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Analysis of the technical and economic possibilities of using wind energy in the conditions of Uzbekistan

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ABSTRACT: This paper analyzes the technical and economic possibilities of using wind energy in the mountainous regions of the Republic of Uzbekistan. The relevance of the topic, the level of coverage in international scientific articles, its scientific foundations and importance are highlighted in the article. Also, the theoretical framework used in the implementation of this analysis is analyzed.

KEY WORDS: Wind speed, wind energy efficiency, generator, wind power plants.

I.INTRODUCTION

Mankind has always tried to use the forces of nature to control them. First of all, man mastered the use of water and wind energy. With the help of wind, the ground was created for the operation of ship sails, windmills were created, etc. The first windmills were created 2 thousand years ago. But even before that, there are written sources about the use of windmills in Babylon to drain swamps[1].

In 1941, the first large-capacity WPP was built in the USA. Its capacity was 1.25 MW. It provided electricity to a local power station for several years, but in 1945, due to damage to one of its wings, it vibrated and ceased operation. After World War II, the sharp increase in the demand for energy led to an increase in the construction of large-capacity WPP. Their capacity was around 100-800 kW. According to the UNESCO Foundation, in 1960 there were more than 1 million wind turbines on earth. Of these, 0.5 million were high-speed wind generators[2,3]. They were mainly used in the power supply of small objects, power supply of radio communication networks and similar fields. Australia alone had 250,000 wind turbines in 1968. These numbers alone show how high the demand for wind energy is.

On a part of the territory of the Republic of Uzbekistan with an area of 100 thousand sq.km. (the territory in the Aral Sea areas, the Ustyurt plateau, Navoi, Bukhara and other regions) there are wind flows, the magnitudes and structures of which provide the possibility of wind energy use of their energy with the help of modern serial wind-driven units. The region between Bekabad and Kokand, where winds prevail with a speed of more than 6 m/s with 42% frequency in a year where 400 wind power plants can be located, is considered promising for the production of electric energy on an industrial scale. The total capacity of 240 MW, with an annual output of more than 800 million kWh of electricity [4].

Even in the Republic of Uzbekistan today, effective research is being conducted on the use of wind energy. A wind power plant with a capacity of 500 MW is being built in Tomdi district of Navoi region. When the station is fully operational, 1.8 billion kWh of electricity will be produced per year.

II. METHODOLOGY

Measuring the instantaneous speed of wind equipment is also an important factor in determining its technical parameters. The average $v_{average}$ speed of the wind depends on the selected time interval T=(t_1 -t_2) and the instantaneous value $v_{instant}$ and the number of measurements n .

$$v_{average} = \frac{\sum_{i=1}^{n} v_i}{n} \quad (1)$$

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To find the average speed for one hour, divide the sum of the speeds for one day by 24 to get the average speed for 1 hour. The average wind speed varies depending on the time of day, the months of the year, and the seasons. Therefore, we calculate wind speeds as daily, monthly, and seasonal air currents. The long-term operation of wind turbines and their reliability depend on the limit speed of the wind in that area. It is used in the structural calculations of wind aggregates, in determining the strength of the structure, in obtaining normative dimensions, in determining the aerodynamic characteristics of the aggregate blades.
Maximum use of wind speed is determined by the following formula.

$$F(x) = e^{\frac{-x^y}{\beta}} \quad \textbf{(2)}$$

Here F(x) is the probability of preference of the given quantity. *x*, *y*, *b* are parameters of the equation. These parameters depend on the conditions of the region and its condition. *e* is the base of the natural logarithm.
In metrological practice, the following formula is used to determine the relative estimate of wind speed.

$$k = \frac{v_i - v}{v_{\max} - v_{\min}} * 100\,\% \quad \textbf{(3)}$$

Here v_i is the instantaneous wind speed found during the measurement. *v*- the average speed of the wind during the selected time. v_{max}, v_{min} - maximum and minimum wind speeds during the time of calculation.
If we find the energy of the air flow, then

$$E = mv^2/2 \quad \textbf{(4)}$$

Here m = p*F* *v*
F- air mass t passing through the cross-sectional area of the air stream.
From this

$$E = pv^3F/2 \quad \textbf{(5)}$$

p- air density. 1.23 kg/m ^{3} under normal conditions
It follows that wind energy varies in direct proportion to the cube of its speed. Modern wind generators can convert 35-40% of wind energy into electricity[5].
Putting different wind speeds into the formula for finding energy, we get the following table.

Wind speed (m/s)	4	6	8	10	14	18	22
Current power (kW/m ^{2})	0.04	0.13	0.31	0.61	1.67	3.6	6.25

We can convert wind energy into electrical energy, mechanical energy or thermal energy using various mechanisms (generator, engine, compressor, electrolyzer, etc.).
From (5). $F = \pi R^2$ from being using

$$mv^2/2 = \frac{pv^3F}{2} = pv^3\pi R^2/2 \quad \textbf{(6)}$$

To find the coefficient of utilization of wind energy, we divide the power output from the wind generator by the total power of the wind.

$$\xi = \frac{N_{gen}}{N_{sh.q}} \quad \textbf{(7)}$$

The power of the wind generator is accordingly

$$P = \rho v^3 F\xi/2 \quad \textbf{(8)}$$

Wind energy is hundreds of times greater than all the sea and river energy on earth. At first glance, wind energy seems like the most convenient renewable energy source. Unlike solar energy, it burns day and night, winter and summer, south and north. But it exists in such a spread that it is impossible to fully use its energy.
Wind "farms" occupying a large area are used to make full use of wind energy. There are mainly 2 problems with using wind energy. The first is that the kinetic energy of the wind is not fully utilized due to its spread. The second is that there is no constant air flow. This also causes several inconveniences in the use of wind energy. Currently, the most commonly

used number of wind turbine blades is 1-3. For such wind generators to work effectively, the average wind speed should not be less than 5 m/s.
Wind generators are built in areas where the annual specific power of the wind is 500 W/m ^{2}, we can convert 175 W of it into electricity. Hence its useful work coefficient

$$\eta = \frac{P_{gen}}{P_{sham}} * 100\% = \frac{175}{500} * 100 = 35\%$$

It is equal to **35 %.**

The cost of energy obtained from Wind power plants is decreasing day by day. The reason for this is the use of modern technologies, competition among manufacturers as a result of the demand for wind equipment, which has led to a decrease in the price of wind equipment. A clear example is that the cost of 1 kWh of wind energy around the world today is 10 times cheaper than the same energy cost in 1974 (from 40 cents to 4 cents) [6].

There are also negative aspects of WPP. Large wind power plants disrupt the transmission of television and radio signals and negatively affect their quality. It destroys the seasonal migration of birds. Also, the infrasound emitted by wind turbines with a power greater than 20 kW has a negative effect on the hearing system and nervous system of people and animals around them. Therefore, it is desirable to build large wind power plants outside the city[7,8].

III. EXPERIMENTAL RESULTS

Since the speed of the wind varies over time, we measure its speed several times at different times. For example, measurement works are carried out at different times of the day, month, and sometimes the year. And the average wind speed is found and the power of the wind generator is selected accordingly. For example, in the form of the following table. Here are the daily checks for the first 5 months of the year and the last selected average speed in mountain places of Jizzakh.

Date no	January	February	March	April	May	total	Average daily
1	5.3	6.4	5.2	3.6	5	25.5	5.1
2	3.8	5.6	5.7	5.3	6.7	27.1	5.42
3	5.5	4.5	4.5	4.6	5.1	24.2	4.84
4	5.3	5.5	4.6	4.6	4.7	24.7	4.94
5	5.2	5.6	7	6.2	5.4	29.4	5.88
6	5.3	4.5	4.3	6.4	6.3	26.8	5.36
7	5.4	6.4	5.5	4.7	5.1	27.1	5.42
8	4.3	4.5	5.6	4.2	5.6	24.2	4.84
9	5.2	5.3	3.8	5.6	5.6	25.5	5.1
10	5.7	3.8	5.5	3.8	4.5	23.3	4.66
11	4.5	5.5	5.3	5.5	6.4	27.2	5.44
12	4.6	5.3	5.2	5.3	4.5	24.9	4.98
13	7	5.2	5.6	3.8	5.3	26.9	5.38
14	4.3	5.3	3.8	5.5	3.8	22.7	4.54
15	5.5	5.4	5.5	5.3	5.5	27.2	5.44
16	5.6	4.3	5.3	5.2	5.3	25.7	5.14
17	6.4	5.2	6.7	5.3	5.2	28.8	5.76
18	5.6	5.7	5.1	5.4	5.3	27.1	5.42
19	4.5	4.5	4.7	4.3	6.7	24.7	4.94
20	5.5	4.6	5.4	5.2	5.1	25.8	5.16
21	5.6	6.3	6.3	5.7	4.7	28.6	5.72

22	4.5	5.6	5.1	4.5	5.4	25.1	5.02
23	6.4	4.5	5.6	4.6	6.3	27.4	5.48
24	4.5	5.5	4.5	6.8	5.1	26.4	5.28
25	3.6	5.6	5.5	5.5	5.6	25.8	5.16
26	5.3	4.5	5.6	5.3	6.3	27	5.4
27	4.6	6.4	4.5	5.2	5.6	26.3	5.26
28	4.6	4.5	6.4	5.3	4.5	25.3	5.06
29	6.2		4.5	6.7	5.5	22.9	4.58
30	6.4		3.6	5.1	5.6	20.7	5,175
31	4.7		5.3		5.4	15.4	5.13
Total	**160.9**	**146**	**161.2**	**154.5**	**167.1**	**789.7**	
Average	5.19	5.21	5.2	5.15	5.390323	26.14032	5.228064516

It can be seen from this table that the wind speed in these months is suitable for the construction of medium and small wind power plants.

IV. CONCLUSION

Challenges and Solutions

One of the challenges in expanding wind energy is grid integration. Uzbekistan's power grid may need upgrades to accommodate the intermittent nature of wind energy.

Infrastructure development is another challenge, including the construction of transmission lines to connect wind farms to population centers and industries.

Solutions may involve adopting smart grid technology, investing in energy storage systems, and partnering with international experts for technical assistance and financing [9].

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