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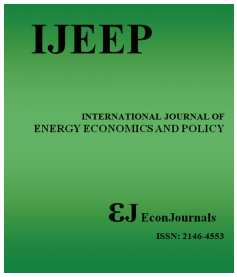

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Wind Power: Current State and Perspectives

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ABSTRACT

Due to the depletion of resources for traditional energy, as well as due to the gradual abandonment of nuclear power in a number of countries, the world pays great attention to energy conservation and energy efficiency, one of the main sources of which is renewable energy, which includes wind energy. Wind power is the most developed renewable energy industry (excluding hydro), which affects its economic characteristics. Thus, onshore wind power plants are characterized by one of the lowest indicators of the cost of electricity production among alternative types of generation. However, offshore wind power plants are still inferior to some types of renewable energy sources and are twice the level of traditional thermal power plants. In this article, the authors consider the state and prospects of development of the world wind energy. The distribution of installed capacity of wind power plants by regions of the world is analyzed and the shares of countries in the total installed capacity are determined. The leading countries were identified as well as the reasons for the rapid growth of wind generation in these countries along with the measures of state support. The state and prospects of wind power development in Russia are considered, and it is also noted that the Russian Federation has significant potential in the field of wind power development, which makes it possible to make optimistic forecasts regarding the provision of electricity to remote areas of Russia. The technical electric power potential of wind energy is about 17.1 TW/year, which is an order of magnitude higher than the amount of electricity generated by all power plants in the country in 2018. The scientific increment is to identify the key problems facing the domestic wind power industry.

Keywords: Energy Efficiency, Energy Saving, Wind Energy, Wind Power Plants, Russian Wind Energy Market
JEL Classifications: Q42, Q47, P28

1. INTRODUCTION

The development of industrial production and improving the welfare of the population requires an increase in the need to use traditional sources of energy, the reserves of which are not unlimited in nature. The constant growth of energy consumption in the world, from 20.75 trillion kW in 2015 to a projected level of 33.4 trillion kW in 2030, has led to increased level of attention to energy efficiency and energy conservation issues around the world.

Until recently, the cost of installing a 1 kW wind generator averaged about $ 1000, and according to experts' forecasts, it will decrease to $ 420 by 2020 (Lyons et al., 2018). As of the end of 2018, electricity generated from wind power has begun to demonstrate competitiveness with energy obtained from traditional sources. Given the finite reserves of traditional energy sources, their prices will increase, which means that the cost of energy produced from oil, gas and coal will also increase, which further increases the competitiveness of wind energy.

Thus, the use of relatively cheap and cleaner energy is a significant factor in improving energy efficiency and energy conservation, which contributes to the economic growth of society, reducing its needs for traditional energy and improving the environment.

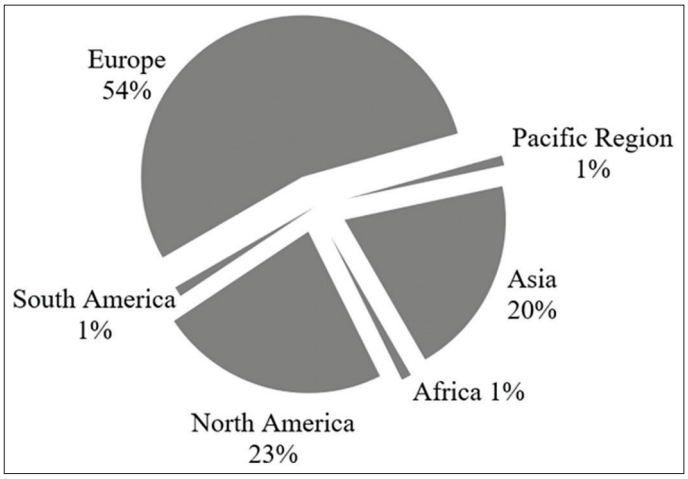
2. LITERATURE REVIEW

Figure 1 shows data on the distribution of total installed capacity of wind power plants (wind turbines) by regions of the world, which shows that the greatest development of wind power has been in Europe, North America and Asia. Approximately one-third of the world's wind power is generated on the Asian continent (Okazaki et al., 2015).

According to the results of 2018, the top three world leaders in total wind power capacity (WPC) included China (184.6 GW), the United States (96.5 GW) and Germany (56.2 GW) (Sidorovich, 2019; Zhang, 2019). The share of the top eight countries in the world wind energy balance is about 83%, with more than a third of the world's installed capacity owned by China and twice as much as the United States (Figure 2) (Zhang, 2019; Pakhomov, 2019).

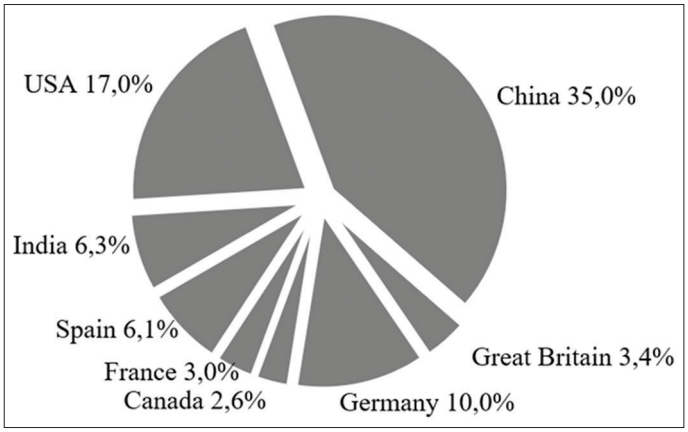
Taking into account the geographical location of the European Union countries, the greatest opportunities for using wind energy are available in Denmark, France, Germany, Norway, Great Britain, Spain, the Netherlands, Italy and France. In this regard, the European Union is implementing a project to create a system of high-voltage transmission lines that will unite all wind farms in Europe in a single network.

Figure 1: Wind power plant capacity by region



Source: Based on the authors' research

Figure 2: The share of countries in the total installed (WPC)



Source: Based on the authors' research

Worldwide interest in wind power has increased so much that industrial and military concerns have become interested in the production of such installations.

Let's briefly consider the state of wind power in the main countries implementing renewable energy development programs (REN).

3. RESULTS

3.1. China

In China, the development of renewable energy, especially wind energy, is considered as one of the priority areas of economic development. The country is implementing a major state program to stimulate the economy, with a total investment of $ 586 billion. Of this amount, 25% is allocated for the implementation of projects on environmental protection, development of renewable energy and energy efficiency. The spread of wind power in China is happening at a rapid pace, largely due to the state support (Lema and Ruby, 2007).

In 2018, China's installed wind power capacity reached 184.6 GW, which is 9.7% of the country's total installed power capacity and about 35% of the world's wind capacity. In 2018, China's wind farms generated 366 billion kW, which accounted for 5.2% of the country's total electricity generation (Tyaglin, 2017).

China ranks first in the world in terms of installed wind farms. The capacity of the largest wind farm in China is about 10 GW with the possibility of increasing to 40 GW at a project cost of $17.6 billion. For comparison, the capacity of one of the world's largest Sayano-Shushenskaya HPS is 6.7 GW (Lema and Ruby, 2007).

To a large extent, this was made possible by the development of China's own production of equipment for wind turbines. Currently, there are about seventy manufacturers of equipment for the wind energy industry in China.

3.2. South Korea

Currently, the share of REN in the country's electricity generation is 8%. According to previously published documents, the Korean authorities planned to increase the share of renewable energy sources to 20% by 2030, with solar and wind energy leading the way.

The new draft energy plan stipulates that the share of REN should reach 30-35% by 2040. The draft policy includes a gradual shift away from coal and nuclear power, the two main pillars of South Korea's current energy supply. At the same time, the role of natural gas will grow. Today, 44% of electricity is generated from coal.

South Korea has a developed shipbuilding and heavy industry, which is a good foundation for creating an offshore wind energy industry.

Doosan Heavy Industries said last year that it would lead a project supported by the South Korean government to develop an 8 MW offshore wind turbine that would both operate in the domestic market and compete globally. Offshore wind power will play an

important role in South Korea's energy future. Consultants from Wood Mackenzie predict 6.4 GW of offshore wind farms in the country by 2030.

3.3. Turkey

The first wind farm zone was built in Izmir in 1998. In 2006, the total capacity of wind turbines was about 19 MW, and in 2007, the capacity increased to almost 140 MW. According to reports prepared by the Turkish Wind Energy Association (TÜREB), in 2018, investments in the wind energy sector amounted to 650 million dollars, which led to an increase in the total installed capacity of wind power plants in 2018 to 7.3 GW, and the wind energy sector itself grew by 7.24%, producing an additional 497.25 MW.

As of the end of 2019, the capacity of 198 wind turbines in Turkey was 8 MW, which is 1.2% of wind generation worldwide (650 GW).

By 2023, Turkey plans to invest € 15 billion in the construction of wind farms. The country's renewable energy development plan calls for bringing the installed capacity of Turkish wind power to 23 GW by 2023. According to TÜREB, during this time, wind farms with a total capacity of 451 MW will be built in the economically significant province of Izmir, which accounts for $ 10.2 billion of Turkish export and $ 7.5 billion of Turkish import. As a result, in Izmir, where the first wind farm in Turkey was built, the capacity of wind farms will increase from 1549 to 2000 MW, and this region will account for 65% of all electricity generated by Turkish wind farms.

3.4. The USA

According to the American wind energy Association, the installed capacity of wind power in 2018 reached 96.5 GW. There are 56,800 wind turbines operating in 41 states.

The growth of the US wind power industry in recent years has been made possible by the demand for this energy resource from companies in various industries that are not directly related to the energy sector. So in 2018, direct contracts (PPA) were signed for the supply of wind energy to companies with a total volume of 4,203 GW. AWEA estimates that the portfolio of wind energy projects under construction or in the final stages of development has reached 35.1 GW (Sugimoto, 2019). The US energy information administration (EIA) has estimated that by the end of 2019, US wind power will provide 6.9% of industrial-scale electricity generation.

The cost of energy produced by wind farms is still relatively high in the United States, but with the increase in the size of wind farms and the development of technologies, we can expect a decrease in the cost of energy to 2-3 cents/kW, especially in areas with a relatively high average annual wind speed (Ratner, 2012; Anup et al., 2019).

The rapid development of wind power in the United States in recent years has been made possible by government support for the development of the industry. For example, when building a new wind farm, the state allocates a so-called tax credit to the company (Simão et al., 2017; Gillenwater et al., 2014).

3.5. Germany

Currently, in Germany, wind energy is one of the most important renewable energy sources and ranks third in the world in total installed wind power capacity after China and the United States. At the beginning of 2018, the total installed capacity of Germany's wind power plants was 56.2 GW, of which the capacity of mainland wind farms reached 50.777 GW. In 2016, the share of wind power in total electricity consumption in Germany was 13.2%, significantly ahead of bio-and hydro-power (Ibrahim, 2017; Sow et al., 2019).

In line with industry trends, the average size of wind turbines is also increasing. The largest share of wind power is accounted for by installations with a capacity of 2 MW, but in projects introduced in Germany in 2017, the average capacity of a wind generator has already reached almost 3 MW.

Active development of wind power in Germany began after the Chernobyl disaster. It was then that the government program for the development of wind energy was launched, and after the adoption of the law "Stromeinspeisegesetz vom 7.12.1990," the development of the industry accelerated even more. According to this law, energy sales companies are required to buy electricity from solar and wind power producers with a capacity of up to 5 MW at a higher price than before the law was adopted. The difference in price should be covered by energy sales companies at the expense of ultimate consumers. The law adopted in Germany has become a model for supporting RES in many countries around the world. 19 European countries, as well as Japan, Brazil and China, have used this model in their legislation. Following the adoption of the law "Stromeinspeisegesetz vom 7.12.1990" in 2000, Germany adopted the law on renewable energy (Das Erneuerbare-Energien-Gesetz [EEG]). Thanks to these legislative acts, by 2002 the total capacity of the German wind power industry reached 10.0 GW (Ketterer, 2014; Usmanova, 2019).

Offshore wind energy is actively developing in Germany. By 2030 The German government intends to increase the total capacity of the offshore national wind energy complex to 25 GW. For this purpose, it is planned to build at least 33 offshore wind farms.

In Germany, there are several large companies that produce wind turbines (Vestas, Enercon, Repower, Nordex, Fuhrlander), which share in the local market is about 65%.

3.6. India

The development of wind power in India began in 1952, when a project was initiated to study the possibilities of using wind energy in the country. Large-scale development of wind power in India began in 1986, when the first demonstration wind installations were built in the coastal areas of Maharashtra, Gujarat and Tamil Nadu, equipped with 55 and 110 kW Vestas wind turbines.

According to 2018 data, India became the fourth country in the world in terms of installed wind power capacity with an indicator

of 34,293 GW. In 2017, wind power in India accounted for almost 10% of the total installed power generation capacity, generating 52.67 GW of electricity, which is almost 3% of the total electricity production in the country (Dipen et al., 2020; Shawon et al., 2013).

The rapid development of wind power in India was the result of a number of legislative acts adopted by the Government of the country. Thanks to the decisions taken, wind energy costs in India have rapidly started to decrease (Dipen et al., 2020; Shawon et al., 2013). The wind energy tariff reached a record low of 3.4 us cents per kilowatt hour in 2017 without any direct or indirect subsidies (Dipen et al., 2020).

The Ministry of New and Renewable Energy has also developed a national offshore wind energy policy that aims to promote the deployment of offshore wind turbines up to 12 nautical miles offshore. The first 100 MW demonstration project is expected to be launched in Gujarat. Given that India has a 7600-km coastline, opportunities in offshore energy have great potential.

3.7. State and Prospects of Wind Power Development in Russia

The technical electric power potential of the Russian wind power industry is about 17.1 TW/year, which is an order of magnitude higher than the amount of electricity generated by all the country's power plants in 2018 (Tulupov et al., 2019; Fedotova, 2019).

Most of the wind zones in Russia are located in the South of Russia (Kalmykia, Stavropol and Krasnodar Territories, Rostov, Volgograd and Astrakhan region, The North Caucasus Federal District), on the sea coasts. The ideal place for building a wind farm is the Far East, which has about 30% of the economic potential of wind power.

The problems of wind energy in Russia began to be addressed in the 20s of the last century, when the Central Aerohydrodynamic Institute named after Professor N. E. Zhukovsky (TsAGI) first developed wind farms and wind turbines for agriculture. However, despite this seemingly impressive history, the Russian wind power industry is currently still significantly behind the growth rate of the industry from other countries of the world (Kushnir, 2013; Bushukina, 2019).

Today, more than 50 wind power producers operate on the Russian wind power market, among which the largest players are "Rosatom" State Corporation, the Finnish company "FortumCorporation" and the Italian group of companies "Enel."

In 2017, Rosatom's subsidiary "Novavind" JSC and "Lagerwey," a Dutch wind turbine manufacturer, established a joint venture called "RedWind," which is responsible for turnkey deliveries of wind turbines and their after-sales service. Another subsidiary of Rosatom group, JSC "VetroOGK," is responsible for the construction of the wind farm. The latter company plans to build four wind farms in the Stavropol territory with a total capacity of 260 MW at a cost of 26 billion rubles.

In 2017 The Ministry of Energy of Russia held a competition to select renewable energy projects, as a result of which the Investment Fund for wind energy development, created by "Fortum Corporation" and "Rosnano," received the right to build a wind power plant with a total capacity of 1000 MW. The result was the launch in the Ulyanovsk region of the country's first 35 MW wind farm connected to the wholesale market. As part of this project, the main manufacturer of wind generators, the Danish company "Vestas Wind Systems A/S," will create enterprises on the territory of Russia for the production of components for wind generators, the first of which, located in Ulyanovsk, will specialize in the production of wind turbine blades (Vestas Manufacturing Rus) (Lopatkin et al., 2019; Alekseev and Afanasev, 2020).

In early 2018, PJSC "Enel Russia," controlled by "Enel," signed an agreement to build a wind power plant in the Rostov region with a capacity of 90 MW and in the Stavropol Territory with a capacity of 300 MW. The international concern "Siemens Gamesa," which specializes in the production of wind turbine generators, will supply equipment and then localize production for future wind farms. The start of commissioning of the wind farm is planned for 2020.

To date, Russia has 11 large wind farm with a capacity of over 1 MW, 8 wind power <0.1 MW and the project more than 20 wind farms, mainly intended for placement in the southern regions of the country. The most powerful wind farm in Russia today is considered to be the Ulyanovsk WPS-1. It includes 14 wind turbines with a total capacity of 35 MW with an annual sales volume of about 85 GWh.

4. CONCLUSION

According to a report entitled "the Future of Wind," presented on October 21 at the China Wind Power event in Beijing, by 2050, the world's wind power could grow tenfold and cross the threshold of 6,000 GW. By the middle of the century, wind power could meet a third of the world's electricity demand and, combined with further electrification, reduce the carbon emissions generated by the energy industry by a quarter, which is necessary to meet the terms of the Paris Agreement. To achieve these goals, it is necessary to increase wind power capacity on land and at sea by four and ten times, respectively, compared to the existing ones.

The bet on renewable energy is correct. For the state, wind farms are not just an object of generation, but also the development of new technologies, the creation of additional jobs, and the growth of orders for equipment. The global wind power industry can become a true driver of job creation, providing employment for more than 3.7 million people by 2030 and more than 6 million by 2050. These figures are almost 3.5 times higher, respectively, than the number of jobs that make up just over a million in 2018. Sound industrial and labour policies that build on and strengthen domestic supply chains can help increase income and employment by attracting existing economic activities to support wind energy development.

As for the prospects for the development of this market in the regional context, the authors believe that Asia can increase the installed capacity of its own onshore wind power from 230 GW in 2018 to more than 2600 GW by 2050. By this time, the region

will be a world leader in wind power, accounting for more than 50% of all onshore installed capacity and more than 60% of all the offshore capacity.

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