Wind energy applied as a sustainable technology to produce electrical energy in Basra

Ahmad K Jassim1,* and Adnan A Ateeq2
1Research & Development Department, The State Company for Iron and Steel, Iraq, Basra
2Basrah Engineering Technical College, Southern Technical University, Iraq, Basra
*Email: ahmadkj1966@yahoo.com

Abstract. Wind energy is one of the main renewable energy sources that applied as sustainable technology to produce electricity. It is an environmentally friendly system that generating electricity without using any consumable materials and without producing any greenhouse gases and waste. In this research, a horizontal upwind turbine system was designed and manufactured with three blades using polyvinyl chloride PVC and high-density polyethylene HDPE, Aluminium and carbon steel material. It was applied to study the efficiency of the wind energy system in Basra to produce electricity in different airspeed and directions. The results show that the maximum airspeed in Basra is 6 m/s at a height of 4 m which produced 21 Volt and 1323 Watt. The greatest range of speed is 4-5 m/s on the south, east and north. However, the lowest airspeed is 2.45-3.5 m/s on west direction. Moreover, PVC material is not suitable to produce wind blades because it is broken fast due to a sudden change in the air direction.

1. Introduction
Energy is a basic necessity in a civilized world which is playing a major role in any field of activity involving people. The overpopulation and fast growth of activities and technology lead to raise energy consumption and demand. Therefore, the traditional methods that applied to produce electricity generated a high amount of emission and waste which affected our environment and resource. Moreover, climate change and global warming are predominantly caused by the emission of carbon dioxide generated by the traditional power station. For that reason, the designer is focusing on Sustainable Manufacturing Process SMP to eliminate the negative environmental impact and save natural resources [1-6].

SMP is well-defined as the formation of products for present-day without compromising the ability of upcoming generations by minimizing the negative environmental impact, conserve energy and natural resources. Renewable energies become a wonderful economic opportunity for states looking for clean energy technologies which do not cause any side effects [7-9].

Wind energy is one of the main renewable energy sources that belong to the sustainable manufacturing process can be applied to produce electricity without consuming any materials and without any environmental impact. It is the fastest-growing renewable energy source. The production of wind energy is a dynamic and nonlinear process that is affected by several factors such as turbine positions, windmill and blades orientation. Moreover, it is a non-programmable form of generation, which can be considered as a randomly and discontinuously resource. Although, it is hard to identify in advance the amount of wind energy that can be generated. Wind energy can be considered as an economically viable and financial profitable project which becomes self-sustainable finance. Wind turbines should be optimized by considering the swept area, in terms of the local area conditions to capture power as maximum as possible [10-17].
Wind energy is defined as an environmentally friendly technology because it does not cause any acid rain, no carbon dioxide emission and no radiation effect. The application of renewable energy resources to produce electrical energy will be increased up to 6% until 2030. It is currently meeting nearly 14% of energy demand worldwide. A wind energy system can be classified into three types that include horizontal axis wind turbine, vertical axis wind turbines and the H-rotor. The most communal type of wind energy is the horizontal axis wind turbine. Horizontal-axis wind turbines can be classified by their technical characteristics, including rotor placement (upwind or downwind), the number of blades, rotational speed and wind turbine capacity. However, the most modern wind energy system has three blades rotating around the horizontal axis [15-18].

Wind energy is conversing into more useful forms by using a wind turbine to produce electricity. It is an abundant and renewable resource of energy that can be widely distributed. Moreover, it is cleansing and mitigating the greenhouse effect when it is applied instead of fossil-fuel-derived electricity. The main advantages are including gain energy independence, ease demand on the power grid, reduce vulnerability to volatile utility costs and air pollution. Although it is environmentally friendly and cheaper renewable energy that will protect the earth, it has some limitations. The most critical environmental impact is noise pollution and visual interference [6, 19].

K. Beldoud et al, [8] made evaluation and investigation of wind energy generation and power control that installed near to Rabah Bitat international airport of Annaba in Algeria. Moreover, R. D. Labati et al, [10] presented a novel decision support system to predict the production of wind energy. In addition, Q. Yang et al, [4] studied the environmental sustainability of wind power in China by making energy analysis of wind farm. The results show that wind energy has a much more sustainable advantage comparing with solar energy. It has better renewability with high productivity and lowers environmental impact [4, 8, 10].

S. M. Salih et al studied the performance analysis of small wind turbine systems based on the different parameters that include air density and pressure, atmosphere temperature, wind speed and the length of wind energy blades. The result demonstrates that there is a high effect of air characteristics on mechanical and electrical power. On the other hand, P. Quan and T. Leephakpreeda studied the financial feasibility of wind energy in Thailand for one year measuring data at three levels of 65, 90 and 120 m [20, 21].

2. Wind Speed
Wind speed differs according to geographical locations, time of day, height above the earth’s surface and weather. It found that the height of the tower and diameter of wind blades has a direct relationship with the productivity of wind energy. The average wind speeds at height of wind tower up to 10 m equal to 4.4 to 7 m/s. [22, 26].

3. Wind Energy in Iraq
A few attempts have been made since 1960 till now to analysis wind energy in for nine cities in Iraq which are Mosul, Anah, Baghdad, Habbania, Rutba, Hal, Najaf, Nasiriyah and Basra [22]. The results show that wind speed reading lied in the range of 2.5 m/s and the greater speed was 5 m/s at a height of 10 meters above the ground in the open area. The best wind speed in Basra equal to 4.1 - 5.0 m/s in the North-West direction [22, 26].

S. K. Ameen et al, [23] had been studied the environmental impact of wind energy to generate electric power in Iraq. The results show that Basra and Baghdad are the best places for implementing the project. Aida M J Mahdy et al, [24] had been found that the acceptable wind speed in Iraqi is in winter season and the best usage of wind turbines for lighting highway. Wind speed less than 5 m/s on average make the use of wind speed not economically feasible. Iraq is considered as low wind speed area and some parts have high speed. Therefore in this research, wind energy applied as a sustainable technology to produce electrical energy in Basra city to study the feasibility to establish and insulation wind energy station in Basra.
4. Experimental Work

4.1. Material
Different type of materials had been used to manufacture wind energy blades which include aluminium metal, PVC and HDPE material to study the effect of these materials on the efficiency of wind energy system. However, wind energy structure was made from carbon steel material.

4.2. Wind Tower
Wind tower with dimension shown in figure 1 was manufactured from a galvanized carbon steel material with length 4 m and tapered diameters ranged 18-23 cm.

![Figure 1. Galvanized carbon steel wind tower](image)

4.3. Wind Blade
Nine wind blades were manufactured from aluminium, polyvinyl chloride PVC and high-density polyethylene HDPE materials with dimension shown in figures 2 to 4.

![Figure 2. Aluminium wind blades](image)

![Figure 3. PVC wind blades](image)

![Figure 4. HDPE wind blades](image)
4.4. Rotation Body
Rotary body for wind energy system was manufactured from carbon steel structure as shown in figure 5.

![Rotation body for wind energy system](image)

Figure 5. Rotation body for wind energy system

4.5. Power Transition System
Two types of transitions system are used in this research to convert power from one shaft to another by using pulleys with different diameters. Chain system and V-belt pulley system were used with diameters of 300 mm as a driver and 30 mm as driven to increase the rotary speed of the wind energy system as shown in figure 6-7. They were used to study their effect on the efficiency of wind energy.

![Two wheeler chain sprockets kill](image)

Figure 6. Two wheeler chain sprockets kill

![Pulley transition system](image)

Figure 7. Pulley transition system

4.6. Rotary Flange
The rotary flange was manufactured from carbon steel to support and fix wind tower with wind tow as shown in figure 8.

![Rotary flange system](image)

Figure 8. Rotary flange system
4.7. Wind Direction plate
Wind direction plate was manufactured from carbon steel plate to control wind blades direction and orientation with a high speed as presented in figure 9.

![Wind direction plate](image)

Figure 9. Wind direction plate

4.8. Electrical Motor Generator
Electrical motor with capacity voltage of 48 V type Hall Motor JBM14-48V is used to transmit kinetic energy to electrical energy as shown in figure 10.

![Electrical motor-generator](image)

Figure 10. Electrical motor-generator

4.9. Electrical Transportation System
The electrical transportation system was manufactured from different parts as shown in figure 11. It was used to transport electricity from wind energy generator to final use.

![Electrical transportation system](image)

Figure 11. Electrical transportation system

4.10. Wind Tower Foundation
Carbon steel structure as a square section was manufacturing by using carbon steel channel section to build a base of the wind energy system by welding the parts together as a mobile foundation can be fixed any place with bolts, nut and washers as shown in figure 12.
4.11. Assembled Wind Energy System
All parts of the wind energy system that manufacturing was assembled and fixed in Basra in the South of Iraq as shown in figure 13 and 14.

5. Results and Discussion
5.1. Wind Speed and Direction
Wind speed was measured by using EXTECH instrument type AN 100: CFM/CMM Mini Thermo-Anemometer. It was measured on the date of 13/5/2019 to 21/5/2019 in different directions in north, south, east and west direction at the height of 4 meters. The results of wind speed and their direction are shown in tables 1-4 and figure 15. The maximum wind speed in Basra city is equal to 6 m/s and the greatest range of speed is 4-5 m/s on the south, east and north. However, in the west direction, the lower wind speed appeared which are in the range of 2.45-3.5 m/s. The result values agreed with the results found by Y. H. Mahmood and their group, Darwish and Sayigh [22, 25]. The voltage was measured as an indicator for study the efficiency of the wind energy system. It was found measured voltage increase with increasing wind speed.
Figure 15. Relation between wind speed and direction

Table 1. Measured wind speed in Basra at South

| Wind speed (m/s) | Voltage (V) | Wind direction |
|-----------------|-------------|----------------|
| 3.6             | 15          | South          |
| 4.14            | 16          | South          |
| 4.73            | 20          | South          |
| 6               | 21          | South          |
| 4               | 17          | South          |
| 4.25            | 14          | South          |
| 3.75            | 18          | South          |
| 5.9             | 17          | South          |
| 4.6             | 16          | South          |
| 3.34            | 12          | South          |
| 3.72            | 11          | South          |
| 4.15            | 16          | South          |
| 4.14            | 14          | South          |

Table 2. Measured wind speed in Basra at East

| Wind speed (m/s) | Voltage (V) | Wind direction |
|-----------------|-------------|----------------|
| 4.14            | 14          | East           |
| 4.97            | 17          | East           |
| 4.97            | 16          | East           |
| 4.16            | 16          | East           |
| 6               | 15          | East           |
| 4.8             | 15.5        | East           |
| 4.1             | 15          | East           |
| 3.8             | 10.5        | East           |
| 3.96            | 14          | East           |
| 4               | 11          | East           |
| 4.5             | 13          | East           |
| 3.9             | 14          | East           |
| 4               | 14          | East           |
| 3.6             | 12          | East           |
5.2. Wind Energy Power

Theoretical power can be calculated by using equation (1) and (2) depending on air density $\rho_{\text{air}}$, the diameter of wind blades D and wind speed V [24, 26]. The theoretical results of wind power in Basra for some measured wind speed shown in figure 16. However, the real power values will study in future as future work.

$$\text{Power} = 0.5 \times \rho_{\text{air}} \times A_{\text{blades}} \times V^3$$

(1)

$$A = 3.14 \times \left(\frac{3.5}{2}\right)^2 = 9.61 \text{ m}^2$$

(2)

$$\text{Power} = 0.5 \times 1.275 \times 9.61 \times 6^3 = 1323 \text{ watt}$$
5.3. Wind Energy System Problems

Noise and vibration are the main problems found in a wind energy system that made in this research work. The noise was generated by using chain transition system because of the friction between chain and drives. On the other hand, the vibration was happened due to automatically change of wind direction which leads to a sudden change of wind blades direction. Besides, the wind tower needs to be fixed and tight. Moreover, PVC material is not suitable for manufacturing wind blades because it is very brittle which broken very fast with air direction change.

6. Conclusion

One can summarize the following remarks:

- PVC material is not suitable for manufacturing wind blades because it is a very brittle material that broken during the operation of the wind energy system.
- High-density polyethylene HDPE and Aluminum material are suitable for manufacturing wind blades because they have better properties.
- Car dynamo motor is not suitable for our wind system because it needs high wind speed and rotation to generate electricity. However, bicycle dynamo is more suitable for the system because it works with low wind speed and rotation.
- The position of the wind energy system is very important to generate energy. South and North are the best position in Basra which gives speed between 5-6 m/s. However, West direction gives the lowest wind speed which is lower 4 m/s.
- Wind tower needs to be fixed by using steel wire because there is a vibration that was happened due to an automatic change of wind direction.
- Maximum wind speed is 6 m/s which could generate a maximum theoretical power of 21 V and 1323 watt.

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