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Wind energy characteristics and wind park installation in Shark El-Ouinat, Egypt

Ahmed Shata Ahmed

Department of Physics, Faculty of Science, Port Said University, Egypt

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ABSTRACT

This work presents the first statistical analysis about the wind characteristics using measured wind speed data for the period of five years by the meteorological station on Shark El-Ouinat City in depth west southern Egyptian desert. The average annual wind speed is obtained as 6.5 m/s over 10 m height. The annual average of Weibull parameters is 2.1 for shape factor k and 7.4 m/s for the scale parameter c. The predominant winds are (360°) with a percentage 47.1% throughout the year. Estimation of wind energy potential per month at 10 m altitude via two various techniques was studied, where Rayleigh distribution is not accurate for fitting it for this location. The wind energy potential from wind that can be arrived is nearly 582 kW/m^2 per year at 100 m height that are comparable with and higher than its counterparts at much nations like USA, Brazil, Great Britain, Holland, and Russia.

A technical estimation is introduced of electric current production from – a 150 MW wind park- considered at this area, which will which will generate an electrical energy at a rate of 730,791 MWh yearly with capacity factor of 56%, at hub height 100 m. And the expected cost is *1.3 € cent/kWh* by using a new simple procedure (methodology) to account for the cost analysis of electricity generated from the wind farms.

1. Introduction

The mean meridional circulation of the atmosphere provides some insight into the wind characteristics that may be expected over Egypt. The forces driving the circulation originate in the differential heating of the earth by the sun, which causes a temperature gradient to develop between the equator and the northern pole. The associated density and pressure gradients would, if the earth did not rotate, lead to a poleward flow of air in the upper atmosphere and flow towards the equator at lower levels.

Even though this picture of the meridional circulation may be oversimplified, it sets the scene for the interpretation of the meteorological data collected at the stations. As an example, the seasonal change in the position of the high–pressure systems is clearly seen in the pressure measurements at Hurghada [7]. Also, the winds over Egypt are predominantly northerly and fairly steady–and the desert landscape testifies to the generally clear skies and lack of precipitation. Additionally,to fully benefit from large amounts of wind energy in a grid, it is needful having knowledge the part of electricity generated by the wind.

In parallel to these of the wind climate and wind resources in the country, the Egyptian government through its foundation New and Renewable Energy Authority in Cairo (NREA) in cooperation with Denmark. Consequently, Egypt has the long-term plan was suggested in April 2007, when the Supreme Council of Energy (SCE) elaborated on a plan to increase the share of wind energy such that it would represent 12% of total electricity demand in the 2010–2021 fiscal year. This would require wind capacity to reach 7500 MW by 2020. Egypt would turn into one of the large wind power users in the world.

To take into account: Egypt is one of the highly energy dependent countries in the region of Middle East. Where it has two costal areas situated on southern Mediterranean and western of Red Sea. It is common knowledge that the speed of the wind near the shores of the sea is generally greater than that over the lower-lying flat ground near to it. Electricity generation from the wind will play a particularly important role in coastal countries with plentiful of wind power like Egypt. Furthermore, it has great areas of desert regions with a perfect wind conditions that are appropriate to wind power plants.

In the last decade, some investigators studied the wind power potential of some sites and its wind characteristics in desert regions of south Egypt and have been achieved with very little articles [1–10]. Accordingly, the objective of this study is useful from two points of view:

(1) This paper will describe the first comprehensive study of wind energy characteristics for Shark El-Ouinat area in depth west southern

E-mail address: ahmedshata72@hotmail.com.

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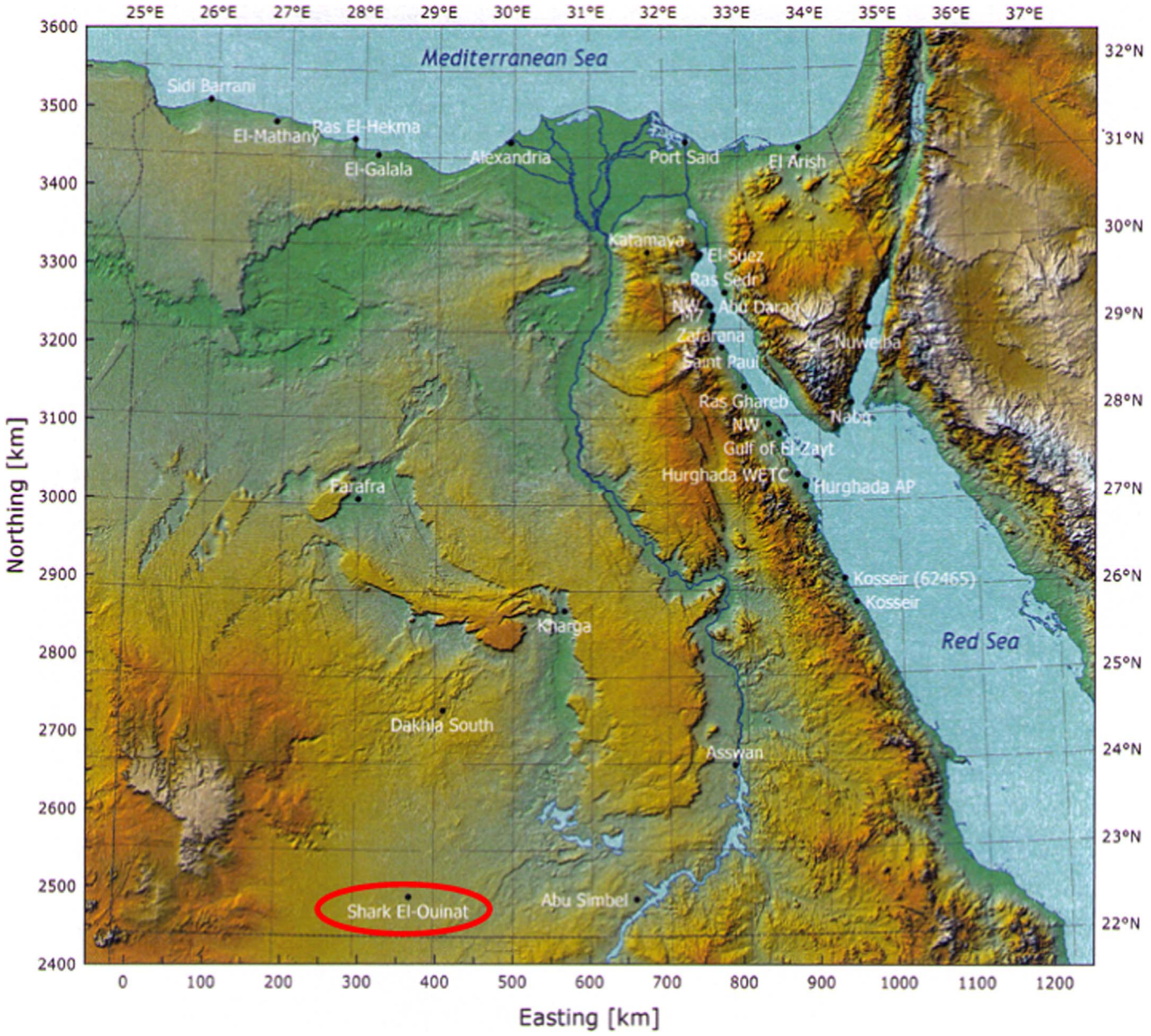

Fig. 1. Location of Shark El-Ouinat station in depth southern Egyptian desert.

Egyptian desert.

(2) Another important aspect of this work is that it studies the electricity generation and its cost of production from a 150 MW wind farm at a given location using a new method of calculations. As a result, this information may be important for the design of several wind farms and implementation the outlook wind power plants at this region by the cooperation between the Egyptian government and foreign investors there.

2. Mathematical model

2.1. Characterization of the site and monthly wind speeds

The wind can be a fickle servant. At any given site, there will be a length of time when there is absolutely no wind. For some other length of time, the wind will blow at an average speed, and for another length of time–perhaps only a few minutes over an entire year–it will blow at its maximum speed. Moreover, the air flow and amount of power available from the wind are strongly influenced by the local terrain characteristics [11]. To harness the wind you must become familiar with its moods and be able to select a site suitable for a wind machine–a site where strong, steady breezes blow most of the year.

The measurement station has been created by (NREA) in Cairo, Egypt at Shark El-Ouinat City and data recorded for a period of five years. The map in Fig. 1 shows the location of chosen site, which lies on latitude 22° 34′ and longitude 28° 43′. The site is located at the Shark El-Ouinat airport, the location is near a tourist village. The station is 320 km from Dakhla City in south-west direction. It is located in a flat and an open sandy area. Table 1 lists the wind characteristics of the station and its geographical coordinates. This region has a great altitude 271 m above the ground level. So, Shark El-Ouinat owns annually wind speeds with a high value of 6.5 m/s. Where the mast of measured data is found at a distance of 10 m from the ground at the site, and Table 2 illustrates the average monthly wind speeds. Also, Table 3 shows the classification of the wind speed on the foundation of directions of 30°.

The wind speed at a site increases dramatically with height. The