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WIND ENERGY IN THE EUROPEAN UNION

Introduction

Shrinking reserves of energy resources and increasingly deteriorated state of the natural environment stimulate seeking for alternative and renewable sources of energy. The renewable sources do not cause any side effects or emissions of hazardous substances. Their utilization does not disturb natural resources, natural environment, landscape, vegetation and animal living conditions. They cause improved energy safety and the new workplaces are created; also, different regions are promoted.

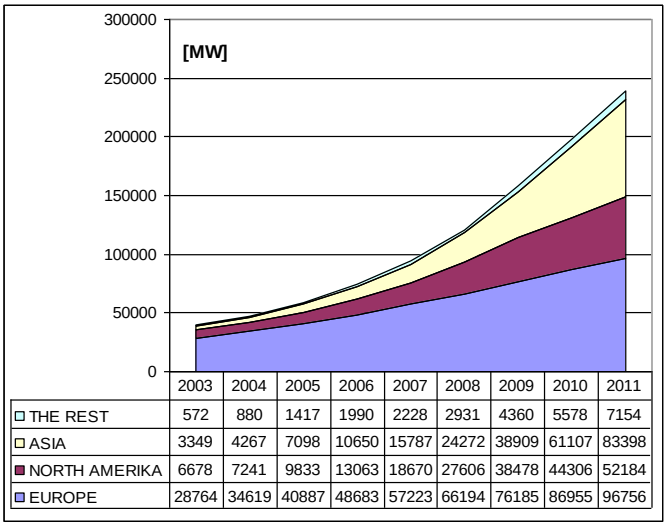
One of the most important elements of energy and environmental policies in the European Union, also those implemented in Poland as a member state, is to enhance energy effectiveness and to increase share of renewable resources in its total consumption. These policies are reflected by the Climate and Energy Package and **3 x 20** plan whose basic obligations until 2020 were formulated as follows [1]:

- increase in use of energy from renewable resources up to 20%,
- increase in efficiency of energy use, also up to 20%,
- reduction in greenhouse gas emissions by 20%.

1. Wind energy

Last decades have seen a very dynamic growth of renewable energy sector based on such sources as wind energy. The figures presented below allow to take a closer look at the tendencies in world and European development of wind energy sector as well as the position of Poland in this environment. Installed capacity of the world energy sector soared from 39,363 MW in 1993 to 238,947 MW in 2011, thus increasing by almost 5 times [2-4].

Development of world energy sector based on the use of wind energy is presented in Figure 1, accompanied with the relevant data contained in the table [4]. The figure shows the tendencies that occurred in Europe, Asia, North America for eight years (2003-2011), where considerable shares and increments of wind power energy share are observed.



	2003	2004	2005	2006	2007	2008	2009	2010	2011
THE REST	572	880	1417	1990	2228	2931	4360	5578	7154
ASIA	3349	4267	7098	10650	15787	24272	38909	61107	83398
NORTH AMERIKA	6678	7241	9833	13063	18670	27606	38478	44306	52184
EUROPE	28764	34619	40887	48683	57223	66194	76185	86955	96756

Fig. 1. Development of wind energy sector worldwide in MW
Source: author's own elaboration on the base of EC BREC IEO

Wind power capacities in Europe rose from 28,764 MW in 2003 to 96,756 MW in 2011, which means 3.36 times. Despite this considerable growth, European share in world wind energy capacity declined throughout the presented period of time from 73% in 2003 to 40.2% in 2011.

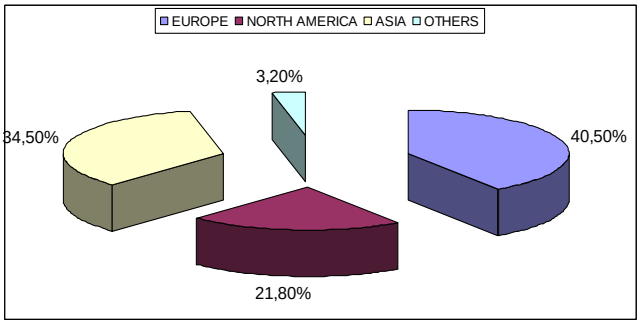


Fig. 2. The structure of the global wind energy in 2011
Source: author's own elaboration on the base of EC BREC IEO

This is caused by growing importance of wind energy sector in other continents which were less visible so far in this area. Asian share rose from 8.5 in 2003 to 34.5% in 2011, and from 17% to 21.8% in North America, respectively. It should be emphasized that in the studied period of 8 years, wind power plant capacity in China rose from 644 to 62,733 MW, thus almost 100 times [3, 4]. Wind power plants capacity in North America and Asia is comparable, and their global share in 2011 is respectively 21.8 and 34.5%. Share of other countries worldwide in wind

power energy sectors amounts to barely 2.9%, which points to the multitude of tasks and prospects faced by other continents.

Share of the EU member states in development of European wind energy sector is dominant. Installed capacity in the European Union amounted to 94,097 MW in 2011 compared to 96,756 MW in all Europe [3, 4].

Share of individual countries of the EU in development of wind power energy sector is presented in Figure 3. It presents increments of installed capacities for wind power energy in eight years (from 2003 to 2011) [3, 4].

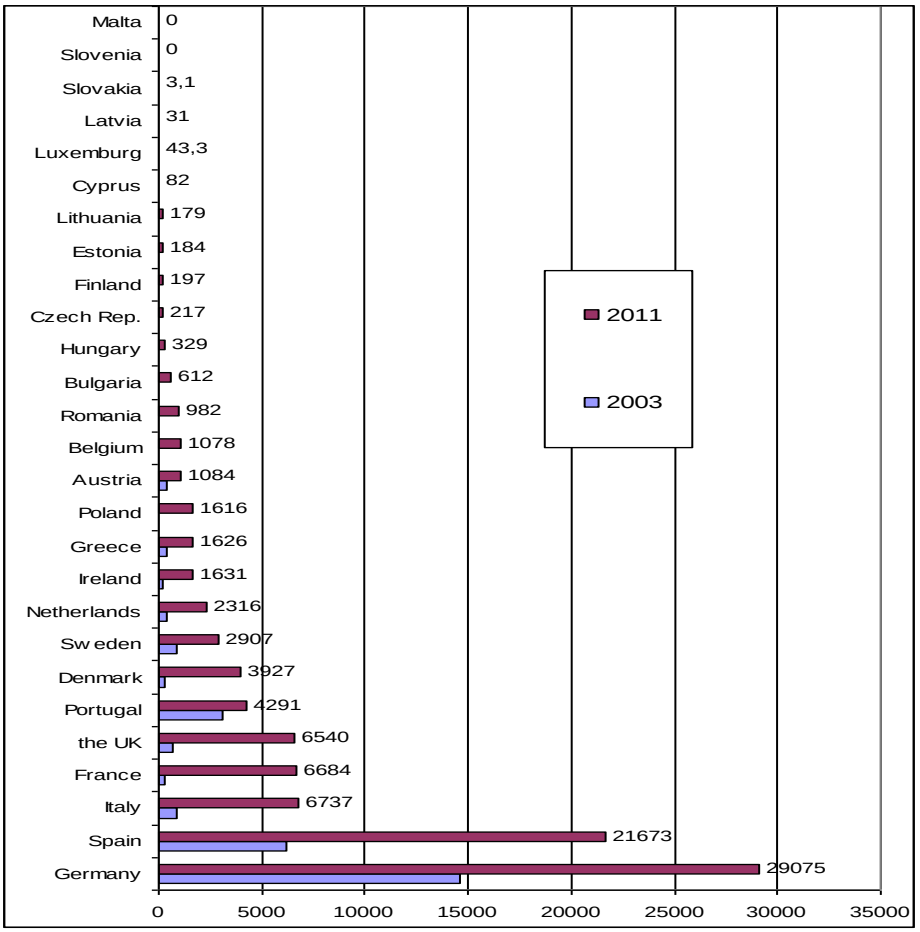


Fig. 3. Capacity of wind power plants in the EU countries in 2003 and 2011 in MW
Source: author's own elaboration on the base of EC BREC IEO

Electrical capacity in individual countries of the EU reached different levels. The capacity for the year 2003, shown additionally in Figure 3, should be treated as

a reference level to allow for assessment of the effects achieved in individual EU countries in terms of development of wind energy sector within last eight years.

It is remarkable that a dominant role in the European wind power sector is played by Germany. Its share in the whole installed capacity in the European Union amounted to 30.8% in 2011, i.e. 29,075 MW. Another leading country is Spain with its wind power capacity of 21,673 MW in 2011, which accounts for 23% of the whole EU wind energy sector. Therefore, these two European countries show greater capacity than the other 25 member states (Fig. 4).

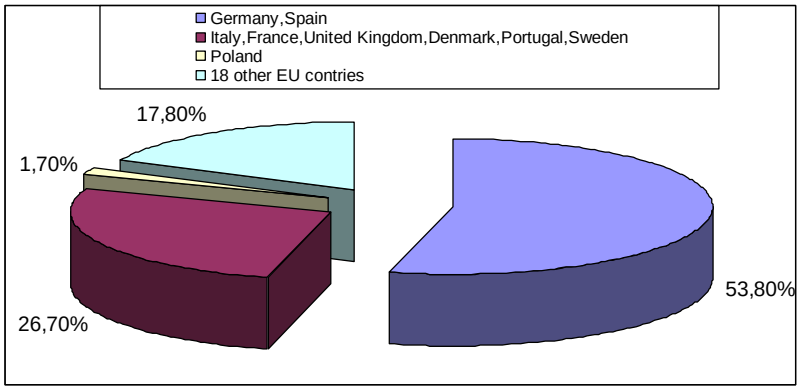


Fig. 4. The structure of participation of the EU in wind energy in 2011
Source: author's own elaboration on the base of EC BREC IEO

Poland, with its capacity of 1,616 MW at the end of 2011, takes medium place among 27 EU countries. However, it should be emphasized that last years have seen a dynamic development of wind power sector in Poland, which manifested itself in over twenty times' rise in installed capacity from 61 MW in 2003 to 1,616 MW in 2011 [3, 4].

A more objective indicator which demonstrates utilization of wind energy is installed capacity per 1000 inhabitants in each EU country. Figure 5 presents installed capacity in 2011 in the countries of the European Union per 1000 inhabitants [3]. The figure demonstrates a high differentiation of this indicator. Its average value for the whole European Union amounts to 187.2 kW/1000 inhabitants. The scatter of the results is enormous: for inhabitants of Slovakia it amounts to 0.6 kW/1000 inhabitants, whereas the same indicator in Denmark reaches 706.2 kW/1000 inhabitants. However, one should take objective conditions into consideration . The countries show different resources and potential of wind energy and are at different stage of economic growth (new EU countries compared to the 'old 15'). Economics and downturn in some countries clearly prove the value of the indicators from Figure 5. Higher values of indicators can be observed in highly developed coastal countries (Denmark, Spain, Portugal, Ireland, Germany and Sweden), which have also strongly supported wind power development in recent years.

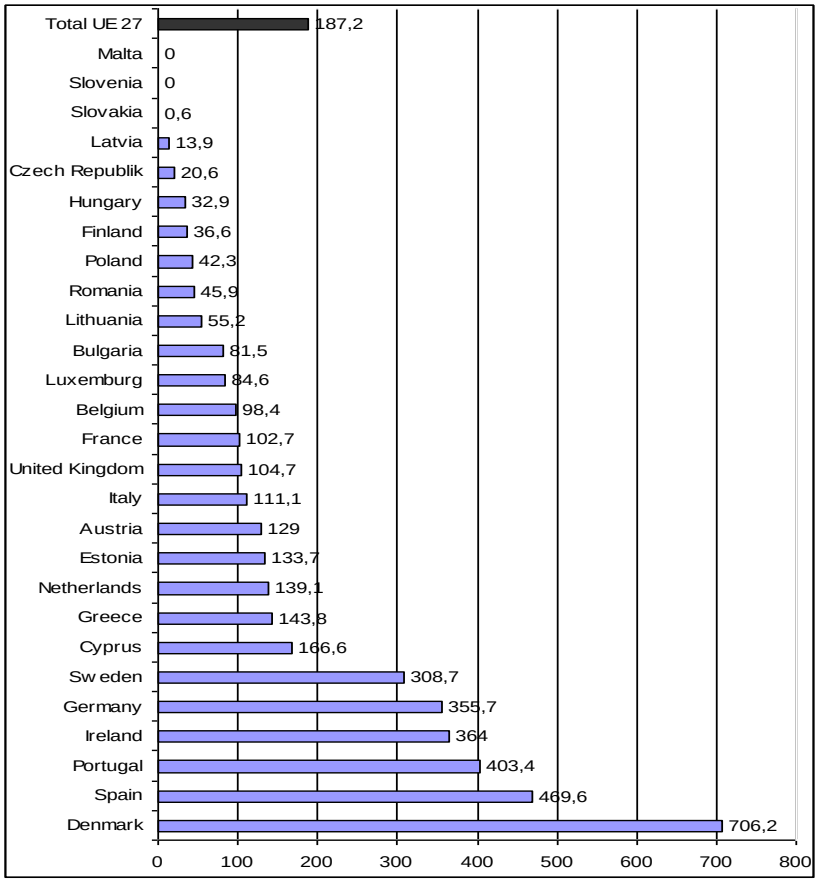


Fig. 5. Wind power capacity per 1000 inhabitants in the European countries in 2011 in kW/1000 inhab.
Source: author's own elaboration on the base of EC BREC IEO

Poland, with its 42.3 kW /1000 inhabitants, takes one of the last places in the European Union. This indicator reveals the magnitude of work and opportunities that emerge for the domestic wind power sector, which should strive for achievement of the levels reached by the leading countries.

2. Efficiency of energy sources

From the standpoint of the prospects and the scale of use of renewable energy sources for production of electricity, costs and efficiency of conversion seem to be key factors. They depend on the type of source, local conditions, development of conversion technologies as well as the scale and popularity. In the comparative analysis presented in the figure below, official data were used. The data were averaged for the bigger group of the countries, particularly for EU countries, where the

systems of support and energy markets do not essentially differ from each other [5].

Economic efficiency of each energy technology for the condition averaged over the whole EU was presented in the document by the European Union: *Energy Sources, Production Costs and Performance of Technologies for Power Generation, Heating and Transport*. It constitutes an appendix for the *Second Strategic Energy Review* within the framework of actions towards energy safety and energy solidarity in the EU [5]. The document compares the costs and effectiveness of different technologies used for production of energy from renewable resources. This study is both reliable and formal and can become the framework for comparative economic assessment of different renewable energy technologies in the EU, particularly in terms of costs of electricity production today and in the perspective of 2020. The document was prepared based on the newest cost-related data concerning technologies used within the EU. For comparative purposes, all the costs were expressed in € in 2005 based on annual inflation rate for the eurozone, according to the data from Eurostat (after previous conversion into € from other currencies, according to the average exchange rates for the given year). Fundamental indexes which were employed for the comparison of economic efficiency of the individual technologies included: investment expenditures, costs of maintenance and total costs of energy production.

Figure 6 presents the forecast of average costs of electricity production in 2020 for different renewable energy sources. Even at relatively conservative assumptions of productivity of wind power plants at the cost averaged for sea and land-based wind farms of 73 €$_{2005}$/kW (50÷95 €$_{2005}$/kW) they will be the cheapest source of electricity.

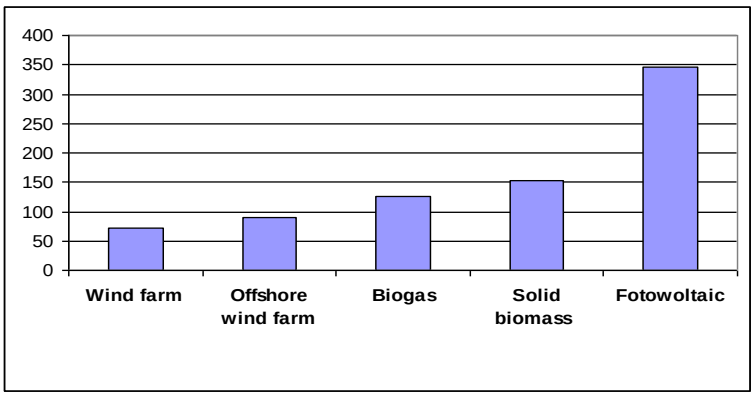


Fig. 6. The forecast of average costs of electricity production in Europe in 2020 expressed in €$_{2005}$/MW
Source: author's own elaboration on the base of EC BREC IEO

Wind energy is also very favourable when its costs are compared with the costs of production of electricity from conventional sources. According to the European

Commission, costs of electricity production in wind power plants in 2020 in the EU will be comparable with the costs of electricity production in nuclear power plants, however, they will be lower than all other technologies of electricity generation from combustion of coal, gas and oil for all the adopted scenarios of fluctuations of fossil fuel prices [5].

According to the European Commission, wind farms are also characterized by the shortest time of construction, comparable to installations which use landfill gas. Wind farms are built in the EU twice shorter than CHP biomass systems, four times shorter than water power plants and 6 times shorter than nuclear plants [5].

A determinant criterion for the choice of a source of primary energy for electricity generation is the potential profits. The choice of the source is affected by a number of factors, with the key factors including availability and cost of acquisition and technical level of conversion technology.

Figure 7 presents the net growth since 2000 of gas power (116 GW), wind power (84.2 GW) and solar PV (47.4 MW) which was at the expense of fuel oil (down 14.2 GW), nuclear power (down 13.5 GW) and coal (down 10.3 GW). 2011 saw a sharp decrease in nuclear capacity due to the early decommissioning of a number of reactors in Germany. The other renewable technologies (hydro, biomass, waste, CSP, geothermal and ocean energies) have also been increasing installed capacity over the past decade, albeit more slowly than wind and solar PV.

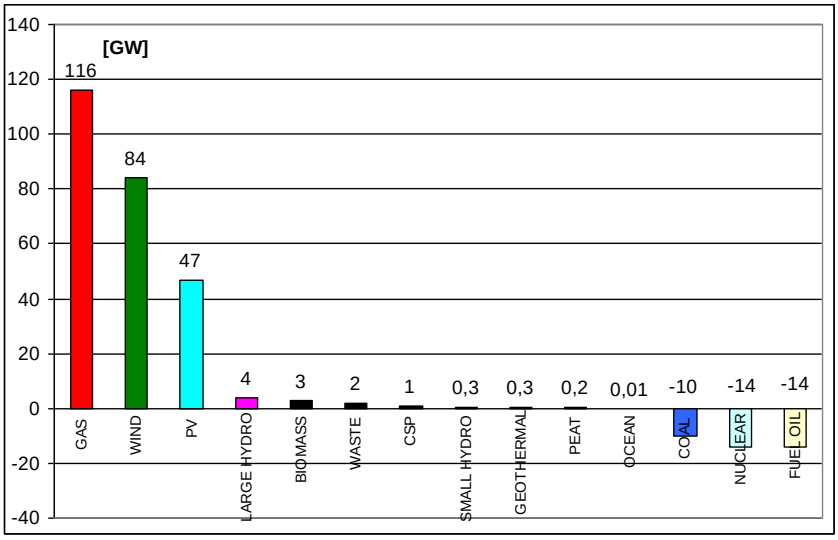


Fig. 7. Net electricity generating installations in EU 2000-2011 in GW
Source: author's own elaboration on the base of EWEA

The 21st century sees the EU power sector moving away from fuel oil, coal and nuclear energy while continuing to increase its total installed capacity with gas, wind and solar PV to meet increasing demand.

It is worth noting that the reduction of generated power concerns power plants based on fuel oil, nuclear energy and coal. This situation is typical of the energy policies adopted by the EU, particularly in the case of the role of fossil fuels, especially coal. In the case of nuclear energy, the essential effect on slowdown in its development is from the concerns over its safety. This tendency, in view of the recent nuclear disaster in Japan, will be deepening. A number of European countries have brought the decisions on new investments to a standstill, and some nuclear power plants have stopped operating. The European energy sector, based on coal, will be reducing its manufacturing potential. There are a number of new investments and the life cycle of a number of currently used power plants is coming to an end. New clean energy technologies of electricity generation from coal are still at the stage of the research and economic and ecological analyses.

3. Wind energy use

The wind capacity installed at the end of 2011 will, in a normal wind year, produce 204 TWh of electricity, representing 6.3% of the EU's gross final consumption. Figure 8 presents that Denmark remains the country with the highest penetration of wind power in electricity consumption (almost 26%), followed by Spain (15.9%), Portugal (15.6%), Ireland (12%) and Germany (10.6%). Overall, in a normal wind year, wind capacity installed at the end of 2011 will meet 6.3% of the EU's electricity needs [4].

Dynamic development of wind energy sector is possible through enhanced nominal capacity in individual wind power plants (development of modern materials and aerodynamic structures for windmills and the systems for conversion of mechanical energy into electricity). Rise in unit capacities forces operators of heat and power systems to develop detailed requirements concerning control of farms under normal and disturbance states of *Krajowy System Elektroenergetyczny* (*National Energy Grid*).

Wind power plants demonstrate the following advantages [5-7]:

- they do not cause environmental pollution,
- wind energy is free,
- wind power plants can be built in the areas of wastelands (desert, shores, rocks),
- they ensure new workplaces.

Disadvantages of wind power plants include:

- potential destabilization of the national energy system (German experience from the period of 2003-2004),
- requirement for using batteries due to the difficulties in forecasting the capacity (especially in long-term perspective),
- threat to birds,
- negative impact of poor technological structures on the environment since they are too loud.

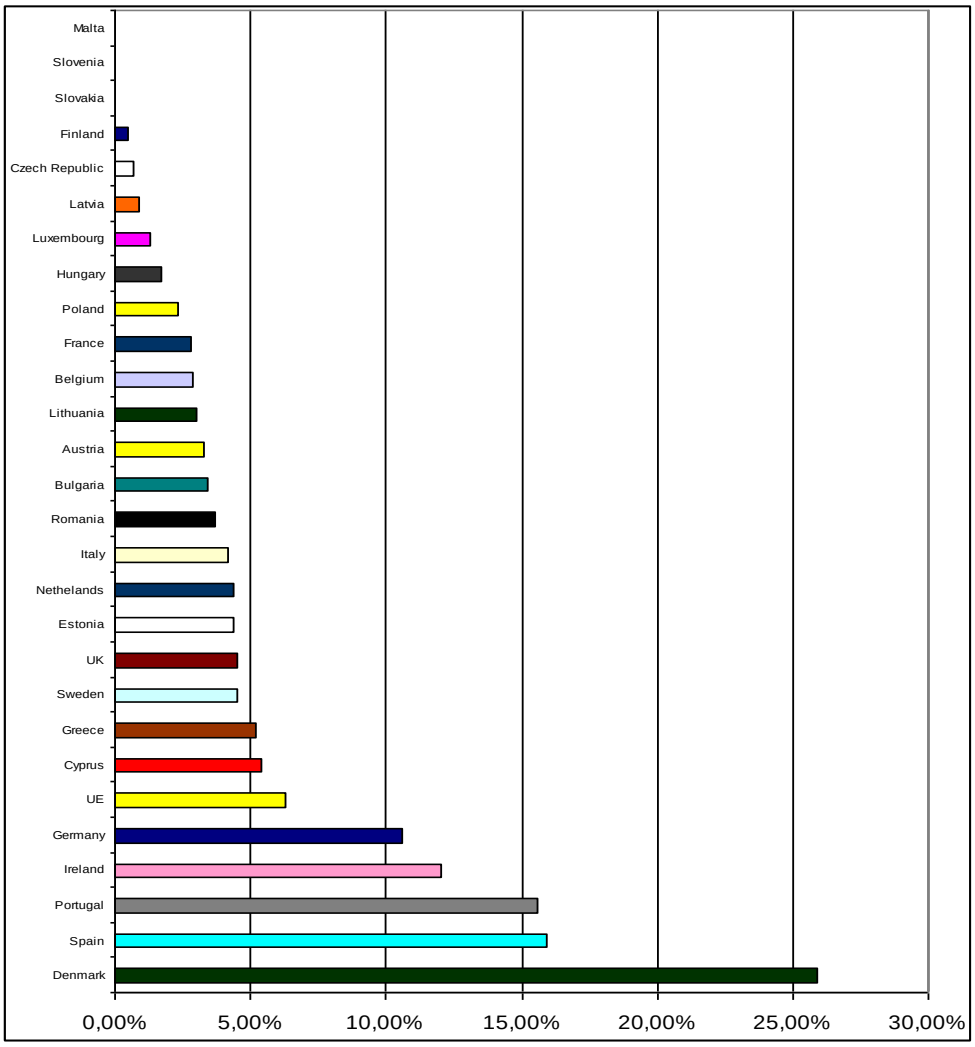


Fig. 8. Wind share of total electricity consumption in EU 2011
Source: author's own elaboration on the base of EWEA

Summary

Implementation of the EU's climate package of 3 x 20 is both a challenge and a chance for EU countries in terms of modernization of energy sector so that it does not lose its competitiveness as the requirements of greenhouse gas emissions are becoming even stricter, prices for allowances for emissions of CO_2 are rising and the resources of fossil fuels (easily accessible and the cheapest) are being gradually depleted.

Wind energy is a fundamental element of the market of green electricity in Europe. In consideration of contemporary climate policies and dynamic economic growth, it is also an important segment of the whole energy market.

One of the main directions for expansion of wind power sector in Europe today is to build offshore wind parks. The countries with access to the sea can make use of the area of their waters and economic zone to build wind power plants. However, investments in offshore farms is a rather complicated project which requires higher expenditures compared to land farms. These investments should be supported by the EU and by each country through implementation of suitable mechanisms for offshore projects. Use of potential in wind locations might considerably stimulate development of wind power sector in Europe.

Wind power energy sector should not be limited to building another land-based and offshore plants. These areas, as a consequence of too intensive concentration of wind farms, might cause disturbance to unrecoverable landscapes, which might result to reduction in their tourism and recreational values. Therefore, further development of wind power sector should take into consideration building small wind turbines which provide decentralized sources of energy for local needs.

Wind energy might be also captured for other purposes than electricity production e.g. through building of hybrid combined wind and solar installations as a source of hot tap water and water for heating the buildings.

References

[1] Commission of the European Communities: Second Strategic Energy Review - AN EU ENERGY SECURITY AND SOLIDARITY ACTION PLAN COM(2008)781, Bruksela 2008.

[2] Kurzak L., Development in wind energy sector in the European Union, Rynek Energii 2010, nr 4(89), 119-124.

[3] Statistical information concerning individual sectors of renewable energy in Poland and EU countries, EurObserv'ER, EC BREC IEO.

[4] Wind in power, 2011 European statistics, February 2012, EWEA.

[5] Wiśniewski G., Michałowska-Knap K., Dziamski P., Oniszk-Popławska A., Regulski P., Wizja rozwoju energetyki wiatrowej w Polsce until 2020, Instytut Energetyki Odnawialnej, PSEW Warsaw 2009.

[6] Kurzak L., Tendencies in Development of Renewable Energy Sector and Energy-Saving Civil Engineering in the European Union, Wydawnictwo Wydziału Zarządzania Politechniki Częstochowskiej, Częstochowa 2009.

[7] Kurzak L., Rajczyk J., State and Perspectives of Wind Energy in the European Union, [in:] ELECTROENERGETICA 2011, Proceedings of the 6th International Scientific Symposium on Electrical Power Engineering, Stara Lesna 2011, Slovak Republic.

Abstract

This study presents the state and prospects of use of electricity production from wind energy, which is a renewable energy source. Obligations by the EU countries to ensure 20% share of renewable energy in consumption of primary energy until 2020 also stimulate searching and analysis of opportunities to improve wind energy utilization as an energy source. The problems and directions

connected with operation of wind energy power plants as well as their advantages and drawbacks were also characterized.

Energia wiatru w Unii Europejskiej

Streszczenie

W pracy przedstawiono stan i perspektywy wykorzystania produkcji energii elektrycznej ze źródła odnawialnego, jakim jest energia wiatru. Zobowiązania państw Unii Europejskiej do osiągnięcia 20% udziału energii odnawialnej w 2020 roku w zużyciu energii pierwotnej wymuszają dodatkowo poszukiwanie i analizowanie możliwości większego wykorzystania wiatru jako źródła energii. Scharakteryzowano problemy i kierunki związane z pracą elektrowni wiatrowych oraz ich zalety i wady.