Aeolian plants

Wind generator

The most important way to use wind power is to produce electric power through wind generators, namely aerogenerators. Electric power is obtained by exploiting wind kinetic energy: airflows move at more than 10 km/h speed making the blades of a propeller turn. They are connected to a generator that transforms mechanic power into electric power. There are different types of aerogenerators, that differ in shape and dimension. They can have one, two or three blades, of different length. Those with 50 cm length are used as battery chargers, while those with 30 cm blades can supply 1,500 kW power, managing to satisfy the daily power need of around 1000 households.

The most popular aerogenerator is made up of a steel tower of 60-100 meter height, with two or three blades that are around 20 metres long. It generates a power of 600 kW, which equals the daily power need of 500 families.

The blades of the wind generator are fixed on a mechanical element called hub and form the rotor. According to the position of the axis, it is possible to distinguish between horizontal and vertical axis rotors. The first ones are the most common and popular; while the second ones have been used since ancient times but only recently they have been subject to studies and researches to improve their efficiency (the main advantages of vertical axes are: their constant functioning regardless of the wind direction, a better resistance even when the wind is strong and turbulent).

The structure of a wind generator with horizontal axis is simple: a support (foundations and tower) with a gondola or nacelle on the top. Inside there is a slow-driving shaft, as well as a turn multiplier, the fast shaft, the power generator and auxiliary devices (braking system and control system).

The rotor (consisting of the hub, on which the blades are mounted) is fixed at the extremity of the slow shaft.

The shape of the blades is designed in such a way that the incoming airflow activates the rotor.

From the rotor, the wind kinetic energy is transmitted to a power generator. The wind generator works according to the strength of the wind. Under 4/5 metres per second it cannot start. The minimum speed allowing the device to provide power is 10/12 metres per second to produce a few hundred kilowatts. When the speed is high (20/25 m/s) the generator is switched off for safety reasons.

The progress made in the design of aeolian rotors in the last 10 years allow them to work at lower wind speed, catching a higher quantity of energy also at higher levels, increasing the quantity of wind power that can be exploited.

Rotors with “mobile” blades have been created: by changing the blade inclination with a different wind speed it is possible to keep the quantity of power produced by the aerogenerator constant.

Onshore wind farm

Several aerogenerators connected together form the wind-farms, which are real electric plants. A wind farm is based on a group of aeolian turbines, placed in the same area, interconnected by a middle-voltage linking net. This net gathers the energy created by each turbine, convoying it to a collection station. Here a transformer converts the middle-voltage electric energy in high-tension electric current, introducing it in the distribution system. A large wind farm may have dozens of aeolian generators and more than one hundred of single turbines, being placed on an area of several km^2: however, being the space of each generator very little, all the places between the turbines could be used for agriculture or livestock holdings.

United States of America currently own the most quantity of wind farms, followed by Germany, Spain and Denmark. Italy is on the fourth place; then we have the United Kingdom, Portugal, France and Ireland. . World's largest wind farm onshore is placed in Roscoe, Texas. This plant owns 627 turbines with a power of 781 MW. The European largest plant is the new Glasgow (Scotland) farm, with 140 turbines, that will give their energy to 180.000 houses, with an effective power of 322 MW.

Offshore wind farm

The most recent wind farms are usually placed offshore, on the sea, far from the coasts, where it is possible to exploit the strong winds not delayed by obstacles. This happens on the sea surface, but also on the great lakes.

Unluckily, the realisation and maintenance costs of these offshore wind farms are more elevated than the onshore ones, because of the transportation costs, the great building problems, the difficulty to anchor their towers on the bottom and, in the end, the corrosive action of the sea water on their structures. For instance, it would be possible to work on a maximum depth of 200 meters, but usually no more than 20 m or not beyond than 20 km from the coast, to allow low costs. Anyway, these marine plants have great productivity advantages. On the sea surface, as matter of fact, winds blow without any obstacle, with a higher speed and with less changeableness. The offshore placement of great wind farms also solve the acoustic and aesthetical problems, the tower being placed beyond the line of the horizon, at least 3 km from the coast. This would solve the danger for the most part of bats and birds, migratory and birds of prey, too.
Some researchers affirm that the creation of undersea platforms and pylon and cable systems could realize, after some time, restocking and biodiversity areas on the sea bottom, like it currently happens with the anchorages of the offshore rigs.
Therefore, the offshore plants represent, according to the most part of the specialists of this sector, the true future of the aeolian energy, for what concerns both the environmental problem and the production potential.
In 2007, the offshore plants produced about the 3,5% of the European aeolian energy, owned for the most part from Denmark and United Kingdom, followed by Holland and Sweden; in 2008 the largest aeolian offshore production happened in the UK, followed by Denmark. At present, the largest offshore wind farm is placed off the Lincolnshire coasts (Great Britain), with an installation power of 194 MW.
Nowadays, we may see great projects for the offshore aeolian: the United Kingdom planned to enlighten every house of the country with the wind farm offshore energy within 2020, while Canada is planning to build an offshore wind farm on the Great Lakes. One of the world's largest offshore wind farm, called London Array, will be built on the estuary of the Thames, with an installed power of 630 MW (then, 1 GW). This plant will give energy to 750.000 houses, about ¼ of the London houses, with 341 turbines placed 12 nautical miles from the coast. Even this European offshore wind farm will be interconnected, also connected with all the onshore farms.

Wind map

In order to produce enough electric power the place where the aerogenerator is installed has to be very windy.
The assessment of the output potential of a wind power plant is a difficult and complex operation, depending on the characteristics of the winds that blow in the area where the plant is to be created. The conformation of a land affects the speed of the wind. Obstacles can strongly influence the speed, power, direction and distribution of winds. For example, as regards mountains, it has been shown that whereas steep slopes create turbulences that are dangerous in terms of stability and negative in terms of plant efficiency, more gradual slopes favour the concentration of the wind.
In general, the ideal position for an aerogenerator is a land with a limited number of obstacles with an inclination between 6 and 16 degrees.
The wind must be faster than 5.5 metres a second and blow constantly during most of the year.
As for the off-shore wind sites, the best are the ones where the wind exceeds 7-8 metres a second, which have shallow waters (between 4 and 40 metres) and are more than 3 km far from the coast.
The creation of a plant presumes the knowledge of the “wind map” of the area, that shows how and how much wind blows in the interested site.
Moreover, before building a plant, the power, speed and paths of the winds blowing in the selected areas are systematically recorded for extended periods of time.

Types of wind plants

Electric power can be used through two types of plants: plants for isolated users and plants to be connected to already-existing electric networks.
The first type of plant is the one to produce “utility” electric power supplied by small aerogenerators with less than 1 kilowatt power (1-2 metre rotor) to feed equipment in isolated areas, like radio relay stations, detectors, signalling systems, etc. these systems often compete or are used together with photovoltaic systems.

Moreover electricity is produced to supply isolated houses or settlements that are not connected to the network. These installations are made up of small aerogenerators (3-20 kilowatts) and a system (battery) that accumulates electric power when the wind is favourable.
These applications have a limited distribution in industrialized countries, but they could have interesting perspectives in developing countries with strong winds.
The second type of Aeolian installations is connected to the network and divided into two categories: one to produce power to supply small networks and one connected to the national network. The first are plants located on small islands or remote areas that are supplied by power systems not connected to the national network. Also for this type of systems it is possible to use wind power and photovoltaic power together (hybrid plants) that could integrate on an annual basis.
The most interesting application for wind power is the supply of large national networks. For this reason medium-large sized machines or wind-farms have been used for a total power of some megawatts or a few tens of megawatts.

Mini wind power plants

Generally, using nominal power as a criterion for classification, we speak of mini wind power plants when the power ranges from 20 kW to 200 kW (plants with powers lower than this are considered micro-wind power plants). In the case of larger amounts, the power plants are classified as large-scale wind power plants.
Current technologies include two macro-types of wind generators: Horizontal Axis Wind Turbines (HAWT) which are the conventional turbines whose axis is parallel to the direction of the wind, and Vertical Axis Wind Turbines (VAWT) whose axis is perpendicular to the direction of the wind. There are many types of turbines, depending on the number of blades they are made of (one-bladed, two-bladed, three-bladed, multi-bladed). To date, the technology that is used the most is the three-bladed horizontal axis system, even though it is not uncommon to find installations with two-bladed vertical axis turbines. There are numerous advantages for those who install mini wind power plants. The main applications of mini wind power are:

- Systems connected with the main network (grid – connected systems).
- Exchange on site: excess energy, that is not utilized, is sent to the main network, it is accounted for and credited when energy is taken from the network at a later time. Resolution AEEG n°186 issued in 2009, gives the user the possibility to be paid for the excess electricity by GSE - Gestore dei Servizi Elettrici (the Italian company for electric services).
- Sale of energy (all inclusive rate): energy is paid for at a rate equal to 0.3e/kWh, which includes the incentive. In this situation the installation of an inverter is necessary, which transforms the current from continuous into alternating current, according to the standards of the distribution network, thus making the exchange possible. Furthermore, the installation of special meters is necessary, which in the case of an exchange in on a site (two-directional), enable the calculation of the balance of energy that is released to and energy that is drawn from the main network.
- Off-grid systems, feeding isolated users.
- For homes or small industries (single turbines or stand-alone systems, or systems coupled with cogeneration or photovoltaic plants, hybrid systems).
- To serve telecommunication systems (signal repeaters, antennas).
- Air quality monitoring systems.
- Water pumping plants.
- Sea water desalination plants (drinking water).