# Dynamics Analysis of Wind Energy Production Development

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**Abstract.** The paper presents the analysis of the introduction experience and dynamics development of the world wind energy production. Calculated the amount of wind energy sources investments and the production capacity growth dynamics of the wind turbines. The studies have shown that the introduction dynamics of new wind energy sources is higher than any other energy source.

## Introduction

In 2015, the government of the Russian Federation approved the concept of energy-efficient low-hydrocarbon way of industrial economy sectors development for the period till 2020. During this period the reduction of the greenhouse gas emissions is being planned up to the level not less than 25% of the emissions' level in 1990. Taking into consideration the current economic and technological conditions of the development in Russia, namely, the record hydrocarbon production and the established embargo on the high-tech equipment purchase in foreign companies, the realization of the greenhouse gases level reduction concept is extremely difficult [1].

One of the ways of the emissions reduction and at the same time the solution of the economy diversification is the development and use of alternative (renewable) energy sources on the territory of the Russian Federation with the possibility to use the electricity for the internal needs and for sale to the neighbouring countries, including the Scandinavian Peninsula [2].

The countries of the Scandinavian Peninsula are major importers of electricity from the Russian Federation. During the period from 2006 to 2012 Russia has exported in total more than 70 billion kW·h of electrical energy to Finland, however since 2012 there has been a decrease in electricity demand from Russia, due to the constant cost increasing of electricity in Russia and the comparative cheapness of electricity on the Nordic market thanks to the generating capacity increasing the cost of alternative energy sources use [3]. The growth of prices in Russia is stipulated by the liberal reforms in the energy sector and by the formation of free prices.

The analysis of the electricity prices growth in Russia has shown that the average annual price increase is almost 9%; this fact indicates that there is a necessity to improve energy efficiency. If we take into account the requirements to the greenhouse gas emissions reduction, there will be further increase of electricity prices.

The wind energy industry is a promising direction to develop. According to the Russian Association of Wind Energy Industry (RAWI) the Russian Federation has the world's largest wind energy capacity, constituting more than 40 billion kWh of electricity per year. So the Northern regions

such as the Kola Peninsula, located near the Scandinavian countries, the Gulf of Ob, the coastal territory of the Far Eastern Federal district are the wind zones with the highest wind capacity coefficient [4, 5]. The wind speed at the height of modern wind equipment, calculated according to the annual average values, is 11-13 m/s. It exceeds the economic payback threshold of wind energy twice. Also it is very important to take into account the low rating of environmental damage from wind energy, so the total environmental damage from the wind energy is significantly lower compared to "traditional" ways of energy generating. In Europe the external negative socio-environmental impact of 1 kWh of the produced electricity is estimated at 0.15 cents for wind energy, 1.1 cents for gas power plants and 2.5 cents for coal.

The aim of the article is the analysis of the introduction experience and the dynamics development of the world wind energy production.

## Materials and methods

The analysis of the empirical material the period 2004 – 2015 and news articles were used as our primary empirical data to study: renewables - global status report and renewable energy capacity statistics.

## Results and Discussion

From 2004 to 2015, the total amount of investments in the wind energy sources amounted to more than $ 2.6 trillion, and the dynamics of investments is constantly increasing, with the exception of 2012 and 2013. In the table 1 and figure 1 there are shown the annual investments and the topics of their growth.

**Table 1 -** The amount of wind energy sources investments.

| Year | The volume of investments, bln. $ | The increase as compared to the previous year |
|---|---|---|
| 2004 | 62 | - |
| 2005 | 88 | 42 |
| 2006 | 128 | 46 |
| 2007 | 175 | 36 |
| 2008 | 206 | 18 |
| 2009 | 207 | 0.8 |
| 2010 | 274 | 32 |
| 2011 | 318 | 16 |
| 2012 | 297 | -7 |
| 2013 | 272 | -8 |
| 2014 | 316 | 16 |
| 2015 | 329 | 4 |

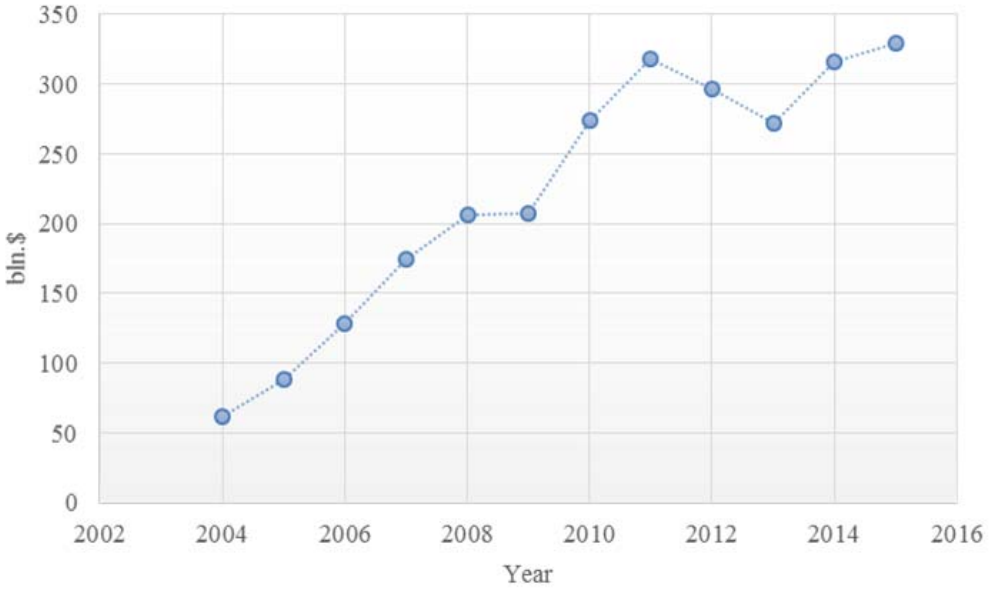


**Figure 1 -** The amount of wind energy sources investments.

The graph shows that investments have positive dynamics and they change depending on the political courses of the countries, developing wind energy and world energy prices. In contrast to the investment's dynamics, the growth of wind turbines production capacity has only a positive trend. In 2014 there was introduced a record number of production capacity equal to 51 GW, which is 44% more than in 2013 [6]. Currently, the global production capacity of wind energy industry can be estimated as 370 GW. Figure 2 presents the production capacity growth dynamics.

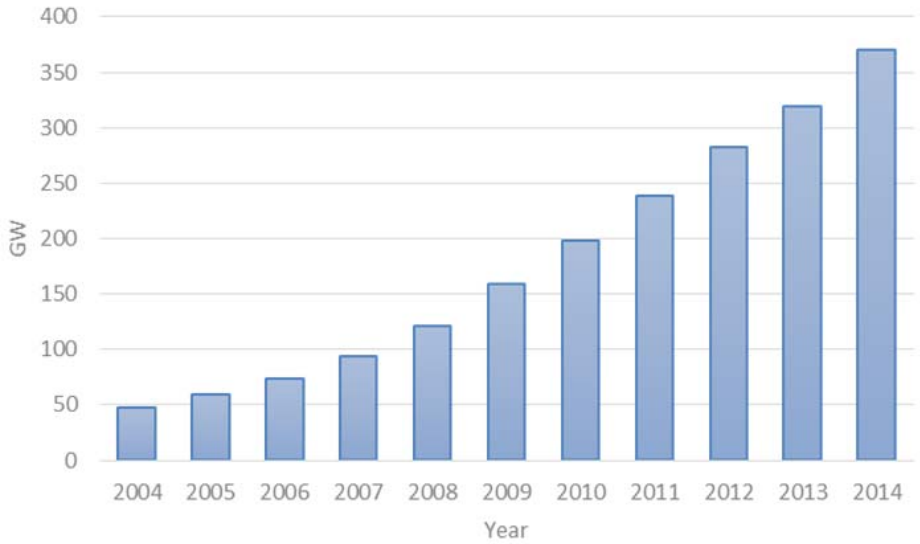


**Figure 2 -** The production capacity growth dynamics of the wind turbines

85% of all wind energy industry production capacity is given to the top ten leading countries, but the growth analysis has shown that about 80 countries put into operation on-site wind energy sources at the end of 2014 [7, 8]. So, Asian countries remain the largest producers of wind energy accounting for 50% of all productivity in the world, the second place is given to the EU with 23% in 2014, the third place ranks North America with 13%. Figure 3 presents the dynamics of production capacity growth of ten leading countries for 2014 year.

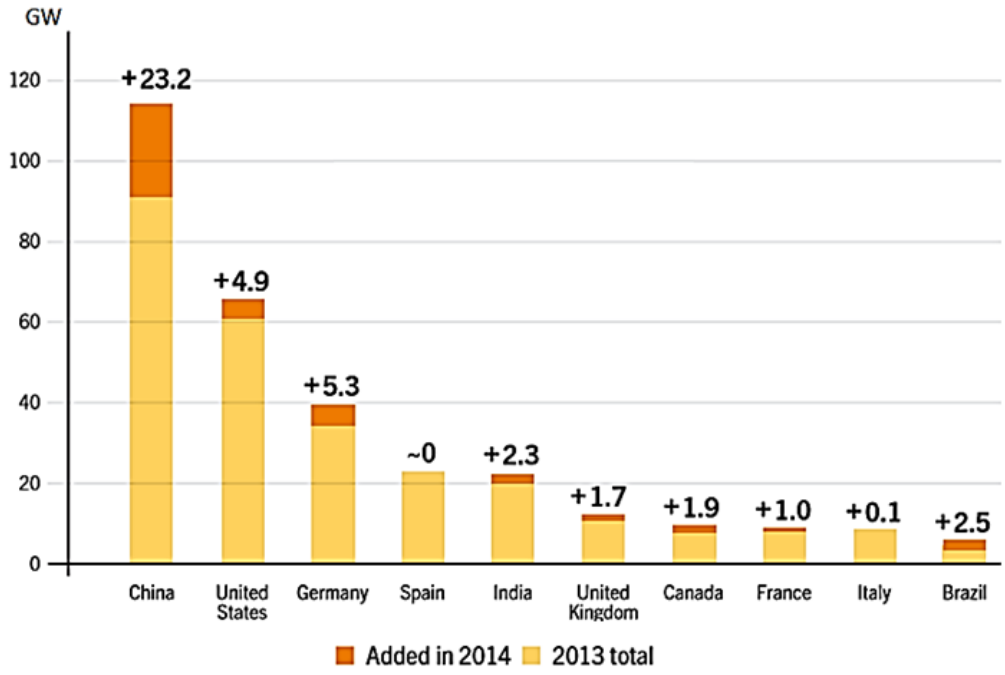


**Figure 3 -** The production capacity growth dynamics of ten leading countries in wind energy industry

At the end of 2014 Asian countries ranked the first place for production capacity amount of wind power plants. The EU countries despite the increase by 4% took the second place, but in general, the wind energy generation took about 44% of the market among all the rest alternative sources of energy. Figure 4 show the distribution of production capacity growth in the total amount of energy.

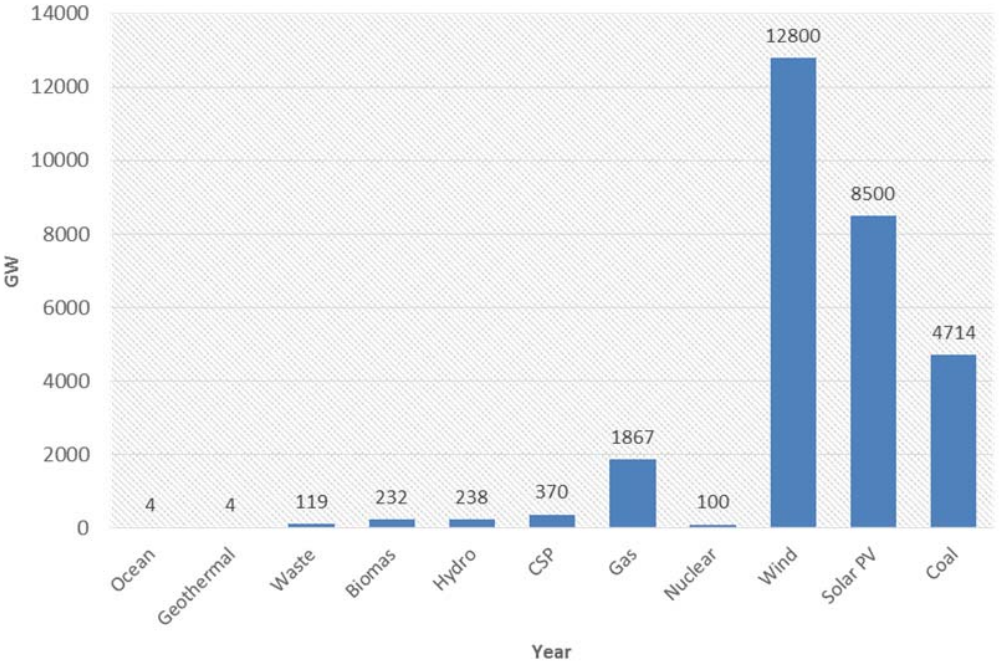


**Figure 4 -** The distribution of production capacity growth in the EU in the total energy sources amount.

The largest increase is given to Germany and the UK. These countries provided an increase of 59% of the production capacity of the entire Eurozone. This increase is provoked by the policy aimed at the development of "green energy" and relatively calm political situation. Thanks to the coordinated actions and large investments wind energy in 2014 took 7.5% of the total energy balance of the Eurozone, and according to 2015 year data it is more than 10%. The countries such as Denmark, Ireland, Portugal, Spain provided more than 20% of their own energy consumption by means of wind energy. Denmark, Sweden, Spain, Ireland and Germany became the leading countries in the growth of generation per inhabitant [9,10]

In 2015 the European Union introduced 29 GW of new production capacity of wind energy. It is interesting to mention that in 2015 there was not built any station for generating energy from peat and fuel oil, but total energy generation from coal reduced by 8 GW, gas by 4 GW, fuel oil by 3 GW, nuclear power by 1.8 GW.

In 2014, China introduced additional 23.2 GW of production capacity of wind power plants, 20.7 GW of which were connected directly into the national energy system, which is a record for the growth among all the countries. Currently in China, there are about 115 GW of energy generated by wind energy plants, or it is 3% of the total production. So, the region of Inner Mongolia provides 21% of energy by means of wind turbines, Gansu provides in such a way 10.3%, and Xinjiang - 8.1%.

The main problems, affecting the development of wind energy in China, are the difficulties with the lack of the infrastructure preparedness and delayed building, also, here we can include the necessity to integrate a large amount of energy in the national energy network.

Starting with 2011 the capital expenditures for the construction of wind power plants have had a downward trend, which is ensured by the development of competition and technological innovations introduction that have led to the capacity increase. It is estimated that wind turbines located on the land are economically competitive with coal and gas power plants without taking into account the compensation costs and state support. The most economical from the operation point of view are high-power wind turbines located on the sea shelf.

## Conclusion

As it can be observed from the analysis, the introduction dynamics of new wind energy sources is higher than any other energy source. Governmental support of European and Asian countries in the field of renewable energy, high rates of technological progress, as well as the instability of the prices for hydrocarbons, set wind energy up in the rank of the future traditional energy in the medium term. Globally, in 2014 the production capacity generated by the wind stations around the world is enough to satisfy at least 3% of the total electricity consumption in the world that tells about the growing influence of "green energy".

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