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# ANALYSIS OF DEVELOPING WIND POWER APPARATUS IN KAZAKHSTAN

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*The article is devoted to problems of wind energy. Data growth rate of the installed capacity of wind power plants in the world are shown. The authors analyzed the technical and economic performance of wind power systems developed by Kazakhstan scientists. The technical characteristics of Darrieus type wind turbines have been described. The advantages of the Bidarrieus wind turbine were studied.*

**Keywords:** wind power apparatus, Betz-Zhukovsky postulate, Bidarrieus wind turbine, coaxial shaft, usage coefficient of wind energy

## Introduction

Today one of the most promising directions in alternative energy is - wind energy. In recent years, wind energy has become a truly thriving industry of "pure", or as it is called "green" energy. Means of converting the kinetic energy of the wind flow into the mechanical, thermal and electrical forms of energy are taking a greater share in the global energy industry.

Based on the report of the development of the global wind energy industry for 2016 by the World Wind Energy Association (World Wind Energy Association - WWEA) [1], it is shown that the power of the global wind power industry has reached 456,486 MW in 2016 (Figure 1). 21,714 MW from total were added during the first six months of 2016. This increase was added similarly as in the first half of 2015, when 21.6 GW. All wind turbines installed worldwide by the middle of 2016 could generate about 4.7% of the world's electricity demand.

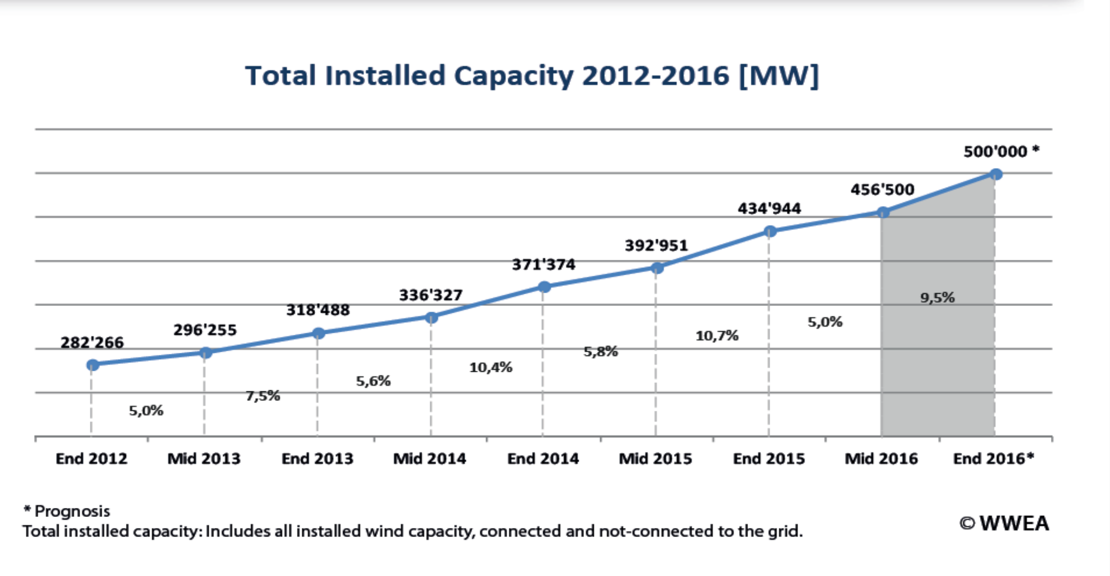



Fig.1. Worldwide power of wind energy installations 2012-2016 years

Overall, 103 countries and regions use wind energy for electricity production. Kazakhstan became the eighty-fourth country in the world using 2 MW wind energy technology in 2014[1]. According to estimates of experts [2, 3] the potential of renewable energy resources (hydro, wind and solar energy) in Kazakhstan is very significant and estimated at over $ 1 trillion kWh / year.

## 1. Overview of the wind turbine developed in Kazakhstan

Depth study of the problems of wind energy in Kazakhstan started in the last 15-20 years by works of academician of the National Academy of Sciences of Kazakhstan Sh.A. Yershin (Kazakh National University, Almaty) academician of the National Academy of Engineering A.V. Bolotov (AUPET, Almaty), prof. N.S. Buktukov (Institute of Mining, Almaty), Doctor of Technical Sciences (DofTS), H.Zh. Bayshagirov (Scientific Production Association-Wind Energy Apparatus with Diffuser(WEAD), Kokshetau), O.Bayaliev (IE “Innovative bureau of Bayaliev”), prof. A.K. Kusainov (Asiamontazhengeneering, Almaty), M.M. Maylibaev (Almaty), DofTS, prof M.B. Koshumbayev (Kazakh Research Institute of Energy of Sh.Ch. Chokina.), DofTS, prof. G.B. Nurpeisova (Kazakh Research Institute of Energy mechanisation and electrification of agriculture), Ph.D., prof. K.Kussaiynov (Institution of Applied Math, Karagandy ) et al. with the lack of financial support from government and UNDP [4 - 16].

The first development and use of wind power plants owned by professor of Almaty University of Energy and Communications A.V. Bolotov, the foundation of which was model of the device Savonius based on the principle of the sailing type wind turbines [4]. Kazakhstan has about 50 stations with wind rotor turbine. Vertical Axis Turbine rotor consists of several individual modules (Figure 2) and the power can be increased by the increasing of their number. The parameters of Bolotov Wind Rotor Turbine (BWRT): weight is 750 kg, temperature range of is (-40) - (+40) Celsius, power is 3-10 kW, nominal speed is 12.3 m / s, features are high security (no vibration open moving parts), available resources, reliability, endurance is more than 10 years, does not depend on wind direction, works in conditions of turbulence, modularity, low operating costs, a synergistic effect in combination with solar panels.

Unfortunately, this type of wind turbine has low technical and economic indicators with high costs of material and cannot compete with modern wind turbines. Wind turbine developed by M.M. Maylibaev has the same features with some changes. Such wind turbine with some changes and development relates M.M. Maylibaev (Figure 3). Apparatus of professor N.S. Buktukov (Institute of Mining MES) can work in any wind direction and speed, from 3 m/s up to 60-80 m / s, all 300-330 days in a year, and its price is only 5000$.

Fig.2. Wind rotor turbine of A.V. Bolotov

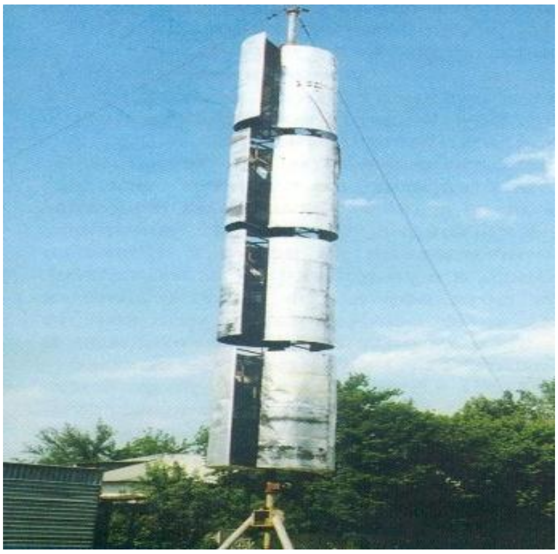


Fig.3. Wind turbine of M.M. Maylibayev

Additionally, in contrast to the expensive foreign wind plants it has a complete generator, multiplexer equipment control device, charging and battery protection device [4, 5]. There is no tower in Buktukov’s apparatus and it is easy to produce. Furthermore, the invention simultaneously can be as a beacon in the steppes of Kazakhstan, as well as in the islands. Another advantage is that with increasing of wind speed blades are compressed and acquire a tubular shape. This invention of professor N.S. Buktukov has not found sufficient development and application yet (Fig. 4).

Fig.4. N.S. Buktukov's wind turbine

Fig.5. Wind energy apparatus with diffuser (WEAD), developed by professor H.Zh. Bayshagirov

Professor H.Zh. Bayshagirov (Director of LLP Research and Production Association, WEAD) uses the original proposal to increase wind energy utilization, (Fig. 5) [4, 15]. The idea of creating a device called WEAD is in the fact that the wind turbine installed in the narrow part of the considerable dimensions of the diffuser. It is expected that improvements in energy efficiency of ratio propeller of wind turbines will be determined by the ratio of the sizes of the wide input portion of the diffuser and narrow output portion of this system by accelerating the wind flow in a diffuser.

Prototype of wind energy plant with a diffuser (WEAD) created by professor H.Zh. Bayshagirov gave positive results. WEAD made from fiberglass is environmentally friendly, easy to use and portable power source. Tests have shown that WEAD is twice more powerful than the wind turbine without the diffuser. Main theoretical idea that diffuser is effective was confirmed. Parameters of WEAD: weight is 95 kg, height of the tower is 4 m, design capacity is 1 kW, temperature ranges from -50 ° C to + 80 ° C, the duration of operation is 20 years, produces a current at a wind speed of 4-25 m/s. Installation (dismantling) can be done by the 3 employees in 2-3 hours without lifting devices. Core nodes and the diffuser were manufactured from fiberglass with the use of resource-saving technology of the processing of composite materials; through this method increases the duration of turbine's operating mode and the geography of its use. High mobility, ease of maintenance, increased serviceability, resistance to various manifestations of climate, security in the broadest range of use, quiet operation, small metal content, design appeal, the absence of interference can be highlighted as well. WEAD covers costs of building in 4-5 months when it is used in conjunction with the pump "Vodoley-3" to supply drinking water from the well (Fig. 5).

Professor M.N. Kambarov (LPP "Ecowatt") proposed new model of wind turbine called "Kazkanat" (Fig.6) [4]. Assumed parameters are the following: power is max.15 kW, nominal is 5 kW, wind speed is (3 – 40) m / s, the voltage is (380 – 200) V; the number of blades is 2, the bottom chord of the blade is 1m, the upper chord is 0.5 m, radius of the blades is 1.8 m, the number of poles is 2, height is 2.4 m, height above the shaft ground is 2.4 m. It orientates to the wind through vane blades effects and 4 flat supports (without special arrangements); the angle of attack of the blades is

8 degrees (without regulation). The effort to develop a sailing type machine specifically for the Zhungar Gates ended unsuccessfully.

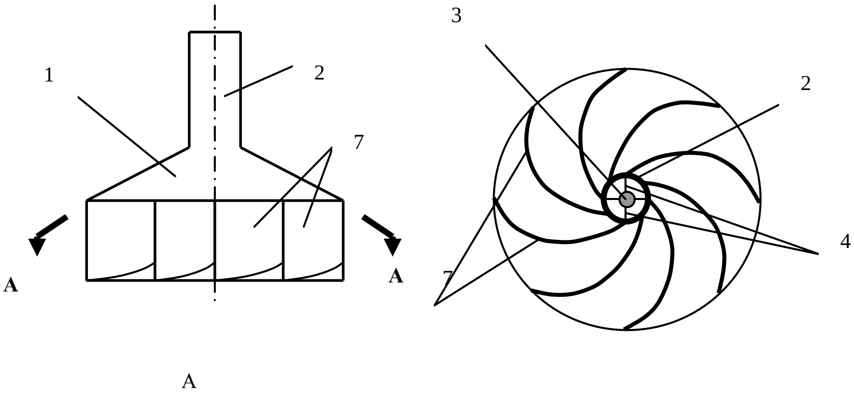
Fig.6. «Kazkanat» wind turbine, developed by professor M.N. Kambarov

Professor M.B. Koshumbaev from Kazakh Research Institute of Energy developed vortex wind power apparatus with flow concentrator [16]. Improving the efficiency and reliability of wind machine is achieved by generation of swirling motion of the air flow, which occurs due to the curved guiding walls and the tangential air supply to the exhaust pipe. The curvature of the walls and the blade are described by a logarithmic dependence. Furthermore, concentrator consists of a marquee and a cone, which is located between the curved guiding walls. The outer parts of the marquee and black exhaust pipe are heated by solar energy, which also increases the exhaust thrust.

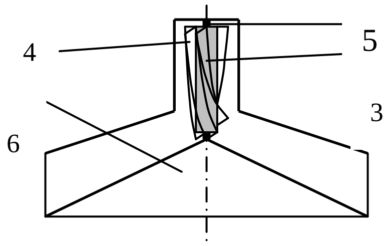
Another feature of the Wind Energy Plants (WEP) is wind wheel, designed as shell of generator which on the outer side curved blade is installed, wherein one end of the generator's shaft fixed in the center of the cone, and another end to the top of the chimney. After entering of airflow to the concentrator it is heated; due to curved guiding walls it receives a rotational movement. An increase in temperature and decrease in effective cross-section of flow also contributes to its stable accelerated rotational motion. The swirling airflow causes the rotation of the blades and generator; additionally, when the blades return, they do not experience resistance. The new WEP allows achieve the technical result that gives increased efficiency by eliminating the heating system, optimization of tangential flow entering to the pipe, assembly reliability by eliminating the effect of the flow on the return stroke of the blade, improving aerodynamic operation [16].

In Figure 7 schematics illustrate the structure of the proposed wind machine. In Fig.7a is shown a side view and a section along A-A, sectional view of an image of the propeller blades of the generator is reflected. In the center of the tent (1) the exhaust pipe (2) is installed. Inside of the tube wind wheel generator (3) is placed, on the outer side of which is rigidly fixed curved blades (4). Shaft generator (5) is fixed on the center of the cone (6) and on the top of the tube. In flow concentrator between the tent and cone curved guide walls (7) are arranged, which curvilinear tapered air passages provide a tangential inlet air flow in the chimney.

Since 90s Kazakh Research Institute of Mechanization and Electrification of Agriculture has been actively working on the development of wind power plants and water lifting machines by wind. The result of researches are standard series of apparatus such as VV-3T, VV-5T, VE-2T, VGE-2.7T, VE-5T, VGE-5T and VE-5T-2M, according to the wind characteristics in Kazakhstan they are slow multi-bladed settings (Fig. 8).




a)




b)

Fig.7. Structure of the wind machine:
a) scheme of wind turbine; b) sectional view of an image of the propeller.

In the laboratory (Institute of Applied Mathematics, Karaganda) professor K. Kussaiynov conducted a research named "Development of a wind turbine for small wind speeds based on variable cross-section of the rotating cylinder" (Fig. 9) [4]. In the wide range of the incoming flow rate (3 - 15) m/s and changes in geometrical parameters the lifting force was generated by the Magnus effect is investigated.

Fig.8. Slow multi-bladed installation of Kazakh Research Institute of Mechanization and Electrification of Agriculture

Fig. 9. Wind turbine model, developed by professor K.Kussaiynov

The dependences of the coefficients of aerodynamic lift force from the wind speed, from the speed of rotation of the cylinder with spherical ends, from the diameter of the test body were found. The range of optimum parameters, providing a stable maximum lift force coefficient, was determined. Sample model of two-bladed wind turbine with car generator as a source of 700 watts was designed and manufactured.

## 2. Wind turbines Darrieus and Bidarrieus

Last years The Kazakh National University developing promising two-rotor machines (Bidart, HBI-rotor, etc.) under the leadership of Sh.A. Yershin [6-14]. Design of Darrieus apparatus with two coaxial shafts was named Bidarrieus. To some extent, this wind turbine can be considered as unit of two Darrieus rotor deployed in $90^0$, so that swings perpendicular to each other. Carousel wind turbine can operate in normal Darrieus mode and Bidarrieus mode (Fig.10). The shafts are separated by a bearing and they can work autonomously and independently from each other. There is a special correcting device (retainer) which supports an angle $\alpha = 90^0$ between the swings of the Bidarrieus.

Fig.10. Sh.A.Yershin's wind turbine

The rotational energy is transferred to the two different current generators, in other words, each shaft runs in its own generator. Then electricity produced by them is summed. Design of semi-industrial sample of Bidarrieus allows coaxially disposed shafts to rotate in the opposite directions. In this case, a dual circuit electric generator can be used. Thus, the advantage of this design is increased obtain of wind energy by the two independent shafts with the same swept area. Therefore, efficiency value of the wind energy in high production can be increased to 0.65.

Bidarrieus Wind Turbine provides power generation at a speed of 5-15 m/s. The total height of the wind turbine is 10.6m, weight is 800 kg. The turbine mounted on a lightweight foundation and additionally secured by a rope. Size of rotors: swing of the outer rotor - 2 m, the length of blade - 4.5 m, swing of inner rotor - 1.7 m, the length of blade - 4 m. Profile of blades is NASA-0021, chord of blades is 0.3 m. Testing of Bidarrieus wind turbines showed that utilization of wind energy $\xi$ is 40% higher than the Darrieus wind turbine with the same capacity (shaded area in Fig.11). Thus, the value $\xi$ reaches the max of the value limited by Betz postulate. The invention protected by patents of the Republic of Kazakhstan.

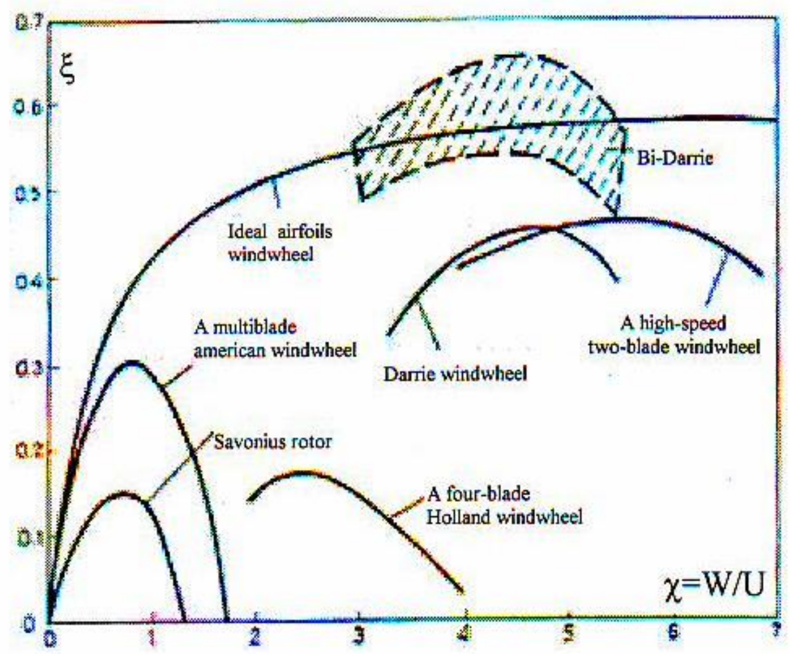



Fig.11. Dependencies of wind energy utilization factor ξ for different types and constructions of wind turbine on their degree of their specific speed χ [7].

## Conclusion

In recent years, wind energy has become a truly thriving industry of "pure", or as it is called "green" energy. Based on the report of the development of the global wind energy industry for 2016 by the World Wind Energy Association, it is shown that the power of the global wind power industry has reached 456.486 MW in 2016.

Due to lack of wind machine industry and import substitution, all devices that created by scientists from Kazakhstan have not found its application yet. It seems that the most promising invention from Kazakhstan's scientists is twin-rotor machines carousel developed in the Kazakh National University under the leadership of Sh.A.Yershina. Twin-rotor wind turbine with high technical and economic indicators Bidarrieus does not have analogue.

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