The Potential of Wind Energy Development in Poland in the Context of Legal and Economic Changes

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Abstract: The main topic of the work is the analysis of the development of wind farms in Poland. In addition, the aim of the publication is to assess the current development of wind energy compared to other renewable energy sources in Poland. As well as, the comparison of the dynamics of development of this renewable energy source in Poland in relation to other European Union countries. The development of wind energy in Poland has been limited in recent years due to the legal regulations introduced in 2016. However, the current situation on the market of conventional energy resources and growing ecological standards may force dynamic changes in the legal solutions related to the possibility of building new wind farms.

Keywords: energy transition; sustainable development; energy policy; renewable energy; Poland

1 Introduction

The popularity of wind energy can be considered in several aspects. Firstly, wind is a common phenomenon and, despite the fluctuations in wind speeds (daily, monthly and seasonal fluctuations), it is easily accessible and stable. Secondly, wind is a clean source of energy that does not emit any pollutants. Especially the latter property is important from the point of view of the transformation of economies towards low-emission, including the departure from coal as the main raw material for the production of electricity and heat. In the global dimension, this applies primarily to China and India [1-3] and what is important, it is noticed in these countries in current development activities aimed at increasing the importance of RES and in development activities in the medium and long-term [4-5]. In the case of China, the large-scale deployment of wind energy installations plays an important

role in the transition to energy neutrality before 2060 [6]. In relation to India, wind energy is also the largest share of all renewables and currently, opportunities for development are being sought, e.g. in the area of offshore wind farms [7-8]. The issues related to moving away from coal in the professional power industry also concern countries in Europe, including, above all, Poland. The energy policy of the European Union also gives renewable energy sources, including wind energy, a high priority of promotion by introducing a number of programs and aid packages for investors. Obviously, the basis is the development of wind farms in accordance with the principle of sustainable development. In the area of sustainable development of wind energy, the following stand out: impacts on birds, noise pollution, visual effects, microclimate and vegetation [9-11].

China is the world leader in the wind energy market [12-13]. The USA, Germany and India follow. The data from the International Renewable Energy Agency (IRENA) shows that in 2021 China had 328,973 MW of wind energy capacity, which accounted for 39.9% of global capacity. Not only is the result in terms of installed capacity impressive, but also the dynamics of changes in recent years. At the same time, China has set ambitious goals for the development of wind energy as part of its national development programs, including energy security [14]. According to the analyses, in the years 2012-2021, the increase in installed capacity in wind energy in China was more than 5-fold (from 61,597 MW in 2012). In China, the growth of the wind power is mainly influenced by policy and market (government support through various subsidies, electricity price and cheap raw material supply, etc.) [15]. In 2021, the USA had 132,738 MW of wind energy capacity (59,075 MW in 2012), Germany 63,760 MW, and India 40,067 MW [16].

Wind energy is currently the most important source of RES in total electricity consumption in the European Union [17-18]. In addition to the high capacity installed in Germany, a relatively large capacity among the European Union countries is in Spain (in 2021 - 27,497 MW) and in France (in 2021 - 18,676 MW) [16]. The total installed capacity in the EU-27 in 2021 was 187,497 MW. Therefore, analyses in the field of wind energy are very important, and the significance of the subject is determined by, among the others, huge potential of windmills and wind turbines located at sea or on land. The importance of wind energy among renewable energy sources also results from economic motives, from the ability to generate large amounts of energy at competitive costs [19-20]. Obviously, there is considerable uncertainty as to how these costs will develop in the future, however, many experts predict further reductions in the cost of energy generated on the basis of wind energy [21]. Nevertheless, in recent years there has been a significant technological progress in the area under study, including the field of turbine design in terms of efficiency increase (more MWh of electricity generated per MW of installed wind turbines). Moreover, the latest improvements in the researched area (including increased hub height, larger rotors and improved energy capture methods) can contribute to the development of wind energy in areas so far inaccessible to this RES technology (less windy regions) [22].

This article aims to describe the current situation of wind energy development in Poland against the background of the EU-27 countries, including the prospects for the development of onshore and offshore wind energy. Comparative analyses were carried out both in relation to other renewable energy sources in Poland and internationally. The basic source material was data from public statistics, both the Central Statistical Office in Poland and Eurostat. The data on installed capacity in wind energy in global terms was taken from the data of the International Renewable Energy Agency. The basic time range of the analyses covered the years 2011-2020.

The first part of the article describes the situation of wind energy in the EU-27 and in Poland. The following parts of the article present issues related to the use of this source of renewable energy in Poland, paying particular attention to the development opportunities and actions necessary to accelerate the development of this RES sector in Poland.

2 Development of Wind Energy in Poland against the Background of the European Union

Obviously, the basis for the development of wind energy are wind speed and wind power density as well as appropriate decisions on the location of turbines based on the spatial-temporal distribution of wind resources. Nevertheless, economic conditions and socio-economic factors (including local acceptance) are also very important, both at the stage of construction of wind turbines and as part of the operation of wind turbines in the energy system.

As mentioned in the introduction, wind energy is a priority (like other sources of renewable energy) supported in the European Union. Until 2020, various support schemes and programs were implemented in individual European Union countries. In the EU countries, two direct support mechanisms can be distinguished, the so-called a feed-in system in which the energy producer receives a specific price for the energy produced. This system may also include additional financial resources for electricity sold at the market price. In the second system, obligations are imposed on entities in the energy market specified in the law to purchase a certain amount of energy from renewable sources [23].

An important element of the development of wind energy is also the current state and energy mix in individual countries. For instance, the little importance of wind energy in Slovakia results from the fact that over 50% of electricity in this country comes from nuclear energy, and hydro-power is the most important source of renewable energy. Similarly, onshore wind plays a rather minor role in Czech renewable power generation [24].

The volumes of electricity production in the EU-27 countries in general terms, energy generated from renewable sources and energy from wind are presented in

Tab. 1. In turn, the share of wind energy production in total energy production and in the generation of energy from renewable sources is shown in Fig. 1 and 2, respectively (country codes are used to create figures).

Table 1

Total production of electricity and energy generated from renewable sources and wind in the EU-27 in 2011 and 2020

Specification	Country code	Total gross electricity production		Renewables and biofuels		Wind	
		2011	2020	2011	2020	2011	2020
		[GWh]					
European Union - 27 countries	EU-27	2,937,062.863	2,781,332.496	670,927.321	1,086,087.1	165,346.901	397,418.088
Belgium	BE	90,294.200	88,890.800	9,561.200	24,458.500	2,312.000	12,763.600
Bulgaria	BG	50,773.608	40,731.058	4,708.608	7,977.586	861.095	1,477.131
Czechia	CZ	87,390.007	81,398.928	7,946.512	11,637.853	397.003	699.083
Denmark	DK	35,229.121	28,733.461	14,180.853	23,451.670	9,774.184	16,330.214
Germany	DE	611,023.000	571,089.000	129,878.000	256,708.000	49,858.000	132,102.000
Estonia	EE	12,893.720	5,955.864	1,179.720	2,848.097	368.659	844.000
Ireland	IE	27,164.029	32,290.479	5,423.595	13,774.793	4,380.315	11,549.420
Greece	EL	59,436.571	48,251.884	8,407.571	17,650.815	3,315.227	9,310.104
Spain	ES	293,676.000	263,213.000	89,837.000	117,274.000	42,918.000	56,444.000
France	FR	572,560.345	531,201.048	71,179.656	129,182.768	12,371.621	39,791.901
Croatia	HR	11,372.169	13,385.300	5,417.169	8,698.600	201.000	1,720.700
Italy	IT	301,772.343	280,029.531	84,895.649	118,858.209	9,856.375	18,761.557
Cyprus	CY	4,929.212	4,849.194	178.212	596.648	114.665	240.408
Latvia	LV	6,094.262	5,724.846	3,077.262	3,649.529	70.894	176.842
Lithuania	LT	4,565.000	5,310.900	1,688.000	3,354.700	475.000	1,551.700
Luxembourg	LU	3,716.293	2,233.901	1,313.279	1,978.397	64.050	351.135
Hungary	HU	36,019.176	34,787.000	2,708.192	5,529.000	625.693	655.000
Malta	MT	2,178.900	2,143.050	9.900	242.788	0.000	0.058
Netherlands	NL	113,813.185	123,041.421	12,320.182	32,997.892	5,100.171	15,339.130
Austria	AT	65,801.609	72,556.246	44,451.164	58,779.511	1,936.196	6,791.530
Poland	PL	163,442.826	157,949.038	13,567.236	29,045.213	3,204.548	15,800.049
Portugal	PT	52,458.252	53,078.401	24,689.717	31,649.727	9,161.612	12,298.663
Romania	RO	62,214.975	55,934.902	16,530.975	24,926.760	1,387.200	6,945.462
Slovenia	SI	16,057.989	17,190.698	4,023.428	5,873.234	0.000	6.251
Slovakia	SK	28,578.187	28,807.000	5,367.187	7,139.000	5.000	4.000
Finland	FI	73,202.395	68,722.546	24,176.565	35,609.814	481.393	7,938.150
Sweden	SE	150,405.489	163,833.000	84,210.489	112,194.000	6,107.000	27,526.000

Source: own elaboration based on [25]

As mentioned before, Germany is the EU-27 leader in wind energy production. In 2020, 132,102 GWh of wind energy was produced in Germany, i.e. 33.2% of the volume of this energy generated in the entire EU-27. Other leading producers in the EU-27 include Spain (with a share of 14.2% in total production in the EU-27) and France (with a share of 10%). Poland was ranked 7th in the EU-27 (also behind Sweden, Italy and Denmark), with a share of 4%, taking into account the production volume in 2020.

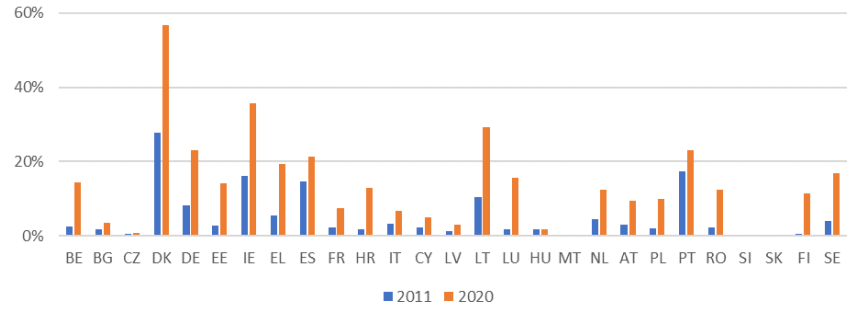

Figure 1
Share of wind energy production in total electricity production in the EU-27 in 2011 and 2020
Source: own elaboration based on [25]

Taking into account changes in the share of wind energy production in electricity production, a significant increase in this share in 2011-2020 was recorded in Denmark (by 29.1 p.p.). Denmark is the only EU-27 country where the share of wind energy volume in the structure of total energy production exceeds 50%. Also in Poland, the share of wind energy production in the total volume of electricity generation increased in the analysed years (by 8 p.p.), however, this difference is at the average level in the EU-27 (13th place in this respect out of 27 countries).

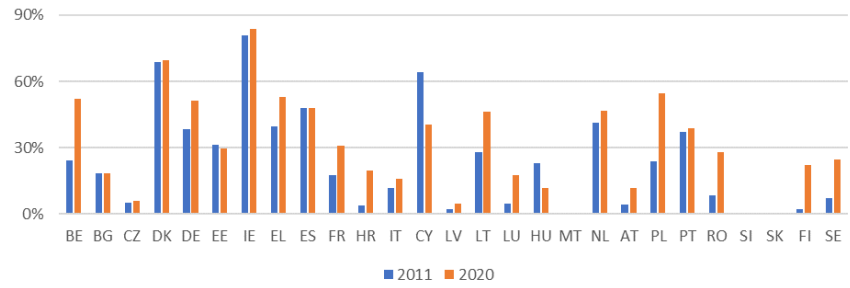

Figure 2
Share of wind energy production in renewable energy production (renewables and biofuels) in the EU-27 countries in 2011 and 2020
Source: own elaboration based on [25]

In turn, taking into account the share of wind energy generation in the production of energy from renewable sources and considering the differences in the years 2011-2020, Poland recorded the largest increase in this share in the EU-27 (by 30.8 p.p.). A large increase in this share resulted in Poland being ranked 3rd in the EU-27 in 2020 (after Ireland and Denmark). The share of wind energy generation in renewable energy production in Poland in 2020 was 54.4%.

3 Wind Power Development Opportunities in Poland

Wind energy in Poland has been developing since the early 1990s. The first windmill in Poland (150 kW turbine) producing electricity was built in 1991 in Żarnowiec. However, the first commercial wind farm (Barzowice farm) was commissioned in April 2001 in the commune of Darłowo (it consisted of six turbines with a total installed capacity of 5 MW) [26].

From 2005 to 2016, a very dynamic development of wind energy was recorded in Poland. This was favoured by legal and economic reasons. Since 2016, mainly as a result of the introduction of legal solutions unfavourable for wind energy, i.e. the entry into force of the so-called distance act. This act defined the minimum distance between wind installations, e.g. from residential buildings at a level of at least 10 times the height of the entire installation. Since then, the growth dynamics of this energy sector has been low. The entry into force of the above-mentioned act meant in practice that the windmill should be located approx. 1.5-2 km from the buildings. The technical potential calculated by Igliński indicates that only 0.02% of Poland's land area meets the requirements of this distance act [27]. In addition to the legal situation, the lack of development of wind energy was caused by the situation on the commodity and financial markets, including the record oversupply of certificates of origin (green certificates), leading to a significant reduction in their price. Problems of this nature in Poland are not isolated on the European market. One of the European leaders in this market – Spain, also experienced development problems due to the lack of an integrated regulatory framework for the industry and rapid changes in legal regulations [28-29]. Recently, an opportunity has appeared in Poland to liberalize the distance act, which is to restore the conditions for the development of this important part of the RES market. This is very important in times of energy crisis. In addition to the legal issue, it is also necessary to review and possibly adjust financial issues. Nolden's research shows that feed-in tariffs alone do not offer greater opportunities for multi-scalar energy transformations [30]. Financial support for investors is important, especially in the current situation of high inflation.

Wind energy is also a significant element in the development of Community Energy. The literature on the subject analyses the participation of citizens and communities in relation to wind cooperatives, e.g. in Denmark, Germany and

Belgium [31]. Energy cooperatives are a new phenomenon in the Polish energy sector, with great prospects for development. Undoubtedly, the experience of countries such as Germany and Denmark should be applied. Conclusions and simulations in the area of the possibility of creating profitable energy cooperatives in rural areas in Poland are optimistic. According to the analyses of Jasiński et al. [32], the functioning of such groups in practice can be associated with positive economic effects for their members, including, among other things, minimizing the sum of energy purchases from the distribution network. Investments in renewable energy sources, including in the area of grids, energy communities, can have a positive impact on reducing the scale of energy poverty. However, the issue of Energy Communities (REC) and Citizens' Energy Communities (CEC) needs to be unified within the European Union [33].

Another important issue in the development of the wind energy market are micro-installations. Creating appropriate conditions for the development of micro-installations (as was the case with photovoltaic installations) would largely enable a faster transition towards low- and zero-emission energy sources and acceleration of the energy transformation in Poland [34]. Currently, there are 69 wind micro-installations in Poland (as at the end of June 2022), and over 1.1 million photovoltaic [35]. Development opportunities concern mainly farms in Poland (there are over 1 million farms in Poland). Appropriate measures to encourage the construction of such micro-installations (financial incentives and appropriate promotion) are important. Above all, stable legal rules are crucial, including in the tax area related to wind energy (excise duty, property tax and tax on electricity from micro-installations) [36].

Offshore wind energy is also an important development area. The potential of offshore energy in the Baltic Sea, in the area of Polish maritime areas, is estimated at 28 GW [37]. PGE Polish Energy Group, which is the largest electricity company and supplier of electricity and heat in Poland, plans large investments in offshore wind farms. The plan assumes the construction of the Baltica Offshore Wind Farm by 2030, implemented in two stages – Baltica 2 and Baltica 3, with a total installed capacity of up to 2.5 GW. In addition, after 2030, the construction of the Baltica 1 Wind Power Plant with a capacity of approx. 1 GW is planned. Generally, according to the strategy, the PGE Group will build at least 6.5 GW of generation capacity installed in offshore technology by 2040 [38]. As Ziemba points out [39], investments in offshore wind farms can be an effective development impulse for the economy recovering from the crisis caused by the COVID-19 pandemic. It is also crucial from the point of view of current challenges in the area of electricity supply due to current geopolitical challenges.

The expected liberalization of legal regulations regarding the location of onshore wind farms in Poland will undoubtedly contribute to the emergence of new investment projects. Plans in this area are presented, among the others, by Tauron Group (the second largest entity in the energy sector in Poland after PGE). Currently, the Tauron Group has eleven wind farms with a total capacity of 416

MW. There are plans to build another wind farm in the north of Poland (with a capacity of 30 MW). Moreover, in June 2022, Tauron purchased the Mierzyn wind farm project in the Zachodniopomorskie Voivodeship. The implementation of this investment (60 MW capacity) is to be completed by the end of 2024 [40].

Summary

Taking into account the volume of wind energy production, in 2020 Poland was ranked 7th in the EU-27 (behind Germany, Spain, France, Sweden, Italy and Denmark), with a 4% share in the structure of this energy generation in the EU-27. In 2020, Poland was ranked third in the EU-27 in terms of the share of wind energy generation in renewable energy production.

The Polish energy sector, which does not have nuclear power plants, is traditionally based on fossil resources – hard coal and lignite. Currently, a lively discussion is taking place in Poland on the paths and development priorities in the field of energy transformation. This is due to both the adopted climate and energy commitments and the current geopolitical situation. In this context, the development of wind energy is also important from the point of view of the problem of rising electricity prices in Poland, which is the result of, among the others, higher fees for CO_2 emission allowances. However, the development of wind energy by changing the legal regulations (increasing the distance between the wind turbine and residential buildings) has clearly slowed down in Poland after 2016. Work is currently under way to modernize these regulations, additionally, there are plans to develop offshore wind energy.

The planned implementation of offshore energy projects in Poland will start a new chapter in the Polish wind energy sector, which is important not only from the point of view of a further increase in the share of RES in the structure of electricity production, but also in terms of power interconnections. Particularly important are the combinations of solar, wind and energy storage systems. According to current plans, offshore wind farms with a capacity of approx. 6 GW will be built in Poland by 2030. This requires significant financial outlays in the area of construction of equipment for the production, transmission and storage of energy as well as changes in many formal and legal regulations. The construction and operation of offshore wind farms can change the functioning of the Polish energy sector and become a pillar of the Polish energy transformation.

The development of wind energy depends to a large extent on the system of investment incentives and settlement methods on the energy market. Undoubtedly, an important issue in the development of onshore wind energy is the acceleration of activities towards the development of energy cooperatives in Poland, which can combine general objectives (low-emission development) with social objectives (reducing energy poverty). The aspect of development of micro-installations is also interesting, especially in the case of inhabitants of rural areas, including farmers. Wind micro-installations can be competitive with other RES in rural areas in a situation where there are appropriate wind conditions and where there are no terrain

obstacles. Furthermore, it is possible to use hybrid solutions, e.g. with photovoltaics.

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References

[1] P. Oskarsson, K.B. Nielsen, K. Lahiri-Dutt, B. Roy, India's new coal geography: Coastal transformations, imported fuel and state-business collaboration in the transition to more fossil fuel energy. Energy Research & Social Science 73 (2021), 101903, https://doi.org/10.1016/j.erss.2020.101903

[2] B. Li, N. Haneklaus, The role of clean energy, fossil fuel consumption and trade openness for carbon neutrality in China. Energy Reports 8 (2022), 1090-1098, https://doi.org/10.1016/j.egyr.2022.02.092

[3] M. Kumar, Fossil neoliberalism and its limits: Governing coal in South India. Environment and Planning E: Nature and Space 5(4) (2022) https://doi.org/10.1177/251484862210993

[4] J. Charles Rajesh Kumar, D. Vinod Kumar, D. Baskar, B. Mary Arunsi, R. Jenova, M. A. Majid, Offshore wind energy status, challenges, opportunities, environmental impacts, occupational health, and safety management in India. Energy & Environment 32(4) (2021), 565-603, https://doi.org/10.1177/0958305X20946483

[5] J. Tian, L. Yu, R. Xue, S. Zhuang, Y. Shan, Global low-carbon energy transition in the post-COVID-19 era. Applied Energy 307 (2022) 118205, https://doi.org/10.1016/j.apenergy.2021.118205

[6] K. Xu, J. Chang, W. Zhou, S. Li, Z. Shi, H. Zhu, Y. Chen, K. Guo, A comprehensive estimate of life cycle greenhouse gas emissions from onshore wind energy in China. Journal of Cleaner Production 338(2022) 130683, https://doi.org/10.1016/j.jclepro.2022.130683

[7] O. Siram, N. Sahoo, U. K Saha, Changing landscape of India's renewable energy and the contribution of wind energy. Cleaner Engineering and Technology 8 (2022) 100506, https://doi.org/10.1016/j.clet.2022.100506

[8] U. Singh, M. Rizwan, H. Malik, F. P. García Márquez, Wind energy scenario, success and initiatives towards renewable energy in India—A review. Energies 15(6) (2022) 2291, https://doi.org/10.3390/en15062291

[9] G. Msigwa, J. O. Ighalo, P. S. Yap, Considerations on environmental, economic, and energy impacts of wind energy generation: Projections towards sustainability initiatives. Science of the Total Environment 25 (2022) 157755, https://doi.org/10.1016/j.scitotenv.2022.157755

[10. J. Emblemsvåg, Wind energy is not sustainable when balanced by fossil energy. Applied Energy 305 (2022) 117748, https://doi.org/10.1016/j.apenergy.2021.117748

[11] J. Zhao, A. K. Patwary, A. Qayyum, M. Alharthi, F. Bashir, M. Mohsin, I. Hanif, Q. Abbas, The determinants of renewable energy sources for the fueling of green and sustainable economy. Energy 238 (2022) 122029, https://doi.org/10.1016/j.energy.2021.122029

[12] A. Sharma, M. Dharwal, T. Kumari, Renewable energy for sustainable development: A comparative study of India and China. Materials Today: Proceedings 60 (2022) 788-790, https://doi.org/10.1016/j.matpr.2021.09.242

[13] B. K. Sahu, Wind energy developments and policies in China: A short review. Renewable and Sustainable Energy Reviews 81 (2018) 1393-1405, https://doi.org/10.1016/j.rser.2017.05.183

[14] F. Liu, F. Sun, W. Liu, T. Wang, H. Wang, X. Wang, W.H. Lim, On wind speed pattern and energy potential in China. Applied Energy 236 (2019) 867-876, https://doi.org/10.1016/j.apenergy.2018.12.056

[15] C. Zhuo, G. Junhong, L. Wei, Z. Fei, X. Chan, P. Zhangrong, Changes in wind energy potential over China using a regional climate model ensemble. Renewable and Sustainable Energy Reviews 159 (2022) 112219, https://doi.org/10.1016/j.rser.2022.112219

[16] IRENA_RE_Capacity_Statistics_2022 https://irena.org/publications/2022/Apr/Renewable-Capacity-Statistics-2022?_gl=1*l1e3ia*_ga*ODYwODYyNzg0LjE2NjQ5Nzg1OTY.*_ga_7W6ZEF19K4*MTY2NDk3ODU5NS4xLjAuMTY2NDk3ODYwOS40Ni4wLjA (accessed: 24 April 2022)

[17] Y. Yang, K. Javanroodi, V. M. Nik, Climate Change and Renewable Energy Generation in Europe—Long-Term Impact Assessment on Solar and Wind Energy Using High-Resolution Future Climate Data and Considering Climate Uncertainties. Energies 15(1) (2022) 302, https://doi.org/10.3390/en15010302

[18] P. Swisher, J. P. M. Leon, J. Gea-Bermúdez, M. Koivisto, H.A. Madsen, M. Münster, Competitiveness of a low specific power, low cut-out wind speed wind turbine in North and Central Europe towards 2050. Applied Energy 306 (2022) 118043, https://doi.org/10.1016/j.apenergy.2021.118043

[19] B. Sliz-Szkliniarz, J. Eberbach, B. Hoffmann, M. Fortin, Assessing the cost of onshore wind development scenarios: Modelling of spatial and temporal distribution of wind power for the case of Poland. Renewable and Sustainable Energy Reviews 109 (2019) 514-531, https://doi.org/10.1016/j.rser.2019.04.039

[20] J. R. F. Diógenes, J. C. Rodrigues, M. C. F. Diógenes, J. Claro, Overcoming barriers to onshore wind farm implementation in Brazil. Energy Policy 138 (2020) 111165, https://doi.org/10.1016/j.enpol.2019.111165

[21] R. Wiser, J. Rand, J. Seel, P. Beiter, E. Baker, E. Lantz, P. Gilman, Expert elicitation survey predicts 37% to 49% declines in wind energy costs by 2050. Nature Energy 6(5) (2021) 555-565, https://doi.org/10.1038/s41560-021-00810-z

[22] S. Martin, S. Jung, A. Vanli, Impact of near-future turbine technology on the wind power potential of low wind regions. Applied Energy 272 (2020) 115251, https://doi.org/10.1016/j.apenergy.2020.115251

[23] J. Paska, T. Surma, Wind energy in the European Union – current status and 2020 perspective. Energy Market 2 (2012) 37-42 [In Polish]

[24] K. Gürtler, R. Postpischil, R. Quitzow, The dismantling of renewable energy policies: The cases of Spain and the Czech Republic. Energy Policy 133 (2019) 110881, https://doi.org/10.1016/j.enpol.2019.110881

[25] Eurostat (Production of electricity and derived heat by type of fuel [NRG_BAL_PEH__custom_3531267[). Available online at https://ec.europa.eu/eurostat/databrowser/view/NRG_BAL_PEH__custom_3531267/default/table?lang=en (accessed 27 April 2022)

[26] Global Energy Portal, https://globenergia.pl/szlakiem-polskich-elektrowni-wiatrowych/ (accessed 27 April 2022)

[27] B. Igliński, The Polish wind energy sector against the background of the global wind energy, In: M. Smol (Ed.), Water, resources and energy. Monograph, part II, Publishing House of the Mineral and Energy Economy Research Institute of the Polish Academy of Sciences, Cracow, 2022, pp. 25-42 [In Polish]

[28] M. J. Barradale, Impact of public policy uncertainty on renewable energy investment: Wind power and the production tax credit. Energy Policy 38(12) (2010) 7698-7709, https://doi.org/10.1016/j.enpol.2010.08.021

[29] E. Rosales-Asensio, D. Borge-Diez, J. J. Blanes-Peiró, A. Pérez-Hoyos, A. Comenar-Santos, Review of wind energy technology and associated market and economic conditions in Spain. Renewable and Sustainable Energy Reviews 101 (2019) 415-427, https://doi.org/10.1016/j.rser.2018.11.029

[30] C. Nolden, Governing community energy—Feed-in tariffs and the development of community wind energy schemes in the United Kingdom

and Germany. Energy Policy 63 (2013) 543-552, https://doi.org/10.1016/j.enpol.2013.08.050.

[31] T. Bauwens, B. Gotchev, L. Holstenkamp, What drives the development of community energy in Europe? The case of wind power cooperatives. Energy Research & Social Science 13 (2016) 136-147, https://doi.org/10.1016/j.erss.2015.12.016

[32] J. Jasiński, M. Kozakiewicz, M. Sołtysik, Determinants of Energy Cooperatives' Development in Rural Areas—Evidence from Poland. Energies 14(2) (2021) 319, https://doi.org/10.3390/en14020319

[33] M. M. Sokołowski, Renewable and citizen energy communities in the European Union: How (not) to regulate community energy in national laws and policies. Journal of Energy & Natural Resources Law 38(3) (2020) 289-304, https://doi.org/10.1080/02646811.2020.1759247

[34] E. Chomać-Pierzecka, A. Sobczak, D. Soboń, Wind Energy Market in Poland in the Background of the Baltic Sea Bordering Countries in the Era of the COVID-19 Pandemic. Energies 15(7) (2022) 2470, https://doi.org/10.3390/en15072470

[35] Green News Portal, https://www.green-news.pl/2923-rzad-uwolni-wiatraki-ale-te-przydomowe (accessed 27 April 2022)

[36] M. Czuba, M. Wielec, Taxation of wind farms in Poland - selected aspects, Internet Quarterly on Antitrust and Regulation 5 (2019) 169-179 [In Polish]

[37] M. Kurtyka, Challenges of transformation and the goals of Polish energy policy. In: A. Z. Nowak, M. Kurtyka, G. Tchorek (Eds.), Energy and climate transformation - selected dilemmas and recommendations, The University of Warsaw Press, Warsaw, 2021, pp. 28-43 [In Polish]

[38] Money.pl Portal, https://www.money.pl/gospodarka/to-ma-byc-najwieksza-farma-wiatrowa-na-polskim-baltyku-jest-wykonawca-6804477965867744a.html (accessed 27 December 2022)

[39] P. Ziemba, Uncertain Multi-Criteria analysis of offshore wind farms projects investments–Case study of the Polish Economic Zone of the Baltic Sea. Applied Energy 309 (2022) 118232, https://doi.org/10.1016/j.apenergy.2021.118232

[40] Interia.pl Portal, https://biznes.interia.pl/gieldy/aktualnosci/news-kolejna-elektrownia-wiatrowa-na-pomorzu-tauron-planuje-budow,nId,6484608 (accessed 25 December 2022