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THE STATE OF WIND ENERGY IN POLAND

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The process of current and future wind power development in Poland is analysed. Wind power worldwide and wind power in Poland are shown. Technical, economical and market potential of wind energy in Poland is defined. Analysis and assessment of wind power market in Poland in technical, economical and environmental aspects is made. Perspectives of wind power development up to 2020 are described. References 10, tables 2.

***Key words**:* wind power, development, state.

Introduction. Wind power is one of the cleanest and cost effective energy technologies. It is based on highly effective technology and vast wind resources. It is also characterised by short construction time.

Wind power is a worldwide leader among "green" technologies. It plays key role on the "green" energy market. In terms of market share it is way ahead of other renewable energy sources (RES).

Wind power is the leading and prospective technology for combating global warming, which is one of the most significant challenges to the development of modern civilisation. Positive environmental effects, in particular stemming from abatement of atmospheric pollution emissions, including greenhouse gas, are one of important advantages of wind power. Wind power has and will have extraordinary contribution to the abatement of greenhouse gas emissions compared to other RES technologies [9].

Wind power worldwide. In 2016, with installed capacity of 486.7 GW, wind power supplied more than 7% of worldwide electricity and become the only RES technology in the world combining rapid growth with significant market share. New installed capacity in 2016 reached 54.6 GW, and although it was lower than in 2015 (with 63.6 GW of new capacity), it was still the second highest in history. During the last 10 years the capacity increased more than 6.5 times (in 2006 – installed capacity 74 GW) [5].

The world leaders of wind power in 2016 included: China (168.7 GW /34.7% of global capacity/), the United States (82.2 GW/16.9%/), Germany (50 GW/10.3%/), India (28.7 GW/5.9%/) and Spain (23 GW/4.7%/) [5].

The total wind energy capacity installed in the European Union (EU) at the end of 2016 was 153.7 GW. New installed capacity in 2016 reached 12.5 GW, and it was slightly lower than in 2015 (with 12.8 GW of new capacity). The wind power was a leader with regard to the value of capacity of new facilities using RES. It constituted 86% of capacity of all new sources in the EU [5]. Additionally, the capacity in wind in the EU has now surpassed the total capacity of coal-fired plants, and is second only to gas power plants.

The European leaders of wind power in 2016 included: Germany (50 GW), Spain (23 GW), Great Britain (14.5 GW), France (12.1 GW), Italy (9.3 GW), Sweden (6.5 GW) and Poland (5.8 GW) [5].

During an average wind power density year in Europe, wind farms are currently able to satisfy 10.4% of the EU's demand for electricity [5].

Wind power potential in Poland. Poland has significant wind resources. In particular, the following areas are very advantageous in terms of wind resources: Baltic shore, north-eastern Poland, open areas of north Poland with differentiated orography and submontane areas of southern Poland [8].

Potential wind farm sites are considered also outside those areas; however, they usually require higher wind turbines to achieve economically viable wind speeds.

However, in technical terms wind power development to date primarily depends on the area available for building wind turbines and constrained by infrastructural, environmental and economic considerations.

The technical potential of wind energy in Poland amount to 1400 GW (onshore) [8]. The technical potential of wind energy is related primarily to spatial distribution of open land (characterised by low roughness, without objects disturbing the airflow). Such areas are primarily occupied by farmland, currently comprising approximately 59% of the country's area [8]. Given current technical capabilities of the wind power technology it is assumed that it is possible to effectively (in technical terms) use areas with wind speed above 5 m/s and energy density above 200 W/m^2 at the height of 50 m above ground level. Such conditions occur on 80% of farmland [8].

The economical potential of wind energy in Poland amount to 82 GW (onshore) [8]. The economical potential of wind energy is related to areas with very advantageous wind conditions, with the highest potential productivity.

Wind power has enormous technical and economic potential. In 2016 used economic potential only to an insignificant degree – 7.14% [10].

Wind power in Poland. The total wind installed capacity in Poland amounted to 5807 MW at the end of 2016 [4]. It was 14% of the total capacity installed in the Polish national electric power system (41396 MW). It gave 7th place in the European Union and 1st place in Central and Eastern Europe in terms of cumulated capacity.

Total installed capacity and electricity generation from wind power in 2010-2016 are shown in Table 1. Growth rates in the wind power sector and electricity production from wind turbines accelerated significantly since 2010. However, the relatively high increase in the percentage data is still attributable to the medium level of market development in absolute numbers. In Germany, a country characterised by geographic and environmental conditions similar to Poland, the potential of wind energy sources is almost 9 times higher than in Poland [6]. Currently, there are 1193 licensed wind power plants operating nationwide [4]. Most of them are located in northern Poland (West Pomeranian and Pomerania provinces).

A significant increase in installed capacity and in energy production stems from high technological maturity of wind power, increased output of individual wind turbines and wind farms and cost competitiveness compared to other renewable technologies used in Poland to produce electricity [6]. Wind farms are based on quiet, modern and efficient wind turbines.

Table 1

	2010	2011	2012	2013	2014	2015	2016
Nominal power [MW]	1180.27	1616.36	2496.75	3389.54	3833.83	4582.04	5807.40
Amount of produced electricity [GWh] in year	1823	3129	4613	6077	7624	10687	11623

Wind energy is the main source of energy among all renewable energy sources in Poland (69% of all RES capacity in 2016). It is a leader in the production of "green" electricity and also the fastest developing renewable energy source in Poland (almost 70-fold increase in the period of 2005-2016). Biomass came in second place (15.2% share and 1.3 GW capacity), with hydro in third (11.8% share and 1.0 GW capacity) [5].

Total installed capacity of RES and total amount of produced electricity in RES in years 2010–2015 in Poland are shown in Table 2.

Table 2

	Source	2010	2011	2012	2013	2014	2015
Nominal power [MW]	Biogas	82.88	103.49	131.25	162.24	188.55	212.50
Amount of produced electricity [MWh] in year	Biogas	363596	430537	529384	665143	782744	875773
Nominal power [MW]	Biomass	356.19	409.68	820.70	986.87	1008.24	1222.67
Amount of produced electricity [MWh] in year	Biomass	635635	1101189	2208508	3919874	4617235	4714700
Nominal power [MW]	Wind	1180.27	1616.36	2496.75	3389.54	3833.83	4582.04
Amount of produced electricity [MWh] in year	Wind	1823297	3128673	4612894	6077358	7624018	10687321
Nominal power [MW]	Water	937.04	951.39	966.10	970.13	977.01	981.8
Amount of produced electricity [MWh] in year	Water	2922052	2316833	2031725	2439460	2181187	1829409
Nominal power [MW]	Photo-voltaic	0.03	1.12	1.29	1.90	21.00	71.03
Amount of produced electricity [MWh] in year	Photo-voltaic	2	178	1178	1419	4515	43066
Nominal power [MW]	Total	2556,41	3082.04	4416.09	5510.68	6028.63	7070.04
Amount of produced electricity [MWh] in year	Total	5744582	6977410	9383689	13103254	15209699	18150269

It is a similar phenomenon like in the Europe, although at a much lesser scale. The wind power is the leading and prospective technology for combating global warming. Onshore wind power is the inexpensiveest "green" electricity production technology in investment terms and exhibits the lowest cost range [7]. The same situation is in terms of operational costs. Offshore wind power is not used in Poland. First installations will appear on the Polish sea territory probably in 2020 [7].

Wind power development in Poland. The national wind power sector up 2016 had a phase of rapid development. It was a similar phenomenon like in the world, although at a much lesser scale. High relative growth rates after 2010 resulted from just a number of wind farms per year. In consideration of several dozen percent high dynamics

of installed capacity growth in wind farms, Poland was one of the leading users of that form of renewable energy in Europe.

The national wind power sector has a very significant development potential, but the conditions and development perspectives are closely connected with law regulations, national energy policy, national renewable energy action plan, government undertakings, support systems and many other elements, which are not good now. The RES sector in Poland is undergoing significant and continuous transformations. Until 2015 the Polish legislation did not have a dedicated piece of legislation of a statutory character which would comprehensively regulate conducting business activity in the field of renewable energy sources. Legal framework for the development of renewable energy sector was set forth exclusively in the Energy Law [1]. The law regulated among other things rules of granting support, connecting RES to the grid, and conducting business activity in the field of production of electrical energy from renewable energy sources [1]. This state of affairs was changed in 2015, when the Polish Parliament adopted the Act on Renewable Energy Sources (RES Act) [2]. The RES act introduced a new auction-based support scheme for renewable energy sources. However, an overwhelming majority of existing RES producers did not have the possibility to switch to the new system. Under the new system, the government announces the volume and budget for energy it is going to purchase from generators, and the support for a maximum of 15 years is granted to those investors who offer the lowest price. By means of technical specifications for the so-called "auction baskets" and free allocation of volumes between baskets, the government can arbitrarily decide which technologies can participate in auctions. RES generators who cannot take part in auctions remain in the old green certificate system.

The wind power sector in Poland is undergoing the largest crisis in its history. Both companies with a solid market position and smaller investors are facing the enormous problem of oversupply of green certificates, leading to their prices falling below 40 PLN/MWh and reducing the profitability of very many RES projects, wind farms included [5]. Such a level is not even sufficient to pay back the loans that were used to build a large share of Polish wind farms. It can lead to a risk of bankruptcy for them.

The second factor connected with support system for new RES installations is that during the 2016 RES auctions the government did not organize any auction for wind farms with a capacity above 1 MW. In 2017, an auction for only 150 MW of capacity was announced, which is only a fraction of projects waiting for the auctions and ready to be built at any time [5].

The situation was additionally worsened by the coming into effect of the Wind Farm Act (also called the "distance act") [3], which was adopted by the Polish Parliament in 2016. The Wind Farm Act provides for, among other things, significant restrictions in respect of the location, development and operation of wind farm projects on the territory of Poland, namely: (i) introduces a minimum distance requirement, (ii) introduces possibility to locate wind farms exclusively on the basis of local master plans and (iii) affects the manner of calculation of real estate tax (RET) for structures [3]. On the one hand, it completely blocked the possibility for future development of wind power and on the other it significantly increased the burden of property tax due to the inclusion of technical elements of wind turbines in the definition of building structure.

The "distance act" introduced a minimum distance of wind turbines from residential buildings and selected forms of nature protection areas (national parks, nature reserves, landscape parks, Nature 2000 areas) at 10 times the height of the entire installation [3]. This, in practice, means that a modern wind turbine has to be located at a distance of 1.5–2 km from housing, regardless of the opinion of local residents.

Poland adopted stringent restrictions with low flexibility of application – not only as a statutory obligation, but also on a much higher level than in other European countries (for example Germany, Italy, Great Britain), including those that have a longer history of experience with development of wind power and a higher population density.

Analysis of the possibilities for location of wind farms in Poland show that with other existing restrictions and with 1 km setback from housing, 93.9% of the country is a no-go area for wind power projects, and in case of a 2 km minimum distance – as much as 99.1% of Poland's surface area, which almost equates to a total ban on wind investments [5].

Conclusions.

Wind power is the fundamental element of the green electricity market in Poland. Its development is a chance to achieve ecological, low-emission electricity generation, higher energy security, and to meet the EU requirements with regard to energy generation from renewable sources.

Wind power in Poland had a phase of rapid development up 2016, but now is in phase of stop the wind power sector and legal and political destabilization.

The wind power sector in Poland has a very significant development potential, but the conditions and development perspectives closely connected with law regulations, national energy policy and government undertakings are not good. Key barriers to wind power development in Poland are connected with: wrong legal solutions, the uncertainty and instability law, lack of clear energy policy in area of RES, the auction system implementation for new installations, oversupply of green certificates, complexity and lengthiness of procedures, complex procedures related to environmental protection, overgrowth formal obligations and lack of competence of the relevant authorities, social

protests of local communities, lack of a permanent financial long-term support system for investor, grid connection policy of system operators, difficulties with obtaining grid connection, and the lack of sufficient grid infrastructure.

Wind power development in Poland requires solutions of many legal, technical and economic problems which put a number of hindrances and formal, legal and technical development barriers.

1. Act of 10 April 1997. The Energy Law. *Journal of Laws of 2006*. No 89. Item 625, with later changes.
2. Act of 20 February 2015. Renewable Energy Sources. *Journal of Laws of 2015*. Item 475, with later changes.
3. Act of 20 May 2016. On investments in wind farms. *Journal of Laws of 2016*. Item 961.
4. Activity of the President of Energy Regulatory Office in 2016. *Report.* The Energy Regulatory Office, Warsaw, 2017. https://www.ure.gov.pl/pl/urzad/informacje-ogolne/sprawozdania/2916,Sprawozdania.html. (accessed January 15, 2018).
5. The state of wind energy in Poland in 2016. The Polish Wind Energy Association. Report. June 2017. http://psew.pl/wp-content/uploads/2017/06/Stan-energetyki-wiatrowej-w-Polsce-w-2016-r.pdf. (accessed January 15, 2018).
6. Dolega W. Problems, barriers and perspectives of RES development in Poland. Trivent Publishing papers, 2016. Engineering and Industry Series, Volume Power Systems, Energy Markets and Renewable Energy Sources in South-Eastern Europe. 2016. Volume 3. Pp. 265-282. http://trivent-publishing.eu/engineeringandindustry.html (accessed January 15, 2018).
7. Dolega W. Perspectives of RES development in Poland up to 2020. *Tekhnichna Elektrodynamika*. 2014. No 4. Pp. 29–31.
8. Dolega W. Wind power development in Poland. *Tekhnichna Elektrodynamika*. 2012. No 3. Pp. 99–100.
9. Dolega W. Selected problems of expansion of renewable distributed generation – case study Poland. Institute of Electrodynamics of NAS of Ukraine, Kyiv, 2011. Research work compilation. Special issue. Part I. Pp. 36-43.
10. National potential of RES - Energy Regulatory Office. https://www.ure.gov.pl/pl/rynki-energii/energia-elektryczna/odnawialne-zrodla-ener/potencjal-krajowy-oze (accessed January 15, 2018).

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СОСТОЯНИЕ ВЕТРОВОЙ ЭНЕРГИИ В ПОЛЬШЕ

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Проанализирован процесс развития текущей и будущей ветроэнергетики в Польше. Показана мощность ветра во всем мире и энергия ветра в Польше. Определен технический, экономический и рыночный потенциал ветровой энергии в Польше. Проводится анализ и оценка рынка ветроэнергетики в Польше по техническим, экономическим и экологическим аспектам. Описаны перспективы развития ветроэнергетики до 2020 года. Библ. 10, табл. 2.

Ключевые слова: энергия ветра, развитие, состояние.

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СТАН ВІТРОВОЇ ЕНЕРГІЇ В ПОЛЬЩІ

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Проаналізовано процес розвитку поточної і майбутньої вітроенергетики в Польщі. Показана потужність вітру в усьому світі та енергія вітру в Польщі. Визначено технічний, економічний і ринковий потенціал вітрової енергії в Польщі. Проводиться аналіз і оцінка ринку вітроенергетики в Польщі з технічних, економічних і екологічних аспектів. Описано перспективи розвитку вітроенергетики до 2020 року.
Бібл. 10, табл. 2.

Ключові слова: енергія вітру, розвиток, стан.

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