Oriental Renaissance: Innovative, educational, natural and social sciences
SJIF 2023 = 6.131 / ASI Factor = 1.7
(E)ISSN:2181-1784
www.oriens.uz
3(9), September, 2023

RESULTS OF THE RESEARCH OF THE POSSIBILITIES OF USING WIND ENERGY IN THE NORTHERN AREAS OF BUKHARA REGION

A.B. Safarov,
Q.E. Sayfiddinov
Bukhara engineering technological institute

ABSTRACT

The article illustrates that the scientific basis of the assessment of the potential of wind energy resources at different heights by statistical processing of the average wind speed data measured at the weather station (at a height of 10 m) is presented. The research was conducted in the Gijduvan district of the northern region of Bukhara region. An algorithm for determining the potential of wind energy resources using a two-parameter Weibull probability distribution function has been developed. The average speed of the wind at different heights, the specific power of the wind flow, the specific energy of the wind flow, the gross (theoretical) potential of wind energy and technical resources were determined by modeling in the Matlab/Simulink system. According to the results of the conducted scientific research, it was determined that the average wind speed at a height of 100 m in Gijduvon district is 4.85 m/s, the specific power of the wind current is 404.85 W/m ^{2}, and the specific energy of the wind current is 3546.6 kWh/m ^{2}. By using wind energy in the region, social and economic sectors can be developed.

Key words: *average wind speed, algorithm, Weibull probability distribution function, relative wind power, relative wind energy, gross (theoretical) potential of wind energy and technical resources.*

АННОТАЦИЯ

В данной статье представлено научное обоснование оценки ресурсов ветроэнергетического потенциала на разных высотах путем статистической обработки данных о средней скорости ветра, измеренных на метеорологической станции (на высоте 10 м). Исследование проводилось в Гиждуванском районе в северной части Бухарской области. Разработан алгоритм определения ресурсов ветроэнергетического потенциала с использованием двухпараметрической функции распределения вероятностей Вейбулла. Путём моделирования в системе Matlab/Simulink были определены средняя скорость ветра на разных высотах, удельная мощность потока ветра, удельная энергия потока ветра, ресурсы валового (теоретический) и технического ветроэнергетического потенциала. По результатам научных исследований, средняя скорость ветра на высоте 100 м в Гиждуванском районе составляет 4,85 м/с, удельная мощность потока ветра 404,85 Вт/м2,

удельная энергия потока ветра - 3546,6 кВт·ч/м2. За счёт использования энергии ветра в регионе можно развить социальные и экономические секторы.

Ключевые слова: *средняя скорость ветра, алгоритм, функция распределения вероятностей Вейбулла, удельная мощность ветра, удельная энергия ветра, ресурсы валового (теоретический) и технического ветроэнергетического потенциала.*

INTRODUCTION

Increasing the scope of use of renewable energy sources in the world energy system, saving fuel resources, using ecologically clean energy resources, and solving the problems of environmental protection are gaining importance. Based on this, in the long-term national energy programs of developed countries, in the period from 2021 to 2030, greenhouse gases and emissions should be reduced by at least 40% (compared to the situation in 1990), the share of renewable energy sources should be increased by 32%, and energy efficiency should be increased by 32.5%. planned" [1]. In this regard, special attention is being paid to the use of renewable energy sources and scientific research in this field.

Centralized energy systems and the use of renewable energy sources wind, solar, hydro and other power plants in supplying electricity to autonomous consumers is one of the important directions of energy supply development. In order to solve the problem of evaluating the possibilities and effectiveness of renewable energy sources for providing energy to the regions, information covering the natural resources of the region, as well as economic, demographic, other factors and characteristics of the region is needed. The diversity of these factors and characteristics, their insufficient research, lack of connection to the geographical coordinates of the area, it is very difficult to assess the feasibility of installing devices based on renewable energy sources. One of the solutions to the existing problem is the creation of a geographic information system base for assessing the potential of renewable energy resources, including indicators of energy reserves connected to a certain area, which are models for assessing their technical and economic efficiency.

Today, the use of wind energy is one of the most promising projects among renewable energy sources in the world . China, USA, India, Brazil and European countries are leading in the use of wind energy. In 2020, the installed capacity of wind power plants in China is 100 GW, a 60% increase compared to 2019 [2]. Figure 1 shows the indicators of installed capacity of wind power plants in the world by year. In 2019, the installed capacity of wind power plants in the world was equal to 60.4 GW [3].

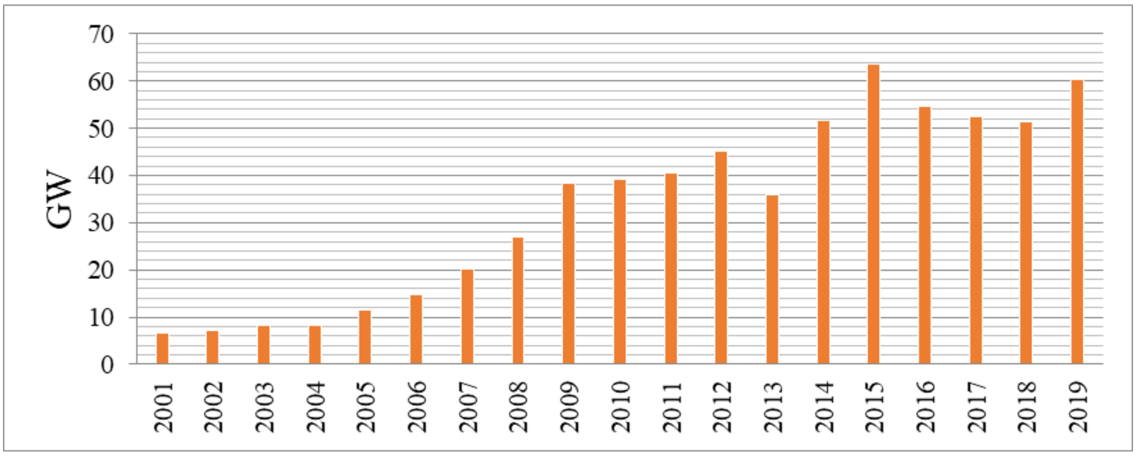


Figure 1. Indicators of the installed capacity of wind energy installations in the world in a cross-section of years

In Uzbekistan, scientific research work is being carried out on the evaluation of the potential of wind energy resources and their use. Until recently, the gross (theoretical) potential of wind energy resources of our republic was 2.2 mln. was estimated as t.n.e. However, the potential of wind energy in local, separate areas (Navoi, Ustyurt, Bukhara, Bekobad) was not fully taken into account. In addition, this indicator was calculated for a height of 5-8 meters according to the data of actinometric stations located far from each other (actually it should be determined at 25-100 meters).

German **"Intec-COPA, GEONET"** and **"Uzbekenerego" JSC** companies carried out research on wind energy potential assessment and wind mapping in Uzbekistan. According to the results of the conducted research, the gross potential of wind energy is 520 GW per year. It is determined that this will allow to receive approximately 1.7 trillion kWh of electricity per year [4]. We can develop the social and economic sectors of remote areas by assessing the potential of using wind energy to provide reliable and continuous electricity to settlements, farms and farms located far from centralized energy supply .

Based on the results of scientific research carried out in the world, it was found that we can reliably estimate the potential of wind energy resources at different heights by statistical processing of wind speed data measured at a height of 10 m using the Weibull probability distribution function. We estimate the wind flow potential of Gijduvan district at different heights using the Weibull probability distribution function.

METHODOLOGY.

Modern wind energy devices of various forms are being designed in the world today in order to reduce costs when using wind energy, increase the reliability and efficiency of wind devices. Analyzing data on wind power properties is very important for evaluating the performance characteristics of wind power plants. The use of the Weibull distribution function in the static analysis of wind energy potential is effective in reliable estimation of wind speed characteristics and energy potential [11].

When evaluating wind speed characteristics, we need to determine the empirical (reproducibility of wind speed) and density functions of the Weibull distribution. These expressions are defined as follows [12,13]:

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

$$F(v) = \int_0^\infty f(v)dv = 1 - e^{-\left(\frac{v}{c}\right)^k} \qquad 1 \le k \le 10 (2)$$

where k – the shape parameter (depends on the location of the area); c – a parameter that determines the scale of the distribution of the function (parameter depending on the average wind speed m/s).

and parameters $c$of the Weibull distribution $k$are as follows [14]:

$$k = \left(\frac{\sigma}{\bar{v}}\right)^{-1{,}086} (3)$$

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

Expressions of average wind speed and standard deviation are given in the following relations [15]:

$$\bar{v} = \frac{1}{N} \cdot \sum_{i=1}^{N} v_i (5)$$

$$\sigma = \sqrt{\frac{1}{N-1} \cdot \sum_{i=1}^{N} (v_i - \bar{v})^2} (6)$$

in which $\bar{v}$ –the average value of wind speed; v_i –daily measured wind speed; N –number of measured wind speeds; Γ –gamma function.

Through the parameters defined in the Weibull distribution function, the relative power and energy values of the wind flow are determined by the following expressions [16,17]:

$$P = \int_0^\infty \frac{1}{2}\rho v^3 f(v)dv = \frac{1}{2}\rho c^3 \Gamma(1 + \frac{3}{k}) (7)$$

$$W = \int_0^\infty \frac{1}{2}\rho v^3 f(v)dv \cdot T = \frac{1}{2}\rho c^3 \Gamma(1 + \frac{3}{k}) \cdot T \qquad (8)$$

At certain altitudes, air density, temperature, wind speed and direction change. The change in air flow density according to height is determined as follows [18]:

$$\rho = \rho_0 - (1{,}194 \cdot 10^{-4} \cdot H) (9)$$

in this ρ_0 – normal in the circumstances the air of flow density $\rho_0 = 1{,}23$ $кг/м^3$;H – the wind speed measurable height, m.

(E)ISSN:2181-1784
www.oriens.uz
3(9), September, 2023

Wind speed values depend on altitude. Height increased increasingly windy _ speed increases. The following in the formula the wind of speed to the height dependence cited [19]:

$$v_2 = v_1 \cdot \left(\frac{H_2}{H_1}\right)^{\alpha} (10)$$

where v_2 – wind speed measured at a certain height, m/s; v_1 – wind speed measured at initial height, m/s; H_1 – initial height, m; H_2 – selected height, m; $\propto$ –windbreak indicator.

The wind shear index is determined by the following formula:

$$\propto = [0{,}096 \log_{10}(Z_0) + 0{,}016 (\log_{10}(Z_0))^2 + 0{,}24] (11)$$

Z_0 – length of surface irregularities on different land surfaces. It is 0.03-0.05 m for the territory of Bukhara region . $Z_0 =$

At a given height, the values of the shape and scale parameters also change. Determination of these parameters is carried out by the following expressions [20]:

$$k_{H_2} = \frac{k}{1-0{,}0881 \text{лн}\left(\frac{H_2}{H_1}\right)} (12)$$

$$c_{H_2} = c_{H_1} \left(\frac{H_2}{H_1}\right)^n (13)$$

$$n = [0{,}37 - 0{,}0881 \ln(c_{H_1})] (14)$$

RESULTS.

In this article, theoretical and practical studies were carried out on the evaluation of the potential of wind energy resources at different altitudes of Gijduvan district, the northern region of Bukhara region. Figure 2 shows the average wind speed data of Gijduvan district measured at a height of 10 m. Accordingly, it was determined that the average wind speed in summer months is higher than in other months and the average wind speed in the region is 4.85 m/s.

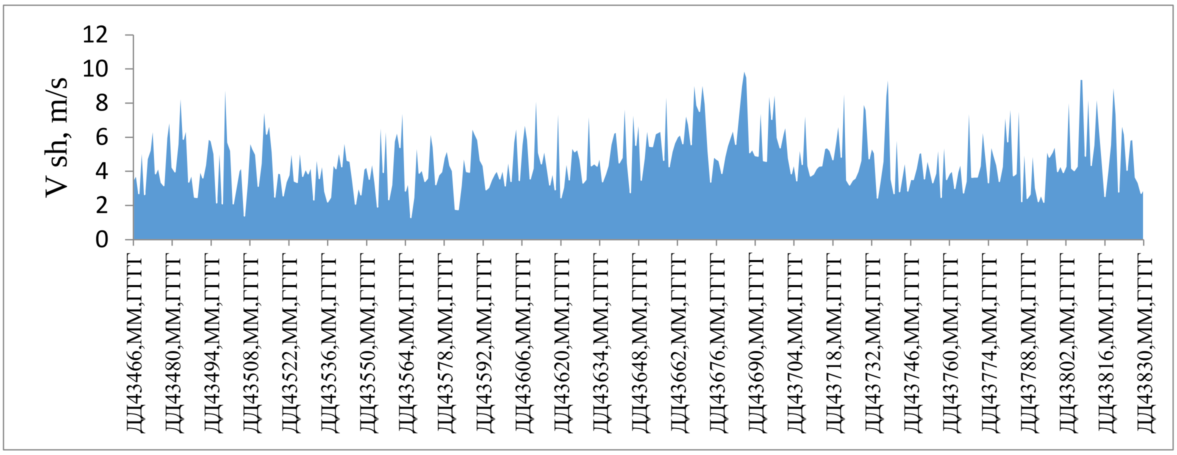
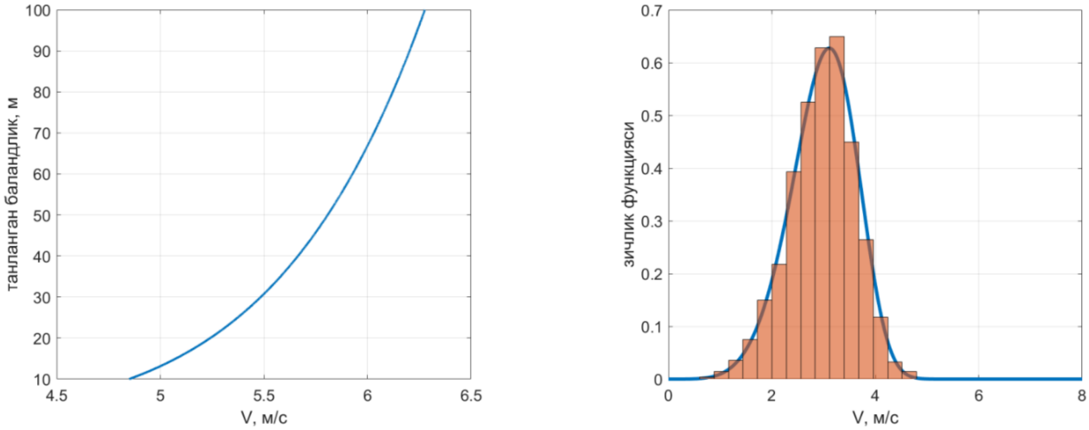


Figure 2. Average values of the wind speed measured at a height of 10 m in Gijduvan district

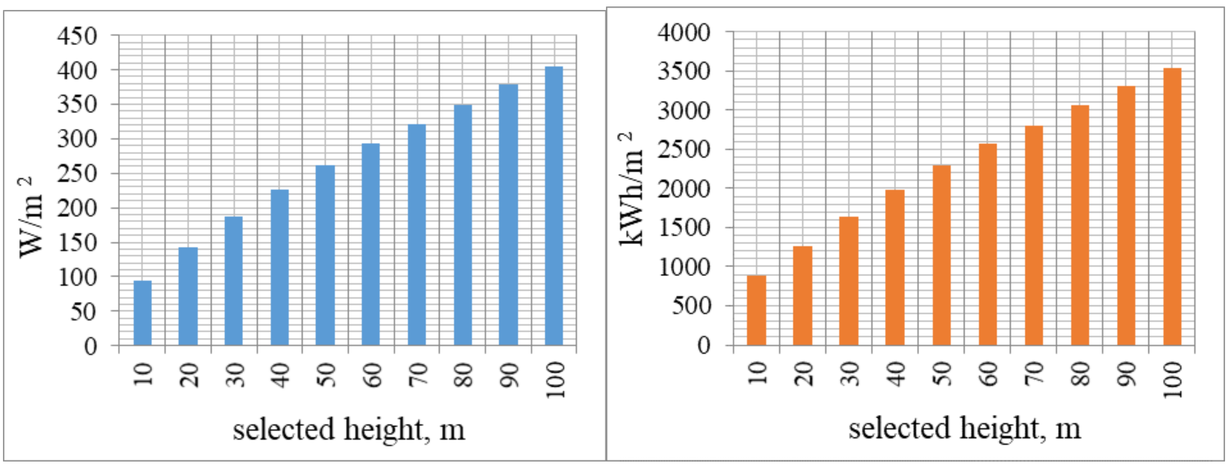
Figure 3 shows the values of the average wind speeds at different heights of the Gijduvan district and the results of the density function of the Weibull distribution. It was theoretically determined that the average wind speed at a height of 100 m is 6.35 m/s.



a) b)

Figure 3. Values of the average speed of the wind flow at different heights of the region (a), the results of the density function of the Weibull distribution

Figure 4 presents the results of estimating the relative power and energy of wind energy at different heights using the Weibull probability distribution function of G'iduvan district. According to this, it was determined that the specific power of the wind current at a height of 100 m is 404.85 W/m ^{2} and its energy is 3546.5 kWh/m ^{2}.



a) b)

Figure 4. Graph showing relative power (a) and energy (b) values of wind energy at different altitudes

CONCLUSION

The data of the meteorological station (MS-Ogitma) located in the Gijduvan district was used to assess the potential of wind energy resources at different heights of the Gijduvan district. Accordingly, it was determined that the average wind speed is 4.85 m/s per year at a height of 10 m. The wind speed data obtained from the MS-Ogitma weather station were statistically processed and the gross (theoretical) and technical potential of the wind flow at different heights was evaluated. Accordingly, the gross (theoretical) potential of wind flow at a height of 100 m is 909.94 mln. per kWh, technical capacity is 18.20 mln. Its equivalence to kWh was scientifically substantiated. According to the results of the conducted research, it was estimated that the possibilities of using wind energy in stabilizing energy insecurity and environmental problems in these regions are high.

REFERENCES

1. https://ec.europa.eu/clima/policies/strategies/2030_en
2. https://www.theguardian.com/business/2021/mar/10/china-leads-world-increase-wind-power-capacity-windfarms
3. https://gwec.net/gwec-over-60gw-of-wind-energy-capacity-installed-in-2019-the-second-biggest-year-in-history/
4. N.N. Sadullayev., A.B. Safarov., Sh.N. Nematov. "Analysis of wind energy potential in using Weibull distribution in Bukhara region Uzbekistan". IJARSET. 1 (2019) 7846-7853.
5. T. Ouarda, Ch. Charron. "On the mixture of wind speed distribution in a Nordic region". Energy Conversion and Management. 174 (2018) 33-44
6. A. Allouhi, O. Zamzoum, M. Islam, R. Saidur, T. Kousksou, A. Jamil, A. Derouich. "**Evaluation of wind energy potential in Morocco's coastal regions".** Renewable and Sustainable Energy Reviews. 27 (2018) 311-324
7. **M. Rasham.** "Analysis of Wind Speed Data and Annual Energy Potential at Three locations in Iraq". International Journal of Computer Applications. 137 (2016) 11-16
8. S. Ali, S. Lee, Ch. Jang. "Statistical analysis of wind characteristics using Weibull and Rayleigh distributions in Deokjeok-do Island-Incheon, South Korea". 123 (2018) 652-663.
9. У.А. Таджиев., Е.И. Киселева., М.У. Таджиев., Р.А. Захидов. Особенности формирования ветровых потоков над территорией Узбекистана и возможности их использования для выработки электроэнергии. часть I // Гелеотехника. 2015(1), 69-76 c.

10. Р.А. Захидов., Е.И. Киселева., Н.И. Орлова., У.А. Таджиев. О прогнозной стоимости электроэнергии, вырабатываемой горизонтально-осевыми ветроэлектро- установками в некоторых районах Узбекистана. Гелеотехника. 2001 (1).
11. N.N. Sadullayev A.B. Safarov., Sh.N. Nematov., R.A. Mamedov. 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, Volume 8, Issue 9S2, 2019. pp. 229 – 235
12. N.N. Sadullayev., A.B. Safarov., Sh.N. Nematov., R.A. Mamedov., Statistical Analysis of Wind Energy Potential in Uzbekistan's Bukhara Region Using Weibull Distribution. Applied Solar Energy, 2019. Volume 55, Issue 2, pp. 126–132
13. Н.Н. Садуллаев., А.Б. Сафаров., Ш.Н. Нематов., М.А. Мамедов. Бухоро вилояти ҳудудида шамол энергиясидан фойдаланиш имкониятларини тадқиқ этиш натижалари. “Инновацион технологиялар”, 2020 2(38), 16-22
14. А.Б. Сафаров. Вейбул эҳтимоллик тақсимот функциясидан фойдаланиб Бухоро вилояти ҳудудининг шамол энергетикаси салоҳиятини таҳлил қилиш. ТошДу хабарлари. 2018 (4). 93-98 б.
15. A. Azad., M. Rasul., T. Yusuf. “Statistical diagnosis of the best Weibull methods for wind power assessment for agricultural applications”. Energies. 7 (2014) 3056-3085.
16. Н.Н. Садуллаев., А.Б. Сафаров. Бухоро вилояти ҳудудининг шамол энергияси салоҳиятини икки параметрли Вейбул ва Релей тақсимот функцияларидан фойдаланиб статик таҳлил қилиш. “Informatika va energetika muammolari”, Тошкент, 2019. №4, б. 68-79
17. N.N. Sadullayev., A.B. Safarov., Sh.N. Nematov., R.A. Mamedov., A.B. Abdujabarov. Opportunities and Prospects for the Using Renewable Energy Sources in Bukhara Region. Applied Solar Energy.2020. Volume 56, Issue 4, pp. 291–301
18. Y. Kantal, I. Usta. “Analysis of the upper-truncated Weibull distribution for wind speed”. Energy conversion and management. 96 (2015) 81-88.
19. Sh. Ahmed. “Wind energy characteristics and wind park installation in Shark El-Ouinat, Egypt”. Renewble and Sustainable Energy Reviews. 82 (2018) 734-742.
20. G. Johnson. “Wind Energy Systems”. 2006. pp. 2-16…2-43
21. П.П. Безруких., П.П. Безруких (мл.)., С.В. Грипков. Ветроэнергетика: Справочно-методическое издание // Под общей редакцией П.П Безруких.-М.: «Интехэнерго-Издат», «Теплоэнергетика», 2014. -304 с.