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Efficient use of wind energy in Lankaran zone

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Abstract

Depletion of traditional energy resources and deterioration of ecology is one of the main issues on the agenda of the whole world in modern times. A number of developed countries are promoting the use of alternative energy sources as one of the ways to solve the problem. Currently, the most widely used alternative energy sources are solar and wind. The advantages of wind energy are that it is inexhaustible and the cost is relatively low. Aerological research results are used in wind energy. Based on these results, the wind energy cadastre is being developed. In this way, the regions where the application of wind energy is profitable are determined. Coastal zones are considered the most promising place to get energy from the wind. Offshore farms are built in the sea at a distance of 10-12 kilometers from the coast, and sometimes more. Towers of wind generators are built on foundations buried up to 30 meters deep, floating foundations are also used. The energy of the wind is directly proportional to the cube of its speed. But unfortunately, not all wind energy can be usefully used. According to theoretical calculations, the value of the coefficient of useful use of the energy of the air flood is 59.3%. Only a certain part of this energy is converted into useful energy. The performance factor of the most modern wind turbines is about 50%.

1. Introduction

One of the most developed sectors of Azerbaijan's economy is the energy sector. At a time when the countries of the world are using alternative energy on a large scale, important work is being done in this field as well in Azerbaijan. Increasing the production of ecologically clean energy is one of the most important priority issues of the economic development of our republic. Being a land of natural resources, Azerbaijan is rich in alternative energy resources such as wind, sun, wave and etc. The goal set in this area is to increase the share of renewable energy produced in the country to 24% in 2025 and 30% in 2030. Currently, this indicator is 17.3%.

There are a number of compelling reasons to switch to green energy in modern times. The most important of these is that traditional energy production damages the environment and has a negative impact on ecology. The increase in carbon dioxide emissions released into the air in Azerbaijan, which is known as a supplier of oil and gas in the world, is also an important reason for the transition to green energy. Another reason is the possibility of future depletion of traditional energy resources, which are increasingly expensive (Cəlilov, 2009).

A number of countries around the world have reduced the use of coal by switching to renewable energy, and as a result, a positive change in the amount of harmful waste emitted into the air has stimulated the improvement of the environmental situation. Currently, steps are being taken in this direction in our country as well. In particular, significant work is being done in our republic to obtain energy from the sun and wind. By studying and researching the areas rich in wind energy in Azerbaijan, it is possible to determine the amount of energy that can be obtained from it. It has been determined that the Caspian Sea coastal zone and the Absheron peninsula are among the areas with the highest wind energy potential. The purpose of this work is to determine the feasibility and usefulness of wind energy production in the Lankaran zone.

2. Method

To achieve this goal, the research was conducted in the following manner. For this, wind rose graphs were drawn up to show the change in wind speed and

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direction over the years. Hourly satellite data obtained from the MERRA-2 satellite with a resolution of 0.5x0.625 at a height of 10 meters from the NASA site was used to determine the wind rose in the given coordinates in Lankaran region.

2.1. Statistical Characteristics of wind speed based on space data

As can be seen from the picture, during both years, easterly winds prevail. To be more precise, in 2001, the phase index of east wind was 8.4%. This indicator increased slightly in 2021 and was 8.9% for eastern winds. At the same time, in 2001, northeast winds accounted for 5.5%, and southeast winds accounted for 5%. In 2021, southeast winds increased by 6.9%, while northeast winds decreased by 4%.

Both westerly and southerly winds show slight annual variations. These changes tend to decrease in the western direction and increase in the southern direction. No significant difference was observed in the north winds.

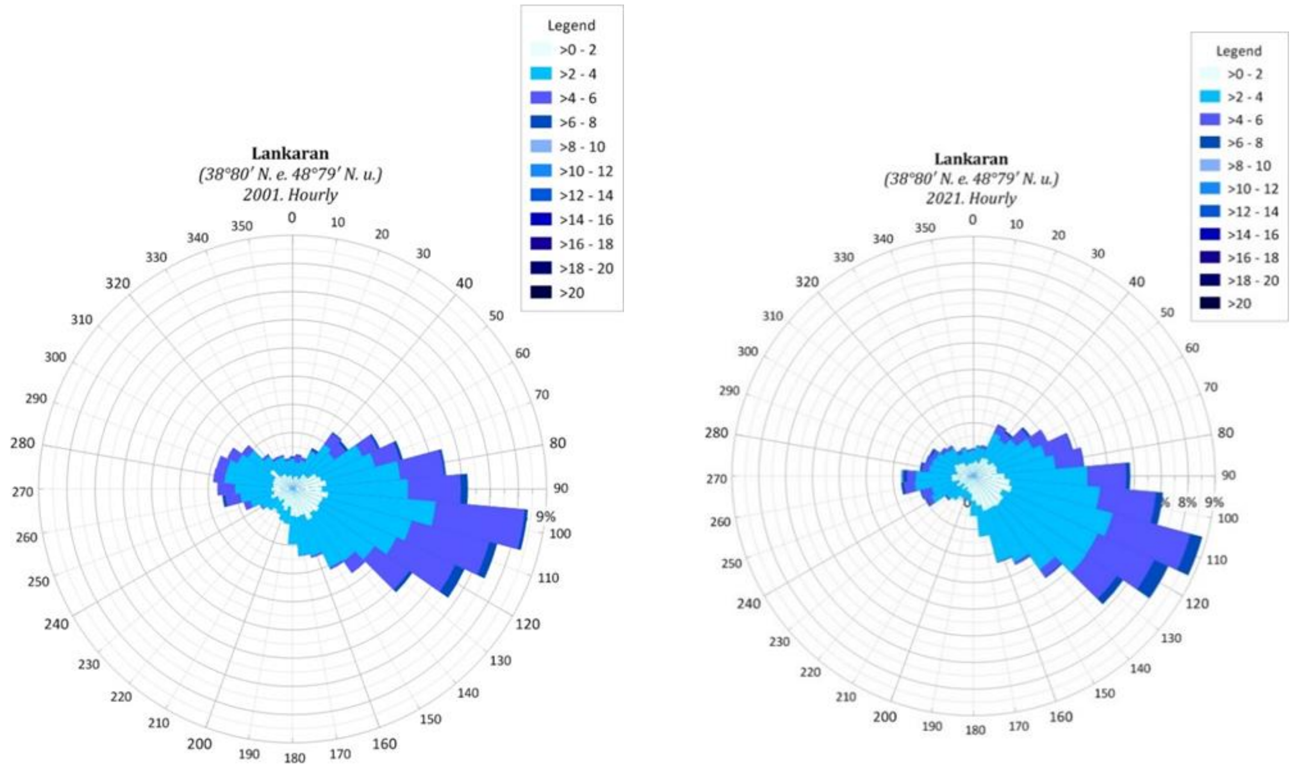

Figure 1. Wind roses for Lankaran for 2001 and 2021

2.2. Determination of wind distribution

The Rayleigh distribution is the simplest parameter to determine the wind resource because it only requires information about the average wind speed. To estimate prospective wind energy sites, a probability distribution function is often fitted to observed wind speed data. Wind speed distributions will be different in different locations (Siddiqui, M. M. 1964). The Weibull model closely reflects the actual hourly/ten-minute wind speed distribution at many locations. The Weibull factor is often close to 2, and therefore the Relay distribution can be used as a less accurate but simpler model. The Rayleigh distribution of the random quantity x is expressed by the Equation 1.

$$W(x) = \frac{x}{s^2} \exp\left(-\frac{x^2}{2s^2}\right) \quad , \quad 0 \leq x \leq +\infty, \quad s > 0; \qquad (1)$$

s - is a parameter of the distribution (Rəsulzadə 2022).

3. Results

Statistical indicators of wind speed and direction by year are given in Table 1.

The data given in Table 1 were obtained according to the wind roses built for 21 years and the calculations made in the "Fortran" program. As in 2001 and 2021, in other years included in this time interval, the predominance of east and southeast winds is evident. Looking at the average wind speed, 2-3 m/s winds are more frequent and the average wind speed for 21 years is 2.89 m/s.

It should be noted that the values of the mean square deviation are slightly different from each other when calculated based on the histogram and the Rayleigh parameter.

In the table, the most frequent wind directions (φ_{max}), average wind speeds ($\vec{v}$), mean square deviation according to histogram $\sqrt{\sigma_v{}^2}$ (H), mean square deviation according to Rayleigh parameter $\sqrt{\sigma_v{}^2}$ (R) and Rayleigh distribution parameter values (S_R) are shown for Lankaran.

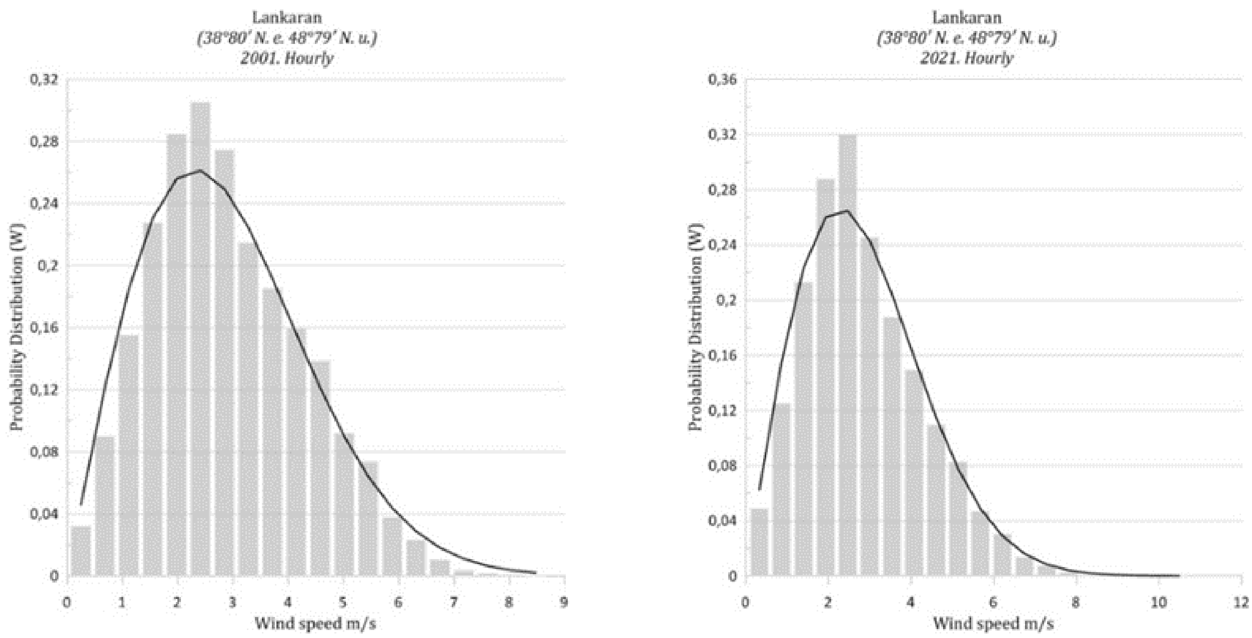

Figure 2. Rayleigh distribution graphs for Lankaran for 2001 and 2021

Table 1. Wind characteristics in Lankaran

Years	φ_{max}	$\vec{v}$ (m/s)	S_R (m/s)	$\sqrt{\sigma_v}^2$ (H) (m/s)	$\sqrt{\sigma_v}^2$ (R) (m/s)
2001	100°	2,90	2,32	1,38	1,52
2002	110°	2,86	2,28	1,39	1,49
2003	90°	2,80	2,24	1,37	1,47
2004	110°	3,02	2,41	1,48	1,58
2005	110°	3	2,39	1,39	1,56
2006	110°	3,05	2,44	1,44	1,60
2007	120°	3,05	2,44	1,42	1,60
2008	110°	2,94	2,34	1,41	1,53
2009	120°	2,86	2,28	1,39	1,49
2010	110°	2,81	2,24	1,38	1,47
2011	110°	2,82	2,25	1,31	1,47
2012	120°	2,78	2,22	1,31	1,45
2013	120°	2,88	2,30	1,39	1,51
2014	120°	2,88	2,30	1,47	1,51
2015	100°	2,88	2,30	1,38	1,51
2016	110°	3,02	2,41	1,39	1,58
2017	120°	2,96	2,36	1,39	1,54
2018	110°	2,82	2,25	1,36	1,47
2019	100°	2,73	2,17	1,31	1,42
2020	110°	2,88	2,29	1,39	1,50
2021	110°	2,85	2,28	1,43	1,49
2001-2021	110°	2,89	2,31	1,39	1,51

4. Discussion and Conclusion

The assessment of the wind energy potential of the territory is carried out on the basis of data on wind speed and wind power density (W/m^2) at various heights, which is the most important parameter for the calculation and selection of wind turbines.

The power of the wind flow P (W) is proportional to the third power of the wind speed $\vec{v}$ (m/s) and is determined by the formula: $P = \frac{\rho}{2} A \overline{v^3}$, where A is the cross-sectional area perpendicular to the wind direction; $\rho = 1.225$ kg/m^3 – air density. If the radius of the wind turbine blade is equal to r then $A = \pi r^2$. The quantity $\frac{P}{A} = \frac{\rho}{2} \overline{v^3}$ is wind power density (Alireza and Onar 2010).

As can be seen from figure 2, the distribution of wind speed in the considered area is expressed quite well by the Rayleigh distribution (Trevor, 2017). Accordingly, the following formula is obtained for calculating wind power density:

$$\frac{P}{A} = 1.88 \, \rho \, {S_R}^3$$

If we take the average value of S_R given in Table 1 (2.31), we get the result of $\frac{P}{A} = 28.4$ (W/m^2). This shows that the wind energy potential of the considered area is very weak.

Figure 3. Distribution of the average wind power density in the Lankaran region

For the 10% of the windiest areas in the Lankaran region, the average wind power density at a height of 50 m is 400 (W/m^2) and the average wind speed is 5.31 m/s. These areas are located at an altitude of approximately 1000 meters (Figure 3).

Application of green technologies and meeting the requirements of energy efficiency in the territory of the Republic of Azerbaijan requires the most accurate assessment of the renewable energy potential of each region of the country.

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