Aeolian knowledge

What is it

Aeolian energy is the energy that derives from the wind.
Men have used its power since ancient times to navigate or to move windmill blades, to grind cereals, to squeeze olives or pump water. Only in the last few decades wind energy has been used to produce electricity.
The word “Aeolian” comes from Aeolus, the Greek god of wind, whose name “aiolos” means “fast”.
Electric power is obtained by exploiting the kinetic energy of the wind that makes the propeller blades move. These are connected to a generator that transforms mechanic energy (blade rotation) into electric power. These modern windmills are called aerogenerators.

Wind formation

Wind is an atmospheric phenomenon due to the heating of the sun. The sun radiates on the Earth a power of 1.74×10^{17} Watts: about 2% of it is converted into wind energy.
The Earth releases the heat received from the Sun, but this is hardly homogeneous. In those areas where less heat is released, the pressure of atmospheric gases increases, while in those areas where more heat is released, the air becomes hot and the gas pressure is reduced. As a consequence, high-pressure areas and low-pressure areas are formed, which are also influenced by the Earth’s rotation. When different masses of air get in contact, the area with a higher pressure tends to transfer air towards the area with lower pressure. It is the same as when we let a balloon deflate. The high pressure inside the balloon tends to transfer air outside, where the pressure is lower, originating a small airflow. Therefore wind is a more or less rapid air transfer between different pressure areas. The higher is the pressure difference, the faster is the air displacement and the stronger is the wind.

How to measure the wind

A wind is described by two parameters: the strength (related to speed) and direction.
We all know that the wind is not constant, as its strength and direction change.
The wind direction can be observed by simply using a weathercock. In order to class the wind according to its direction people name it after the place the wind comes from. Sometimes the name refers to the geographical origin (Grecale if it comes from Greece; Libeccio if it comes from Libia, Scirocco if it comes from Siria). Some other times, like in the “Wind rose”, winds are referred to by using cardinal points (North-eastern wind, South-western wind).
The wind strength can be indicated either by measuring its speed, i.e. in knots that correspond to miles per hour (1 knot = 1 mile per hour = 1.85 km/h), or by the Francis Beaufort scale.
Speed is measured by the anemometer, a simple wheel exposed to the strength of the wind to measure its rotation speed.
Cup anemometer
One of the most used anemometers is the cup anemometer, where the wind, blowing into the cups, makes them rotate around a vertical axis. An electric or mechanic meter measures the number of turns that take place in a certain time interval. By means of adequate calibration charts it is possible to calculate the wind speed

Wind circulation on the Earth

Air masses are moved by solar heating and in particular by the difference in temperature (gradient) between equatorial and tropical areas.
Solar radiation in equatorial areas is more intense than in tropical areas.
Tropical air, warmer and less dense, tends to go up attracting cold air from tropical areas. When it arrives at the tropics, the warm air cools down and starts to go down. And in this way a continuous equator-poles cycle takes place. Without

any other factor, the circulation of winds on the Earth would follow a regular process, like the one that has just been described.

Factors that affect wind circulation

In reality, other geographic-astronomic factors act on air circulation, modifying its movement.

The inclination of the Earth's axis and the revolution of the Earth around the Sun seasonally displace the areas of higher irradiation between the two tropics. Moreover, the Earth's rotation contributes to the alternation of solar irradiation and its surface, scarcely homogeneous, has a different absorption capacity and heat exchange. The Earth's rotation causes another factor that is fundamentally important to understand the wind circulation: Coriolis' acceleration, that produces the typical spiral or rotation movement of air masses.

Another factor determining the direction and the power of the wind is the friction on the Earth's surface, as the wind uses energy to overcome it, as well as the presence of mountain chains, that block or divert the wind path.

The wind and land roughness

The speed of the wind depends, as well as on atmospheric parameters, on land conformation. The rougher the land, the more sudden inclination variations it has, the more forests, buildings and mountains, the more obstacles the wind will meet, the more its speed will be reduced.

In order to define the conformation of a land, four types of roughness have been detected:

- **roughness 0**: the soil is flat, such as the sea, the beach and the snow
- **roughness 1**: open soil with non-farmed land, low vegetation and airports
- **roughness 2**: agricultural areas with few buildings and few trees
- **roughness 3**: rough soil with many variations in soil inclination, forests and villages.

Usually the best position for an aerogenerator is on a land with a low roughness degree.

A bit of history

Man learned how to use the kinetic energy of the wind thousands of years ago. Sailing dates back to at least 10,000 years ago. The first wind mills of which rests were found were Persian and date back to 200 B.C. They were built in a very simple way, with sails mounted on wooden frames. During the following centuries, windmills became common all over the Middle East and became a commonly used machine in the agricultural sector.

Then, between 1200 and 1300 they reached Europe, especially the northern countries. Leonardo da Vinci himself contributed to the evolution of such machines.

More sophisticated technologies were introduced around 1600: the shape of the vanes was improved, and the vanes were streamlined to exploit the wind strength better.

In the Encyclopedie by Diderot and D'Alambert, written towards the end of the 1700s, contains a picture of them. At that time wind power was not exploited to grind cereals but rather to reclaim flooded land.

The invention of the dynamo by the Belgian Gramme in the mid-twentieth century opened up new horizons to the use of water- and wind-energy, and in 1887 the French Duc de La Peltrie built the first aerogenerator in Europe for the production of power: the exploitation of wind energy for the industry was born. In the same period, the United States produced the first "windmill" for the production of electricity (Charles Brush, Ohio, 1890).

The production of electric power from wind energy developed between 1920 and 1930, after the creation of turbines for the processing of hydraulic energy

After a period of oblivion, the oil crisis of 1973 led to a revival of the interest in renewable energy sources, including wind power, which in certain cases is competitive against fossil fuels. Modern mills are faster and more efficient than at the

beginning of the 20th century. They have fewer blades and can reach a speed up to five time great than that of the wind, with an energy output doubled as compared to traditional wind mills.