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WIND AND SOLAR ENERGY: DEVELOPMENT PROSPECTS

Annotation. *The rapid growth of global energy demand and the urgent need to mitigate climate change have positioned wind and solar energy as crucial alternatives to fossil fuels. This analysis explores the development prospects of wind and solar power, considering their principles, technological advancements, environmental benefits, and the challenges associated with their integration into modern energy systems. It highlights the increasing global investments and policy support driving the expansion of these renewable sources. Furthermore, it examines the economic and logistical factors influencing their deployment, including cost reductions, manufacturing scalability, and grid integration requirements.*

Keywords: *Wind energy, solar energy, renewable energy, energy transition, sustainability, energy Security*

Wind energy. For a long time, seeing what destruction storms and hurricanes can bring, people wondered whether it was possible to use wind energy. Windmills with fabric sails were first built by the ancient Persians over 1.5 thousand years ago. Later, windmills were improved. In Europe, they not only ground flour, but also pumped out water, churned butter, as, for example, in Holland. The first electric generator was designed in Denmark in 1890. After 20 years, hundreds of similar installations were already operating in the country [1-4]. Wind energy is very large. According to estimates by the World Meteorological

Organization, its reserves amount to 170 trillion kWh per year. This energy can be obtained without polluting the environment. But the wind has two

significant drawbacks: its energy is highly dispersed in space and it is unpredictable - it often changes direction, suddenly dies down even in the windiest areas of the globe, and sometimes reaches such a force that it breaks wind turbines. Construction, maintenance, and repair of wind turbines that operate around the clock in any weather in the open air are not cheap. A wind power plant of the same capacity as a hydroelectric power station, thermal power plant, or nuclear power plant must occupy a larger area in comparison with them. In addition, wind power plants are not harmless: they interfere with the flights of birds and insects, make noise, and reflect radio waves with rotating blades, creating interference with television reception in nearby settlements [4].

The operating principle of wind turbines is very simple: the blades, which rotate due to the force of the wind, transmit mechanical energy to the electric generator via a shaft. The generator in turn produces electricity. To obtain wind energy, various designs are used: multi-bladed "daisies"; propellers like airplane propellers with three, two, and even one blade (then it has a counterweight); vertical rotors, resembling a barrel cut lengthwise and mounted on an axis; a kind of "standing on end" helicopter propeller: the outer ends of its blades are bent upward and connected to each other [3]. Vertical designs are good because they catch the wind from any direction. The rest have to turn downwind. To somehow compensate for the variability of the wind, huge "wind farms" are built. Wind turbines there are located in rows over a vast area and work on a single network. On one side of the "farm" the wind may blow, while on the other it is calm. Wind turbines cannot be placed too close to each other, so that they do not block each other. Therefore, the farm takes up a lot of space. Such farms exist in the USA, France, England, Ukraine (the Autonomous Republic of Crimea), and in Denmark, a "wind farm" was placed in the coastal shallows of the North Sea: there it does not bother anyone and the wind is more stable than on land. To reduce dependence on the inconstant direction and strength of the

wind, flywheels are included in the system, partially smoothing out gusts of wind, and various types of batteries. Most often they are electric. But they also use air (the wind turbine pumps air into cylinders; coming out of there, its smooth stream rotates a turbine with an electric generator) and hydraulic (the force of the wind raises the water to a certain height, and, falling down, rotates the turbine). Electrolysis batteries are also installed. The wind turbine produces an electric current that decomposes water into oxygen and hydrogen. They are stored in cylinders and, as needed, burned in a fuel cell (i.e., in a chemical reactor where the energy of the fuel is converted into electricity) or in a gas turbine, again receiving current, but without the sharp fluctuations in voltage associated with the vagaries of the wind.

Wind power is the most developed area of practical use of natural renewable energy resources. The total installed capacity of large wind power plants (WPP) in the world is estimated today at 44,000 MW. The unit capacity of the largest wind power plants exceeds 1 MW. In many countries, a new industry has even emerged - wind power engineering. The world leaders in wind power are the USA, Germany, the Netherlands, Denmark, India, etc. In particular, Germany plans to produce up to 30% of all electricity in the country using wind by 2030. The fairly wide distribution of wind power plants is explained by their relatively low specific capital investment compared to other renewable energy sources.

2. Solar energy. The sun, as is known, is the primary and main source of energy for our planet. It warms the entire Earth, sets rivers in motion and gives power to the wind. Under its rays, 1 quadrillion tons of plants grow, which in turn feed 10 trillion tons of animals and bacteria. Thanks to the same Sun, the Earth has accumulated reserves of hydrocarbons, i.e. oil, coal, peat, etc., which we are now actively burning. In order for humanity to be able to satisfy its energy needs today, about 10 billion tons of conventional fuel are required per

year. Solar energy is based on the fact that the flow of solar radiation passing through an area of 1 sq. m., located perpendicular to the radiation flow at a distance of one astronomical unit from the Sun (at the entrance to the Earth's atmosphere), is equal to 1367 W / sq. m. (solar constant) [2-3]. Through absorption, when passing through the Earth's atmosphere, the maximum flow of solar radiation at sea level (at the Equator) is 1020 W / sq. m. However, it should be taken into account that the average daily value of the solar radiation flux through a single horizontal section is at least three times less (due to the alternation of day and night and changes in the angle of the sun above the horizon). In winter, in temperate latitudes, this value is two times less. The following methods of obtaining energy from solar radiation are known: 1. Obtaining electricity using photocells. 2. Conversion of solar energy into electrical energy using heat engines: a) steam engines (piston or turbine) using water vapor, carbon dioxide, propane-butane, freons; b) Stirling engine, etc. 3. Heliothermal energy - conversion of solar energy into thermal energy by heating the surface that absorbs the sun's rays. 4. Solar balloon power plants (generation of water vapor inside the balloon due to heating the surface of the balloon, covered with a selectively absorbing coating, by solar radiation). Disadvantages of solar energy. Construction of solar power plants requires large areas of land due to theoretical limitations for first- and second-generation photovoltaic cells. For example, a 1 GW power plant may require an area of several tens of square kilometers. Construction of solar power plants of such capacity may lead to a change in the microclimate in the surrounding area, so photovoltaic stations with a capacity of 1-2 MW are mainly installed near the consumer or even individual and mobile installations. Photovoltaic converters operate during the day, as well as in the morning and evening twilight (with lower efficiency). At the same time, the peak of electricity consumption occurs precisely in the evening hours. In addition, the electricity they produce can fluctuate sharply and unexpectedly

due to weather changes [2-3]. To overcome these shortcomings, solar power plants use efficient electric batteries. Today, this problem is solved by creating unified energy systems that combine various energy sources that redistribute the produced and consumed power. Today, the price of solar cells is relatively high, but with the development of technology and the rise in prices of fossil fuels, this disadvantage is gradually being overcome.

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