Wind Distribution Map of Iraq - A Comparative Study

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Abstract

Wind speed data of 10m in height for 11 meteorological station in Iraq has been studied, to understand and determine the distribution of wind speed. Wind speed values is increased when we go toward the southern region of Iraq because the flatness of the ground surface. The sites of Basrah, Nasiriya and Hai were the best with respect to wind speed, especially, at summer. These sites have an annual average values of wind speed of about 5m/s and more. A good similarity obtained when comparing the prepared wind map of the annual average wind speed, with the wind map of Iraq that produced by the National Renewable Energy Centre of Spain (CENER). This similarity demonstrates the reliability of the local data used in this paper, which means it is certified and a good source for the researchers in the site assessment. Also, this data is useful to the decision maker when he decide to install wind turbine or establish wind farm to generate electric power.

Keywords: Wind Speed distribution, Meteorological Data, GIS, CENER maps.

1- Introduction:

It is evident that the wind power density is strongly affected by the value of wind speed \((v)\) which is regarded as the major factor in the estimation of wind power density, because it is proportional to the wind speed cube \([1, 2]\). Then, wind speed data of a selected site has to be recorded precisely and analyzed to get the best result when achieving the site assessment \([3, 4]\).

Wind speed is affected by obstacles and surface roughness of the site land \([5, 6]\), atmospheric stability \([7]\), geographical location of the site \([8]\) as well as the altitude above ground level which is directly proportion with wind speed \([9, 10]\).

Wind energy which is extracted from the wind itself is a type of renewable energy, that is sustainable, clean and regarded as the least costly type of renewable energy technology \([3,11]\). To get best benefit from the wind speed, wind map of Iraq must be established. Iraqi wind map is very important to recognize the best locations of the higher wind speeds.
Iraqi Wind Atlas (IWA) has been achieved in 2012, by collaboration between the renewable directorate in the Ministry of Science and Technology (MOST), with the National Renewable Energy Centre of Spain (CENER), IWA illustrates the distribution of wind speed, wind direction (Wind Rose), wind power density as well as maps of Weibull distribution [12]. It covers all regions of Iraq at three heights above ground level 30m, 50m and 100m. IWA is certified and published in the site of the International Renewable Energy Agency (IRENA) [13].

2 - Materials and methods

2 - 1 Data

In this paper, the hourly monthly average meteorological data of wind speed [14] in m/s, at 10m height, for 10 years (2000 - 2009) (as listed in table 1), has been analyzed for eleven site in different locations in Iraq using GIS maps, to compare the obtained results with the wind map of 30m in height. Table 2 includes the coordinates of the studied sites.

Table 1 : The hourly monthly average values of wind speed (m/s) analyzed in this paper

| station | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Avg. |
|---------|------|------|------|------|-----|------|------|------|------|------|------|------|------|
| Kirkuk  | 1.6  | 2    | 2.1  | 2.4  | 2.4 | 2.4  | 2.3  | 2.1  | 1.7  | 1.8  | 1.6  | 1.7  | 2    |
| Mosul   | 1.2  | 1.5  | 1.5  | 1.8  | 2   | 1.9  | 1.7  | 1.6  | 1.3  | 1.1  | 0.8  | 1.2  | 1.4  |
| Khanqin | 1.1  | 1.1  | 1.2  | 1.4  | 1.2 | 1.3  | 1    | 0.9  | 1    | 0.9  | 0.8  | 0.8  | 1    |
| Basrah  | 3.9  | 4.1  | 4.4  | 4.3  | 4.5 | 5.9  | 5.3  | 5    | 4.5  | 3.4  | 3.3  | 3.8  | 4.3  |
| Hai     | 3    | 3.9  | 3.8  | 3.7  | 3.9 | 5.3  | 5.1  | 4.7  | 4.3  | 3.2  | 3    | 2.5  | 3.8  |
| Amara   | 3    | 3.5  | 4    | 3.9  | 4.3 | 5.5  | 4.9  | 4.8  | 4    | 3.1  | 2.8  | 2.9  | 3.8  |
| Tikrit  | 2.6  | 2.8  | 3.1  | 3.4  | 3.3 | 3.8  | 4    | 3.8  | 3.3  | 2.9  | 2.7  | 2.6  | 3.1  |
| Baghdad | 2.6  | 3    | 3.2  | 3.4  | 3.3 | 4.3  | 4    | 3.6  | 3.3  | 2.9  | 2.4  | 2.7  | 3.2  |
| Kerbela | 2.1  | 2.6  | 3    | 3    | 3   | 4.3  | 3.7  | 2.9  | 2.4  | 2.1  | 1.8  | 1.9  | 2.7  |
| Diwaniya| 2    | 2.4  | 2.4  | 3    | 2.3 | 2.8  | 2.5  | 2    | 2    | 1.6  | 1.3  | 1.5  | 2.1  |
| Nasiriya| 2.6  | 3.1  | 3.4  | 3.7  | 3.3 | 4.8  | 4    | 3.9  | 3.4  | 2.6  | 2.4  | 2.3  | 3.2  |

Table 2 : The coordinates of the studied sites

| o. | station | Longitude | Latitude |
|----|---------|-----------|----------|
| 1  | Kirkuk  | 44.35     | 35.47    |
| 2  | Mosul   | 43.15     | 36.31    |
| 3  | Khanqin | 45.38     | 34.35    |
| 4  | Basrah  | 47.78     | 30.52    |
| 5  | Hai     | 46.03     | 32.13    |
| 6  | Amara   | 47.17     | 31.83    |
| 7  | Tikrit  | 43.7      | 34.57    |
Figure 1 shows the CENER wind map of 30 m in Height, that we will compare the prepared map in this paper with it. If the prepared map get a similarity with this wind map, that means the used data is reliable and can be certified in the site assessment.

|    | Baghdad |   44.4   |   33.3   |
|----|----------|----------|----------|
| 8  | Kerbela  |   44.05  |   32.57  |
| 9  | Diwaniya |   44.95  |   31.95  |
| 10 | Nasiriya |   46.23  |   31.02  |

Figure - 1 : wind map of Iraq at 30m height [12,13]

2-2 The study area

Iraq, the Asian country is located, between latitudes of (29-37 ° N) and longitudes of (39-48 ° E) as shown in figure 2. In this paper, the studied sites of wind Speed in Iraq, are applied to the satellite image of the Terra-MODIS satellite with a resolution of 1 km [15].

Figure - 2: Locations of the Studied sites in Iraq
3- Results and discussion:

The data in table 1 has been drawn in maps showing the spatial distribution of the wind speed in Iraq during the studied period. These maps are very useful to understand the behavior of the wind speed in Iraq. This will help to find the superior zones in wind speed, which lead to the best decision to invest in wind energy. The maps is classified according to the sequence of months in the year, as shown in figures 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 and 14 below.

Figure - 3 : The wind map of Iraq of Jan.  Figure - 4 : The wind map of Iraq of Feb.

Figure 5 - The wind map of Iraq of March  Figure 6 - The wind map of Iraq of April
Figure 7 - The wind map of Iraq of May

Figure 8 - The wind map of Iraq of June

Figure 9 - The wind map of Iraq of July

Figure 10 - The wind map of Iraq of Aug.

Figure 11 - The wind map of Iraq of Sep.

Figure 12 - The wind map of Iraq of Oct
From the previous figures (3 - 14), it can be observed that along the studied period and at all over Iraq, wind speed has been increased toward the south of Iraq. This is because the surface of the southern land tends to be flat more than the rest regions of Iraq.

There are some distinguished locations which have good values of wind speed like Basrah, Amara and Hai. These sites have average wind speed values more than 3 m/s as well as values exceed 5m/s in summer season, especially in June. The average value of wind speed in each site is 4.3 m/s, 3.8 m/s and 3.8 m/s, respectively. The maximum values of wind speed at June in the same sites are 5.9m/s, 5.5m/s and 5.3m/s, respectively.

The average wind speed values in Baghdad, Nasiriya and Tikrit exceed 3m/s, too, but the monthly values of wind speed is less than the first group (Basrah, Amara and Hai). The average wind speed value at each site is 3.2m/s, 3.2 m/s and 3.1m/s.

The value 3m/s of wind speed is important in the applications of wind turbines, because this value is the same to the cut-in speed for most wind turbines.

Even though the west of Iraq is not considered in this paper, the wind distribution is appeared in all maps because the selection of extrapolation function in the GIS.

The annual average data confirmed the previous results. Figure 15 shows this fact. The higher values of wind speed is found in the south of Iraq, too.
Figure 15 – Annual average wind map of Iraq

3 - 1 comparison between maps:

Prima facie, it seems that it is not fair to compare wind maps of two different heights, but we just use the CENER wind map of 30m height as an indicator, to compare it with the prepared map of annual average wind speed at 10m, to study the wind speed distribution in Iraq. The difference between the two heights 10m and 30m is not huge. Then, the wind behavior is almost the same. Therefore, if we compare between both maps in figure 1 and figure 15 we will get the following notes:

1 - Both maps show an increment in wind speed when we go toward the south.

2 - There is a different in the values of wind speed in each map. this is because the map of CENER (figure 1) has been established depending on satellite data while the prepared map (figure 15) produced by using real meteorological data.

4 - Conclusions:

1 - Wind speed increases when we go toward the south of Iraq, according to flatness of the ground surface. The best values of wind speed has been recorded in Basrah, Amara and Hai.

2 - The western region of Iraq has a good values of wind speed in both map.
2 - Wind speed increases in the summer season because of the temperature rising. Specifically, June has the higher values of wind speed in Basrah, Amara and Hai

3 - The distribution of wind speed is almost the same in both maps (CENER and prepared). It means that the meteorological data which is used in this paper is reliable and can be certified.

4 - Both maps can be very useful to determine the location of a wind turbine or wind farm.

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