3. *Baharwani V., Meena N., Dubey A*. Life Cycle Analysis of Solar PV System: A Review. International Journal of Environmental Research and Development. 2014. Vol.4. P.183–190.

4. *Simon D., Hook M., Wall G.* A review of life cycle assessments on wind energy systems. The International Journal of Life Cycle Assessment. 2012. Vol. 7. P.678–687.

КЕМСКАЯ ВЕТРОЭЛЕКТРОСТАНЦИЯ КАК РАЦИОНАЛЬНЫЙ ПУТЬ ДЛЯ ЭНЕРГОСНАБЖЕНИЯ КАРЕЛИИ

KEMSKAYA WIND POWER PLANT IS A RATIONAL WAY OF KARELIA'S ENERGY SUPPLY

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Выполнен анализ топливно-энергетического комплекса Карелии и определена его энергоэффективность. Проведены исследования ветровых ресурсов Карелии и определены наиболее благоприятные места для строительства ВЭС. Представлены результаты исследования структуры скорости ветра в г.Кемь. Обоснован рациональный путь развития энергетики Карелии на основе использования энергии ветра. Определены параметры Кемской ВЭС.

The analysis of the Karelia's fuel and energy complex has been carried out and its energy efficiency has been determined. Studies of Karelia's wind resources have been carried out and the most favorable places for the construction of wind power plants have been determined. The results of studying the structure of wind speed in the city of Kem are presented. The rational way of development of the power industry in Karelia based on the use of wind energy has been substantiated. The parameters of the Kemskaya wind power plant have been determined.

Ключевые слова: Республика Карелия, энергетическая эффективность, ветроэнергетические ресурсы, ветровая электростанция, Кемь, параметры, производство электроэнергии, коэффициент использования установленной мощности.

Keywords: Republic of Karelia, energy efficiency, wind energy resources, wind power plant, Kem, parameters, electricity production, capacity factor.

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Introduction

Karelia's fuel-energy complex includes hydropower plants (with total power 632, 8 MW), heat power plants (478 MW total), and big amount of the boiler plants. All the heat power plants use imported fuel.

In the structure of the fuel-energy resources consumption there were essential changes connected with coal and black oil replacement with natural gas and biofuel. The volume of fuel-energy resources consumption in Karelia is not so high. Fuel-energy resources expense in housing and communal services on the person makes nearby 1,2 tons of coal equivalent (t.c.e.) per person. The Republic of Karelia is at the level of Germany on fuel-energy resources expense per capita – approximately 6,7 t.c.e./person in a year (2000).

One of the major indicators of power efficiency is fuel-energy resources expense on 1000$ of Gross Regional Product (GRP) production. The comparative characteristic of the regions of North-West Federal District of Russian Federation under the charge fuel and energy resources is given. For Karelia it is 1,3 t.c.e./1000$ GRP (2000) and 1,5 t.c.e./1000$ GRP (2008). This value is much bigger than average value in North-West Federal District and 4 times bigger, than in the USA. Certainly, it is partly caused by presence of power-consuming industries and a frigid climate.

For an estimation of a perspective current consumption at level of 2030 the approach within the model [1] is used. Particularly, in one of scenarios development of the Pudozhsky mega-project focused on extraction of ores of nonferrous metals is supposed. Only electric power requirement for this project is estimated in 4 TW h.

Substantially volume of local and renewable energy sources usage will depend on predicted volumes of fuel and energy consumption in Republic. The real current consumption mostly corresponds to the moderate development scenario.

Materials and methods

In Karelia the further development of hydroenergy, windenergy and bioenergy is the most perspective. Which resources has the Republic for this purpose? For renewable resources estimation the special software (ENERGOM) was used.

The analyses of energy potential of wind resources of Karelia region is given. With the help of the ENERGOM software the renewable energy sources estimation was received. The study of spatial-time distribution of renewable energy sources demands regular and prolonged observations. We replenished, systematized and treated the observations on the basis of contemporary informational know-how, including the databases of wind energy resources and software for observations treatment. In accordance with these techniques two groups of databases, "Wind Energy Resources" and "Observations", were developed [2-5].

The ENERGOM system has been used for wind energy research. New results in wind energy resources research of Karelia are received. In particular, on fig. 1 the distribution of the wind maximum speeds for every day in a long-term period is shown. As a result of wind resources study the new results and estimations of economic potential of wind energy resources for Karelia are received. Economic potential of Karelia makes 0,7 million t.c.e. The real potential, that can be conversed by 2030, is estimated in 0,44 million t.c.e.

Total renewable energy sources potential is estimated approximately in 6,3 million t.c.e (fig.2) [4].

Fig. 1 – Results of wind energy investigations (Software ENERGOM)

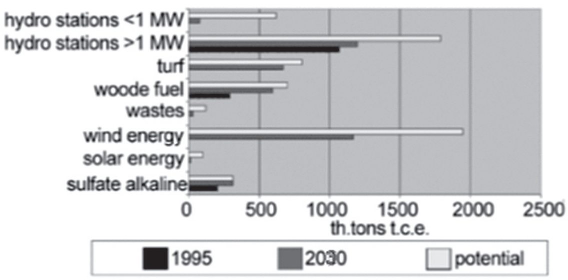


Fig. 2 – The estimations of renewable energy resources of the Republic of Karelia

Results

For large-scale wind power engineering development in Karelia coastal areas of the White sea, the Onega and Ladoga lakes are optimum. Besides, the Karelian coast of the White sea possesses moderate and uniform winds, without strong and heavy impulses within a year. These are the areas authors offer to build large Wind power plant.

There was considered step-by-step wind power development with large wind power plants construction in the area of White Sea seashore, notably near city Kem. Wind resources of this district are examined rather good at the aspect of climate and wind power conditions [4]. The wind directions that contain largest power are determined. These are south-

southeast and east-southeast directions. Thus east-southeast occupies one of last positions on frequency number. That's why it is more reasonable to array wind power station perpendicularly to the south-southeast – west – northwest direction.

As a platform of possible construction field the suburb of Kem, Puh Navolok cape, an island Popov and Goreliha Mountain have been considered. There are power lines 110 kV and 330 kV in close proximity to the city of Kem. Area of Kem obtains enough territory for placing wind powerstation. In addition, power line presence close to the city makes it easier to connect future power station to regional network. As a part of Kemskaya power station it is supposed to establish MW wind turbines. Such decision was accepted on the basis of comparison of turbines with various capacities [5].

All the calculations were made taking into account cold climate of the region. By this time world practice of wind power engineering development has stored sufficient experience of building of stations in regions with a frigid climate. Similar complexes are established in the countries of Europe, North America, Russia and China. By the end of 2008 the total established capacity of stations in which wind turbines work at temperatures below the temperatures corresponding to a normal operating mode of installation, has reached practically 3000 MW. It has allowed to generate standard requirements to wind turbines, placed in areas with a cold or polar climate.

At the estimation of economic efficiency of wind power station project in the areas with cold climate to which Kem concerns as well there have been considered the losses of energy connected with an ice formation on blades and negative temperatures of air.

Around Kem the risk of rime on wind turbine elements makes 32 days in a year.

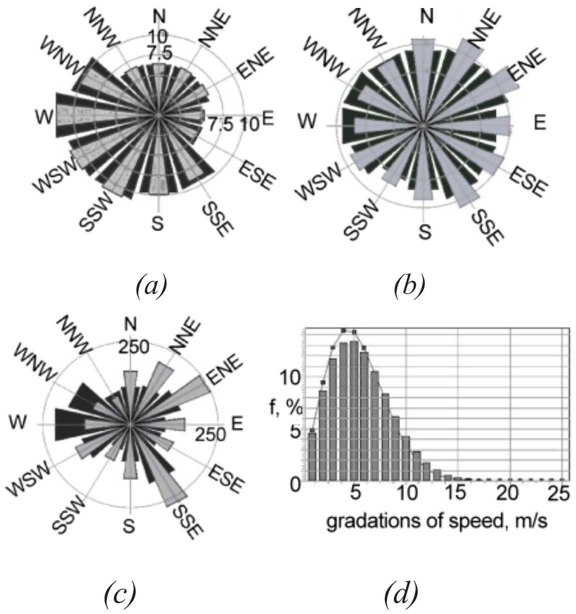


Fig. 3 – Results of investigation wind velocity structure in place Kem.
a) prevailing direction of wind; b) directions appropriate to the greatest speeds of wind;
c) directions greatest on a wind energy; d) distribution of speeds of wind on gradation

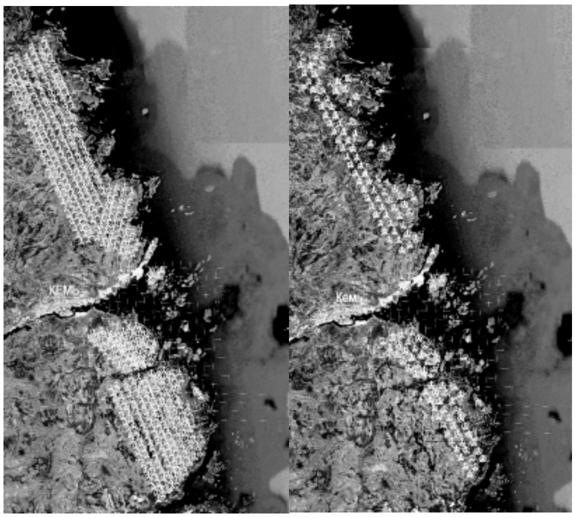
Wind turbines and area selection for the 1000 MW wind power plant

At the analysis and choice of wind turbines there were considered following wind turbines: Enercon E 82 and Enercon E 126. Areas that shown the biggest level of electric output are shown at the fig. 4. Results of WPP electricity production and capacity factor calculation are given in the Table 1.

Wind power plant (WPP) with Enercon E126 wind turbines occupies 2.5 times smaller area than WPP that includes Enercon E82 wind turbines. These are additional expenses on roads, foundations, electrical part, land rent. At the same time wind turbines Enercon E82 show higher output and capacity factor. Moreover, generating cost in the case of Enercon E82 and Enercon E126 turbines make respectively 7,7 c€/kW h and 8,7 c€/ kW h (for effective rate r = 12 %). Therefore, the basic variant is considered to be the WPP including wind turbines Enercon E82 as an optimum for this region.

Table 1

Value	Enercon E82	Enercon E126
Electricity production, TWh	2,44	1,83
Hours of plant's installed capacity utilization, h	2710	2037
Capacity factor, %	27,8	20,9



(a) *(b)*

Fig. 4 – a) Positioning scheme of Enercon E 82 wind turbines; b) Positioning scheme of Enercon E 126 wind turbines

Discussion

Thus, wind energy sector development in Karelia is proved and expediently. To search a rational way of development it is important to take into account changes in carbon balance of region. One of the rational ways of Karelia's development in view of resource, economic and ecological aspects (carbon balance) and restrictions is found.

In this variant further development of the large-scale and small hydro energetics and wind energetics are supposed. The balance is covered by input of heat power plant on natural gas with total power 500-1000 MW. Also it is necessary to build heat power plant on natural gas with total power 180 MW in Petrozavodsk and power plants on biomass.

References

1. Sidorenko G.I., Sidorenko D.G. Model of optimization and rational use of Karelia's renewable energy resources. Journal "Ecology of Industrial Manufacturing", №4, 2007. pp.10-22.

2. Climatic Factors of Renewable Sources of Energy // V.V. Elistratov [et al.]. Ed.: V.V. Elistratov, N.V. Kobysheva and G.I. Sidorenko, 2010, - SPb.: Nauka, - 235 p.: ill

3. Zubarev, V., Minin, V., Stepanov, I., 1989, "Use of wind energy in northernregions", Nauka, Leningrad, Russia.

4. Sidorenko, G., 1993, "Space-time distribution and integral estimates of renewable energy sources of Karelia", Tiedonantoja 15, Vol.1, University of Joensuu, Finland, 19-38.

5. Sidorenko G.I. Kemskaya Wind Power Plant in Karelia // Applied Mechanics and Materials. 2014. №672-674. REET-2014. pp.240-245

МОДЕЛИРОВАНИЕ ПОТОКА СОЛНЕЧНОГО ИЗЛУЧЕНИЯ
MODELING THE FLUX OF SOLAR RADIATION

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Существует ряд методик, позволяющих определить поток солнечного излучения на принимающую поверхность. Наилучшие результаты дает методика Берда. Ее улучшение возможно введением поправочных коэффициентов. Моделирование потока солнечного излучения, построенное на данном подходе, дает достаточно точные результаты для решения практических задач. Для повышения достоверности расчетов целесообразно более широко использовать базы данных актинометрических наблюдений, полученных в постах наблюдений на территории бывшего СССР.