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Technical Note

Comparative simulation of wind park design and siting in Algeria

Fatiha Youcef Ettoumi*, Abd El Hamid Adane, Mohamed Lassaad Benzaoui, Nabila Bouzergui

Faculty of Electronics and Computer Science, Telecommunication Department, Laboratory of Image Processing and Radiation, University of Science and Technology of Algiers (U.S.T.H.B.), P.O. Box 32, El Alia, Bab Ezzouar 16111, Algiers DZ, Algeria

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Abstract

In this paper, five typical regions of Algeria where wind is strong enough are selected. These regions usually intended for traditional agriculture are, centred around the towns of Guelma, El Oued, Tindouf, Touggourt and Tamanrasset. To make wind energy conversion available as an alternative energy source for the populations living in such countries, nine types of small and medium wind turbines constructed by American and European manufacturers are studied for their suitability. To account for the wind variations with height, four possible heights of the pylon holding the turbines are considered: 10, 20, 40 and 60 m. In each of the five locations and at each pylon height, wind energy converted by the turbines, is cumulated over the year and computed. Depending on the site and their size, most of these turbines are found to produce about 1000–10,000 MWh of electricity per year at 60 m of altitude and can easily satisfy the electricity need in irrigation and its household applications in rustic and arid regions. A quick glance of the results of the above computation shows that the choice of pylons of 20 m height yields a trade-off between the production of electrical energy and the requirements of economy. Owing to the sporadic wind variations, wind energy conversion systems can only be used as an auxiliary source. In particular, these systems can advantageously be coupled to stand-alone photovoltaic conversion systems in remote locations or connected to the electric mains in urban zones.
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1. Introduction

Wind energy conversion is among the oldest ways of harnessing renewable energy. For example, wind mills devoted to flour-milling, ornamented the landscape in Europe, especially in Holland, over several centuries. During the last two centuries, wind machines appeared in North America and Australia to supply the farms of these countries with electricity and pump water for domestic and irrigation uses. Today, the investigations on wind energy conversion have extensively been developed over the World. These investigations essentially consist of four principal topics. The first one deals with the sensors and instrumentation used for wind measurements [1–4]. The second one is the evaluation of wind energy potential for a given region using various statistical approaches [2,5–10]. The third one is focused on the design and characterization of wind energy turbines [1,2,10–13]. The fourth one is the development of wind energy applications [14–16]. In a previous work, it was shown that wind energy available at different locations of Algeria, can be divided into three: weak, mean and strong wind, and the statistical features of wind speed are suitably described by the Weibull distribution [6]. This study has emphasized that certain regions of Algeria have sufficiently strong winds and, therefore, are suitable for wind energy conversion applications. These are, for example, the regions of El Oued, Touggourt, Tamanrasset and Tindouf at the south and Guelma at the north east of Algeria. Another typical region is the south west of this nation where wind is very strong. In spite of the hard life conditions and the droughts that occur because of rarity of rains, such regions are suited mainly for agricultural activities such as the vegetable and fruit

*Corresponding author. Tel./fax: +213 21 24 78 94.
E-mail address: youcefettoumi@yahoo.fr (F. Youcef Ettoumi).

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farming or the upkeep of palm groves. Although they use modest and sometimes archaic means, the populations living in these regions contribute to fight against increase of the desertification. In particular, the cultivable areas are either manually watered from wells or irrigated using pumps connected to the electric mains. At the southern Algeria and in the remote regions situated far from the mains, diesel engines are often used by inhabitants to supply the water pumps with electricity and satisfy their household consumption. However, the high freight charges prevailing in these regions make the fuel used by these diesel engines very expansive. In addition, the latter contribute significantly to the pollution of the atmosphere with hydrocarbons. Since such regions are both sunny and windy almost all the time, they are suitable for the implantation of stand-alone photovoltaic systems and wind energy turbines. This kind of renewable energy conversion devices is not pollute and, therefore, can advantageously replace the electric generators, which usually work by consuming fossil energy. Notice that with the recent increase in the cost of fuel, these devices will surely become competitive. The work presented in the following sections aims at analysing the feasibility of exploiting wind energy conversion in Algeria. Briefly, this analysis begins with the description of the social and the geographical features of Algeria. Then, wind speed measurements are processed to analyse the spatial distribution of wind in this country. Nine types of wind turbines taken as examples are selected among those available in the market and wind energy converted by the turbines over one year is evaluated for five typical regions of Algeria. These regions, where wind often blows with sufficient intensity, are centred about the towns of Guelma, El Oued, Touggourt, Tamanrasset and Tindouf. Except the region of Guelma, they are all remote countries lying in the Sahara desert and in the extreme south of Algeria.

2. Socio-geographical features

Algeria is known to be the central part of North Africa represented by a vast territory extending from the 19th to 37th parallels. Its surface of 2,381,741 km^2 is occupied by nearly 33,800,000 inhabitants. As in other countries, there are a variety of activities in Algeria. For example, traditional professions such as trade, craft industry and agriculture are carried on everywhere till today, whereas biggest activities are developed dealing with different sorts of industries at the north and petroleum produced in the south of this country. For several 10 decades, a rural migration has been established for the benefit of the towns, which lie in northern Algeria and, this migration offers better life conditions. Consequently, 80% of the Algerian territory is now deserted. About 90% of the Algerian population is concentrated in the northern band of greenery extending 1200 km from east to west and limited by the Atlas Mountains and Mediterranean coast. Then, only 10% of the population lives in the south of Algeria, in the locations situated in the Sahara desert, Tassili tableland and Hoggar Mountains. Recently, about 20 remote villages in the departments of Tamanrasset, Adrar, Illizi and Tindouf have been electrified using photovoltaic conversion systems sponsored by the Algerian State. This experimentation helps about 1000 families. This has the advantage of stopping the rural depopulation in the localities under consideration. Thanks to this experiment, life conditions have been significantly improved in these villages and the return of rural people is noticed. In addition, new schools have been opened, and jobs offered to the young people. In general, locations of the southern Algeria are usually linked to the chief town of the related department by stony paths one to several hundred kilometres long. This distance makes the connection of remote farms, houses and shops to the electrical mains difficult and so also is the communication. As already explained, wind energy conversion is another way for opening up the remote sites located in windy regions of Algeria. The five locations chosen to illustrate the feasibility of wind applications are in the northeast Guelma [36°28′N, 7°28′E], in the south east El Oued [33°30′N, 6°47′E] and Touggourt [33°07′N, 6°08′E], in the extreme south Tamanrasset [22°47′N, 5°31′E] and in the southwest Tindouf [27°40′N, 8°06′W] (see Table 1). The department of Guelma is an agricultural region surrounded by wooded mountains, watered by the Seybouse river, subjected to wet climate and populated by nearly one hundred inhabitants per km^2. Notice that only about 100 km separates the town of Guelma from the iron and steel industrial complex of El Hadjar. Lying in the same region of the Sahara desert, El

Table 1
Geographical coordinates and Weibull parameters for El Oued, Guelma, Tamanrasset, Tindouf and Touggourt

Station	Geographical coordinates			Weibull parameters		
	Altitude (m)	Latitude (deg)	Longitude (deg)	k (dimensionless)	c (m/s)	$\bar{u}$ (m/s)
El Oued	62	33°30′N	6°47′E	1.90	5.05	3.54
Guelma	290	36°28′N	7°28′E	2.10	4.80	2.48
Tamanrasset	1343	22°47′N	5°31′E	1.85	4.50	4.55
Tindouf	401	27°40′N	8°06′W	2.00	6.25	5.81
Touggourt	85	33°07′N	6°08′E	1.90	4.95	3.92

k = shape factor, c = scale factor and $\bar{u}$ = yearly average of wind speed.

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