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Harnessing Renewable Energy in Basra, Iraq: Study the Wind Energy

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Abstract

This research focuses on an important sector in the field of renewable energies, which is wind energy in Basra Governorate, where an area characterized by high grasses on flat land was chosen, and monthly wind speed data was used for thirty years during the period (1/1/1982 until (1/1/) 2021) and at an altitude of 10 m from the European Center for Weather Forecasting (ECMWF). To calculate the wind speed at several altitudes, the power law was used at several altitudes (70, 80, 90, 100) m, where it was possible to identify the wind behavior during the chosen time period, and a change was observed. Wind speed from one month to another, from one season to another, and from one year to another when changing the height of the wind turbine. The actual power extracted from the wind was also calculated and its effect by changing the height of the wind turbine. It was found that by increasing the height to 70, 80, 90, 100 meters, the power of the wind increases. Each time, its maximum value reached (6.36) megawatts at a height of 100 meters above the ground. By calculating wind energy at different heights, this study can be considered as attempt to develop and harnessing renewable energy in Basra, Iraq.

Keywords: Renewable energy; Wind energy; ECMWF; Power low; Wind speed.

1.Introduction

Renewable energy is becoming more popular in the Middle East and North Africa (MENA) region as a result of the region's rapidly increasing energy demand, which is being caused by factors such as industrialization, water desalination, population growth, changing consumer behavior, and increased urbanization. The majority of MENA countries have developed aggressive plans to boost the generation of renewable energy in order to guarantee long-term energy security and meet climate change commitments. The MENA region's considerable potential for renewable energy generation, particularly wind and solar power, presents an opportunity to produce nearly CO2-neutral electricity while also boosting economic growth. However, the majority of the region's nations continue to rely primarily on fossil fuels for energy, and some of the most populous of these depend on imports of fossil fuels, which presents a risk to public budget spending and energy security [1]. Since 2003, Iraq has been dealing with a serious electricity problem, but in the long run, things are expected to get better. Up until now, efforts have been concentrated on the supply side, ignoring a crucial component of increasing energy efficiency on the demand side. More than half of the power generated is lost due to technical and commercial issues. The drop in world oil prices as a result of COVID-19 has caused Iraq to face unprecedented economic challenges. In April 2020, income barely reached $1.4 billion, when Iraq need $5 billion to cover basic expenses [2]. Iraq uses a combination of gas, hydro, and thermal power plants to generate its electricity. In 2017, natural gas made up 29.8% of the electricity produced, with crude oil accounting for 43.1%.Diesel (1.2%), gasoil (4.6%), and heavy fluidized oil (21.2%) produced the remaining electricity. Hydroelectricity accounts for the majority of the 2% of power generated from renewable sources [3]. Since the energy produced by the wind farm must offset the costs of installation and maintenance, the economic sustainability of wind power projects is dependent on the wind conditions at the location [4]. Wind turbines normally operate at heights below 200 metres, but the convective boundary layer can reach 1000 meters [5]. The wind speed, atmospheric stability, surface roughness, and height spacing all affect the wind shear within 100–200 m [6, 7]. Currently, the power and logarithmic laws are frequently applied to wind speed extrapolation. Under neutral circumstances, the logarithmic law can reasonably accurately depict the vertical wind-speed profiles. In stable or unstable situations, it was expanded to incorporate thermal stratification effects by applying the Monin-Obukhov similarity theory [8]. Because of the shallow surface layer, the logarithmic wind-speed profile based on the Monin Obukhov similarity theory was proved to be erroneous under strong steady conditions. Lackner et al. discovered that the power law is more reliable than the logarithmic law [9-11] at providing a realistic wind profile under unstable situations.

This research focuses on an important sector in the field of renewable energies, which is wind energy in Basra Governorate, where an area characterized by high grasses on flat land was chosen, and monthly wind speed data was used for thirty years during the period (1/1/1982 until (1/1/) 2021) and at an altitude of 10 m from the European Center for Weather Forecasting (ECMWF). To calculate the wind speed at several altitudes, the power law was used at several altitudes (70, 80, 90, 100) m, where it was possible to identify the wind behavior during the chosen time period, and a change was observed. Wind speed from one month to another, from one season to another, and from one year to another when changing the height of the wind turbine. The real power extracted from the wind was also calculated and its effect by changing the height of the wind turbine.

2.Theoretical Part

Wind speed at several heights was calculated using the power law shown in the following equation[12]:

$$\frac{\bar{u}_{(z)}}{\bar{u}_{(z_{ref})}} = \left(\frac{z}{z_{ref}}\right)^{\alpha} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where $\bar{u}_{(z)}$ represents the average wind speed at the desired height.

$\bar{u}_{(z_{ref})}$ represents the average basic wind speed adopted by the European Center at an height of 10 m.

Z is the height at which the wind speed is required to be calculated. In our research, we used the heights of 70, 80, 90, and 100 m.

Z_{ref} represents the basic height used in the wind speed data approved by the European Center, which is 10 m.

As for α, it represents the Surface Fraction Coefficient, and its values for different topography are shown in the following table [13]:

Table 1. Surface Fraction Coefficient (α) values for different topography.

Type of topography	α
Lakes, oceans, and hard lands are smooth	**0.10**
High grasses on flat ground	**0.15**
High crops and a fence of trees	**0.20**
Countries with many trees	**0.25**
A small country with some trees and shrubs	**0.30**
A city containing high-rise buildings	**0.40**

The average wind speed was calculated at several heights (70, 80, 90, 100) m, where it was possible to identify the behavior of the wind during the chosen time period, and it was observed that the average wind speed changed from one month to another, from one season to another, and from one year to another when changing the height of the wind turbine. The real power extracted from the wind was also calculated using equation (1) and its effect by changing the heights of the wind turbine used. It was found that by increasing the height to 70, 80, 90, 100 m, the wind power increases each time.

3. Experimental details

3.1 Study area

The study area of this research is Basrah Governorate. It's located between two latitudes of (29.05 - 31.20) north and two longitudes of (46.40 - 48.40) east in the southeast of Iraq, Fig. (1). It is bordered by Kuwait and the Kingdom of Saudi Arabia to the south, and Iran to the east. With its local borders with the governorates of Dhi Qar and Maysan to the north and the governorate of Muthanna to the west, the governorate is centred in the city of Basra[14].

With 2.9 million residents as of the 2018 census, In terms of population, the Basra Governorate is the third largest in Iraq. and ranks sixth in terms of territory (19,070 km2). Economically speaking, Iraq's sole port is in the Basra Governorate. and primary seaport for the Arabian Gulf.

It features oil fields like as the Rumaila and Shuaiba fields, and due to its location in Mesopotamia's fertile plains, it is regarded as one of the primary centers for rice, barley, wheat, and millet production. It is located on a diversified landscape that includes plains, mountains, plateaus, and deserts. Basra has a hot desert climate with a wide variation of temperatures. If the average annual temperature is 24 degrees Celsius, the average annual temperature in July reaches 34 degrees Celsius and drops to 12 degrees Celsius in January, while the average maximum temperature in August rises to 41 degrees Celsius and the average minimum temperature falls to 7 degrees Celsius in January [15]. In the summer, there are two types of wind phenomena:

The south-easterly (sharqi) wind is dry, dusty, and can reach speeds of up to 80 km/h. It blows from April to June and again from late September to November. From mid-June until mid-September, the prevailing wind is the (shamal), a steady wind coming from the north and northwest. The (shamal's) varied, dry air allows for intense solar heating with a cooling impact. Alongside strong winds come dust storms that can reach heights of several thousand meters, creating dangerous flying conditions and sometimes closing airports [16].

Basra receives little rainfall, with an annual total of less than 140 mm, and it is seasonal, beginning in October with a monthly average of less than 1 mm, peaking at 29.3 mm in December, then declining to 7.8 mm in May, after which the rain stops from June to September. The city's annual average relative humidity is 60%, which peaks in the winter to 78% in January and falls to 48% in August [17].

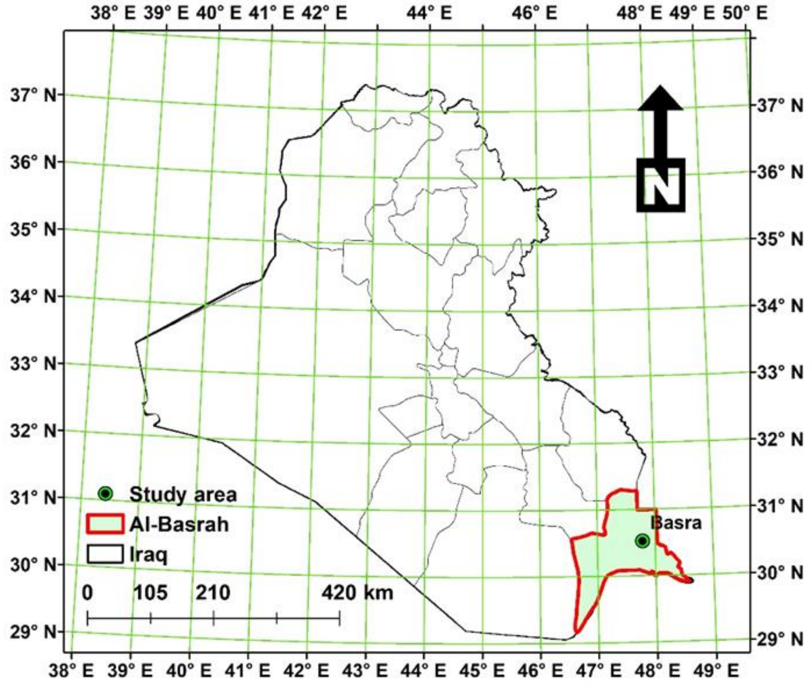

Fig. (1) The study area in Iraq

3.2 Obtain data

The study used monthly Wind Speed (WS) data for Basrah city (Lat. 30.5 N, Long. 47.8 oE) from the European Center for Medium Range Weather Forecasts (ECMWF). Basra Governorate was chosen as a study area because it has a good average wind speed as it overlooks the Arabian Gulf. An area in the governorate was chosen that is characterized by high grasses on flat land. Monthly wind speed data was used for a period of 30 years from (1/1/1982) until (1/1/2021) and at an height of 10 m.

Basra Governorate was chosen as a study area because it has a good average wind speed as it overlooks the Arabian Gulf. An area in the governorate was chosen that is characterized by high grasses on flat land. Monthly wind speed data was used for a period of 30 years from (1/1/1982) until (1/1/2021) and at an height of 10 m from the European Center for Weather Forecast (ECMWF), and then the average wind speed and wind power were calculated in Basra Governorate and at different heights, as explained in detail in the practical part.

4. Results and Discussion

The change in average wind speed in Basra Governorate at heights of 10, 70, 80, 90, and 100 m above the Earth's surface with the monthly time series selected from (1/1/1982) until (1/1/2021)) is shown in Fig. (2).

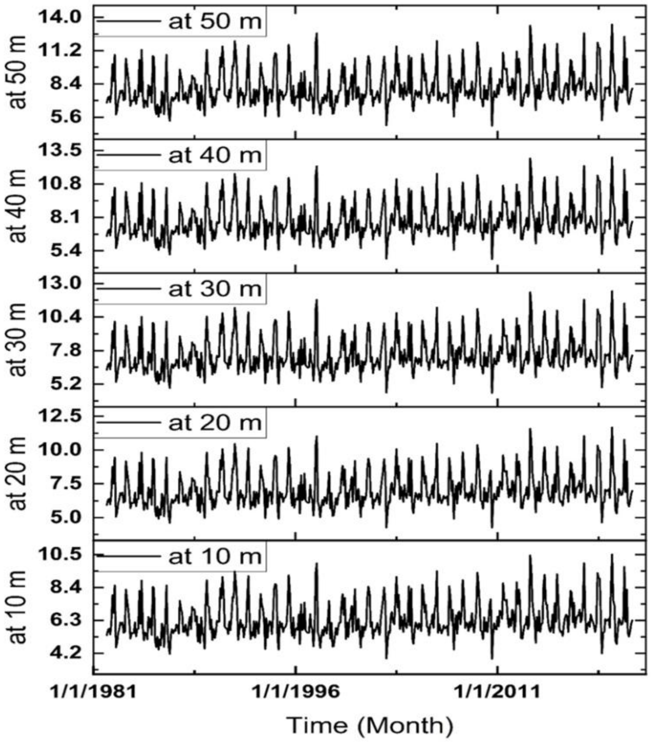

Fig. (2) The relationship between wind speed at heights (10, 70, 80, 90, 100) m with the monthly time series over 30 years.

It is noted that when the height increases, the average wind speed increases, as the dark blue color shows the average wind speed at an height of 100 meters above the ground, and it has the highest values (14.87) m/s when compared to the rest of the wind speed rates at heights of 10, 70, 80, and 90 m. It was possible to identify the behavior of the wind during the chosen time period, and it was observed that the wind speed changed from one month to another, from one season to another, and from one year to another when changing the height of the wind turbine.

The wind power was also calculated based on equation (2-4) and assuming that the radius of rotation of the wind turbine (turbine blade) used for all heights is (50) m, as it was found that if the height of the wind turbine is equal to 70 m, the highest value of the wind power is equal to (5.41) MW, and the lowest value was (0.26) MW, as shown in the Fig. (3).

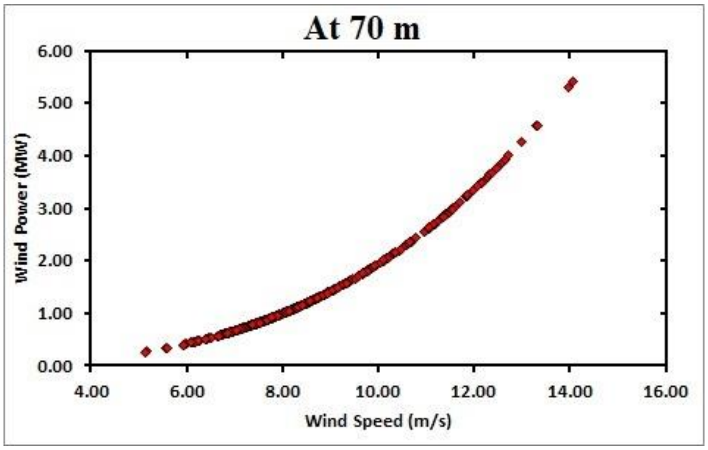

Fig. (3) The relationship between wind speed at a height of (70) m and wind power.

In the case of the wind turbine height of (80) m, the highest value of wind power reached (5.75) MW and the lowest value reached (0.28) MW, as shown in Fig. (4).

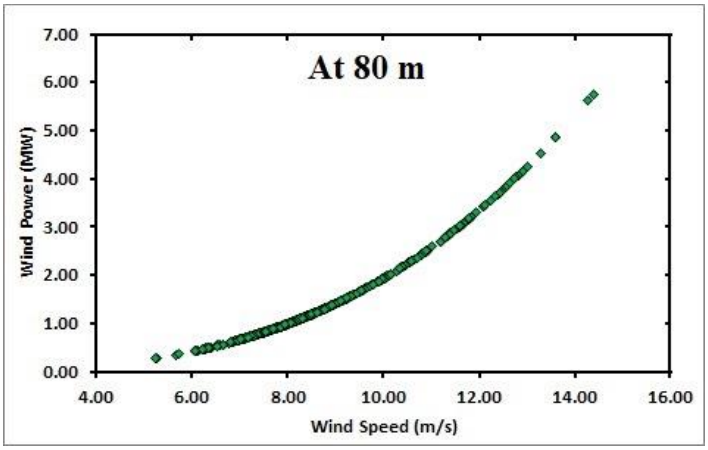

Fig. (4) The relationship between wind speed at a height of (80) m and wind power.

When the turbine height was increased to (90) m, the maximum value of the wind power reached (6.06) MW, and the lowest value reached (0.29) MW, as shown in Fig. (5).

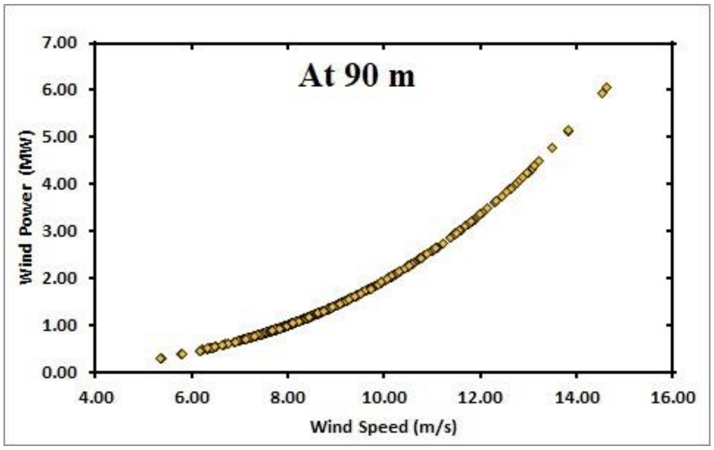

Fig. (5) The relationship between the wind capacity at a height of (90) m with the wind power

The greatest value obtained for wind power for all heights used was (6.36) megawatts when the wind turbine was (100) m above the ground. The lowest value was (0.31) megawatts, as shown in Fig. (6). In all cases and for all heights used, we notice a logarithmic increase in wind power with increase average wind speed for all heights.

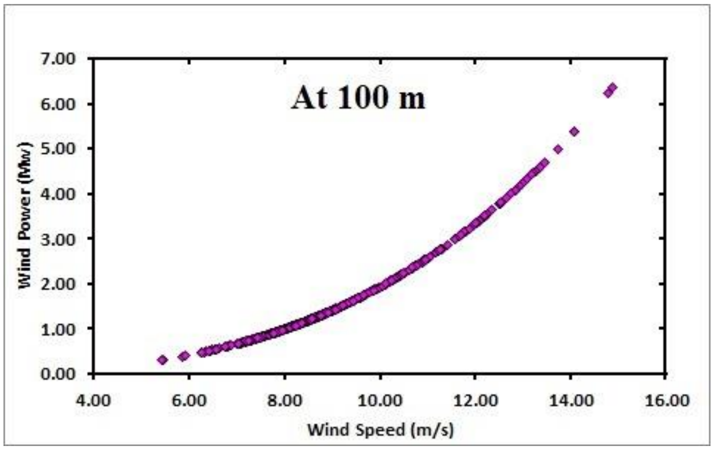

Fig. (6) The relationship between wind speed at an height of (100) m with wind power.

5. Conclusions

The results showed that the change and fluctuation of the monthly, seasonal and annual values of average wind speed during the study period and the average wind speed is affected by the height above the Earth's surface, as the average wind speed increases with the height of the wind turbine, Also the results explained that the wind power increases when the height of the wind turbine increases and the relationship between wind power and wind speed is a logarithmic relationship, where the wind power reached (5.41) MW when the turbine height was (70) m, and it reached (5.75) MW when the wind turbine height was (80) m, but in the case of the wind turbine height (90) The wind power reached (6.06) MW, and the greatest power obtained at height of (100) meters reached (6.36)MW.

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