SHAMOL ENERGETIKASI//ВЕТРОВАЯ ЭНЕРГЕТИКА//WIND ENERGY

ASSESSMENT OF THE OPPORTUNITIES FOR THE USE OF WIND ENERGY IN THE SOUTHERN TERRITORY OF UZBEKISTAN

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***Abstract**: The article presents the results of a study on assessing the potential of wind energy resources in the Kashkadarya region and identifying areas with high wind energy potential. It presents an analysis of scientific studies carried out around the world to assess the potential of wind energy resources and the efficient use of wind energy. Wind speeds at various points in the region were obtained from the Nasa Power Data Access Viewer (GIS). For a reliable assessment of the potential of wind energy resources at different heights, a two-parameter Weibull probability distribution function was used. The shape parameters k and the scale c of the Weibull distribution function are determined using an empirical method. Processing of the obtained data and mathematical modeling was done in the Matlab system. It was determined that the average wind speed in this region at a height of 10 m is (2.3-3.9) m/s, the average specific power is (20-40) W/m^2, the average specific energy is (200-500) kWh/m^2, and at a height of 100 m the average speed wind was (4-5.8) m/s, the average specific power was (113 – 253) W/m^2, the average specific energy was (998.36-2208.03) kWh/m^2. It was found that Mubarek and Mirishkor districts have a high potential for using wind energy. According to the results of the study, the annual gross (theoretical) wind energy potential of the region at a height of 100 m is 2296.15 billion kWh, the technical potential is 45.92 billion kWh. When providing consumers located far from the centralized power supply with uninterrupted and reliable electricity, wind energy can be used.*

***Keywords:** wind speed, geographic information system (GIS), Weibull probability distribution function, shape and scale parameters, specific power, specific energy, gross (theoretical) and technical potential.*

O‘ZBEKISTONNING JANUBIY HUDUDLARIDA SHAMOL ENERGIYASIDAN FOYDALANISHNING IMKONIYATLARINI BAHOLASH

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***Annotatsiya:** Maqolada Qashqadaryo viloyatida shamol energetikasi resurslarining potentsialini baholash va shamol energetikasi potentsiali yuqori bo‘lgan hududlarni aniqlash bo‘yicha o‘tkazilgan tadqiqot natijalari keltirilgan. Unda shamol energiyasi manbalarining potentsialini va shamol energiyasidan samarali foydalanishni baholash bo‘yicha butun dunyo bo‘ylab olib borilgan ilmiy tadqiqotlar tahlili keltirilgan. Mintaqaning turli nuqtalarida shamol tezligi NASA ma’lumotlari asosida (GIS) olingan. Turli balandliklarda shamol energiyasi manbalarining potentsialini ishonchli baholash uchun ikki parametrli Veybull ehtimolligini taqsimlash funktsiyasi ishlatilgan. Veybull tarqatish funktsiyasining k shakli parametrlari va s shkalasi empirik usul yordamida aniqlangan. Olingan ma’lumotlarni qayta ishlash va matematik modellashtirish Matlab tizimida amalga oshirildi. Bu mintaqada 10 m balandlikda shamolning o‘rtacha tezligi (2,3-3,9) m/s, o‘rtacha solishtirma quvvat (20-40) Vt/m^2, o‘rtacha solishtirma energiya (200-500) kVt/m^2 va 100 m balandlikda o‘rtacha quvvat (200 m). tezlik shamol (4-5, 8)* *m/s, o‘rtacha solishtirma quvvat (113 – 253) Vt/m^2, o‘rtacha solishtirma energiya (998,36-2208,03) kVt/m^2 ga teng ekanligi aniqlangan. Muborak va Mirishkor tumanlarida shamol energiyasidan foydalanish potensiali yuqori ekanligi aniqlandi. Tadqiqot natijalariga ko‘ra, 100 m balandlikdagi mintaqaning yillik yalpi (nazariy) shamol energiyasi potensiali 2296,15 milliard kVt/soat, texnik potensiali 45,92 milliard kVt/soatni tashkil qiladi. Markazlashtirilgan elektr ta’minotidan uzoqda joylashgan iste’molchilarni uzluksiz va ishonchli elektr energiyasi bilan ta’minlashda shamol energiyasidan foydalanish mumkin.*

Kalit so‘zlar: *shamol tezligi, geografik axborot tizimi (GIS), Veybull ehtimolini taqsimlash funktsiyasi, shakli va o‘lchov parametrlari, o‘ziga xos quvvat, o‘ziga xos energiya, yalpi (nazariy) va texnik potensial.*

ОЦЕНКА ВОЗМОЖНОСТЕЙ ИСПОЛЬЗОВАНИЯ ЭНЕРГИИ ВЕТРА НА ЮЖНОЙ ТЕРРИТОРИИ УЗБЕКИСТАНА

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Аннотация: *В статье представлены результаты исследования по оценке потенциала ветроэнергетических ресурсов Кашкадарьинской области и выявлению районов с высоким потенциалом ветроэнергетики. В нем представлен анализ научных исследований, проведенных по всему миру с целью оценки потенциала ветроэнергетических ресурсов и эффективного использования энергии ветра. Скорости ветра в различных точках региона были получены с помощью программы Nasa Power Data Access Viewer (GIS). Для надежной оценки потенциала ветроэнергетических ресурсов на разных высотах была использована двухпараметрическая функция распределения вероятностей Вейбулла. Параметры формы k и масштаб c функции распределения Вейбулла определяются эмпирическим методом. Обработка полученных данных и математическое моделирование производились в системе Matlab. Было определено, что средняя скорость ветра в этом регионе на высоте 10 м составляет (2,3-3,9) м/с, средняя удельная мощность составляет (20-40) Вт/м^2, средняя удельная энергия составляет (200-500) кВтч/м^2, а на высоте 100 м средняя удельная мощность скорость ветра составляла (4-5,8) м/с, средняя удельная мощность составляла (113 – 253) Вт/м^2, средняя удельная энергия составляла (998,36-2208,03) кВтч/м^2. Было установлено, что районы Мубарек и Миришкор обладают высоким потенциалом для использования энергии ветра. Согласно результатам исследования, годовой валовой (теоретический) потенциал ветроэнергетики региона на высоте 100 м составляет 2296,15 млрд кВт*ч, технический потенциал - 45,92 млрд кВт*ч. При обеспечении потребителей, расположенных вдали от централизованного электроснабжения, бесперебойной и надежной электроэнергией может использоваться энергия ветра.*

Ключевые слова: *скорость ветра, геоинформационная система (ГИС), функция распределения вероятностей Вейбулла, параметры формы и масштаба, удельная мощность, удельная энергия, общий (теоретический) и технический потенциал.*

1. Introduction.

Increasing the use of renewable energy sources in the global energy system plays an important role in stabilizing issues related to energy security, ecology and environmental protection, saving fuel and energy resources. The use of renewable energy sources such as solar, wind, biomass, geothermal and hydropower is rapidly developing. Due to the low cost of electricity generated from renewable energy sources and the fact that it is practically harmless to the environment, such projects are being implemented more and more often, with large investments in them, promising developments and research.

To date, the use of wind energy is one of the most promising projects among renewable energy sources. The circulation of air masses around the Earth's atmosphere is estimated by experts in different ways. The annual theoretical supply of wind energy is 100 times greater than all energy reserves on Earth and is $330 \cdot 10^{12}$ kWh. However, only (10-12)% of this energy can be used [1].

Today, more than 100 countries around the world use wind energy to provide the population and industrial enterprises with a reliable and environmentally friendly source of energy. On fig. 1 shows the indicators of the installed capacity of wind power plants in the world by years [2]. China is the world leader in wind energy. In 2021, China accounted for 50.9% of the electricity generated from wind farms worldwide.

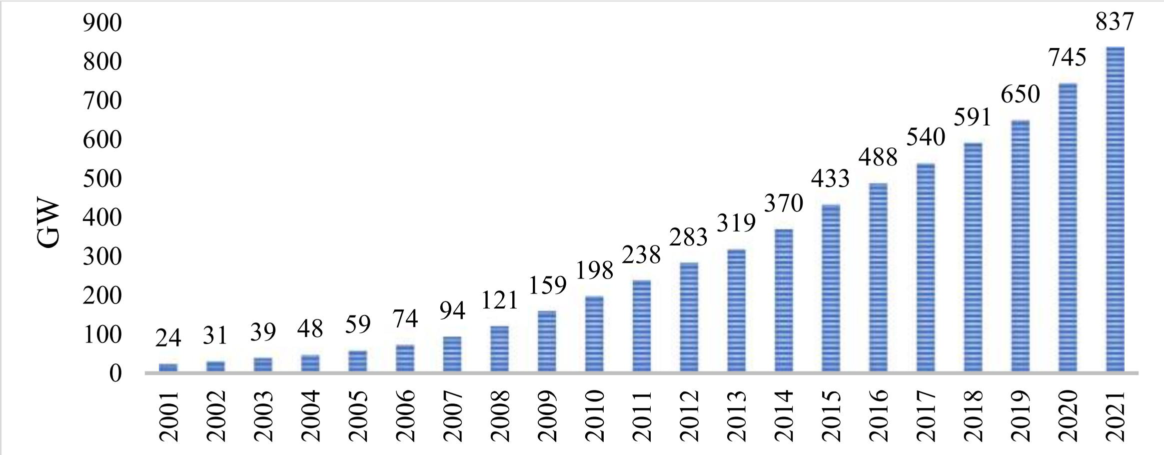


Figure 1. Installed capacity of wind power plants in the world by years.

2.Review of the literature.

On June 13, 2018, NASA's new Prediction Of Worldwide Energy Resources data web portal was launched with great potential to facilitate access to solar isolation parameters and meteorological data around the world. The new POWER Data Portal allows you to access, download and use data in many formats. Daily wind speed data is obtained from the MERRA-2 satellite and analyzes are performed at 1/2° latitude and 1/2° longitude at 2, 10 and 50 m above the local surface. The NASA database contains a wide variety of meteorological data for any point on Earth.

The Global Wind Atlas is a web-based application that helps policy makers and investors identify high wind areas and perform initial calculations to generate wind power from virtually anywhere in the world. The program provides free access to data on the specific power and energy of the wind, the frequency of wind speed (wind rose) and wind speed by modeling the properties of wind energy at different heights. Developed by the Technical University of Denmark in collaboration with the World Bank and funded by the Energy Sector Management Assistance Program (ESMAP) [5].

Let's analyze the studies conducted to assess the potential of wind energy resources: Ch.N. Aung Tan in his Ph.D. thesis used modern technologies of geographic information systems to assess the resource potential of renewable energy sources (solar, wind and hydropower) in the Myanmar region. The study assessed the potential for efficient use of renewable energy sources for agricultural energy consumers in the Mayanma region [6]. A.B. Rykhlov used geographic information systems technologies and statistical analysis methods to assess the potential of wind energy resources at different heights in the southeastern regions of Russia. In this study, a new method for climate assessment of wind speed characteristics at different heights was developed, which provided an accurate assessment of the wind energy potential and an analysis of the possibilities of using wind energy sources [7]. A study by D. Mentis Group analyzed the potential use of wind energy to prevent the current electricity shortage on the African continent. The study assesses the gross (theoretical) and technical potential of wind energy in continental Africa based on modern technologies. The NASA database (POWER) and statistical analysis of wind speed data were used to map the location of modern wind turbines in the regions of the African continent, to study the annual electricity generated by wind turbines [8]. B. Kilich study used data on average wind speeds between 2009 and 2016 from four meteorological stations in the region to analyze the wind energy potential of the Turkish province of Burdur. Data from weather stations in the province of Burdur were studied using the methodology of an artificial neural network (ANN) and estimated wind speed forecasts by the end of 2030 [9]. The study by A. Allowy used various distribution methods to estimate the potential of wind energy resources in the cities of Al-Hoceima, Tetouan, Assila, Essuira, El Aaiun and Dakhla, located in six coastal regions of the Kingdom of Morocco. The analysis showed that the use of the two-parameter Weibull distribution function in assessing the potential of wind energy resources is more accurate than other types of distribution functions [10]. S.A. A study led by Ahmed performed a statistical analysis of the specific density of wind energy in the Panjwen region (Pakistan) between January 2001 and December 2003 based on average monthly wind speeds. Annual, monthly maximum, average, minimum wind speeds and specific wind energy densities of the region were calculated using the distribution functions of Weibull and Rayleigh [11]. In a study led by K. Ozai, the wind energy potential of the Alkati region in Izmir was estimated using a two-parameter Weibul distribution function. In the static analysis of the wind energy potential, data obtained from meteorological stations located in the Alkati region at three different heights of 30, 50 and 70 m were statically analyzed with an interval of 10 minutes over five and a half years. As a result of the study, the distribution of wind speed, frequency of wind direction (average wind speed), average wind speed, shape and scale parameters (k, c) were calculated using the Weibull parameters for the region [12].

Based on the analysis of scientific studies, the statistical analysis of the wind energy resource potential of a given region or area using a two-parameter Weibull probability distribution function is based on the fact that it is more reliable than other types of distribution functions. The purpose of the study: To assess the potential of wind energy at different heights of the Kashkadarya region using a two-parameters Weibull probability distribution function.

3. Materials and methods.

When assessing the wind speed characteristics, the Weibull distribution density is used (f(v) = dF(v)/dv is the differential distribution function equal to the probability density, i.e., the ratio of the probability of finding the velocity in the interval between v and v + dv to the width and) distribution integral functions must be defined (F(v) is the cumulative distribution function equal to the probability that the wind speed is greater than v). These mathematical expressions are defined as follows [13,14]:

$$f(\bar{v}) = \frac{k}{c} \cdot \left(\frac{\bar{v}}{c}\right)^{k-1} \cdot e^{-\left(\frac{\bar{v}}{c}\right)^k} \qquad 0 \le \bar{v} \le \infty \qquad (1)$$

$$F(\bar{v}) = \int_0^\infty f(\bar{v}) d\bar{v} = 1 - e^{-\left(\frac{\bar{v}}{c}\right)^k} \qquad 1 \le k \le 1 \qquad (2)$$

Where: k - is the shape parameter (depending on the location of the region); c - is a parameter that determines the scale of the distribution of the function (a parameter that depends on the average wind speed, m/s).

To analyze wind speed data, we need to define parameters such as the shape and scale parameter of the Weibull probability distribution. The shape and scale parameters are determined by the following expressions [15]:

$$k = \left(\frac{\sigma}{\bar{v}}\right)^{-1,08} \qquad (3)$$

$$c = \frac{\bar{v}}{\Gamma\left(1+\frac{1}{k}\right)} \qquad (4)$$

Where: σ - is the standard deviation (standard deviation, m/s), Γ - is the gamma function (selected from the table).

The standard deviation is used to characterize the scatter of the observed values of a sample around its mean. The expression for the standard deviation is given by the following relation [16]:

$$\sigma = \sqrt{\frac{(v_1-\bar{v})^2+(v_2-\bar{v})^2+\cdots+(v_i-\bar{v})^2}{N-1}} = \sqrt{\frac{1}{N-1}\cdot\sum_{i=1}^{N}(v_i-\bar{v})^2} \quad (5)$$

According to the parameters determined from the Weibull probability distribution function, we can determine the specific values of power and energy obtained from the wind flow of a given region. These parameters are determined by the following mathematical expressions [17,18]:

$$P_W = \frac{1}{2}\rho c^3\Gamma(1+\frac{3}{k}) \quad (6)$$

$$E_W = \frac{1}{2}\rho c^3\Gamma(1+\frac{3}{k})\cdot T \quad (7)$$

Where: P_W - is the specific power determined by the Weibull probability distribution function, W/m^2; E_W - specific energy determined from the Weibull probability distribution function, kWh/m^2; T - duration of time, hours; ρ - is the air flow density (at a height of 10 m, the air flow density is 1.25 kg/m^3).

The change in the air flow density along the height is determined by the following simplified expression [19]:

$$\rho_H = \rho - (1{,}194\cdot 10^{-4}\cdot H) \quad (8)$$

Where: ρ - air flow density under normal conditions, kg/m^3; H - is the height at which the wind speed is measured, m.

The wind speed values depend on the height, and as the height increases, the wind speed increases proportionally. The following formula expresses the dependence of wind speed on height [20]:

$$V_2 = V_1\cdot\left(\frac{H_2}{H_1}\right)^{\alpha} \quad (9)$$

Where: V_2 - wind speed measured at a certain height, m/s; V_1 - wind speed measured at the initial height, m/s; H_1 - initial height, m; H_2 - selected height, m; ∝ - wind shear exponent.

The wind shear exponent is determined by the following formula [21]:

$$\propto = [0{,}096\log_{10}(Z_0) + 0{,}016\,(\log_{10}(Z_0))^2 + 0{,}24] \quad (10)$$

Where: Z_0 - is the length of the surface roughness on different ground surfaces. In pasture and steppe areas, this parameter is Z_0 = 0,03 m [22].

At a certain height, the values of the shape and scale parameters also change. These parameters are determined by the following expressions [23]:

$$k_{H2} = \frac{k_{H1}}{1-0{,}0881\ln\frac{H_2}{H_1})} \quad (11)$$

$$c_{H2} = c_{H1}(\frac{H_2}{H_1})^n \quad (12)$$

$$n = [0{,}37 - 0{,}0881\ln(c_{H1})] \quad (13)$$

Where: k_{H1} - is the shape parameter determined at a height of 10 m; c_{H1} - scale parameter determined at a height of 10 m, (m/s); H_1 - initial height (10 m); H_2 - selected height, m; n - is a coefficient that determines the scale parameter at the selected height.

The specific values of the power and energy of the wind flow at different heights are determined by the values of the shape and scale parameters specified in the Weibull probability distribution functions. These dependences are expressed in the following expressions [24]:

$$P_{W.H2} = \frac{1}{2}\rho_{H2}c_{H2}^3\Gamma\left(1+\frac{3}{k_{H2}}\right) \quad (14)$$

$$E_{W.H2} = \frac{1}{2}\rho_{H2} c_{H2}^3 \Gamma\left(1 + \frac{3}{k_{H2}}\right) \cdot T \quad (15)$$

Where: $P_{W.H2}$ - is the specific power determined by the Weibull probability distribution function at the selected height, W/m^2; $P_{W.H2}$ – is the specific energy determined by the Weibull probability distribution function at the selected height, kWh/m^2; ρ_{H2} - air flow density at the selected height, kg/m^3.

When assessing the gross (theoretical) potential of the region, we use the following formula [25]:

$$E_G = E_{W.H2} \cdot \frac{S}{20} = \frac{1}{40} \cdot \rho T S \sum_{i=1}^{n} V_i^3 t_i \quad (16)$$

Where: $E_{W.H2}$ - specific wind energy (Weibull distribution), kWh/m^2; T - is the operating time of the selected turbine per year, hours; S - is the area of the terrain, km^2; V_i - average annual wind speed, m/s; t_i - the probability of finding the speed at a certain interval, hour.

Let us define the assessment of the technical potential of wind energy resources by the following expression:

$$E_T = \frac{N \cdot T \cdot k \cdot S}{100 \cdot D^2} \quad (17)$$

Where: N - is the rated power of the wind turbine, kW; k - is the utilization factor of the installed capacity of wind turbines [-]; D - is the diameter of the wind turbine, m.

By accurately assessing the potential of wind energy resources, it is possible to determine which types of wind turbines have the greatest potential for use in a given region.

4. Results and discussion. Table 1 provides information on the geographical location and area of the districts located in the Kashkadarya region.

Table 1

№	Districts of Kashkadarya region	Area Surface	Latitude	Longitude
1.	Chirakchi district	2800 km^2	39°1′59″N	66°34′36″E
2.	Dehkanabad district	4000 km^2	38°20′23.3″N	66°33′44.3″E
3.	Guzar district	2620 km^2	38°35′0″N	66°5′0″E
4.	Kasbi district	650 km^2	38°57′33″N	65°25′41″E
5.	Kitab district	1750 km^2	39°7′12.0″N	66°52′58.8″E
6.	Kasan district	1880 km^2	39°2′13″N	65°34′23″E
7.	Mirishkor district	3100 km^2	38°54′7″N	65°0′3″E
8.	Mubarek district	3070 km^2	39°15′30″N	65°11′27″E
9.	Nishan district	2100 km^2	38°33′27″N	65°34′15″E
10.	Kamashi district	2660 km^2	38°47′35″N	66°28′29″E
11.	Karshi district	900 km^2	38°51′55″N	65°42′48″E
12.	Shahrisabz district	1700 km^2	39°3′0″N	66°50′0″E
13.	Yakkabag district	1300 km^2	38°48′0″N	66°52′0″E

On fig. 2 shows the average annual wind speed at a height of 10 m in the districts of the Kashkadarya region. This information is taken from the Nasa Power Data Access Viewer (GIS). It has been established that the average wind speed at different points of the region and at a height of 10 m is in the range of (2.9-3.9) m/s. The average wind speed was 3.73 m/s in Kasbi, Kitab, Kasan, 3.98 m/s in Mirishkar and 3.99 m/s in Mubarek.

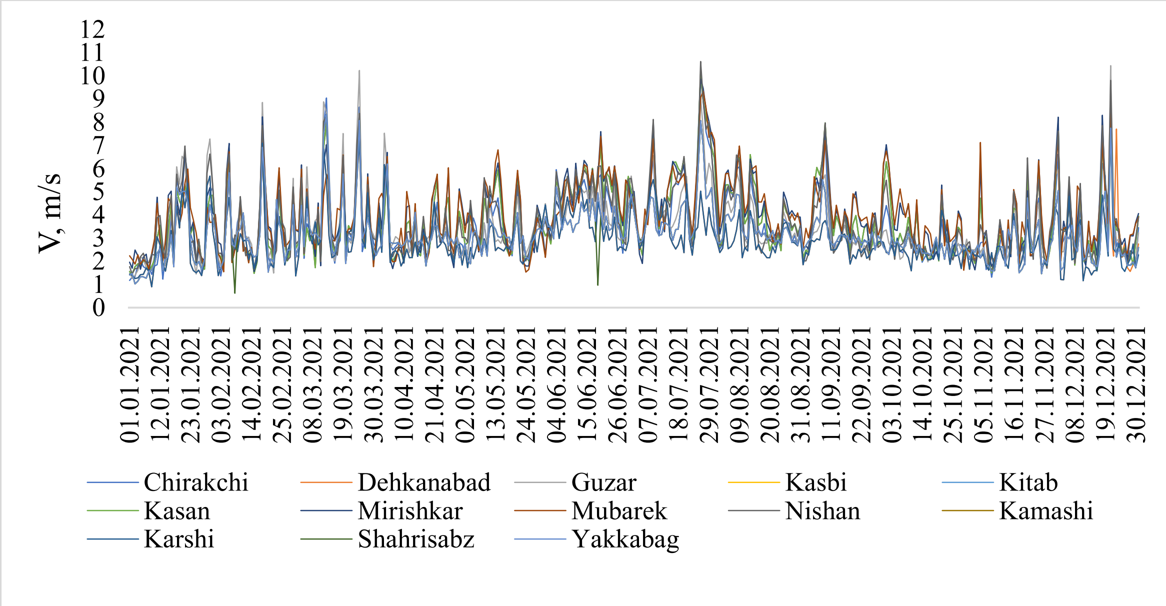


Figure 2. Data on the average wind speed at a height of 10 m in the Kashkadarya region

Table 2 presents the results of statistical processing of data on the average annual wind speed at a height of 10 m for the districts of the Kashkadarya region. The Weibull probability distribution function was used for statistical data processing. In this case, using the following expressions, one can determine the standard deviation (5), two parameters of the Weibull distribution of shape (3) and scale (4), specific power (6), specific energy (7). It was found that with an average wind speed of around 3.5 m/s, the specific power and annual specific energy were 39.68 W/m^2 and 4531.49 kWh/m^2, respectively.

Table 2

Districts	Average wind speed	Standard deviation	Weibull distribution parameters			
			k, (-)	c, (m/s)	Power density (W/m^2)	Specific energy (kW·h/m^2)
Chirakchi	3,465	1,22	3,49	3,85	40,13	352,63
Dehkanabad	2,902	0,92	4,06	3,2	21,37	187,56
Guzar	3,460	1,22	3,70	3,83	39,88	350,61
Kasbi	3,725	1,34	3,18	4,15	49,29	433,13
Kitab	3,725	1,34	3,18	4,15	49,29	433,13
Kasan	3,725	1,34	3,18	4,15	49,29	433,13
Mirishkor	3,988	1,41	3,24	4,44	58,39	512,90
Mubarek	3,991	1,33	3,45	4,43	56,33	494,74
Nishan	3,718	1,38	3,15	4,14	49,86	438,53
Kamashi	3,143	0,92	4,78	3,45	26,84	235,82
Karshi	2,889	0,91	4,06	3,18	21,26	186,56
Shahrisabz	3,126	0,94	4,59	3,44	26,72	234,39
Yakkabag	3,143	0,94	4,61	3,45	27,19	238,36
Averages	**3,523**	**1,17**	**3,74**	**3,84**	**39,68**	**∑ 4531,49**

On fig. 3 shows the average wind speeds for the regions at different heights. Expressions (9) and (10) were used to calculate the values. According to the study, the increase in wind speed depends on the increase in altitude and the geographical location of the region. It was found that at a height of 10 m, the wind speed was 3.99 m/s, and at a height of 100 m at a height of 10 m, the wind speed was 5.5 m/s. This in turn leads to an increase in wind speed by (40-50)%.

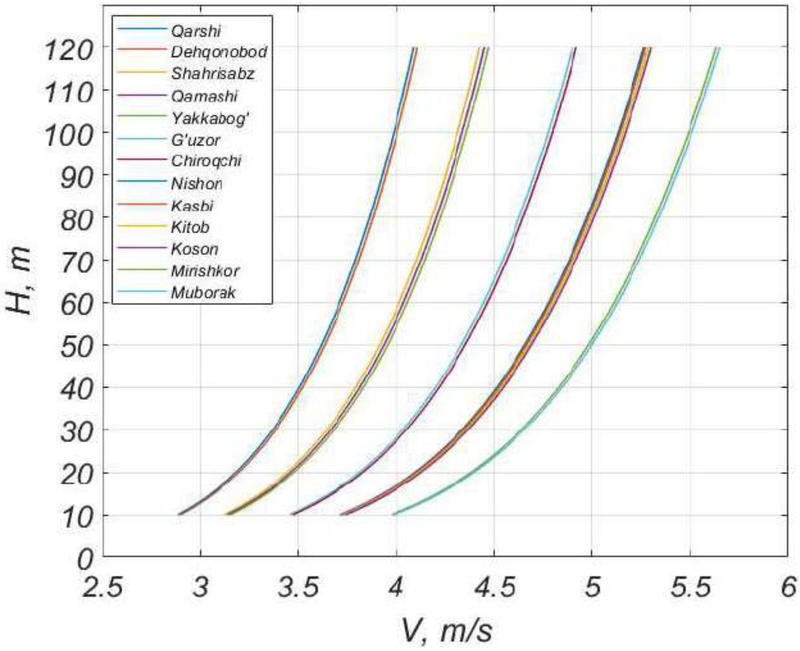
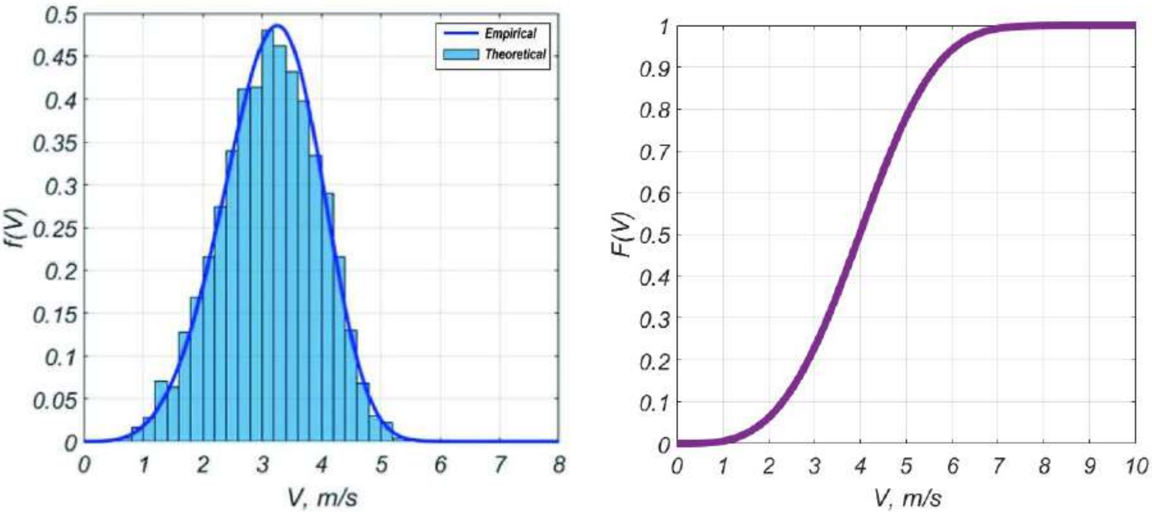


Figure 3. Average wind speed at different heights of the Kashkadarya region

On fig. Figure 4 shows the density (differential) and integral Weibull distribution functions obtained in assessing the characteristics of the wind flow in the Mirishkar region, an area with a high degree of wind energy use. In statistical processing of these results, mathematical expressions (1) and (2) were used.



a) b)

Figure 4. Density (differential) (a) and integral Weibull distribution functions (b)

Table 3 shows the theoretical values of the specific power and energy of the wind flow at various heights of the Kashkadarya region. To determine these indicators, mathematical expressions (14) and (15) were used. During the study, it was found that Mirishkor and Mubarek districts have the highest rates of specific power and energy of the wind flow.

Table 3

Districts	Specific power	Specific energy

	P, W/m^2			E, W·h/m^2		
	50 m	**100 m**	**120 m**	**50 m**	**100 m**	**120 m**
Chirakchi	108,94	178,90	204,86	954,33	1567,14	1794,57
Dehkanabad	67,04	115,11	132,99	587,28	1038,80	1165,01
Guzar	106,53	176,98	202,71	933,20	1550,38	1775,75
Kasbi	132,43	214,47	244,70	1160,09	1818,75	2143,54
Kitab	132,43	214,47	244,70	1160,09	1818,75	2143,54
Kasan	132,43	214,47	244,70	1160,09	1818,75	2143,54
Mirishkar	157,58	252,06	286,65	1380,39	2208,03	2511,05
Mubarek	156,73	250,80	285,25	1372,99	2197,05	2498,81
Nishan	131,98	213,80	243,94	1156,17	1872,85	2136,95
Kamashi	82,27	137,82	158,65	720,65	1207,30	1389,79
Karshi	67,05	113,97	131,70	587,32	998,36	1153,68
Shahrisabz	81,51	136,65	157,33	714,07	1197,05	1378,23
Yakkabag	82,61	138,36	159,26	723,68	1212,01	1395,10
Averages	**110,73**	**181,37**	**207,49**	**∑ 12610,35**	**∑ 20505,22**	**∑ 23629,56**

Figure 5 presents the results of the gross and technical potential of the wind energy resources of the Kashkadarya region. Mathematical expressions (16) and (17) were used in the theoretical calculation of these results. It was found that the gross (theoretical) potential of the Mirishkar and Mubarek regions, which have the highest potential in the region, at a height of 100 meters is 342 and 337 billion kWh, respectively, and the technical potential is 6.84 and 6.74 billion kWh.

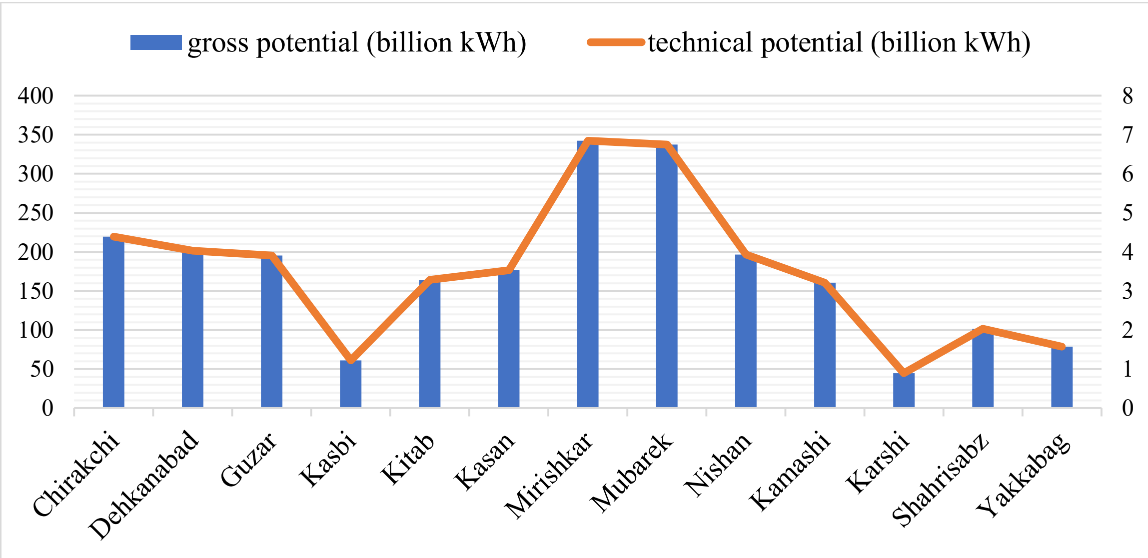


Figure 5. The results of the gross and technical potential of wind energy resources of the Kashkadarya region

On fig. Figure 6 shows a wind map that assesses the potential of wind energy resources in the Kashkadarya region. These data were obtained from the Global Information System "Global Wind Atlas". According to the results of the study and the map of the wind energy resources of the region, the Mirishkar and Mubarek regions, bordering the Bukhara region, have a high wind energy potential. The total gross (theoretical) potential of the region at a height of 100 m is 2296.145 billion kWh, and its technical potential is 45.92 billion kWh.

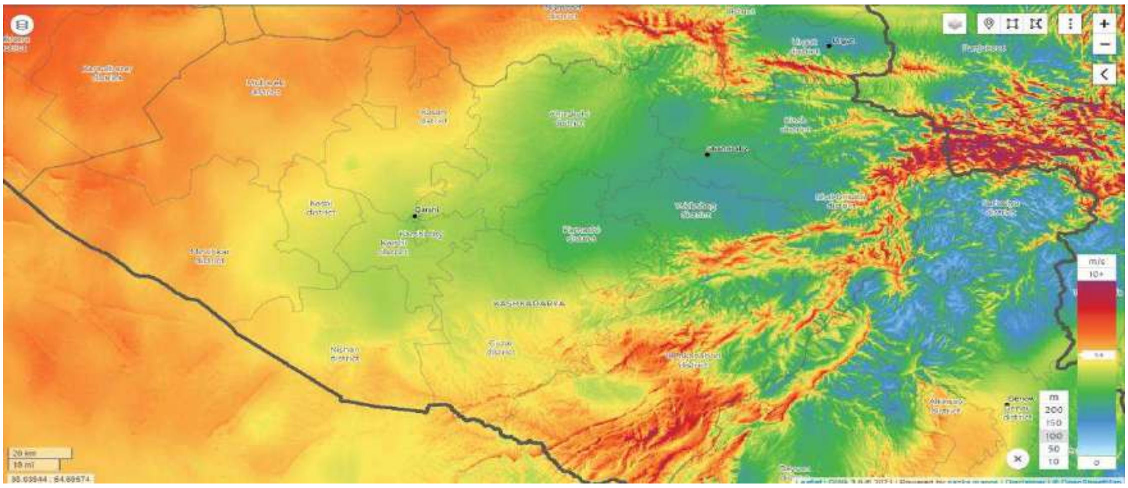


Figure 6. Map for assessing the potential of wind energy resources in Kashkadarya region

5. Conclusions.

1. When assessing the wind energy potential of the Kashkadarya region, data from the "Nasa Power Data Access Viewer" geographic information system (GIS) on wind speed at a height of 10 m in 2021 were used. According to estimates, the average wind speed at a height of 10 m was (2.9-3.9) m/s.

2. In statistical processing of wind speed data obtained at a height of 10 m, a two-parameter Weibull probability distribution function was used. When determining the two shape parameters k and the scale c of the Weibull distribution function, an empirical method with high reliability was used.

3. It has been established that at a height of 10 meters, the average specific wind power is (20-40) W/m^2, the average specific energy is (200-500) kWh, and at a height of 100 meters with an average wind speed of (4-5.8) m/s, the average specific power of the wind flow was (113 – 253) W/m^2, and the average specific energy (998.36-2208.03) kWh.

4. Statistical analysis of wind speed data for 2021 made it possible to estimate the annual gross technical potential of the region. The gross wind energy potential at a height of 100 m was 2296.15 billion kWh/m^2, and the technical potential was 45.92 billion kWh/m^2.

5. According to the results of the study, Mirishkar and Mubarek regions have a high potential for using wind energy. When providing autonomous consumers located far from the centralized power supply with uninterrupted and reliable electricity, wind energy can be used.

References

1. Yunusov TY. (2012) Present and future of energy production. Tashkent. "Science and technology". Monograph. 140 p.
2. https://www.statista.com/statistics/268363/installed-wind-power-capacity-worldwide/#:~:text=Installed%20wind%20power%20capacity%20worldwide%202001%2D2021&text=The%20cumulative%20capacity%20of%20installed,about%20780%20gigawatts%20that%20year.
3. https://gwec.net/global-wind-report-2021/
4. https://power.larc.nasa.gov/data-access-viewer/
5. https://globalwindatlas.info/area/Uzbekistan/Kashkadarya
6. Aung Tan Ch.N. (2014) Issledovanie effektivnosti kompleksnogo ispolzovaniya vozobnovlyaemых istochnikov energii v regionalnoy energetike Myanmы, kandidatskaya dissertatsiya. Moskva. c.132
7. Rixlov AB. (2012) Klimatologicheskaya otsenka vetroenergeticheskogo potensiala na razlichnых vыsotax: na primere Yugo-Vostoka Evropeyskoy territorii Rossii, kandidatskaya dissertatsiya. Saratov. c.255

8. Mentis D, Hermann S, Howells M, Welsch M, Hussain ShS. (2015) Assessing the technical wind energy potential in Africa a GIS-based approach. Renewable Energy. Vol. 83. pp. 110-125
9. Kilich B. (2019) Determination of wind dissipation maps and wind energy potential in Burdur province of Turkey using geographic information system (GIS). Sustainable Energy Technologies and Assessments. Vol. 36, 100555
10. Allouhi A, Zamzoum O, Islam MR, Kousksou T, Jamil A, Derouich A. (2017) Evaluation of wind energy potential in Morocco's coastal regions, Renewable and Sustainable Energy Reviews. Vol. 72. pp.311-324
11. Ahmed SA, Mahammed HO. (2012) A Statistical Analysis of Wind Power Density Based on the Weibull and Ralyeigh models of "Penjwen Region" Sulaimani/Iraq. JJMIE. Vol. 6. Num. 2. pp. 135-140
12. C. Ozay, M.S Celiktas. Statistical analysis of wind speed using two-parameter Weibull distribution in Alacati region, Energy Conversion and Management. 121(2016). pp. 49-54
13. Soulouknga M, Doka S, Revanna N, Djongyang N, Kofane T. (2018) Analysis of wind speed data and wind energy potential in Faya-Largeau, Chad, using Weibull distribution. Renewable energy. Vol.121 pp.1-8
14. Hatata AY, Mousa MG, Elmahdy RM. (2015) Analysis of wind data and assessing wind energy potentiality for selected locations in Egypt. International Journal of Scientific Engineering Research. Vol. 6. Issue 3. pp. 604-609
15. Sadullaev NN, Safarov AB, Nematov ShN, Mamedov RA. (2019) Statistical Analysis of Wind Energy Potential in Uzbekistan's Bukhara Region Using Weibull Distribution. Applied Solar Energy. Vol. 55, Issue 2, pp. 126–132
16. Azad AK, Rasul MG, Islam R, Shishir IR. (2015) Analysis of Wind Energy Prospect for Power Generation by Three Weibull Distribution Methods. Energy Procedia.Vol. 75, pp. 722-727
17. Sadullaev NN, Safarov AB, Mamedov RA. Qodirov D. (2020) Assessment of wind and hydropower potential of Bukhara region. IOP Conference Series: Earth and Environmental Science 614 (1), 012036
18. Sadullaev NN, Safarov AB, Nematov ShN, Mamedov RA. (2019) Research on facilities of power supply of small power capability consumers of Bukhara region by using wind and solar energy. International Journal of Innovative Technology and Exploring Engineering, 8(9S2): pp. 229-235
19. Sadullaev NN, Safarov AB, Nematov ShN, Mamedov RA. Abdujabarov AB. (2020) Opportunities and Prospects for the Using Renewable Energy Sources in Bukhara Region. Applied Solar Energy. Vol. 56, Issue 4, pp. 291–301
20. Safarov AB, Mamedov RA. (2021) Study Of Effective Omni-directional Vertical Axis Wind Turbine For Low Speed Regions. IIUM Engineering Journal 22 (2), 149-160
21. Mousaad A, Whipple J. (2021) Wind Forces on Ground-Mounted Photovoltaic Solar Systems: A Comparative Study. Applied Solar Energy. Vol. 57, pp. 444–471
22. Serban A, Simona LP, Paraschiv S. (2020) Assessment of wind energy potential based on Weibull and Rayleigh distribution models. Energy Reports. Vol. 6, pp. 250-267
23. Cataldo J, Zeballos M. (2009) Roughness terrain consideration in a wind interpolation numerical model, 11th Americas Conference on Wind Engineering San Juan, Puerto Rico.
24. Elistratov V, Ramadan A. (2018) Energy potential assessment of solar and wind resources in Syria. Journal of Applied Engineering Science. Vol.16, pp. 208-216.
25. Rasham M. (2016) Analysis of Wind Speed Data and Annual Energy Potential at Three locations in Iraq. International Journal of Computer Applications. Vol.137, pp. 11-16
26. Bezrukix PP, Gripkov SV. Vetroenergetika: Spravochno-metodicheskoe izdanie. Pod общеу redaksiey P.P Bezrukix.-M.: «Intexenergo-Izdat», «Teploenergetika», 2014. -304 s.

ENERGIYA TEJAMKOR TEXNOLOGIYALAR VA QURILMALAR// ЭНЕРГОСБЕРЕГАЮЩИЕ ТЕХНОЛОГИИ И УСТАНОВКИ//ENERGY SAVING TECHNOLOGIES AND INSTALLATIONS

ELEKTR YURITMALARNI CHASTOTA O‘ZGARTIRGICH ORQALI BOSHQARISHDA YUQORI GARMONIKALAR VA ULARNING TA’SIRINI KAMAYTIRISH USULLARI TAHLILI

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Annotatsiya. *Bugungi kunda barcha sohalarda joriy etilgan elektr yuritmalarning katta qismida energiya samaradorlikni oshirish maqsadida chastota o‘zgartirgich (ChO‘) ga asoslangan boshqarish tizimi qo‘llanilib kelmoqda. Chastota o‘zgartirgich orqali elektr yuritmalarni boshqarish ishlab chiqarishda energiya samaradorlikni oshirishda, asinxron elektr dvigatellarni mexanizatsilash va ularning avtomatik boshqarish jarayonlari imkoniyatlarini kengaytirishda hamda uning energetik koeffitsiyentini yaxshilashda muhim ahamiyatga ega. Biroq chastotaviy rostlanuvchi elektr yuritmalarning qo‘llanilishi ta’minot kuchlanishi, tok va magnit oqimlari yuqori garmonikalarini hosil qilib, natijada uning cho‘lg‘ami va magnit o‘tkazgichida qo‘shimcha quvvat isroflariga olib keladi. Ushbu maqolada elektr yuritmalarni ChO‘ lar bilan boshqarishning ahamiyati, olib borilgan tajriba sinov natijalari, yuqori garmonikalarning salbiy oqibatlari va ularning ta’sirini kamaytirishga imkon beruvchi usullar haqida tahliliy materiallar keltirilgan.*

Kalit so‘zlar. *Elektr yuritma, chastota o‘zgartirgich, tok, kuchlanish, garmonikalar, aktiv va passiv filtrlar, energiya samaradorlik, elektr ta’minoti tizimi,kommutatsiya, elektr qurlmalarining qizishi, quvvat isrofi, texnik xizmat ko‘rsatish xarajatlari, faza toki, to‘g‘ridan-to‘g‘ri ishga tushirish.*

АНАЛИЗ ВЫСОКИХ ГАРМОНИК И МЕТОДЫ СНИЖЕНИЯ ИХ ВЛИЯНИЯ ПРИ УПРАВЛЕНИИ ЭЛЕКТРОПРИВОДОВ ЧЕРЕЗ ПРЕОБРАЗОВАТЕЛИ ЧАСТОТЫ

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Аннотация. *В настоящее время для повышения энергоэффективности в большинстве систем электроснабжения, внедряемых во всех отраслях, применяется система управления на основе преобразователя частоты. Управление электроприводами через преобразователь частоты имеет важное значение для повышения энергоэффективности производства, расширения возможностей механизации асинхронных электродвигателей и процессов их автоматического управления, повышения его энергоэффективности. Однако применение частотно-регулируемых электрических цепей создает высокие гармоники питающего напряжения, тока и магнитных токов, что приводит к дополнительным потерям мощности в его цепи и магнитопроводе. В данной статье представлены аналитические материалы о важности управления электромобилями с преобразователями частоты, результаты экспериментальных испытаний, негативные последствия высших гармоник и методы, позволяющие уменьшить их влияние.*

Ключевые слова. *Электропривод, преобразователь частоты, ток, напряжение, гармоники, активные и пассивные фильтры, энергоэффективность, система электроснабжения, коммутация, нагрев электроприборов, рассеиваемая мощность, эксплуатационные расходы, фазный ток, ток прямого пуска.*