Analysis The Potential Implementation And Use Of The Renewable Energy Sources In The Murmansk Region

S M Chekardovskiy, A G Zakirzakov and E F Gordievskaya
Tyumen Industrial University
Volodarsky str. 38, Tyumen, Russian Federation, 625000
E-mail: Allbert-@mail.ru

Abstract. The paper presents the analysis of the geographical location of the Murmansk region and possibilities of using different renewable energy sources. Present the results of the analysis of using and practicality wind power to wind turbines to generate electricity. The paper presents of average annual consumption of electricity settlements in the Murmansk region, options for replacing the use of diesel fuel by wind energy and recommendations for possible areas of utilization of wind energy.

1. Introduction

The second half of the XXth century was marked by the beginning of the new energy sources search and development. The first energy conflict that occurred in 1979 provoked the beginning of the alternative and renewable energy sources development, including solar and wind energy, hydro and bio-energy, etc.

The reasons of the renewable energy sources development are not only the importance of energy security of the countries, but also ecological safety of citizens. Thus, according to the Tindell’s Center of Climate Studies in Norwich (UK), it follows that in 2012 the volume of CO₂ emissions amounted to 35.6 billion tonnes, the share of China accounted for 28% with a specific volume of emissions per capita of 6.6 tons, the USA – 16% with a specific volume per capita of 17.2 tonnes and the European Union – 11% with a specific volume of emissions per capita of 7.3 tons [1].

The intensity of carbon dioxide emissions from the solid fuel consumption has not decreased until 2010. There is known a case, occurred in the 21st of October, 2013, when smog shrouded the majority of China cities and paralyzed the movement of vehicles and had a negative impact on the citizens’ health. The level of harmful substances from the fuel and energy complex companies’ electricity generation exceeded 40 times the acceptable level set by the World health organization. According to the World Bank rating, 16 of the 20 most polluted cities in the world are in China [2, 3].

Realizing the negative consequences of the fuel and energy sector development and harm to the citizens’ health and environment, the governments of the majority countries have adopted the declaration, concerning the priority development of renewable energy sources. Starting with 2011, the investments in renewable energy development have had a positive trend and in 2015 they amounted to $ 329 billion [4,5].

Unfortunately, the Russian Federation considers the development of oil and gas industry as a priority one, however, in 2014-2015 the decline in world prices for hydrocarbon resources has prompted the government to consider the development of renewable energy in the country and export.
of the generated energy in the neighboring countries, in particular the Scandinavian Peninsula countries [6,7].

The purpose of this article is to analyze the potential implementation and use of the renewable energy sources in the Murmansk region.

2. Materials and methods
The analysis of the empirical material, consisting of 13 publications covering the period 2002 – 2016. The introduction and use of renewable energy is considered to be appropriate in the areas with the existing usage potential and lack of traditional hydrocarbon resources. Such areas include, for example, the Murmansk region, located in the European North of Russia and engaged in electricity generation primarily through imported fuel from the neighboring regions.

3. Results and Discussion
According to the Ministry of Architecture, Construction, Housing and Utilities of the Russian Federation there are 64 oil-fired boilers on the territory of the Murmansk region, where the purchase of oil products in the heating system makes up 1.2 million tons, and the consumption and production of local fuels in the total energy balance of the region is less than 1%.

Previously prospective use of hydro energy in the Murmansk region is currently experiencing a number of difficulties, caused by the development of almost all the possible locations of hydropower plants, the generation of which is not enough to cover the needs of the region [8,9].

Considering the energy potential of renewable energy sources it should be noted that the region has a low potential for the use of bioenergy, the basis of which is wood biomass, due to low volume of timber, weak infrastructure and the fact that a major part of the forests, located in the areas of consumption, refers to the protected forests. The use of solar energy is the least promising because the region is situated beyond the Arctic Circle, having borders with Finland and Norway that can be observed in figure 1.

The analysis of solar radiation observations, conducted by the Centre of physicotechnical problems of power engineering of the North, has shown that the total solar radiation in the clear days ranges from 4500 to 5000 MJ/m², but the presence of high cloudiness and the harshness of Northern weather reduce the fraction of solar radiation that has reached the earth, almost by 75%. Taking into consideration this fact and the low number of sunny days during the year, the use of solar energy is impractical in this region [10].

The analysis of the scientific literature and region climate peculiarities has shown that the most
promising sphere of renewable energy source use is the use of wind power. So the wind speed in the coastal areas is estimated to 10-12 m/s, as the distance moves away from the coastline, the speed is reduced to 5-6 m/s. The given speeds are the highest in the European part of the Russian Federation.

Taking into account the high wind energy potential, the high cost of electric and thermal energy in the region, as well as its successful experience of the wind farms implementation in the neighboring countries, it is considered appropriate to introduce and use the wind power plants, the competitiveness of which has been proven in the countries such as Germany, Denmark, Norway, etc [11, 12].

The available data on the long-term average wind speeds distribution at the height of 10 meters was marked on the map of the Kola Peninsula and is presented in figure 2 and table 1.

![Figure 2. Long-term average wind speeds distribution.](image)

Table 1 represents the characteristics of wind resources of the Kola Peninsula.

| Characteristic                                      | Zona 1     | Zona 2     | Zona 3     |
|-----------------------------------------------------|------------|------------|------------|
| The average annual wind speed on 10 and 50 m., m/s  | 7.4 - 9.8  | 6.4 - 8.6  | 5.4 - 7.6  |
| Specific wind energy, MW·h/m²                       | 10.6       | 7.7        | 5.2        |
| The estimated wind speed, m/s                       | 15.5       | 13.6       | 11.7       |

As it can be seen, at a height of 10 meters on the coastal areas the wind speed reaches 7-8 m/s, with the measurements height increasing the wind speed increases. Figure 3 shows the dependence of the wind growth on the height changing.
To assess the feasibility of the wind power generators use there has been carried out the analysis of speed and consumption in settlements, located in the remote areas of the southern part of the Murmansk region [13]. Annual measurement of air masses during every month took place in the following villages: Chapoma, Tetrino and Strelna. The measurement data are given in figure 4.

An average annual wind speed is 6 m/s, which is a good indicator of the wind power generators introduction. Also, the graph of an average annual load has been evaluated and constructed and shown in figure 5.
The graph demonstrates that the annual average electricity load is 168 kW, maximum and minimum load value is 205 kW and 138 kW, respectively. The introduction of 4 units of wind power generators with a capacity of 50 kW will cover all the energy consumption in every village. The replacing of diesel fuel used for diesel power plant used, for example, in the village Chapoma by the wind power generators, the cost of 1 kW·h is reduced by 30%.

When you use the wind energy on the industrial scale on the territory of the Murmansk region, future export of the generated energy will be possible on the territory of Sweden, Finland and Norway.

4. Conclusion
The analysis of renewable energy sources implementation and use possibilities in the Murmansk region has shown that only wind power has the potential for implementation, covering domestic consumption and the generated electricity export to the neighboring countries.

The territory of the Barents Sea coast in the Murmansk region is one of the most windy sites and has a great potential of wind energy generating. The region has a favorable repeatability of the wind speeds, the steady prevailing wind with abnormally high levels of annual average speeds are observed here, the seasonal maximum of the wind coincides with the seasonal peak of energy consumption.

The main areas of possible wind energy use are: operation of large wind farms, included to the power grid; participation of the wind turbines in the electricity supply of autonomous consumers (joint work of diesel power plants and wind turbines), the participation of the wind power plants in the heat supply of consumers (joint work of boilers and wind turbines) and the use of wind energy in natural gas processing technologies.

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