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CONSTRUCTION OF WIND POWER PLANTS FOR IRRIGATION NEEDS

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The article presents the results of research on the construction and use of renewable wind energy for irrigation needs. It is proposed to use wind energy to reduce the negative impact of humans on the environment and thus improve it. The article deals with various environmental factors, including the use of energy-intensive irrigated agriculture. In order to reduce the cost of growing agricultural products, it is proposed to use inexhaustible energy sources, namely wind energy. The basic design features of different designs of wind power plants are considered in the work. The following diagrams are shown: wind wheel washed areas, aerodynamic brakes, location of wind power plant, dependence of output power on terrain relief, scheme of basic layout of wind power plant. The disadvantages of wind power plants are also given. The technical characteristics of the installations are determined depending on the angle of the wind direction with respect to the axis of the rotor and the area of the wind wheel. The wind speed indexes at which energy production begins. The basic principles of location of the wind power installation on the terrain in relation to the surface of the earth are considered. The basic elements of wind power plants, their purpose, the number and the need for the full operation of the system as a whole. For example, the most used area of Bilozersky district for irrigation application is considered. Wind speed changes in the Bilozersky district are analyzed by months and years. The most productive months of the year for wind energy for irrigation purposes are identified. It is established that in the Bilozersky district wind speeds are sufficient to generate electricity for modern irrigation.

Key words: *construction of power plants, renewable energy sources, wind energy, design features, wind power plant, irrigation.*

Волошин М. М. Будівництво вітрових електростанцій для потреб зрошення
У статті наведено результати досліджень щодо будівництва та використання відновлювальної вітрової енергії для потреб зрошення. Пропонується використання вітрової енергії для зменшення негативного впливу людини на навколишнє середовище і таким чином його покращення. У статті розглянуто різні фактори впливу на довкілля, зокрема і використання енергоємного зрошуваного землеробства. Для зменшення собівартості вирощування сільськогосподарської продукції пропонується використання невичерпних джерел енергії а саме енергії вітру. У роботі розглянуті основні конструктивні особливості різних конструкцій вітроенергетичних установок. Наведено схеми: площі омиваємої

вітровим колесом, аеродинамічні гальма, розміщення вітроенергетичної установки, залежність вихідної потужності від рельєфу місцевості, схема базової компоновки вітроенергетичної установки. У роботі наведено і недоліки вітроенергетичних установок. Визначені технічні характеристики установок залежно від кута напрямку вітру по відношенню до осі ротора та площі омітання вітрового колеса. Наведено показники швидкості вітру при яких починається вироблення енергії. Розглянуті основні принципи місця розміщення вітроенергетичної установки на місцевості по відношенню до поверхні землі. Наведені основні елементи вітроенергетичних установок, їх призначення, кількість та необхідність для повноцінної роботи системи в цілому. Для прикладу розглянуто найбільш використовуваний Білозерський район по відношенню застосування зрошення. Здійснено аналіз змінення швидкості вітру у Білозерському районі за місяцями та роками. Визначенні найбільш продуктивні місяці року для роботи вітрової енергії для потреб зрошення. Встановлено що в Білозерському районі швидкості вітру цілком достатньо для вироблення електроенергії для використання сучасного зрошення.

Ключові слова: *будівництво електростанцій, відновлювальні джерела енергії, вітрова енергія, конструктивні особливості, вітроенергетична установка, зрошення.*

Problem statement. Humanity's interest in the use of renewable or green energy has recently become more and more noticeable. New installations are being developed that use the principles of converting natural energy into heat, electricity, etc., which do not harm the environment [1, p. 5].

Analysis of recent research and publications. One type of such devices is wind turbines (WTU), which use wind energy. Wind is a source that exists in the surrounding space regardless of human desire and activity [2, pp. 11–14].

Task statement. To reduce the negative impact of humanity on the world around us, in a small segment of industry, using the example of irrigated agriculture, it is proposed to use alternative energy sources. This will reduce the price of products, improve the environment, and become independent of electricity suppliers.

Presentation of the main material of the study. Currently, along with the increase in the population, the need to preserve natural resources, exhaustible energy sources, reduce the impact of the greenhouse effect, and all kinds of damaged environment, comes to the fore, because if we do not preserve what is left of nature, and now called the «environment» the consequences will be catastrophic, and humanity will drown in troubles and cataclysms that it itself created. Irrigated agriculture is no exception, because a large amount of energy is absolutely necessary for the operation of pumping stations and irrigation machines. Which has a major impact on the formation of prices for finished products, and makes them more inaccessible for certain segments of the population.

Today, there is a huge variety of machines, mechanisms and installations that catch the wind and convert it into useful electricity. The most common of them are wind turbines with a horizontal axis of rotation (Fig. 1).

However, these machines have one significant drawback – they think long and hard before deploying their blades into the wind, the direction of which can change every second. Depending on the direction of the wind, the area swept by the wind wheel changes, which is the basis for calculating the output power of a wind power plant:

$$P\text{веу} = 0{,}4D_2 \cdot v \cdot E \cdot \rho \cdot \eta_{мех} \cdot \eta_{ген}, \tag{1}$$

where D – is the diameter of the wind wheel; v – is the wind speed, m/s; E – is the coefficient of wind energy utilization; ρ – is the air density of 0.125 kg s^2/m^4; $\eta_{мех}$ – is the efficiency of the reducer; $\eta_{ген}$ – is the efficiency of the generator.

Typically, in the technical specifications of horizontal axis wind turbines, the area swept by the wind turbine is assumed to be equal to the area covered by the blades of the

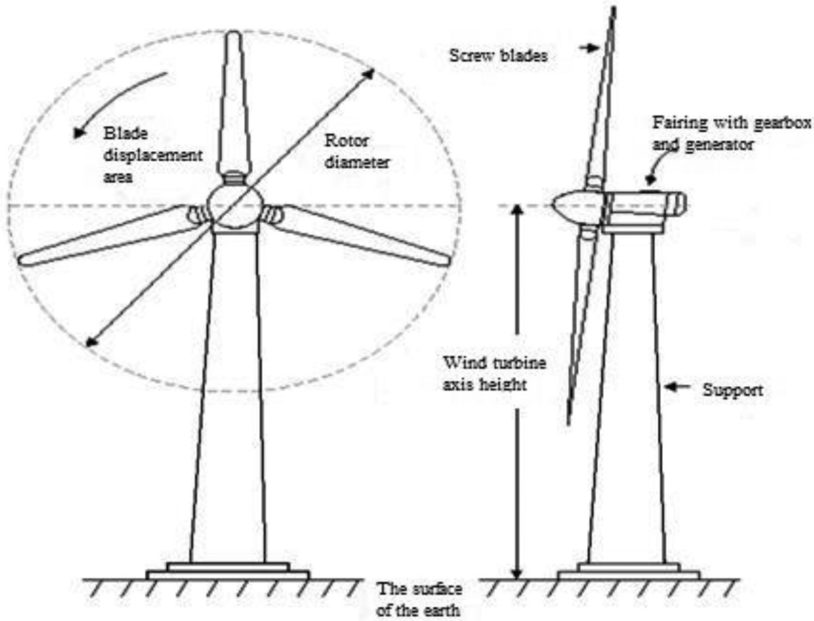

Fig. 1. Wind turbine with horizontal axis of rotation

wind turbine. However, as can be seen from Fig. 2, the swept area depends on the wind direction relative to the rotor axis and at some points may be significantly less than the area of the wind turbine. Therefore, the power produced by the wind turbine will also be variable. The swept area of the rotor at different angles of the wind direction relative to the rotor axis is omitted.

This does not apply to installations with a vertical axis of rotation, although they also have their advantages and disadvantages. Fig. 3 shows a diagram of the operation of an installation with a vertical axis of rotation. In the presence of wind, the wind rotor, consisting of blades fixed between the rings, rotates and drives a generator, which, using an electronic regulator, produces a direct electric current with a voltage of 48 V. Next, the direct current is converted into alternating current with a voltage of 220 V using an inverter and supplied directly to the consumer. The batteries are connected in parallel with the generator output cable and power the inverter in the absence of wind.

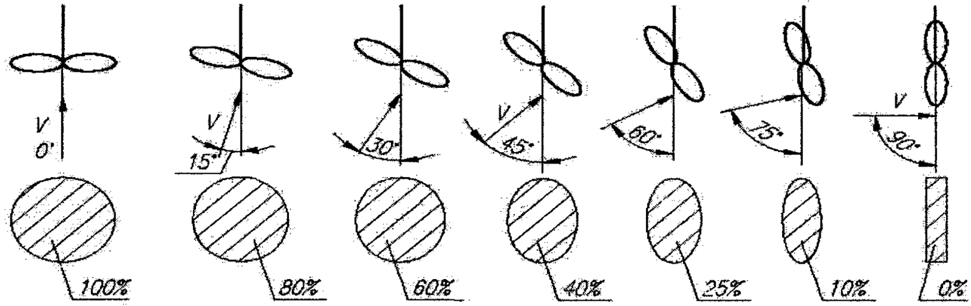

Fig. 2. Area covered by a wind wheel

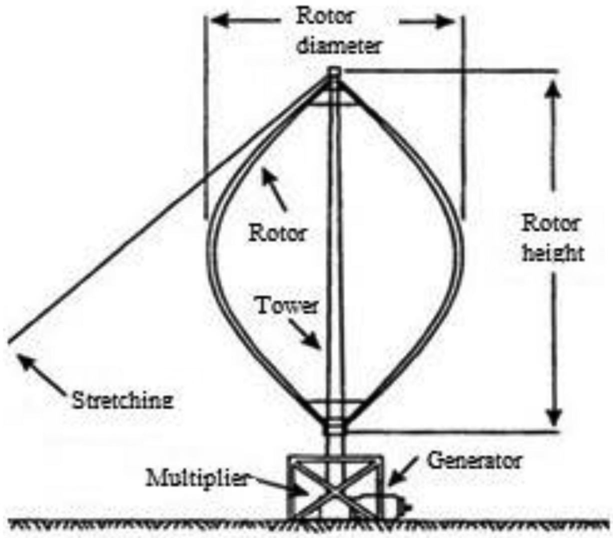

Fig. 3. Wind power plant, with a vertical axis of rotation

The inverter output is connected to the terminals from which the internal wiring to the consumer's premises should go. The wind turbine starts (self-winding) at wind gusts of 3.5 m/s (at this time the anemometer may show a lower wind speed). Energy generation begins at a wind speed of 2 m/s.

The speed of rotation of the wind turbine upon reaching 180 revolutions per second with further strengthening of the wind is stabilized due to aerodynamic brakes (Fig. 4). Thanks to this, the wind turbine does not go into a drift. For operation in conditions of low temperatures, the blades of the wind turbine are equipped with a special carbon-plastic film, which prevents icing of the surface of the blades.

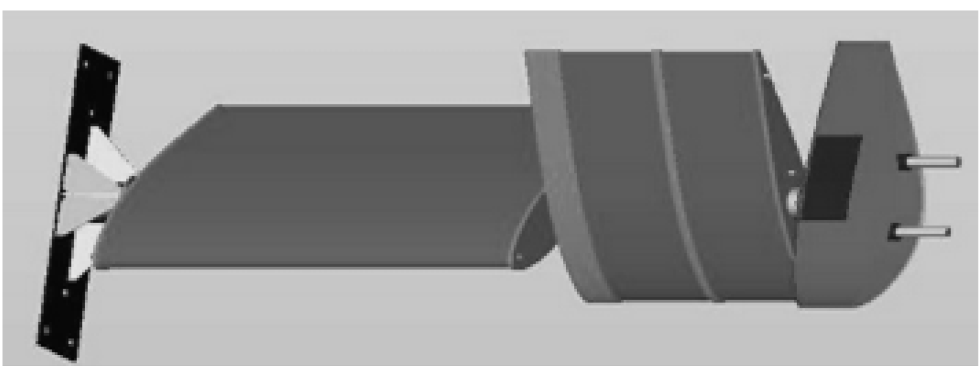

Fig. 4. Aerodynamic brakes

Wind energy is a cubic function of wind speed. This means that small changes in wind speed cause large changes in power output. Doubling the wind speed increases the power output by a factor of eight! Even a small change in one direction or another has significant consequences.

When choosing a location for a wind turbine, it is always necessary to take into account that the closer the blades are to the ground, the lower the wind speed. This is a result of the friction force in the ground and the presence of obstacles on the ground. These obstacles cause turbulence, which reduces the efficiency of any wind turbine. Therefore, the wind turbine should be placed on a site where there are as few obstacles to the wind as possible.

Wind turbines should be installed on a tower that is at least 8–10 meters above any objects within a radius of 150 m. If this is not possible, the wind turbine should be installed as high as possible. In addition, it must be taken into account that the wind turbine can produce vibrations that will be transmitted to the surface on which it is installed (Fig. 5).

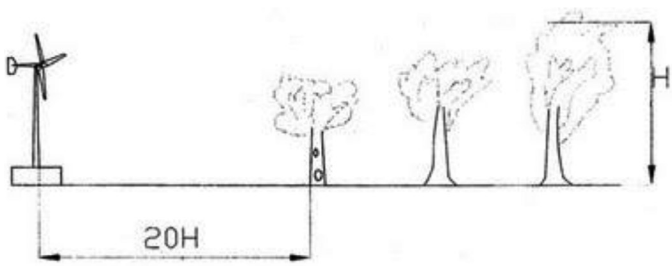

Fig. 5. Example of wind turbine placement

Although it is important to locate the wind turbine in the best wind location to achieve maximum output, the trade-off for this requirement is the cost of the mast and the complexity of the installation (Fig. 6).

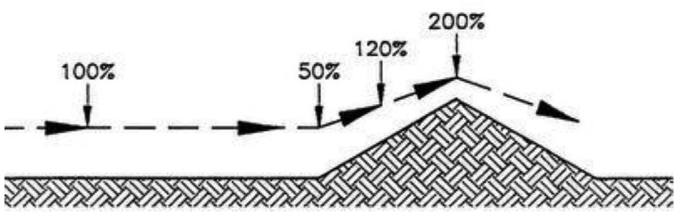

Fig. 6. Dependence of output power on terrain

As a general rule, the higher the mast is installed, the greater the power output. However, the higher the mast, the more expensive it is and the more difficult it is to install. If you can significantly increase the power by purchasing a taller mast, it may be worth the extra cost and effort.

The main elements of a wind power plant include blocks and mechanisms that ensure the normal operation of the unit and help transform wind energy into electric current. The main components include: wind generator, batteries, inverter and controller.

The purpose of a wind turbine is to convert the kinetic energy of an air flow, called wind, into electrical energy. All components, for a particular wind turbine, except for the wind speed, are constants (the density of air, of course, depends on the temperature, but its changes can be neglected as small). Therefore, we can say that the power produced by a wind turbine is proportional to the cube of the wind speed. This means that the power of a wind turbine in weak winds (even if it is rotating) is very small. But as the wind increases, there is a sharp increase in power. And since in practice the wind blows with a constant speed and direction only in a wind tunnel, it is clear that the power produced by a wind turbine is a time-varying quantity. Therefore, any energy system using a wind turbine as an energy source must have a stabilizing link.

In small autonomous systems, the role of such a link is usually played by a battery. If the power of the wind turbine is greater than the load power, the battery is charged. If the load power is greater, the battery is discharged. This leads to the following important feature of a wind generator as a power source: while most other sources are selected based on peak load power, wind generators should be selected based on the amount of electricity consumption per month or per year.

An inverter is a device, circuit, or system that creates alternating voltage when a direct voltage source is connected. There is another way to define it: inversion is the opposite function of rectification. Rectifiers convert alternating voltage to direct, and inverters, on the contrary, convert direct voltage to alternating.

A charge controller is a device that regulates the flow of charge from electricity sources to batteries. It is one of the main parts of a wind power plant. The controller's functions are designed to preserve the life of batteries and increase energy production. Currently, two types of controllers are mainly used: PWM (Pulse – width modulation) and MPPT (Maximum Power Point Tracking). A PWM controller uses conversion to reduce the battery voltage to the desired value and maintain it. This allows you to reach 100 % battery charging level. The MPPT controller constantly monitors the stage of charge of the battery (filling, saturation, equalization, support) and based on this determines what current should be supplied to the batteries (Fig. 7). The incentive for the transition to inexhaustible energy sources is the significant climate change in recent years that has occurred throughout the planet.

Tracking the trend of wind changes, in the territory of the Belozersk district we can confidently say that there is a trend towards an annual increase in wind speed, which will allow us to obtain "clean" electricity when using wind power plants. According to the data of the Kherson weather station, having compiled Table 1, we build a graph of wind speed changes over time (Fig. 8).

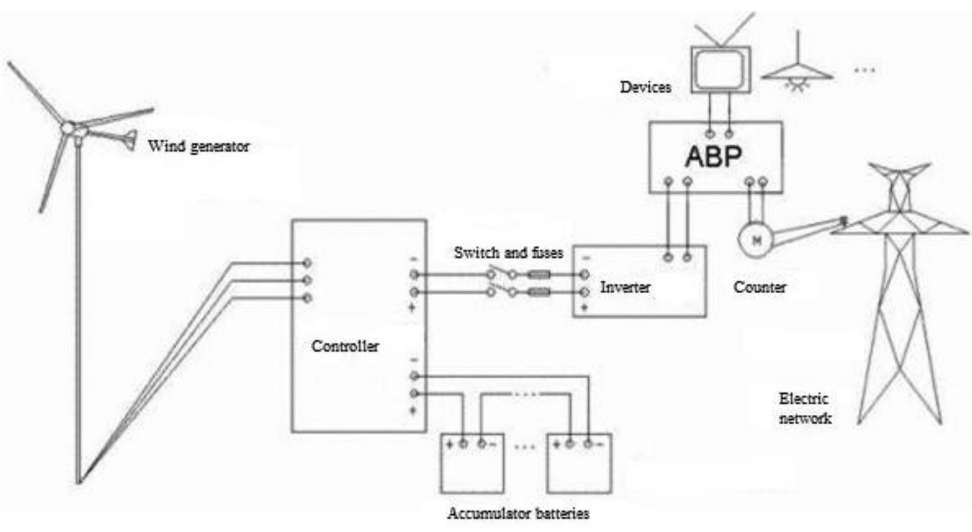

Fig. 7. Diagram of the basic layout of a wind power plant

Table 1

Wind speed change over time

Wind speed changes in the Belozersk district by months and years				
Month	**Wind speed m/s**			
Year	**2021**	**2022**	**2023**	**2024**
January	2,60	3,95	2,87	4,61
February	3,00	3,73	4,52	4,75
March	3,53	3,37	4,01	4,24
April	3,12	3,02	3,65	3,55
May	2,19	2,78	2,65	3,24
June	2,42	2,62	2,47	3,17
July	2,40	2,42	2,85	3,87
August	2,40	2,63	2,84	3,58
September	2,65	3,08	3,22	2,85
October	2,50	3,32	3,74	3,02
November	2,63	3,17	3,42	3,05
December	2,81	3,47	3,98	3,79

* months and years when wind is needed to operate wind turbines for irrigation are highlighted in color.

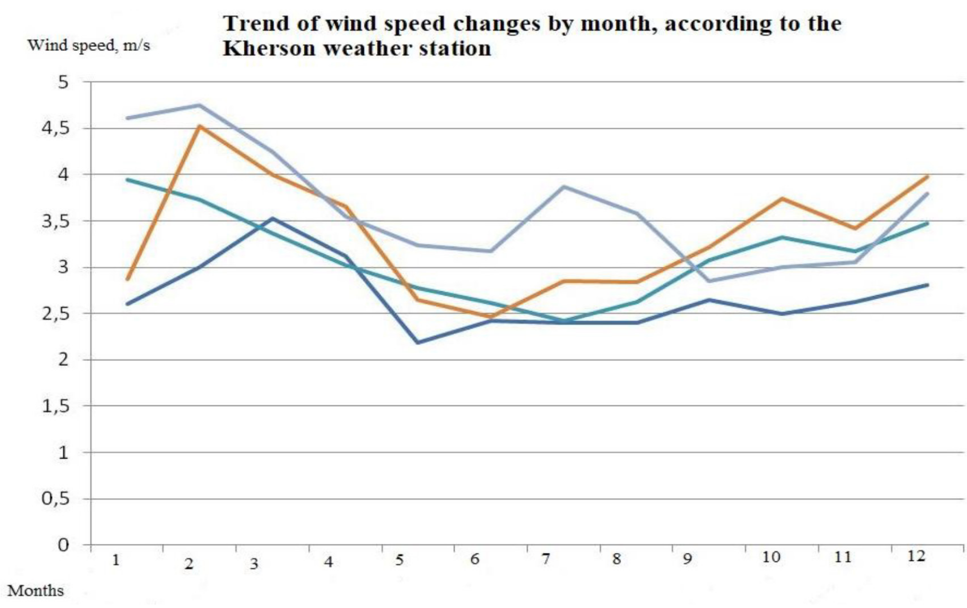

Fig. 8. Dynamics of wind speed changes at the Kherson weather station

As can be seen from Table 1 and the graph in Figure 8, according to the Kherson weather station, the wind speed is quite sufficient to generate electricity for use for irrigation needs [3, c. 257].

Conclusions and suggestions. As the analysis of literary sources shows, wind power plant devices should be used for irrigation needs. When selecting appropriate equipment to meet-electricity needs in wind power plants, the following rules should always be followed:

1. The energy source should not have the same power as the total load of all consumer devices at once.

2. The power of the energy complex is determined by its inverter – a total distributor through which energy is distributed to consumer devices.

3. The volume of the batteries determines not only the time the system can last without wind, but also the degree of uneven consumption.

4. Batteries cannot be kept under-charged. This leads to their rapid failure. The most important conclusion: a wind generator should be selected not by power, but based on the amount of energy it produces per week (month, year).

5. The wind turbine must be able to produce the amount of energy that is consumed. The power of a wind turbine is an important, but secondary characteristic. Much more important than its output is the amount of energy created over a certain period of time.

According to the Kherson weather station, the wind speed is sufficient to generate electricity for modern irrigation.

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