently Repealing Directives

2001/77/EC and 2003/30/EC. Available online: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:en:PDF (accessed on 23 January 2023).

34. Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 Establishing the Framework for Achieving Climate Neutrality and Amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law'). Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32021R1119 (accessed on 17 April 2023).
35. Tamma, P.; Schaart, E.; Gurzu, A. Europe's Green Deal Plan Unveiled. Politico, 11 December 2019. Available online: https://www.politico.eu/article/the-commissions-green-deal-plan-unveiled/ (accessed on 30 January 2023).
36. Simon, F. EU Commission Unveils European Green Deal: The Key Points. Euractiv. 11 December 2019. Available online: https://www.euractiv.com/section/energy-environment/news/eu-commission-unveils-european-green-deal-the-key-points/ (accessed on 30 January 2023).
37. European Commission. Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions. European Commission. REPowerEU Plan. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A230%3AFIN&qid=1653033742483 (accessed on 14 April 2023).
38. IRENA. Global Energy Transformation: A Roadmap to 2050. Available online: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Apr/IRENA_Report_GET_2018.pdf (accessed on 12 April 2023).
39. IRENA. Global Energy Transformation: A Roadmap to 2050–2019 edition. Available online: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Apr/IRENA_Global_Energy_Transformation_2019.p (accessed on 12 April 2023).
40. IRENA. Innovation Outlook: Thermal Energy Storage. Available online: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Nov/IRENA_Innovation_Outlook_TES_2020.pdf?rev=6950b7b9792344b5ab28d58e18209926 (accessed on 13 April 2023).
41. IRENA. World Energy Transitions Outlook: 1.5 °C Pathway. Available online: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/Jun/IRENA_World_Energy_Transitions_Outlook_20 rev=71105a4b8682418297cd220c007da1b9 (accessed on 13 April 2023).
42. European Comission. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. An EU Strategy to Harness the Potential of Offshore Renewable Energy for a Climate Neutral Future. COM (2020) 273 Final. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2020%3A741%3AFIN (accessed on 22 January 2023).
43. European Comission. Regulation (EU) 2018/842 of the European Parliament and of the Council of 30 May 2018 on Binding Annual Greenhouse Gas Emission Reductions by Member States from 2021 to 2030 Contributing to Climate Action to Meet Commitments under the Paris Agreement and Amending Regulation (EU) No 525/2013. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ%3AL%3A2018%3A156%3ATOC (accessed on 14 April 2023).
44. European Comission. Commission Implementing Regulation (EU) 2020/1294 of 15 September 2020 on the Union Renewable Energy Financing Mechanism. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32020R1294&from=PL (accessed on 17 April 2023).
45. European Comission. Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action. Available online: https://eur-

lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R1999&qid=1689185640239 (accessed on 15 April 2023).

46. European Comission. Green Paper. A 2030 Framework for Climate and Energy Policies. COM (2013) 169 Final. Available online: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2013:0169:FIN:en:PDF (accessed on 17 April 2023).
47. Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the Promotion of the Use of Energy from Renewable Sources. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2001 (accessed on 17 April 2023).
48. van Est, R. The Success of Danish Wind Energy Innovation Policy: Combining Visionary Politics and Pragmatic Policymaking. In Successful Public Policy in the Nordic Countries: Cases, Lessons, Challenges; de la Porte, C., Eydal, G.B., Kauko, J., Nohrstedt, D., t Hart, P., Tranøy, B.S., Eds.; Oxford Academic: Oxford, UK, 2022; pp. 45–65. ISBN 978-019-285-629-6.
49. Długosz, T. Społeczności energetyczne z pakietu dyrektyw "Czysta energia dla wszystkich Europejczyków". Forum Prawnicze 2022, 1, 40–57.
50. IEA. Net Zero by 2050: A Roadmap for the Global Energy Sector, International Energy Agency. Available online: https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf (accessed on 22 January 2023).
51. European Comission. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Renewable Energy: A Major Player in the European Energy Market. COM (2021) 271 Final. Available online: https://www.ab.gov.tr/files/ardb/evt/1_avrupa_birligi/1_9_politikalar/1_9_6_enerji_politikasi/comm_renewable_energy_20 (accessed on 21 January 2023).
52. European Comission. A European Strategy for Offshore Renewable Energy. Available online: https://www.europarl.europa.eu/RegData/seance_pleniere/textes_adoptes/definitif/2022/02-16/0032/P9_TA(2022)0032_EN.pdf (accessed on 21 January 2023).
53. Radun, J.; Maula, H.; Saarinen, P.; Keränen, J.; Alakoivu, R.; Hongisto, V. Health effects of wind turbine noise and road traffic noise on people living near wind turbines. Renew. Sustain. Energy Rev. 2022, 157, 112040.
54. European Commission. Final Report Cost of Energy (LCOE). Energy Costs, Taxes and the Impact of Government Interventions on Investments. Available online: https://trinomics.eu/wp-content/uploads/2020/11/Final-Report-Cost-of-Energy-LCOE.pdf (accessed on 10 February 2023).
55. European Commission. Communication from the Commission Europe 2020. A strategy for Smart, Sustainable and Inclusive Growth. COM (2010) 2020 Final. Available online: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:2020:FIN:EN:PDF (accessed on 10 January 2023).
56. IRENA. Renewable Power Generation Costs in 2020. Available online: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/Jun/IRENA_Power_Generation_Costs_2020.pdf?rev=c9e8dfcd1b2048e2b4d30fef671a5b84 (accessed on 14 February 2023).
57. Maradin, D. Advantages and Disadvantages of Renewable Energy Sources Utilization. Int. J. Energy Econ. Policy 2021, 11, 176–183.
58. Halkos, G.E.; Gkampoura, E.-C. Reviewing Usage, Potentials, and Limitations of Renewable Energy Sources. Energies 2020, 13, 2906.

59. REN21. Renewables 2018 Global Status Report. Available online: https://www.ren21.net/wp-content/uploads/2019/08/Full-Report-2018.pdf (accessed on 22 January 2023).
60. Hosking, J.S.; MacLeod, D.; Phillips, T.; Holmes, C.R.; Watson, P.; Shuckburgh, E.F.; Mitchell, D. Changes in European Wind Energy Generation Potential within a 1.5 °C Warmer World. Environ. Res. Lett. 2018, 13, 054032.
61. European Commission. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Energy Roadmap 2050, COM (2011) 885 Final. Available online: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0885:FIN:EN:PDF (accessed on 10 February 2023).
62. Lowitzsch, J.; Hoicka, C.E.; van Tulder, F.J. European Clean Energy Package—Governance Model for the Energy Clusters of the Future? Renew. Sustain. Energy Rev. 2020, 122, 109489.
63. Wiśniewska, M.P.; Pusz, A.; Rogalski, D. Rozwój odnawialnych źródeł energii (OZE) w Unii Europejskiej i w Polsce. Pol. J. Sustain. Dev. 2020, 24, 101–112.
64. NIK. Bariery Rozowju Odnawialnych Źródeł Energii. Available online: https://www.nik.gov.pl/plik/id,24474,vp,27220.pdf (accessed on 21 January 2023).
65. Diógenes, J.R.F.; Claro, J.; Rodrigues, J.C.; Loureiro, M.V. Barriers to onshore wind energy implementation: A systematic review. Energy Res. Soc. Sci. 2020, 60, 101337.
66. Jasiński, A.W.; Kacejko, P.; Matuszczak, K.; Szulczyk, J.; Zagubień, A. Elektrownie Wiatrowe w Środowisku Człowieka; Wydawnictwo Polskiej Akademii Nauk: Lublin, Poland, 2020; ISBN 978-83-63714-77-2.
67. Identyfikacja i Oszacowanie Barier Rozwoju Energetyki z Odnawialnych Źródeł Energii. Available online: https://depot.ceon.pl/bitstream/handle/123456789/10360/072%20Wasiuta%20A.%20-%20identyfikacja%20i%20oszacowanie%20barier....pdf?sequence=1&isAllowed=y (accessed on 12 July 2023).
68. Kalbarczyk, E.; Kalbarczyk, R. Społeczne baroery lokoalizacji farm wiatrowych w Polsce. Studium przpadków. Pract. Nauk. Uniw. Ekon. We Wrocławiu 2018, 504, 81–90.
69. Darwish, A.S.; Al-Dabbagh, R. Wind energy state of the art: Present and future technology advencements. Renew. Energy Environ. Sustain. 2020, 5, 7.
70. Hamerla, E. Innowacje a odnawialne źródła energii. Porównanie siłowni wiatrowych o pionowej i poziomej osi obrotu. Gospod. W Prakt. I Teor. 2018, 50, 21–34.