ENERGY FROM WIND

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Introduction

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.

Wind farms

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 meters 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 meters per second, it cannot start. The minimum speed allowing the device to provide power is 10/12 meters 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 farms

Several wind turbines connected together form wind farms, which are veritable power plants. A wind farm consists of a group of wind turbines located in the same place, interconnected by a medium voltage connection network, which collects the energy produced by each turbine and conveys it to a collecting station where a transformer converts the medium voltage current into high voltage current and feeds it into the transmission and distribution system. A large wind farm can consist of dozens of wind generators, up to more than one hundred individual turbines, and covers an area of several km^2: since, however, the area occupied by individual wind generators is very small, all areas between one turbine and the other can be destined for other uses, such as, for example, agriculture or livestock rearing. In wind farms, the distance between the wind turbines is not random, but is calculated to avoid mutual interference that could cause a decrease in energy production. As a rule, the wind turbines are located at a distance of at least five to ten times the diameter of the blades. In the case of an average wind turbine, with blades approx. 20 meters long, this means installing one every 200 meters.

Offshore wind farms

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 realization 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 Europe, the United Kingdom and Germany own the largest number of offshore wind farms, followed by Denmark and the Netherlands. 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. The world's largest offshore wind farm, called London Array, was built on the estuary of the Thames, with an installed power of 1 GW. This plant gives energy to 600.000 houses, thanks to 175 turbines.

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 meters a second and blow constantly during most of the year. As for the offshore wind sites, the best are the ones where the wind exceeds 7-8 meters a second, which have shallow waters (between 4 and 40 meters) 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 meter rotor) to feed equipment in isolated areas, like radio relay stations, detectors, signaling 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 favorable. 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 windfarms 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).

Environment and territory

However, wind energy has some disadvantages. First of all, it is an intermittent source, that varies with the seasons and from day to day. For this reason, installing 100MW of wind turbines does not

mean having 100MW power constantly available, but less power. The actual annual capacity is equal to 45% of the nominal power in the windier areas, and an average of 30% on a global scale. In other words, in order to have a power of 100MW available, 250MW must be installed.
Another problem that needs to be faced regards power transmission and distribution networks that the wind power plants are connected to. These must be designed to receive an intermittent medium voltage flow of electricity. The distribution networks that are currently present in the industrialized countries are designed in an entirely different manner, because these are connected to few large high-voltage wind power plants where the flow of energy is controlled and predictable. The different production of energy coming from numerous small scale wind power plants and also from other sources, requires suited and costly changes in the electricity distribution network.

Visual impact

The visual impact of an aerogenerator of a 40-60-metre-tall wind power plant is obvious, but it can be downsized by building plants at a certain distance from the nearest urban centre. Today the visual impact is reduced by positioning the machines on a single row and using neutral colours (like white). The lowest impact on the environment and landscape can be obtained by positioning the plants in the open sea, in places that are not visible from the coast. At the moment some less visible building solutions are being studied also with regard to installations on the land. It is possible to use chromatic tricks by painting wind towers with same colour as the surrounding landscape (for example the lower part could be green like the surrounding countryside, while the higher part could be light blue like the sky) or adapting shapes of wind plants to already existing structures. ***Land occupation.*** The necessary land to build a wind power plant is generally wide, since the distance between the generators must be accounted for. From this point of view, the power density (10 watts per square metre) is rather low. However, if we consider that windmills and flanking works only cover 2-3% of the territory, the density grows to hundreds of watts per square metre and the space between the two machines can be used for cattle or rearing purposes.

Noise

The potential acoustic pollution caused by aerogenerators determines two types of noise: mechanical noise that comes from the generator and aerodynamic noise caused by the rotor blades.
With regard to noise, in terms of decibels, the humming of aerogenerators is far lower than town noise. The decibels that one can hear at three hundred metres from a wind farm are the same one would normally hear amidst traffic or near an industry. At the moment high technology aerogenerators are very quiet. It was calculated that, at a distance of around 200 metres, the noise of rotation originated by rotor blades can be confused with wind noise that blows into the surrounding vegetation.
Electromagnetic effects. Possible interferences with telecommunication devices are irrelevant. Like any other obstacle, also the wind machine can interfere with telecommunication services, but a suitable distance makes the interference irrelevant.

Effects on plant and animal life

With regard to possible changes in plant and animal life, based on the available information, it has been reported that possible relevant interferences have been noted only with regard to the birds' impact with the machine rotors. Generally, collisions are rare, and mostly limited to birds of prey. Migratory birds instead seem to adapt to the presence of these obstacles.

According to the US Fish and Wildlife Service the leading cause of mortality in the birds are cats (about one billion birds a year), followed by buildings (a little less than a billion), hunters (about 100 million a year) and lastly vehicles, telecommunication towers, pesticides and high-tension lines (each category accounts for about 60-80 million birds a year); the contribution of wind power plants appears to be an extremely modest fraction.

The impact on plants is noted specially when setting up the power plant, with the construction of roads and foundations, and when handling materials on site. Some measures are taken to reduce the impact on the territory, for example planting plants when the site has been completed or compensating the impact with improvements in the surrounding areas, in order to have a positive overall balance. Concluding, if some measures are taken when designing a wind farm, among all the energy producing industries, wind power plants are among the cleanest and safest. During operation they do not produce polluting substances, dusts and heat, even after they are dismantled, the former pristine state can be restored without leaving any traces in the environment nor on the people.

Text updated to August 2022