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OPPORTUNITIES AND PROSPECTS FOR THE USE OF ALTERNATIVE ENERGY SOURCES IN TERMS OF VITEBSK REGION

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The article discusses the possibilities and prospects for the use of alternative energy sources in world practice and in Belarus. The technical and environmental aspects of the implementation of alternative energy technologies are presented. The factors affecting the spread of green energy in Belarus are also indicated.

Scientists believe that there may be a shortage of traditional energy sources by 2025. It is also predicted that during 2000-2020, the global demand for primary energy sources will increase by 50% at an average annual growth rate of 2-2.5% [1, 2]. As a result, methods for reducing energy consumption are being actively developed; obtaining energy from alternative sources, ways to minimize the negative impact on the environment are being actively developed. Belarus is a country with virtually no domestic energy reserves [3]. In this situation, such developments are of particular relevance. The goal of this work was to explore the potential of the country and the Vitebsk region in the development and implementation of alternative energy sources.

The goal implies the solution of such tasks as analysis of the state and prospects of renewable energy in the world and in Belarus, analysis of climatic conditions and factors affecting the distribution of alternative energy sources in Belarus and the Vitebsk region. The work uses the method of analyzing literary sources in combination with the methods of searching information on the Internet using general-purpose search engines and specialized search engines.

1. The state and prospects of alternative energy in the world.

Today, 1/7 of the world's electricity comes from renewable energy sources (RES) [1]. Hydropower has the highest efficiency – about 80% of all renewable energy. The lowest cost is characterized by the use of geothermal energy [1]. By 2020, global consumption of hydropower will increase by more than 50%. The use of geothermal, solar, wind energy, biomass and waste energy will grow at the highest rates, an average of 2.8% per year [2].

National programs have been created to stimulate research, development and production of wind turbines, solar panels and installations for the use of organic and wood waste in the USA, England, Canada, Germany, Russia, Denmark, Sweden, India and other countries. The greatest successes in wind energy have been achieved in the USA and Germany [1]. In Germany, the development of group accommodation of wind turbines in the coastal zones of the North and Baltic Seas is under way [1]. The cost of electricity generated from low-power wind generators is 1.7-2.0 times lower in comparison with to the cost of energy from diesel units of the same capacity [1]. A 1 MW wind generator reduces annual emissions to the atmosphere – 1,800 tons of CO_2, 9 tons of SO_2, 4 tons of nitrogen oxides. The Global Wind Energy Council estimates that by 2050, global wind energy will reduce annual CO_2 emissions by 1.5 billion tons [4].

In the city of Inko in Finland, the northernmost solar power plant in the world was created and incorporated into the country's energy system [1]. In Japan, the total power of solar stations reaches 150 thousand kW and provides 2% of the country's electricity needs [1]. Solar panels are widely used in Germany. Much attention is paid to the development of solar energy in France, USA, Spain and Italy. The World Energy Council predicts that in 2020 the cost of solar electricity will be 2-3 cents per 1 kW·h [1].

In EU countries, the amount of energy from solid biomass (mainly wood) is about 5.0% of total energy consumption. In the US, the priority of biomass use is the generation of electricity and the production of liquid fuels. Currently, there are about 500 power plants with a total capacity of 8500 MW [1].

2. The state and prospects of alternative energy in the Belarus

The main objectives of the energy policy of Belarus - reducing the cost of energy consumption, environmental protection. Based on the Concept of the National Sustainable Development Strategy, a fuel and energy balance for the period up to 2020 has been developed. According to experts, energy consumption in 2020 will increase to 41 billion kWh [4]. At the moment, the construction of the Belarussian nuclear power plant is underway, but the use of atomic energy in the future until 2021 is not envisaged. The main type of fuel for Belarus is still natural gas [5].

If in [3-6, 9] an unfavorable combination of conditions for the development of alternative energy in Belarus is noted, the authors [1, 7, 8] give very optimistic forecasts. The emphasis is on a combination of solar and

wind energy, as well as on the possibility of small hydropower plants. In [1], this indicates the possible negative impact on the environment in the area of construction of hydroelectric power plants.

In [2], a model of a power plant with direct conversion of water energy into electricity is proposed with the possibility of using the installation in the power supply of private sector dwellings. R.N. Melenchuk, A.A. Kivshar also offers a plant using a combination of natural RES (sun, wind, rain, biomass, etc.). Consideration is given to improving the efficiency of existing elements of alternative power plants.

The authors [3, 10] propose a new approach to ensuring the energy security of Belarus - to consider consumers as active participants in the energy market with the possibility of free trade in energy surpluses, installing home and commercial energy consumption controls with the goal of aligning electrical load schedules and other economic mechanisms to encourage rational energy consumption.

In [7], the development of wind and hydropower as the priority areas of "green" energy in Belarus, with the prevalence of hydropower resources is noted. At the same time, wind generators would be the most paid back in the Vitebsk and Minsk regions, where the wind speed often exceeds 15 m/s.

At present, 17 biogas plants with a total capacity of about 34 MW, 56 wind power plants (43.2 MW), 30 photovoltaic plants (31.5 MW), 287 solar water heating plants (3.8 MW) and 51 hydroelectric power plants are operating in Belarus with capacity of 34.6 MW. There are also 3265 energy sources on local types of fuel with an installed thermal capacity of more than 6 GW, including 22 wood-fired CHP plants with 129 MW of electrical and 345 MW of thermal power. At the same time, installations operating in Belarus produce only about 0.7% of electricity. At the same time, in order to achieve the objectives set out in the program documents, it is necessary to make great efforts to improve the legislative base, eliminate stereotypes and overcome barriers in the development of renewable energy [6]. Also in [6], it is suggested that new types of high-efficiency solar and wind power plants should be created, in combination with other non-traditional energy sources in the composition of micro networks. It is noted that the simultaneous use of several alternative energy sources improves the quality and reliability of electricity generation by the power system, reduces the cost of energy production in autonomous industries and ensures the safety of the environment in rural areas [11].

Solar energy in Belarus is actively used in the agro-industrial complex when greenhouses are maintained [6], in the production of electric shepherds [1]. The first samples of silicon for solar cells were obtained at the Gomel Chemical Plant from chemical production wastes [1]. In the short term, the main areas of solar energy will be solar power plants for drying and for heating water in agricultural production [1]. Currently, the efficiency of solar installations for generating electric current is in the range of 6-17%, while in heating systems due to solar thermal energy, the efficiency rises to 30-45% [8]. [8] also notes the feasibility of using solar energy for the purposes of hot water supply and heating with the help of solar collectors, in the construction of houses of "solar architecture" and for the production of electricity using photovoltaic installations (converters). Belarus predicts a significant increase in the introduction of photovoltaic stations due to cheaper solar panels. The results of calculations showed that, provided that the current state support continues, the payback period for solar power plants is about 9 years [6].

The wind energy resources of Belarus by the electric potential amount to more than 200 billion kW·h [1]. At the same time, in [3] an estimate is made of the maximum possible potential of wind power at the level of 2.8 billion kW·h, or about 8% of today's consumption. Some Belarusian scientists believe that there are more than 300 thousand places in Belarus for the installation of small and medium-capacity wind turbines. For Vitebsk region, wind energy potential ranges from 1 MW to 4 MW [8]. By wind energy potential, Belarus complies with the requirements of commercial expediency of introducing wind engineering [12, 1].

The efficiency of wind power plants (WPP) increases by two or more times in the cold period compared with the warm period [1]. The correct choice of the location of wind turbines and the development of new installations that ensure maximum energy removal with relatively weak winds will allow starting large-scale development of wind energy in the conditions of the republic and save 2 million tons of standard fuel (tons of diesel fuel) per year [1, 12] .

Under the conditions of Belarus, it is recommended to use wind turbines with a capacity of 1-2.5 MW with a tower height of at least 80 m. Taking this into account, the electricity generation in these areas will amount to 9 billion kW·h and will allow replacing 1,100 thousand tons of fuel equivalent in year. The cost of electricity can be 5-7 cents / kWh, and the payback period of installations does not exceed 6 years [5]. The issue of using low-power wind generators (100–150 kW) in the agricultural sector is being considered. [12]. To date, the total installed capacity of wind power plants in Belarus reaches 43.2 MW. [10, 12].

Sanitary standards set the minimum allowable distance from individual wind turbines and wind farms to populated areas. When wind farms are located, the established migration routes of migratory birds are taken into account. Despite bright prospects, there is still no legal basis in Belarus that will contribute to the develop-

ment of renewable energy [12]. The results of calculations for the territory where the average wind speed exceeds 4 m / s showed that installing a wind generator for daily electricity generation up to 200 kWh will be cheaper than using a diesel generator, expanding the grid or installing photovoltaic systems [12].

Hydropower. The economically viable hydropower potential of the rivers of Belarus is about 250 MW, or 2% of the total energy consumption [3]. It is most concentrated in the Grodno, Vitebsk and Mogilev regions in the areas of the Neman, Zapadnaya Dvina and Dnieper river basins. According to the State program of construction in 2011-2015 of hydroelectric power stations in the Republic of Belarus, on the Zapadnaya Dvina, a cascade of four hydroelectric power stations was planned: Verkhnedvinsk, Polotsk, Beshenkovichi and Vitebsk. On the Neman River - the construction of a cascade of two hydroelectric power stations: Grodno and Nemnovskaya. A cascade of three hydroelectric power plants was planned on the Dnieper River: the Orsha, Shklov and Mogilev stations with a capacity of about 5 MW each [6]. In 2012, the Grodno hydropower plant with a capacity of 17 MW was commissioned, in 2017, the Vitebsk hydropower plant with a capacity of 40 MW and the Polotsk hydropower plant (HPP) with a capacity of about 22 MW. It is planned to build another hydroelectric station near Beshenkovichi. Work is underway to implement the project Nemnovskaya HPP with a capacity of 20 MW [3].

During operation of hydroelectric power station there are no emissions of pollutants into the atmosphere. Of the possible environmental consequences, consideration should be given to flooding and flooding of lands adjacent to hydroelectric power plants, changes in the thermal and ice regimes of rivers, soil and vegetation of coastal areas, habitat conditions of amphibious animals, birds, fish. At the same time, the approximate amount of reduction of emissions of pollutants into the atmosphere due to the construction of new hydropower plants with a total capacity of 102.2 MW with an annual electricity generation of about 460 million kW·h compared to emissions from thermal power plants using fossil fuels of similar capacity is 230 700 tons, including sulfur dioxide – 850 tons, nitrogen dioxide – 210 tons, carbon monoxide – 229 640 tons [7].

Bioenergy. In Belarus, the list of bioenergy resources mainly includes wood, canola, peat, woody biomass. Recently, the processing of municipal solid waste (MSW) [1, 3, 6, 7] is gaining momentum.

According to Belneftekhim concern, diesel biofuel obtained from rapeseed processing conforms to EURO-4 standard. It has been proven that out of 3 tons of rapeseed seeds, about 2 tons of rapeseed oil cake used for the production of animal feed and 0.9 tons of diesel biofuel are extracted [7]. The use of peat can grow to 2.0-2.5 million tonnes of coal equivalent. by 2020. Thanks to the use of peat and wood, the country can satisfy 25% of the total energy demand [3]. At Postavskiy flax factory, they mastered the Japanese technology for producing fuel from flax processing waste - castrobriquettes, which are not inferior to coal in terms of heat transfer [1].

The total area of forests in the country is 8 676.1 thousand hectares, the timber stock is more than 1100 million m^3. The annual increase is 32.37 million m^3, the average increase minus litter is 25 million m^3. Extensive use of woody biomass as a fuel can provide up to 15% of its own energy potential versus 5% in the energy mix today [1].

Over the past 15 years in Belarus, the indicator of the formation of MSW has increased to 1.5 kg / person. in a day. Taking into account the country's population, it is about 13.5 thousand tons of MSW per day. The energy potential of biogas generated from MSW in Belarus is estimated at 480 thousand tons of fuel equivalent. in year. But its use is difficult due to a number of factors. In most places of storage of MSW, there is no "purge", impervious screens and external insulation, i.e. safe conditions for their processing are not provided [6].

3. Climatic conditions of Belarus in the context of solar and wind energy.

The last 30 years in Belarus there has been a change in climate towards an increase in air temperature, compared to the accepted climate-wide norm. The greatest deviations in the positive direction are observed in winter. In percentage terms, this anomaly is maximum in the Vitebsk region [13]. The territory of the country receives more solar radiation and can count on realizing the potential of solar power.

The amount of solar radiation arriving on the earth's surface depends on the time of year and day, the latitude of the place, the cloudiness and transparency of the atmosphere, the closeness of the horizon, and the time the sun stays above the horizon. An important energy indicator of solar radiation resources is the duration of sunshine, which characterizes the flow of direct sunlight in hours with the sun disk open. This indicator decreases in cities due to the dustiness of the atmosphere and the shading of urban buildings [1, 8]. On the territory of Belarus, the duration of sunshine for the year increases from north, northwest to south, southeast from 1750 to 1870 hours [8]. In the annual course, the maximum duration of sunshine is in June (from 265 to 290 hours), the minimum - in December (from 25 to 35 hours) [1, 8]. The warm season accounts for 80% of the annual sunshine duration. The number of days without the sun decreases from north to south from 100-115 to 93-100 [1]. The average annual arrival of total radiation varies from 4,100 MJ/m^2 in the south of the republic to 3,500 MJ/m^2 (85-97 kcal/cm^2) in the north [1]. The intensity of total solar radiation varies from 165 kW/m^2 in the Vitebsk region to 185 kW/m^2 and higher in Gomel region [8].

Taking into account all factors, experts believe that to cover all the needs of the republic in electricity, it is enough to use the total land area equivalent to a square with a side of 18 km, or 0.5% of the total area of the country. To do this, the roofs of houses, farms, land unsuitable for agriculture must be used [1].

For wind power plants, average wind speeds, annual and daily wind speeds, repeatability of speeds (year or period) and wind directions, distribution of wind periods and calm periods by duration are of great importance [8]. The mode of wind speeds is determined by atmospheric circulation and the physical-geographical conditions of the area. Surface wind is closely dependent on the conditions of the underlying surface [1].

Hills occupy about 30% of the territory of the surface of Belarus, the plateau – 10%, and the remaining 60% are lowlands. Winds are stronger on elevations or open convex forms of relief than on flat terrain and lowlands. In the northern part of the country, south-west and south wind directions have a high frequency, in the south part – west wind directions. From June to August the northwesterly and westerly winds prevail. In the winter period – south-western and western with a frequency of 40% [1]. The variability of the average annual wind speed is small, the standard deviation is 0.3-0.4 m/s. Continental winds prevail in Belarus at an average speed of 4-6 m/s [12]. The maximum wind speeds are characteristic for the autumn-winter periods, the minimum ones are observed at the end of the summer. Differences in wind speed in the winter and summer months are 1.0-1.5 m/s [12]. In the Vitebsk region, the average monthly wind speed ranges from 3.3 m/s in August to 4.8 m/s in December. The recurrence of these speeds in winter is 80-85%, in the summer – 70-75% [1]. Moderate winds (6-9 m/s) are noted in the republic up to 25% of the time of the year [1]. The most favorable for the placement of wind turbines are hilly-moraine hills (Novogrudskaya, Minsk, Vitebsk, Gorodok, Orshanskaya), occupying the north-eastern and central parts of the country. The maximum values of the specific power of the wind flow here exceed 150 W/m² [1].

The minimum starting wind speed at which it is advisable to use wind turbines is 2 m/s. According to [15] for Belarus, the minimum average annual wind speed at a height of 10 m is 2.9 m/s. For the Vitebsk region – from 3.0 m/s to 3.8 m/s, which exceeds the threshold value [8] and indirectly confirms the prospects for the development of wind energy in the Vitebsk region.

The main factors hindering the development of alternative energy sources in Belarus are the following [3, 11, 13, 14]: the lack of an exhaustive legal and regulatory framework [6, 12]; climatogeographical limitations [3, 4-6, 9]; the stereotype of economic thinking of the main actors of the power system; lack of a developed infrastructure, in particular, in the sphere of processing of MSW [6], technical difficulties in realizing the potential of renewable energy sources.

Based on the results of the work, it is possible to formulate the following conclusions:

1) The elaboration of alternative energy sources is a global practice, acquiring particular relevance in the context of increasing demand and the projected shortage of primary energy sources. The most actively used resources are hydropower and biomass. The latter makes a significant contribution to the reduction of polluting emissions into the atmosphere.

2) Belarus is actively working on the development of alternative energy sources, along with a policy of rational energy consumption. The country has enough potential for the development of hydro and wind energy, biomass energy; hybrid energy based on a combination of solar and wind energy.

3) Vitebsk region, compared with other regions of Belarus, is more promising for the development of wind turbines. Also it is of practical interest for the development of hybrid installations, in the summer months using mainly the energy of the sun, in the winter – the wind. It is preferable to use wind turbines with a capacity of up to 150 kW with a starting wind speed of 2 m/s.

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