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Study of the currentology of Moroccan facades and assessment of the marine energy potential for the fight against the impact of climate changes

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ABSTRACT

Morocco has an exceptional maritime potential especially on its two 500-km Mediterranean and 300-km Atlantic coastlines. The assessment of this potential for marine currents, wind and temperature is largely necessary for the various activities related to the coastline: fishing, exploitation of aggregates, tourism, transport services, desalination and marine renewable energies.

Morocco is engaged in a policy of preservation of the environment, the fight against global warming and reducing the emission of greenhouse gases. It is reviewing its 'electric mix' and promoting all renewable energies including marine energy.

The results of this study show clearly that Morocco can boast of the potential of its Atlantic and Mediterranean coasts, thanks to the strong winds that blow in the North Atlantic and around the city of Dakhla, at sea currents speeds in vicinity of the Strait of Gibraltar and the difference in temperature between the surface and deep sea.

We are particularly interested in the study of the behavior of the marine current, temperature and wind. This is based on monthly data provided by a credible website with free access and statistics from the MATLAB Software.

Selection and peer-review under responsibility of the scientific committee of the International Conference on Plasma and Energy Materials ICPEM2019.

1. Introduction

The ocean is a huge reservoir of energy. The marine waters cover 71% of the globe. These waters in all their forms bring energy by their displacements [1]. This energy should be exploited wisely by techniques and procedures associated with marine renewable energy technologies. In the face of dwindling fossil resources, the goal of the world is to find inexhaustible alternatives to meet energy needs and preserve the environment [2,3]. Morocco has carried out a series of projects on an international scale to reach these objectives (the big solar power station of Ouarzazate and the biggest wind farm of Africa Tarfaya, etc.) and which have borne fruit. Indeed, Morocco has a considerable maritime potential including its two coasts: Mediterranean which extends over 500 km and 3000 km long Atlantic untapped nowadays. It would be convenient to exploit this source of energy through the different technologies of marine renewable energies [4].

2. The characteristics of the marine environment.

A current is a displacement of seawater or ocean characterized by its direction, speed and flow. There are two types of currents: the surface currents (from 0 m up to 50 m) and the currents of depth (from 50 m). Currents can involve other phenomena: internal ripples, gyres and other vortices. The velocity C of the current is the result of the speed of the East component U and the speed of the North component V, see Fig. 1.

$$U = \|\vec{U}\| \sin\theta \quad (1)$$

$$V = \|\vec{V}\| \cos\theta \quad (2)$$

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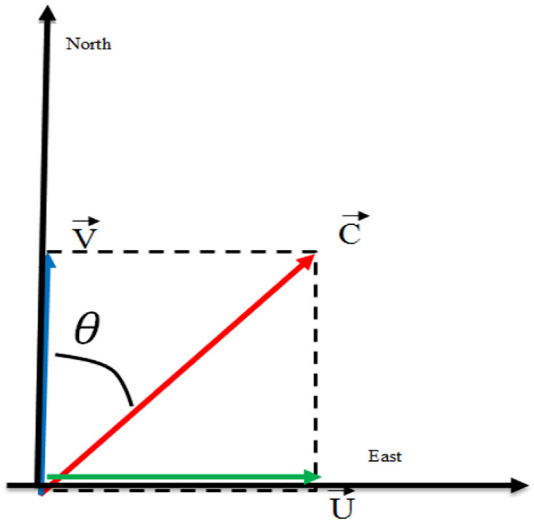

Fig 1. The resultant C of the speeds U and V.

$$\theta = \text{Arctan}\frac{U}{V} \quad (3)$$

$$C = \|\vec{C}\| = \sqrt{U^2 + V^2} \quad (4)$$

2.1. Wind

In the strict sense of the term, the wind is a movement of air. At sea, the wind is strong, more constant and more predictable than on land. For wind energy (Offshore and Onshore), as for tidal turbines, power is simply expressed as a function of the fluid velocity (V) and its density (ρ) and the surface area (s). The wind power (W/m^2) is governed by a formula:

$$P = \rho S V^3 \quad (5)$$

2.2. Temperature

The sea current is not only due to the combined effects of wind and Coriolis force, but is also sensitive to temperature. The density of water is directly related to its salinity and temperature. We are particularly interested in the sea surface temperature, which is the temperature of a layer near the sea surface. It is at this layer that the interactions between the ocean and the atmosphere occur govern the climate. This temperature is critical for the development of weather systems.

3. Results for the Moroccan Mediterranean Sea

Analysis of the behavior of the intensity of surface currents in the Mediterranean, which extended from 2002 to 2014, showed that the minimum current values are almost zero. On the other hand, the observed maximum intensities reached high values of 1 m/s, all found around the Strait of Gibraltar (lat: 36,000°, long: −5.2°) and (lat: 36°, long: −5°) near Sebta and Tetouan.

The analysis of wind in the Mediterranean over thirteen years (2002–2014) has shown that it is regular. The minimum speed is about 6 m/s, however, strong winds are around 8 m/s. The wind is very abundant between the cities of Al-Hoceima and Mallilia in winter.

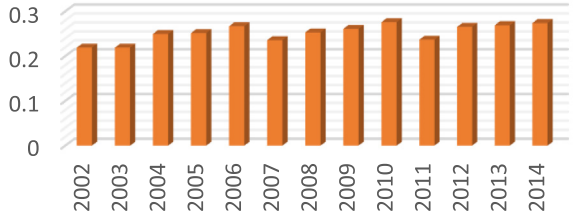

Fig 2. Annual average of current intensities (m/s) at the surface in the Mediterranean Sea.

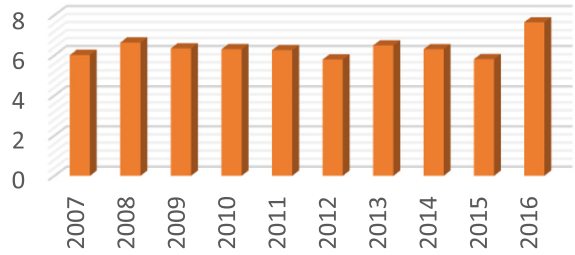

Fig 3. Annual average of wind intensities (m/s) at the surface in the Mediterranean Sea.

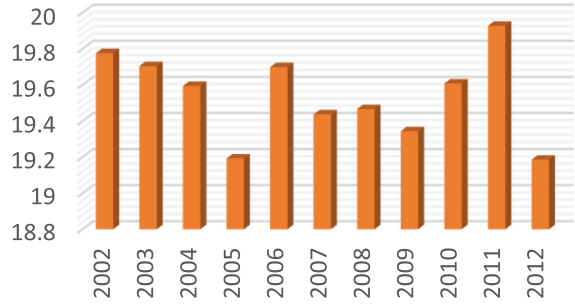

Fig 4. Annual average of temperatures (°C) at the surface in the Mediterranean Sea.

In the Mediterranean, the study of surface temperature variations over thirteen years shows that this quantity has minimum values taking values close to 17 °C.

In addition, the high temperatures observed in summer, around Mellilia and Berkane, reach 26 °C. In addition, the temperatures at depth (1000 m) do not exceed 13 °C.

Annual averages for the year 2002 to 2014 current speeds are around 0.25 m/s (Fig. 2).

Annual averages of wind speeds in the Mediterranean Sea have taken values between (5 and 6) m/s apart from the annual average of 2016 which exceeded 7 m/s (see Fig. 3).

Annual average values of temperature in the Mediterranean Sea varied from one year to another and decreased particularly in 2005 and 2012 (see Fig. 4).

4. Results for the North Atlantic

The study of wind intensities from 2002 to 2014 shows that in the North, the wind is very strong. These strong ocean winds surpassed 11 m/s especially in summer and off the coast of Laayoune at latitude: 27° and longitude: −16° and the coast of Laarache (latitude: 35°, longitude: −14°).

The minimum speeds noted during these years do not exceed 6 m/s.

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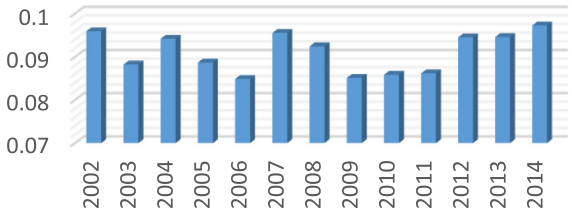

Fig 5. Annual average of current intensities (m/s) at the surface in the North Atlantic.

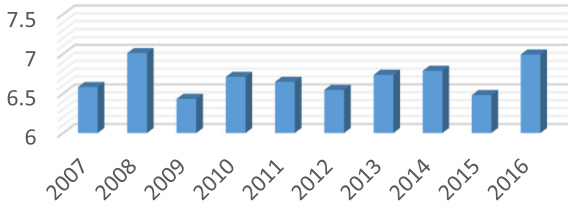

Fig 6. Annual average of wind speeds (m/s) at the surface in the North Atlantic.

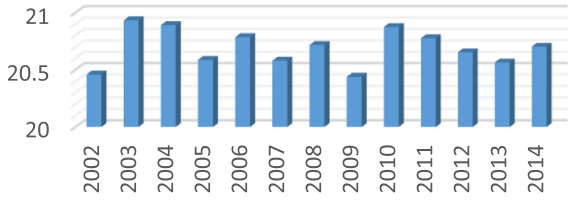

Fig 7. Annual average of temperatures (°C) at the surface in the North Atlantic.

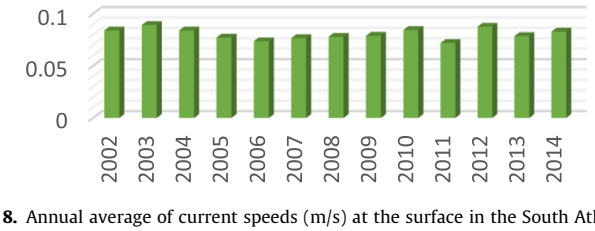

Fig 8. Annual average of current speeds (m/s) at the surface in the South Atlantic.

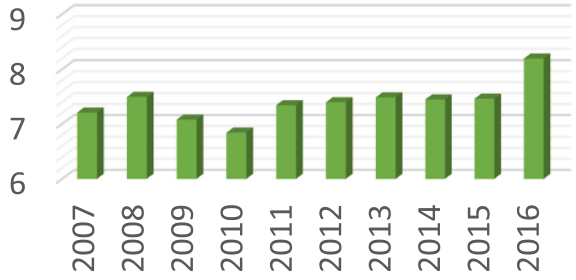

Fig 9. Annual average of wind speeds (°C) at the surface in the South Atlantic.

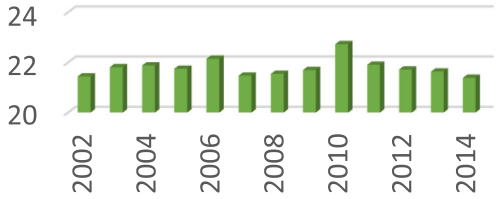

Fig. 10. Annual average of temperatures (°C) at the surface in the South Atlantic.

Through these analyzes, we find that off the North Atlantic the temperature is very high and has crossed 26 °C/27 °C especially in autumn in September and October. However, the minimum values are coastal and do not exceed 10.5 °C.

The temperature differences of the maximum values between the surface and a depth of 1000 m are 15 °C.

The average means of current intensities in this area are, in the main, variants and other variations of the course of the study years (Fig. 5).

North of the Atlantic coast of Morocco, annual averages of wind speeds are around (6 and 7) m/s except the averages in 2008 and 2016 where averages exceeded 7 m/s (Fig. 6).

Mean temperatures from 2002 to 2014 varied over the years and peaked in 2003, 2004 and 2010 (Fig. 7).

5. Results for South Atlantic

The study of the intensity of surface current in the South Atlantic has also covered thirteen years (2002–2014), it has clearly shown that the minimum intensities are almost zero. The maximum values over the thirteen years are coastal and (0.1–0.4) m/s between southern Dakhla (latitude: 21° and longitude: −17°) and Boujedour latitude: 25° and longitude: −17°. The results thus obtained are very close to the statistics made in 30 m depth.

The study of the wind in the South Atlantic revealed to us that the wind, during the ten years (2007–2016), takes minimum values which are close to 6 m/s and the strong winds, reach 9 m/s. The higher values of the wind intensity are generally found in the broad, south of Dakhla between latitudes (21°) and (−22°) and longitudes (−18°) and (−22°).

Analysis of the behavior of the surface temperature in the South Atlantic coast of Morocco, shows that the minimum values of the temperature turn around 18 °C whereas the maximum values often exceed the 26 °C. The temperatures are strong in autumn more particularly in the September and off the coast of Dakhla region.

In the South Atlantic of Morocco, the values of the annual average intensities of the current are not very variable, they take low values between 0.07 m/s and 0.08 m/s during the thirteen years (Fig. 8).

Annual averages of wind intensities in the South Atlantic are around 7 m/s with the exception of 2010 and 2016 (Fig. 9).

The average annual temperature values are around 21 °C except for the averages for 2006 and 2010 (Fig. 10).

At depth (−1000 m), the maximum temperatures are low around 8 °C which contributes to a difference of 17 °C between the surface and the depth.

6. Conclusion

Studies carried out on the potential of the Moroccan Mediterranean coast, in terms of current, wind and temperature, stipulate that the implantation of certain forms of energy such as tidal turbine is possible.

This sea holds currents of up to 1 m/s.

The analysis of the characteristics of the marine environment in the North of the year 2002 to 2014: current, wind and temperature, stipulate that in this area of the Atlantic, the marine currents are quite weak. The wind speeds are very high, in the same way, the offshore temperatures have reached very high values.

The analyzes of the characteristics of the marine environment in southern Morocco, inform us that this area of the Moroccan

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Atlantic possesses considerable wind potential especially close to Dakhla.

Surface temperatures off the coast are high, while currents are very low.

Offshore seems the most appropriate type of marine energy in southern Morocco.

By way of conclusion, the results of the present study clearly show that Morocco can boast of the potential of its Atlantic and Mediterranean coasts in terms of sea current, wind, temperature, so that we can reveal that the ambitious objectives of the Morocco's marine renewable energy have a good chance of being met.

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