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Research Article

Comparative evaluation of wind resources using the computer tool WAPs, case study of Mecheria West Algeria

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Abstract

The aim of this work is to assess the wind potential in the Mecheriaregion, located in Western Algerian Hautes plains that are characterized by an important elevation average between 800m and 1400m, which has a major impact on wind speed acceleration. Using ten years of collected data from 2011 to 2021, the statistical analysis gives an annual mean wind speed equal to 5.6 m/s at 10m hub height above the ground level. Then four main types of wind turbines: NEG-Micon 44/750 kW, Nordex N50/800 kW, Vestas V50/850 kW and PowerWind 56/900 kW. **are compared and analyzed using WAsP software** to obtain the annual wind characteristics A, k, V and P **for each wind turbine and select the most appropriate technology in the study area. Furthermore, an economic analysis was carried out by RETScreen software, to select the turbine that produces low cost and high capacity factors, and the results show that PwerWind 56 turbine is the most suitable one for the selected site.**

Introduction

Recently, The Algerian government has embarked on a new attractive policy for exploiting renewable energies, Although, Algeria has a significant wind potential and many studies have been carried out to assess it using various tools such as AIOLOS and WasP software [1-2] wind energy is in the second development program axis compared to photovoltaic systems, by installing 5GW of wind power in 2030 [3]. As part of the application of the renewable energy program "2011-2030", a 10.2 MW wind farm has been installed and put into service in 2014 in the province of KaberteneAdrar, which consists of 12 wind turbines with a power of 850 kW [4].

Instead of the Saharan regions of Algeria that have been targeted as the most suitable regions for the exploitation of wind energy (Adrar, Timimoun, Ain salah) [3], Highlands also shows an important promising average wind speed, in the middle of the eastern Highlands, Mila seems to be an interesting area with annual mean speeds of 5.3 m/s [5]. A little further to the west, Tiaret and Djelfa sites usually identified as windy sites [6-7] provide speeds of about 5.6 m/s and 5.1 respectively. Still in the Highlands, the new wind dataset recorded in Mecheria in the extreme west shows a very promising average wind speed of 5.6 m/s in the southeast dominant direction. In the same area, annual speeds of 4.9 m/s, 4.4 m/s, and 4.3 m/s are observed in the sites of El Kheiter, Naama and El Bayadh respectively [8].

The present study concerns an Algerian area situated in the westernHautes Plaines. The principal reason for choosing the site of Mecheria is that the recent measurement recorded at the meteorological station of the site show very interesting winds during several months of the year, and according to the latest Wind Atlas done by [9] which has confirmed its important wind potential and indicated the site suitable to receive a wind farm project.

This study focuses on the main following points:

- Determination of the relative wind potential of the

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study area using 10 years of measured data (wind speed and direction) from 2011 to 2021using WAsP software.

- Mapping the site (Drawing the Atlas map and the elevation map).
- Comparative analysis between four main types of wind turbine technology and determination of the expected annual energy production (AEP) and capacity factor for each one of them.
- Economical study and cost comparison using RETScreen software.

Methods and data

study area

Manchuria is situated in the northeastern of Naàma province located in the southwest of the Algerian Hautes Plaines, it lies between the Tell Atlas and the Saharan Atlas.

It is dominated by the mountain of DjbelAntar which culminates at 1721m and is made part of the Saharan Atlas (Figure 1). Manchuria region occupies an area of 736.25 km² and it is the most populated municipality in the Naama province [Table 1].

Used data

Wind data used in this study were recorded at 10m above ground level at Mecheriametrological station during a period of ten years from 2011 to 2021.

The Digital map used in this study is a contour map (Figure 2) created from a DEM (Digital Elevation Model) which represents the ground surface topography of the area to use as an input in the WAsP map editor, this is extracted from the

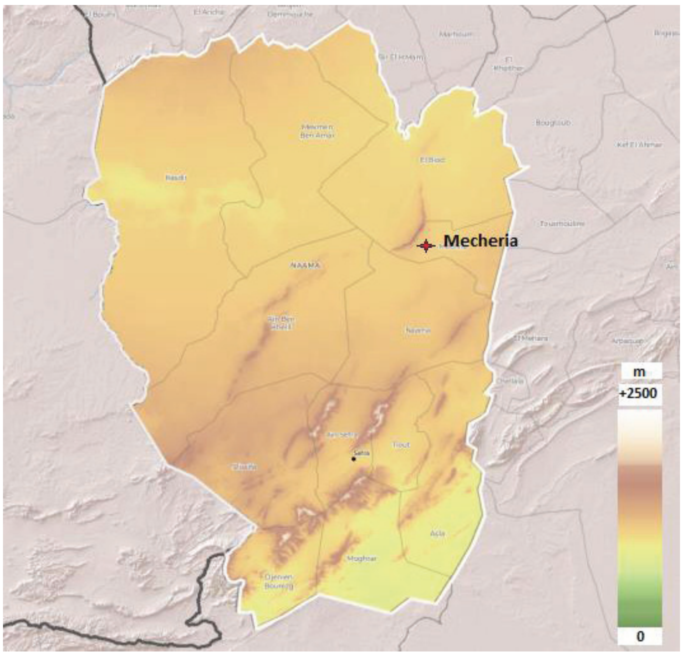

Figure 1: Overview of the study area (Orography map) [9].

Table 1: Geographical coordinates of the site [8].

Station	latitude	longitude	Elevation	Climate zone
Manchuria	33.536°	-0.242°	1175m	3B worm Dry

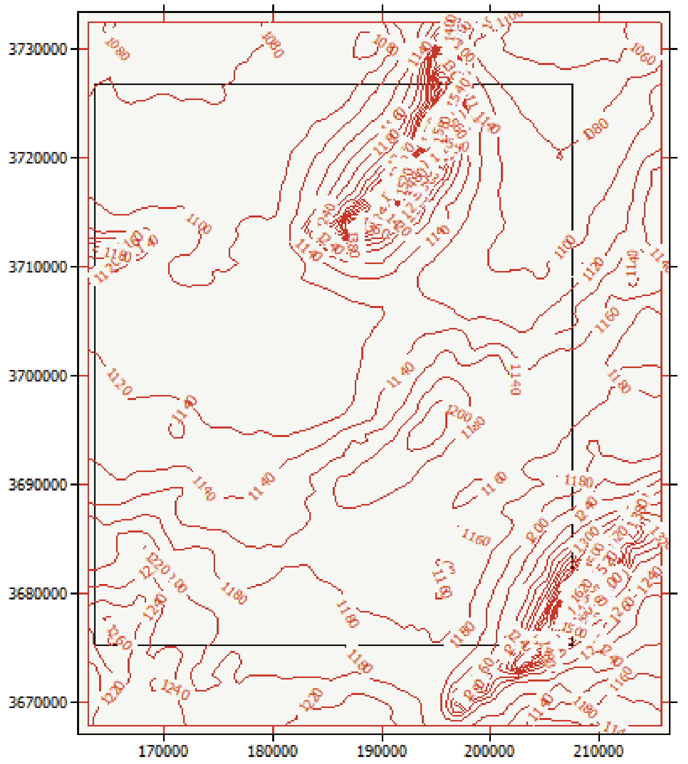

Figure 2: Contour map of the case study region.

database SRTM (Shuttle Radar Topographical Mission) 1 arc-second global with 30m resolution.

WindAtlas for the region of Mecheria were drawn at 10m altitude to represent the wind field in the entire area(Figure 3), where the roughness length adopted in this study is 0.003m.

Methodology

In order to estimate the wind potential in the case study region of Mecheria, we used the WasP (Wind Atlas Analysis And Application Program) software for the simulation. WAsP software is a PC-Program for the vertical and horizontal extrapolation of wind climate statistics. It contains several models to describe the wind flow over different terrains and close to sheltering obstacles and it can also estimate the mean wind energy distribution and the mean annual wind energy production of a turbine at any point.

The principal reason for using WAsP software in this study is to determine the most suitable wind turbine for the selected area by comparing four main types of wind turbines, the characteristics of the chosen turbine are demonstrated in Table 2.

The main function that WAsP software use to characterize the variation of wind speed and the available wind power density in the selected site is the Weibull probability because it is the

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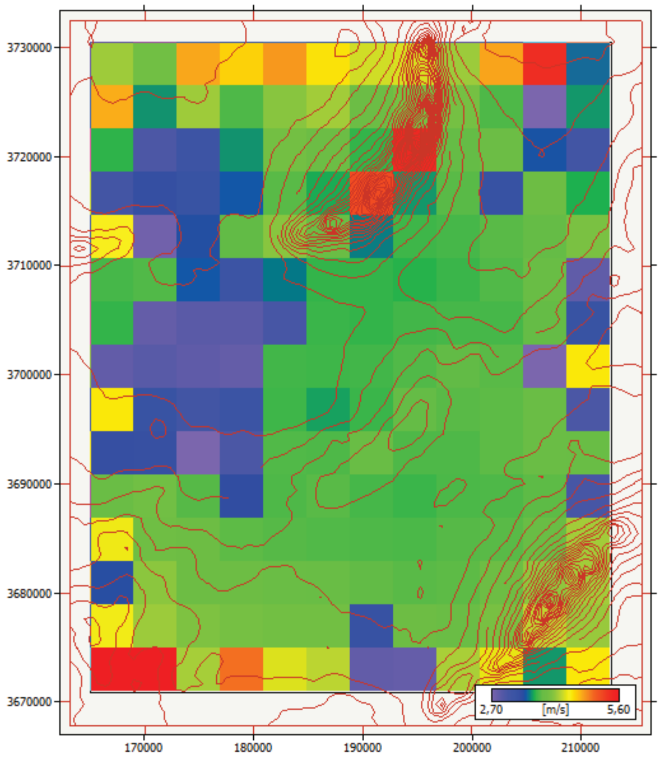

Figure 3: Mean wind speed of the case study region at 10m above ground level.

Table 2: Main characteristics of the selected turbines.

Turbine type	Rated capacity (kW)	Hub height (m)	Rotor diameter (m)	Cut-in speed (m/s)	Cut-out speed (m/s)	Rated speed (m/s)
NEG-Micon 750/44	750	50	44	4	25	16
Nordex N50	800	50	50	4	25	16
Vestas V52	850	55	52	4	25	17
Power Wind 56	900	59	56	3	25	13

most used in this field and its parameters were determined. It has been used to represent wind speed distributions for application in wind load studies for a period of time and can give a good fit to experimental data and provides a good approximation to many measured wind speed distributions., which has the function [10]:

$$f(v) = \left(\frac{k}{A}\right)\left(\frac{v}{A}\right)^{k-1} \exp\left[-\left(\frac{v}{A}\right)^{k}\right] \tag{1}$$

With f(V) being the occurrence frequency of the wind speed V, k(which is a measurement of the width of the distribution) and A(which is closely related to the mean wind speed)are parameters commonly known as the Weibullparameters called respectively shape and scale factors.

Using the Weibull distribution, the mean wind speed and the available wind power density in the site are given by the following relation[11]:

$$v = A \cdot \Gamma\left(1 + \frac{1}{k}\right) \tag{2}$$

$$p = \frac{1}{2}\rho A^{3}\Gamma\left(1 + \frac{3}{k}\right) \tag{3}$$

Where, $\Gamma$is the Gamma function and $\rho$is the air density, equal to 1.225 kg/m3 at sea level and at 15°C.

Result and discussion

This section shows a detailed discussion of results presented in form of wind roses, histograms, maps and tables. in the first part, the statical analysis of the entire region is presented. Then, the second part shows the results of the comparative study of four main types of a wind turbine in order to find the optimum one for the selected site which include the principal reason that this study was initiated.

Statistical analysis of the site

The results obtained by analyzing 10 years of wind data (speed and direction) at 10m height as mentioned earlier for the whole site are shown in (Figure 4).

The chart of the Wind rose observed in (fig 4) demonstrates that the general wind direction of the anemometer was modeled in the North-West orbit and 12% of the remarkable winds are in the 11 and 12 sectors which means that almost 23.5% of wind lie between 300 and 330 degrees clockwise up to 5.6m/s mean velocity. Regarding the wind speed histogram as can be seen in (Figure 4b), the Weibull parameters A and K obtained are 4.6m/s and 1.71 respectively, which corresponds to a steady and regular wind around 4.15m/s wind speed average.

Comparative analysis

Depending on the motivating results obtained in part one of the analysis, the second part of the analysis process consists to find the optimal Wind turbine for the selected area, by comparing four main types of wind turbine technology. The comparison was done by posing each type of wind turbine generator with power ratings from 750KW to 900KWin the same selected area and extracting their results using the WAsP tool. the results of the simulation were presented in Table 3.

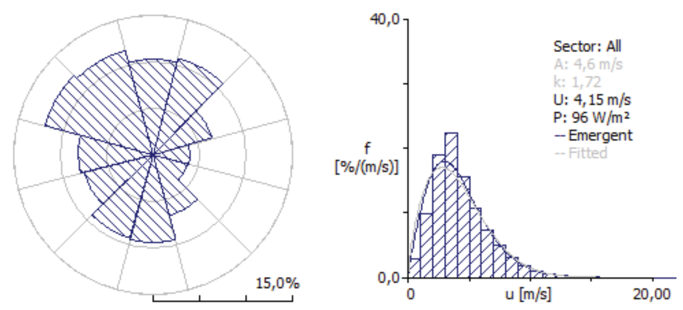

Figure 4: Mean wind speed of the case study region at 10m above ground level. (a) Annual wind rose, (b) Annual wind speed frequency with fitted Weibull distribution at 10m above ground level.

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Processed wind data and the contour map were infused to create the wind resource (Figure 5) which also indicates the chosen emplacement for the installation of the turbine at 50m above ground level.

Economic analyses

The economic study was performed using RETScreen software and data resulted from WAsP's analysis. The RETScreen software is an excel based modeling tool that helps in the comprehensive identification, assessment, and optimization of the technical and financial viability of potential renewable energy projects [12]. the results of the economic simulation for each turbine type are summarized in Tables 4,5.

Conclusion

Rather than the massive wind potential that exists in the sauterne regions of Algeria, the high temperature recorded in summer times may affect negatively wind turbines' work and sometimes lead to damage. So that Algerian highlands are the most appropriate solution due to their lower temperatures compared to those recorded in the desert and according to their acceptable wind potential.

Table 3: Result of the selected wind turbines.

Turbine type	Weibull-A (m/s)	Weibull-K	Mean speed (m/s)	Power density (w/m²)	Elevation (m)	AEP (GWh)
NEG-Micon 750/44	6.0	1.35	5.56	439	913.4	1.110
Nordex N50	6.1	1.35	5.6	468	922.6	1.357
Vestas V52	6.0	1.39	5.45	364	909.1	1.524
PowerWind 56	6.2	1.41	5.65	412	922	1.833

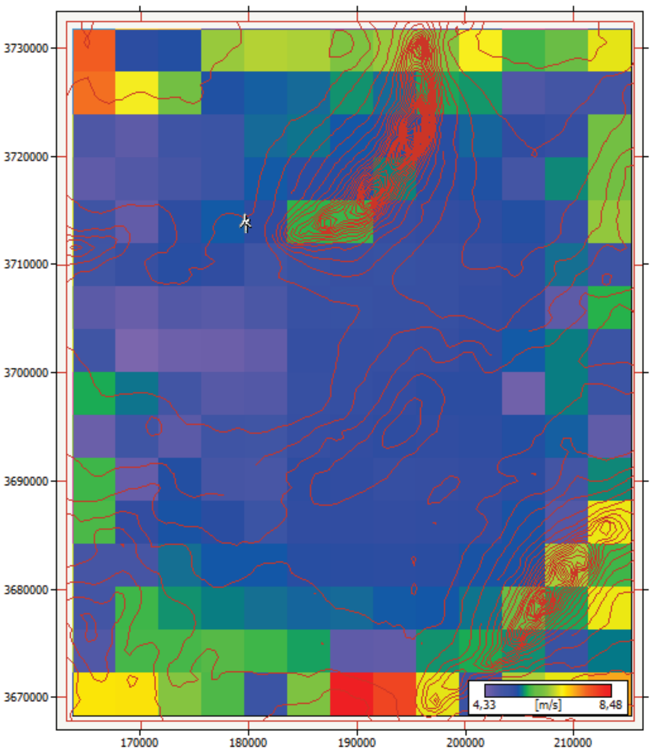

Figure 5: Mean wind speed of Mecheria region at 50m above ground level.

Table 4: Input cost parameters In the RETScreen model.

Turbine type / Cost structure$	NEG-Micon 750/44	Nordex N50	Vestas V52	PowerWind 56
Turbine (75%)	1,840,000	1,490,000	1,506,000	1,240,000
Civil engineering (8%)	157,866	155,733	160,640	132,266
Electrical connection (7%)	125,533	136,266	140,560	115,733
Engineering (5%)	98,666	97,333	100,400	82,866
Transmission and distribution (2%)	39,466	38,933	40,160	32,066
Study (2%)	39,466	38,933	40,160	32,066
Miscellaneous (1%)	19,733	19,466	20,080	16,533
Initial cost (100%)	1,973,333	1,946,666	2,008,000	1,653,333

Table 5: COE calculating the result of each turbine.

Turbine type	COE($/KWh)
NEG-Micon 750/44	1.77
Nordex N50	1.27
Vestas V52	1.47
PowerWind 56	0.90

In this study, we evaluated the wind resource in a newly discovered wind site in Algerialocated in Western Algerian highlands named Mecheria, which previous studies have dealt with it before. Also, this work has shown the importance of the WAsP tool which allowed us to evaluate the wind potential available in this area very easily in comparison to other tools such as the AIOLOS tool [1].so it is necessary to generalize the use of this tool in the field of Wind energy. From the comparative result of the four types of wind turbines with power ratings from 750KW to 900KW, we concluded from the preceding results that PowerWind 56 wind turbine will have a good match for the selected site.

WAsP results determined the Weibull parameters A and K, mean speed, power density and AEP of PowerWind 56 are 6.2m/s, 1.41, 5.65m/s, 412w/m²and 1833GWh respectively. the economic analysis comparison done by RETScreen software also highlights the PowerWind 56 turbine as almost identical costing about 0.9$ per KWh.

Finally, the obtained results are satisfying and in future work, other renewable energy sources can be added to achieve a better result and to benefit the other resources that existed in this region such as photovoltaic and concentrating systems.

References

1. Abdeladim K, Rome R, Magri S. Wind mapping of a region in thenorth-east of Algeria, WREC .789-793,1996.

2. Chabani A, Makhloufi S, Lachtar S. Overview and impact of the renewable energy plants connected to the electrical network in southwest Algeria. EAI Endorsed Transactions on Energy Web. 2021; 8(36), e7-e7,.

3. CREG. Programme de Développement des Energies Renouvelables 2015-2030. 2015.

4. Sonelgaz. https://www.sonelgaz.dz/fr/790/energies-renouvelables. Accessed 24 07 2022.

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5. Abdeslame D, Kasbadji N, Mekhtoub S, Abbas M, Dehmas M. Estimation of power generation capacities of a wind farms installed in windy sites in Algerian high plateaus, Renewable Energy. 2017; 103: 630-640,.

6. Hammouche R . Atlas vent de l'Algérie/ONM . Office des Publications Universitaire (OPU). Alger. 1990

7. Aiche L, Khellaf A. Evolution Mensuelle de la Ressource Eolienne à travers l'Algérie. Revue des Energies Renouvelables: ICPWE. 2003;147–152,.

8. DaaouNedjari H, Haddouche SK, Balehouane A, Guerri O. Optimal windy sites in Algeria: Potential and perspectives. Energy. 2018; 147:1240–1255,.

9. Global Wind Atlas web application. 2022. https://globalwindatlas.info..

10. Justus CG, Hargraves WR, Mikhail A, Graber D. Methods for estimating wind speed frequency distributions. Journal of Applied Meteorology. 1978; 350-353:.

11. Zohbi Al, Hendrick G, Bouillard P.Evaluation of the impact of wind farms on birds: The case study of Lebanon. Renewable Energy. 2015; 80: 682–689,.

12. Riaz MM, Badrul HK. Techno-Economic Analysis and Planning for the Development of Large Scale Offshore Wind Farm in India. International Journal of Renewable Energy Development. 10.2.2021.

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