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# Evaluation of wind energy potential and estimation of cost using wind energy turbines for electricity generation in north of Algeria

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ABSTRACT

A technical and economic assessment has been made for the generation of electricity using wind turbines at six sites of the north of Algeria. The annual mean wind speed of the six stations (Oran, Setif, Skikda, Tlemcen, Tiaret, and Miliana) was obtained as 4.20, 3.46, 3.18, 2.64, 5.07, and 2.91 m/s at 10 m height, respectively. We used wind data recorded over 10 years for those sites. The Weibull parameters ($k$) and the power law coefficient ($c$) for all months at different heights (30–50–70 m) were obtained by extrapolation of the 10 m data at all sites. The WAsP program was used and three commercial wind turbines namely AN Bonus 300 kW/33, AN Bonus 1.0 MW/54 and Vestas V80/2 MW were technically assessed for electricity generation in the six selected sites by computing their capacity factors, annual power and energy outputs. The economic evaluation was also estimated using the present value cost method (PVC). The results showed that the mean monthly value of Weibull shape parameter k is between 1.02 at Tlemcen site and 2.06 at Oran site while the monthly value of scale parameter $c$ is between 2.2 m/s at Tlemcen site and 9.2 m/s at Tiaret site. In addition, the capacity factors of the three turbines in the selected sites are ranged between 5.40% and 33.16%. The average minimum cost per kW h was obtained in Tiaret as US$0.0342/kW h with Vestas V80/2 MW while the highest average cost is US $0.2105/kW h with AN Bonus 1.0 MW/54 in Tlemcen. The highest cost in each location was obtained with the medium Wind energy turbine (AN Bonus 1.0 MW/54). In addition, Tiaret and Oran were also found to be very economical for any of the adopted wind turbine models. Miliana, Skikda and Tlemcen were found to be more profitable for non-connected electrical and mechanical applications (water pumping, battery charging) than a diesel generator as they exhibit higher cost than US$0.10/kW h.



**Contents**



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## 1. Introduction

The negative influences of fossil fuels forced scientists to call attention to cleaner energy sources that are both friendly and renewable most suitable environment; among these sources, wind energy has been selected [1].

The global market for renewable energy sources including wind energy is growing rapidly, especially during the last two decades. The turbine has a power source fuel-free, and does not cause any inexhaustible amount of pollution during the production of electricity.

In addition, it can produce wind turbine energy close to load centers eliminated a transmission loss in the lines in rural and urban landscapes [2]. Energy is a powerful and key activity for the techno-industrial and socio-economic development for all aspiring countries move beyond to subsistence level [3]. To ensure a good standard of living in industrialized countries and improved living conditions in developing countries, it must therefore carefully studied and understood the energy model to be studied [4].

Bulk through the generation of energy from fossil fuels whose reserves are being depleted and non-environmentally friendly, requiring the attention of modern research to focus on different energy sources, renewable (alternative) such as wind, solar, hydro (large and small) and biomass. Energy from renewable sources has been gaining momentum in developed countries over the years with the increase in the efficiency of renewable energy technologies and associated costs decrease. These energy sources will never run dry, clean and free. They offer many environmental and economic advantages, and profits, contrary to conventional energy sources. Wind energy is considered today as that energy cost effective and technological advancements allow competition with the production technology of conventional energy. It is a source of energy without fuel, pollution and having an advantage that it can produce near load centers eliminating transmission losses.

In Algeria, with the absence of nuclear power and large hydro sources, fossil fuels draw most of its electricity production (99.2% in 2009) [5]. The majority of power plants installed in Algeria is gas plants, except for the deep south where power plants running on diesel are used and the fact that southern Algeria is not supplied with natural gas. 97% of the populated sites are covered by power network. It reflects the potential for significant power generation and evolving face rising demand standing at nearly 7% per year during the period from 1963 to 2007 [6]. The construction of new generation capacity, transmission and distribution of electricity is one of the biggest challenges of the sector.

The National electricity production has increased sharply. It went from 63% in 1980 to 97% in 2007. Leading indicators and their evolution over the period 1962 to 1999 and from 2000 to 2007 show the huge effort made by the government in this field. Indeed, during the period 2000–2007, electricity generation has experienced strong growth. It increased from 25 TW h in 2000 to 37 TW h in 2007, corresponding to an average annual increase of 6%. This production was only 2 TW h in the 60. Regarding to the electricity cost approved in Algeria, Algerian state practice the same policy costs to sell of the eclectic energy and that, whatever type of production systems (diesel or gas).

Since 2010, Algeria has implemented an ambitious strategy to promote and develop renewable energy on its territory (the plan for the promotion of renewable energy, approved by government on February 3, 2011 in order to produce 40% of total energy consumption from renewable sources by 2030 [7].

The Algerian government ensures the development of renewable energies to keep reserves of the fossil energy that is in the way to go. This strategic choice is motivated by the enormous potential of solar energy. This energy is the major focus of the program dedicated to the solar thermal and the solar photovoltaic as an essential part. The solar is expected to reach by 2030 over 37% of the national electricity production, despite a relatively low potential, the program does not exclude the wind, which is the second development and whose share should be around 3% of the electricity production in 2030. Algeria also provides for the installation of some size experimental units to test different technologies for biomass, geothermal, and desalination of brackish water by various renewable energy sectors.

Fig. 1 represents the different phases of the renewable energy and fossil energy program in Algeria that is defined as [8]:

- By 2013 it is planned to install a total power of about 110 MW;
- In 2015, a total power near of 650 MW would be installed;
- By 2020, it is expected that the installation of a total capacity of about 2600 MW;
- For the domestic market and possibility of export of around 2000 MW;
- By 2030 it is planned to install a capacity of nearly 12,000 MW.

For the domestic market and possibility of export of around 10,000 MW.

This strategy would gradually replace the use of fossil fuels (natural gas and oil) which currently are the main resource for the country's electricity generation, by other energy sources like solar and wind energy. The geographical location of Algeria has several advantages for extensive use of most of the renewable resources.

The wind energy potential for a selected site is determined by developing detailed knowledge of the wind characteristics, such as speed, direction, continuity and availability [9,10]. These wind characteristics have been analyzed using different techniques, such

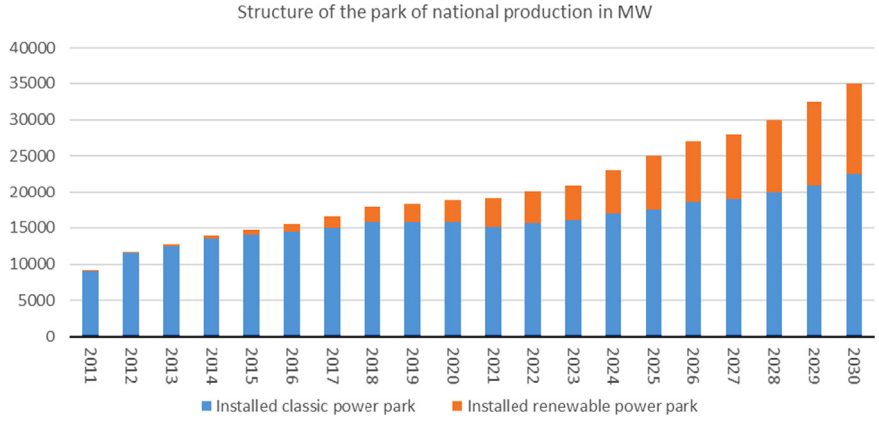


**Fig. 1.** Structure of the park of national production in MW [8].