CENTRAL ASIAN JOURNAL OF
MEDICAL AND NATURAL SCIENCES
https://cajmns.centralasianstudies.org/index.php/CAJMNS
*Volume: 05 Issue: 04 | October 2024 ISSN: 2660-4159*

*Article*

# Manufacture of a Horizontal Type Wind Turbine WIND MILL and Study of Its Characteristics in the Qayyarah Region

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**Abstract:** The main goal of our research is to design a windmill to withdraw and pump groundwater in agricultural areas where delivering electrical current is expensive and requires high voltage. We designed, manufactured, studied and described horizontal axis wind turbines, as the system was designed locally. It is considered one of the best options for low-speed winds. The turbine contains ten blades, the length of each blade is 1.2 meters, and the turbine area is 4,524 square meters, with the height of the wind turbine tower reaching 8 meters. The gearbox contains 2 gears, one of which is a small one consisting of 24 teeth called Driver and the large gear contains 120 teeth called Driving, where the conversion ratio is 5:1 in order to obtain a lower speed and greater torque. The best characterization of the system was studied at low wind speeds, as the turbine power depends on the wind speed. It is suitable for use in the Qayyarah district during the summer. The cost of this project is very low compared to other projects that are used to pump water. It is also considered important for reducing desertification and increasing investment.

**Keywords:** Manufacture, Horizontal Type Wind Turbine, Wind Mill

**Citation:** Bakkal, A. A., & Mahmoud, Y. H. Manufacture of a Horizontal Type Wind Turbine WIND MILL and Study of Its Characteristics in the Qayyarah Region. Central Asian Journal of Medical and Natural Science 2024, 5(4), 485-495.

Received: 2nd Aug 2024
Revised: 9th Aug 2024
Accepted: 16th Aug 2024
Published: 18th Aug 2024



## 1. Introduction

There is currently significant global progress to capitalize on the need for renewable energy by converting wind energy into mechanical form through the design and construction of various forms of windmills. The main interest in wind energy is that the conversion process does not release carbon emissions into the environment and results in less resource consumption. In order to mitigate the side effects of fossil fuels, the use of renewable energy sources has become extremely important. In this regard, wind energy is considered one of the promising renewable energy sources that can be generated continuously by the forces of nature and the design of the rotor blade is considered crucial in harvesting wind energy optimally [1].

### Previous studies:

Study and design (Abdel Basit Muhammad et al.): (2021 AD) Determining the optimal design of the rotary blade for wind-powered water pumping systems for selected local sites. A study was conducted to improve the design and performance of the rotor blade suitable for low wind conditions. The rotor blades of windmills are aerodynamically designed based on an airfoilSG6043 and wind speed data at selected local locations. The aerodynamic profile of the rotor blade that can deliver the maximum power coefficient is calculated, which is the relationship between real rotor performance and the wind energy available in a given reference area. Various parameters, such as blade shapes, chord distributions, tip speed ratio, specific geometric angles, etc., have been used to optimize the blade design with the aim of extracting maximum wind energy for the water pumping system. A windmill rotor with diameters of 10.74 m, 7.34 m and 6.34 m and three blades was obtained for the selected sites in Abomsa, Metehara and Ziway in south-eastern Ethiopia. While optimizing the performance of rotor blades, blade element momentum (BEM) theory was used and the iteration was solved by MATLAB® coding [2]. Dalero and Musa designed (2021 AD) the performance of a prototype of a water pump for pumping water in the KPAKUNGU community in Niger State, Nigeria. This research deals with providing water to a community in Nigeria using wind energy. The design results show that a windmill with a diameter of 2,076 meters is needed to pump water from the well over a total head of 45 meters to meet the daily demand of 3.5 cubic meters of water. Performance testing of the horizontal axis wind pump was carried out. The lowest wind speed measured during the test was 0.4 m/s, while the corresponding water discharge flow rate was 0.032 L/s. The highest flow rate of 0.113 L/s was recorded at a wind speed of 2.4 m/s. Computer simulation was performed to validate the performance testing of the windmill prototype. The results showed that water discharge is proportional to wind speed [3].

Study (Saint Debbie Christmas Dew et al.): (2020) Traditional Indonesian windmill in Demak, Central Java for water pumping in traditional salt production. This study aims to identify the performance of the wind pump of salt farmers from Demak region, Central Java to raise water using a vertical reciprocating pump. The shaft rotation is directly converted into linear translation by the crankshaft and is connected to the piston pump. This study uses three variations of the crankshaft arm length in a piston pump. In the wind speed range of 2 to 5 m/s, Demac windmills with boom lengths of 5.0 cm, 7.5 cm and 10.0 cm have an average volumetric flow rate of 0.89 L/s, 1.8 L/s and 1.3 L/s, respectively. For a single day, these variations average daily volumes of 19,278 litres, 39,162 litres, and 27,804 litres [4].

Study and design (Nabil Al-Mayahi et al.): (2022) Design of a water pumping mechanism using wind energy (analytical study). The main objective of this study was to design a wind-powered water pumping turbine. One of the most important results of the study was the design of a pump to raise water from a well using wind energy to irrigate farms with an area of (2.5) hectares. A two-piston pump is designed, the first to draw water from the well and the second to push water into the reserve tank. (Irrigation is done during periods of unavailability of rainwater). The software used under study is MATLAB for the analysis and Solidworks for the 3D pump. The place of work is Iraq, Mosul. [5] Review (Omar Abdel Karim Qasim and Ahmed Samanji): (2021 AD) A review of the effects of stiffness and rotor size on windmills that pump water. In this paper, horizontal axis multi-blade wind turbines, which are used for water pumping, are discussed. In addition, a literature review was described, which provided basic design requirements for windmill rotors such as stiffness, diameter and tip speed ratio, as well as information provided about the materials used in manufacturing. The research for this research focused on the effect of the number of blades to achieve the main goal and the best performance at existing wind speeds [6].

Study and simulation (Khaing Zaw Lin et al.): (2018) Aerodynamic analysis of the curved blade of a water pumping mill. Aerodynamic analysis of the curved blade of a windmill was simulated by comparing NACA standard airfoils. Two-dimensional numerical modeling of the windmill airfoil was performed using COMSOL Multiphysics software. The velocity and pressure distribution around the airfoil can be verified from the simulation results. The 2D airfoil geometry is realized in COMSOL's geometry tools. A two-dimensional model and a steady-state model were used, and boundary conditions were taken into account within the calculations, such as the flow in the wind tunnel [7].

Rajesh Kohit designed (in 2018) the design and manufacture of a wind-powered water pump. In this project, we used a vertical axis multi-blade wind turbine and a single-acting reciprocating pump. The windmill is connected to a reciprocating pump through two bicycle discs. These disks are installed and connected to each other. The blade is positioned outside the edge for better performance. Wind imposes two driving forces - lift and drag - on the turbine blades. When these forces act on the blade, it rotates and this rotating blade converts the rotary motion of the windmill into the reciprocating motion of the pump. This is how water is drained. Apart from this, we also generate electricity. This applies to pumping water for irrigation [8].

Study and design (Mr. Thangaraj et al.): (2021) Manufacturing of a water pumping system using a vertical axis wind mill. In this system, a vertical axis multi-bladed wind turbine with a piston pump is used. This windmill is connected to a piston pump through two discs screwed together. The blades are positioned outside the edge for better performance when the wind imposes both lift and drag forces on the blades. This rotating blade converts rotary motion into reciprocating motion for the pump that is used to deliver water. This system mainly uses water pumping for irrigation purposes [9].

Study (Ahmed S. Awad): (2021 AD) Practical design and testing of wind-powered water pumping systems. Classic 24-blade windmills are the most common type of windmill chosen for the current study. The goal of this study can be achieved through careful design of the rotor, transmission system, and pump. Good pump design will increase the efficiency of the system. The design was done and all calculations showed very good pumping productivity. The model is then manufactured in the College of Engineering workshop from local materials. It is designed to be used in wind speeds of approximately 3.5 m/s at a tower height of 8 metres. The goal is to pump 15 m3/day of water to cover the needs of the Student Services Building. Testing after installation showed that a pumping flow rate of 0.2 L/s was achieved; This result shows that the designed and manufactured wind pumping system can pump a larger than standard volume allowing water to be stored [10].

Designed by (Jamal Al-Din et al):(2019 AD) Design of a prototype of a wind-powered water pump for irrigation purposes. The main objective of this research was to produce a prototype of a simple water pump using a TSAV (vertical axis wind turbine) wind turbine as the main drive and to analyze the relationship between wind speed and windmill rotation speed with the dependent variable in the form of water flow from the pump. The study used experimental and design methods. Test results obtained a wind speed of 3.6 m/s at an average windmill rotation of 5.6 rpm. Based on the ANOVA test, there was a significant difference in wind speed in morning, afternoon, evening and night. The highest wind speed occurred during the day at 4.3 m/s, while the lowest wind speed occurred at night at 2.2 m/s. The pump's water discharge rate was 2.0347 liters/min, with a pump efficiency of 89.7%. The analysis results showed that wind speed, windmill rotation, and water discharge could change linearly. The higher the wind speed, the greater the number of rotating windmills, and the greater the discharge of water produced. Therefore the test results of the pump can work well and have the potential to be developed in the area with current wind speed [11].

Study (2018) by Chamlong Prabkyaw and Akapot Tantrapiwat: A study on the potential of wind energy for an agricultural water pumping system in the central part of Thailand. A study was conducted on a wind powered water pumping system for agriculture in the central part of Thailand. In this alluvial plain, wind energy potential was determined by surveying 21 monitoring sites. The survey was conducted within one year, and it was found that this area is located in a calm climate zone with an average wind speed of about 2 m/s. A wind turbine water pumping system was installed and its performance and efficiency were evaluated. The results showed a linear relationship between water drainage capacity and wind speeds. Due to the type of turbines and low wind speed in this area, the efficiency of the system was found to be minimal, yet it was practical because wind energy was free. A simple cost analysis from the survey data also showed that the use of wind turbines in this region would be beneficial when they could be operated for approximately two decades. [12] (2018) Study on wind energy potential for agricultural water pumping system in the central part of Thailand. A study was conducted on a wind powered water pumping system for agriculture in the central part of Thailand. In this alluvial plain, wind energy potential was determined by surveying 21 monitoring sites. The survey was conducted within one year, and it was found that this area is located in a calm climate zone with an average wind speed of about 2 m/s. A wind turbine water pumping system was installed and its performance and efficiency were evaluated. The results showed a linear relationship between water drainage capacity and wind speeds. Due to the type of turbines and low wind speed in this area, the efficiency of the system was found to be minimal, yet it was practical because wind energy was free. A simple cost analysis from the survey data also showed that the use of wind turbines in this region would be beneficial when they could be operated for approximately two decades. [12] (2018) Study on wind energy potential for agricultural water pumping system in the central part of Thailand. A study was conducted on a wind powered water pumping system for agriculture in the central part of Thailand. In this alluvial plain, wind energy potential was determined by surveying 21 monitoring sites. The survey was conducted within one year, and it was found that this area is located in a calm climate zone with an average wind speed of about 2 m/s. A wind turbine water pumping system was installed and its performance and efficiency were evaluated. The results showed a linear relationship between water drainage capacity and wind speeds. Due to the type of turbines and low wind speed in this area, the efficiency of the system was found to be minimal, yet it was practical because wind energy was free. A simple cost analysis from the survey data also showed that the use of wind turbines in this region would be beneficial when they could be operated for approximately two decades [12].

**Research objective:**

The windmill was designed to withdraw and pump groundwater in agricultural areas where electricity delivery is expensive and requires high voltage, as well as far from rivers and lakes. We designed, manufactured, studied and described horizontal axis wind turbines, as the system was designed locally. It is considered one of the best options for low-speed winds. The conversion ratio was 5:1 to obtain lower speed and greater torque.

## 2. Materials and Methods

**Weibull distribution function:**

The Weibull distribution function is named after Waloddi Weibull in 1951, it has been widely used to characterize wind systems. The probability density function for wind speed can be calculated with Equation 1 [13]:

$$f(v) = \frac{k}{c}\left(\frac{v}{c}\right)^{k-1} exp\left[-\left(\frac{v}{c}\right)^{k}\right] \tag{1}$$

Where f (v) is the probability density function for observing wind speed v, c is the Weibull scale parameter and k is the dimensionless Weibull shape parameter [13, 14].

**Wind energy intensity**

The wind energy density is defined (WPD, Watt/m2) is defined as the wind power available per unit area swept by the turbine blades and is obtained by equation (2) [15]:

$$WPD = \frac{1}{2n}\sum_{i=1}^{n} \rho\,(v_i^3) \qquad (2)$$

Where n is the number of records in the averaging period, ϱ is the air density, and is the cube of the wind speed value [2]. Furthermore, a wind power density calculation (P/A, W/m2) can be developed based on the measured wind speed through Weibull distribution analysis using the following model [15]:$v_i^3$

$$\frac{P}{A} = \int_0^\infty \frac{1}{2}\rho U^3 f(U)dU = \frac{1}{2}\rho c^3 \Gamma\left(\frac{k+3}{k}\right) \qquad (3)$$

Where U is the average wind speed and A is the blade area. The gamma function of (x) (standard form) is calculated as [14]:

$$\Gamma(x) = \int_0^\infty e^{-u}\, u^{x-1} du \qquad (4)$$

**System design:**

The design of the wind-powered water pump can be seen in Figure 1. The manufacturing of the system begins with the process of making the components of the pump and windmills and ends with the process of assembling the system. The type of windmill made was a horizontal axis wind turbine (HAWTs). The diameter of the windmill was 220 cm, and 10 blades were made. The fan is made of stainless steel. The height of the tower was 8 metres. The pump made was a piston type water pump made of iron pipes. A piston pump consists of three main components, namely the pump tube, valve and piston. The pump pipe is 100 cm long and 2.5 inches in diameter (6.35 cm). The pump suction hose was inserted into the water source at a depth of 20 m between the water surface and the pump.

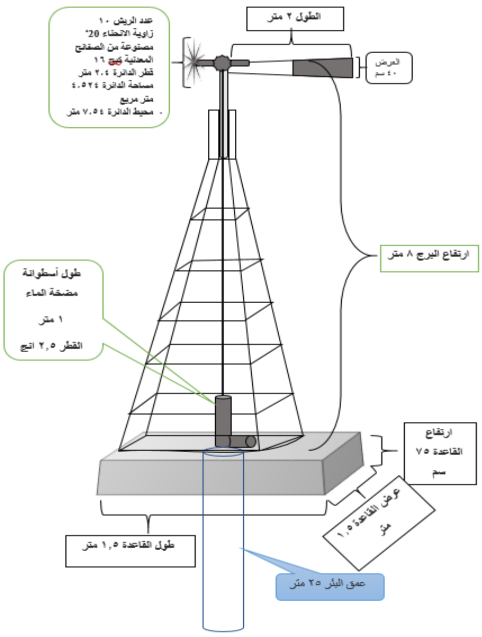


**Figure 1**. Wind water pump diagram

**Rule**

The turbine base was designed and manufactured from materials available in local markets, which are cheap in cost and high in performance. It is designed to withstand the pressure and vibration of the turbine. It is in the form of a square base made of reinforced concrete, with a height of (75 cm), width (150 cm), and length (150 cm). The turbine tower is well fixed on the concrete base to resist strong winds.

**Fan blades**

The blades are made of iron, a strong and non-shockable material (16 mm). It has a trapezoidal shape with dimensions (width 15-20 cm, height 120 cm). The number of blades is 10, the diameter of the circle is 240 cm, its area is 4524 square centimeters, and the circumference of the circle is 754 cm. When the wind hits the blades, the wind energy is transformed into rotational kinetic energy. These blades are attached to a pivot via a blade loading lever, as shown in Figure 2.

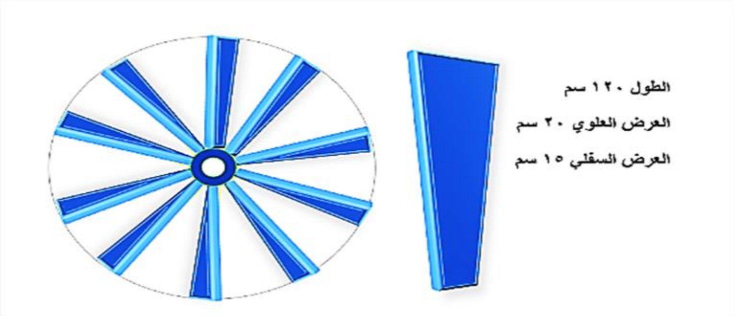


**Figure 2**. Fan blades design diagram

**Turbine**

The ten blades are mounted on a transmission containing a circular gear tightly mounted on a circular cylindrical shank made of steel, 60 cm long and 35 mm in diameter. The rotary transmission is fixed in the upper center of the tower by two ball bearings to hold the structure. (Figure 3).

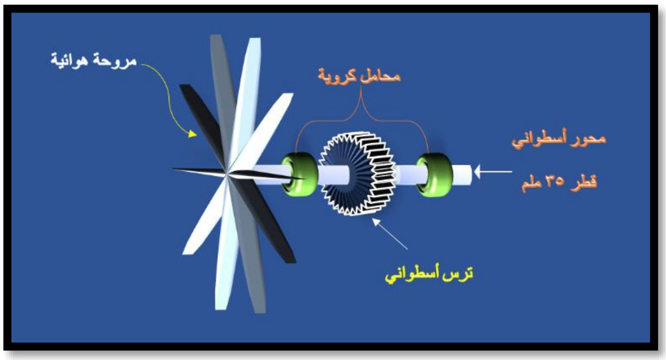


**Figure 3**. Turbine design

**Axis**

A heavy-duty steel shank was used to withstand the pressure and tension of the axle. The stem is 3.5 cm in diameter and 80 cm long. It is responsible for communicating the movement of the blades fixed to the axis through the blade loading arms generated by wind energy. The shaft is connected to the turbine structure by ball bearings. The thickness of the shaft is 2 cm and its diameter is 3.5 cm. As in Figure (4).

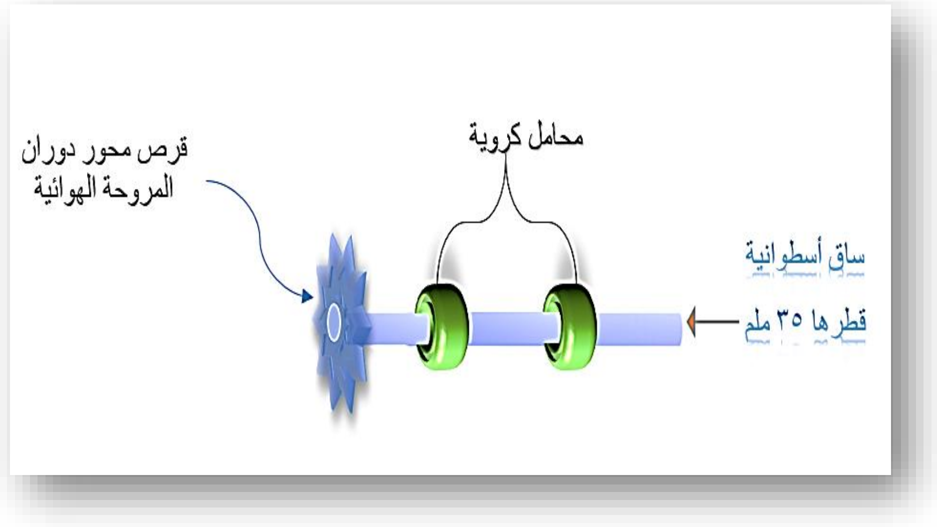


**Figure 4**. Design of the axle and bearings

**Tail Design**

The tail of the wind turbine is located on the opposite side of the wind turbine assembly. The tail has two main functions:

The first job is to ensure that the wind blades are always facing in the direction the wind is blowing. This ensures optimal interaction with the wind and rotation of the blade assembly. The tail wing consisted of a trapezoidal steel frame 2 m long, 40 cm wide, 20 cm frontal and flat sheet metal. This frame allows the tail to withstand the forces exerted by the wind on the propeller. The flat sheet metal is the main component responsible for the rotation of the tail fin, which is achieved by balancing the lift force on both sides, as shown in Figure 5 below:

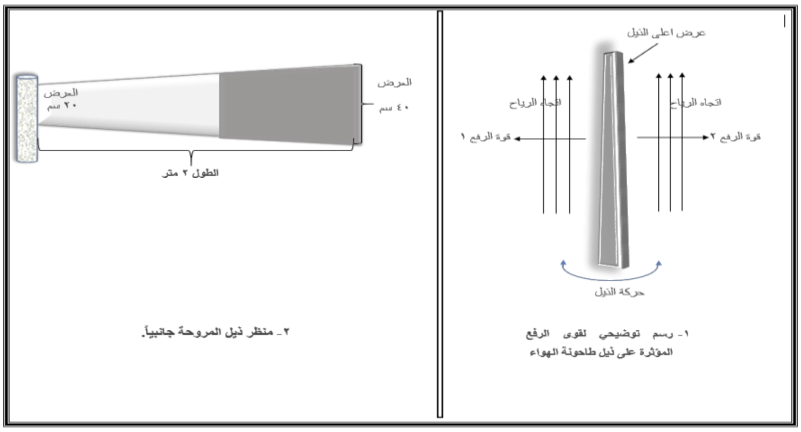


**Figure 5**. Diagram of the propeller tail and the force acting on it

The wind causes lift 1 and lift 2. If the two lift forces are not equal, the tail rotates in the direction of the tail motion mentioned above until equilibrium is achieved. The tail fin is connected to a gearbox that rotates until the propeller assembly faces the wind direction.

The second function of the tail fin is to balance the torque generated by the rotor assembly. If this torque is not balanced, it may eventually cause the rotor to fail.

**Turntable:**

The rotor plays a very important role in the overall design of a wind turbine. The rotating disk allows the wind turbine to move along a vertical axis. The proper design of the rotor disk allows the wind turbine to rotate and face the wind thanks to the tail assembly.

In wind turbine designs, the rotor disk design consists of a cylindrical casing. The outer shell is strong and welded to the top of the platform. This shell has a concentric inner shell. This inner sleeve is welded to the gearbox base. It has two bearings that allow it to rotate along a vertical axis. There is a needle bearing in the base and a ball bearing in the neck. This reduces friction when turning in the wind. Figure 6 below shows a cross-sectional view of the turntable.

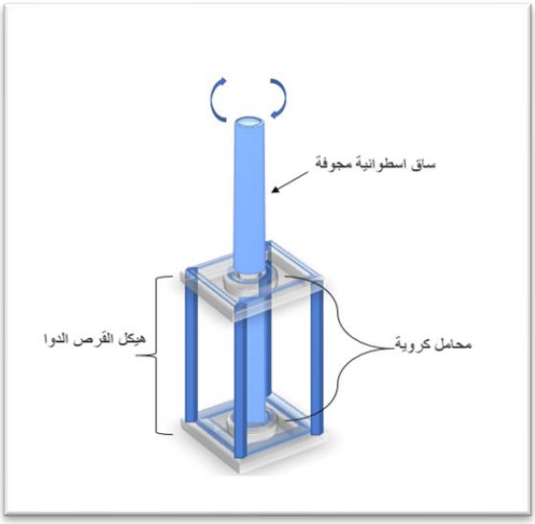


**Figure 6**. A cross-section of the rotating disk design

The welds at the top of the drilling rig should be somewhat reinforced in addition to the strong welds. This will also enable the rotor to withstand stresses caused by different bending moments caused by the interaction between the wind turbine and the wind.

**Working of the wind turbine system to withdraw groundwater:**

The windmill rotates when the blowing wind hits the windmill blade. The blades converted the dynamic movement of the wind into the rotation of the mill. The rotary motion of the pinwheel was converted into translational motion (back and forth) by the crankshaft which resulted in the pump working. The backward movement of the piston causes water to be sucked into the pump pipe through the suction valve (suction step). After the backward motion reached its peak, the piston motion changed direction to forward motion causing water to be pushed out through the exhaust valve (exhaust step). During the suction step, the pump's suction valve is automatically opened while the exhaust valve is closed. This happened in reverse in the ignore step process. The windmill blade is 1.2 meters long and 2.4 meters in diameter. The wind blow area against the mill was 4,524 $m^2$. The length of the crankshaft was 8 meters, the length of the pump also reached 1 meter, and the total height of the tower supporting the windmill reached 8.4 meters. As in Figure (7).

**Figure 7**. The final design of the windmill

To determine the system performance, the wind turbine and water pump were considered as one piece of equipment. All frictions between these two devices were considered losses to the system. Therefore, the energy input to the system is wind energy, which is determined by the following equation:

$$P_W = \frac{1}{2} \rho A\, V^3 \qquad (5)$$

Where ϱ The density of air is equal to 1.2 kg/m3, and A It is the projected area of the wind turbine perpendicular to the turbine's axis of rotation, and V It is the wind speed. For the system output (water injected by the pump), the power can be written as follows:

$$P_w = \frac{\rho_w g H Q \times 10^{-3}}{60} \qquad (6)$$

Where $\rho_w$ is the density of water at 1000 kg/m3, and g is the gravitational acceleration, and H she to rise Pump head, f Q she Water flow rate. Considering the input and output power, the efficiency of the wind turbine pumping system can be determined as follows:

$$\eta = \frac{\rho_w g H Q * 10^{-3}}{\rho A V^3 * 30} \qquad (7)$$

The system efficiency is relatively low, but the input power is free. The system is economically viable. Compared to other energy sources, including electric motors and diesel engines, a simple analysis of investment and operating costs shows that a wind turbine with an average wind speed of 2 m/s can pump about 500,000 liters of water per month. Fortunately, wind turbines do not require fuel and only require simple maintenance once a year. For the same pumping rate, electric motors and diesel engines have the lowest initial costs because they operate for only two hours a day and the engines can be operated anywhere. On the other hand, electric motors can be powered by cheaper energy sources, but the initial cost is relatively higher than motors because electricity is not available and they have to be built in rural areas. This estimate is based on current average prices for equipment and energy. If energy prices rise in the future as expected, the investment in wind turbines could be recovered early.

## 3. Results and Discussion

Wind speed is an important factor in wind energy research, and the experiment was conducted in Al-Qayyarah district area Located on a line of longitude (35.79) East and latitude (43.27) north. As shown in the figure9, the energy changes were analyzed and measured directly (before) and when the wind speed passed through the turbine (after), since the energy depends on the third exponent of the speed, according to the equation fig (5) and (6). It appears that the energy increases as the wind speed increases. The speed of the wind before it passes through the turbine generates power when it passes through the turbine, given the area of the turbine, and after interacting with the blades, the turbine moves to benefit from the wind energy, so power decreases after the turbine due to the availability of movement and torque [15]. The turbine power factor is a function of the tip speed ratio and depends on the diameter of the wind turbine. The turbine efficiency value is the power factor that represents the ratio of turbine output to input for a fixed wind turbine area. In this case time has no effect, but wind speed and energy have an effect. The geometry of the parabolic blade is chosen to utilize maximum air volume at minimum wind speed.

## 4. Conclusion

The results of the survey and design showed that the agricultural area in MD in ah the QYara enjoys a moderate climate throughout the year, and the wind speed generally reaches about 2 meters/second. At this low level of wind speed, a wind turbine was chosen with a horizontal axis multi-blade and installed at the pilot site. Tests were performed to evaluate the capabilities of the pumping system Water with energy Wind. Based on turbine performance and survey data, a cost analysis was performed Where it turns out the use of wind turbines is beneficial in areas where electricity is difficult to reach, as well as areas far from rivers and lakes.

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