Wind Energy.

Wind Energy is an indirect source of solar energy and it a form of solar power, or "solar related power". The winds on earth surface are caused primarily by the unequal heating of the land and water by the sun. The differences in temperature gradients induce the circulation of air from one zone to another. The global circulation of the atmosphere occurs in five rather distinct zones; the tropical zone near the equator, the two temperature zones, and the north and south polar zones. The circulation in the temperature zones conducts an enormous amount of heat from the solar-heated tropics to the radiation cooled Polar Regions in an interesting and complicated way. It has been estimated that roughly 10 million megawatts of energy are continuously available in the earth's winds.

The Power from the wind

The power in the wind can be computed by using the concept of kinetics. The wind mill works on the principle of converting kinetic energy of the wind to mechanical energy. We know that $power$ is equal to energy per unit time. The energy available is the kinetic energy of the wind. The kinetic energy of any particle is equal to one-half its mass times the square of its velocity, or $\frac{1}{2}MV^2$. The volume of air passing in unit time, through an area A, with velocity V, is $A.V$ and its mass M is equal to its volume, multiplied by its density ρ of air, or

$$M = \rho.A.V \qquad 1$$

(M is the mass of air traversing the area A swept by the rotating blades of a wind mill type generator). Substituting this value of the mass in the expression for the kinetic energy, we obtain

$$\text{Kinetic energy} = \frac{1}{2}MV^2$$

$$= \frac{1}{2}\rho AV.V^2$$

$$= \frac{1}{2}\rho AV^3 watts \qquad 2$$

It is not possible to convert all the wind energy into another form of energy because the load would reduce the wind speed through the generator to zero, thus stopping the machine. It is concluded from theoretical considerations that the maximum conversion rate is $\frac{16}{27}$ (0.573) of the energy of the wind,(for horizontal axis wind mill).

Wind power P is given by the following expression

$$P = \frac{1}{2}\rho AV^3 C_p \qquad (3)$$

Where $C_p = power\ coefficient$

$$= \left(\frac{Energy\ available}{Energy\ input}\right)$$

i.e. fraction of the available energy that is converted is called the power coefficient

$$P = KAV^3 \qquad (4)$$

Where K is a constant.

There are losses to be encountered before the energy is delivered, due to bearings, gears and other transmission system, represented through η_m, i.e. mechanical efficiency.

Here $$P = \eta_m KAV^3 \qquad (5)$$

Further conversion factors like $\eta_E, and\ \eta_r$ electrical and transmission efficiency can be calculated from the above equation.

In practice, the wind power is measured by wind mill type devices or anemometers. The wind power P is related to the wind speed by empirical formula:

$$P = 0.37(\frac{V}{10})^3 \qquad (6)$$

Where P is in Kilowatts per square meter of area normal to direction of the wind, and V is in meters per second.

It is important to note that the convertible power or energy is proportional to the cube of the wind speed. Thus if the wind speed decreases by 20%, the power output is reduced by almost 50%. The wind speed may vary considerably from day to day and from season to season. Standard wind maps are available, in which the annual wind velocity zones are marked. One can see that only some parts of the country have reasonably good velocity from the point of view of wind mill operation.

There are various ways the data on wind behavior is collected depending on the use it is to be put into. The hourly mean wind velocity as collected by the meteorological observations is the basic data used in wind mill designs. The hourly mean is the averaged over a particular hour of the day, over the day, month, year and years. The factors which affect the nature of the wind close to the surface of the earth, they are:

(i) Latitude of the place
(ii) Altitude of the place
(iii) Topography of the place
(iv) Scale of the hours, month or year.

Wind being an unsteady phenomenon, the scale of the periods considered is an important set of data required in the design. The hourly mean velocity (for many years) provides the data for establishing the potential of the place for tapping the wind energy. The scale of the month is useful to indicate whether it is going to be useful during particular periods of the year and what shortage if necessary is to be provided for. The data based on scale of the hour is useful for mechanical aspects of design.

In addition to the data on the hourly mean velocity, two other informations required are spells of low wind speeds are gusts. A number of criteria can be applied in estimating the importance of wind potential as a function of height and location. First of all, careful sitting is important because wind speed near the ground is greatly affected by houses, trees and similar features. Wind speed increases with height above ground, the rate of increases being about the same at all locations. Therefore, if the wind speed at a given height is known, the speed at any other height may be calculated.

The wind flow in the atmosphere is also influenced by some other parameters. The following guidelines may be useful (all figures are for a height of 20m, which seems to be reasonable minimum):

1. The best sites for wind energy are found off shore and on the sea coast. An average value on the coast is 2400 KWh/m^2 per year.
2. The second best sites for wind energy are in mountains. A typical average value is 1600 KWh/m^2 per year.
3. The lowest level of the wind energy is found in plains, where values are generally three or four times lower than that at the coast. A typical average is 750 KWh/m^2 per year.

As regards climates, other criteria interact with those discussed thus for:

1. In the humid equatorial region, there is virtually no wind energy, whether at sea, along the coast or in the mountains.
2. The amount of convertible wind energy is fair of good in dry or hot climates, as well as in temperature and cold climates.
3. In some warm, windy countries, wind energy may not be usual because of the frequency of cyclones.

Advantages of wind energy are:

(i) It is a renewable source of energy
(ii) Like all forms of solar energy, wind power systems are non-polluting, so it has no adverse influence on the environment.
(iii) Wind energy systems avoid fuel provision and transport.
(iv) On a small scale, up to a few kilowatt system, is less costly.

On a large scale costs can be competitive with conventional electricity and lower costs could be achieved by mass production.

Disadvantages of wind energy are:

(i) Wind energy available is dilute and fluctuating in nature.
(ii) Unlike water energy wind energy needs storage capacity because of its irregularity.
(iii) Wind energy systems are noisy in operation; a large unit can be heard many kilometers away.
(iv) Wind power systems have relatively high overall weight, because they involve the construction of a high tower and include also a gearbox, a hub and pitch changer, a generator, coupling shaft etc. for large systems a weight of 110 Kg/KW (rated) has been estimated.
(v) Large areas are needed; typically, propellers 1 to 3m in diameter deliver power in the 30 to 300W range.
(vi) Present systems are neither maintenance free nor practically reliable. However, the fact that highly reliable propeller engines are built for aircraft suggests that the present troubles could be overcome by industrial development work.

3. Windmills Types and Performance

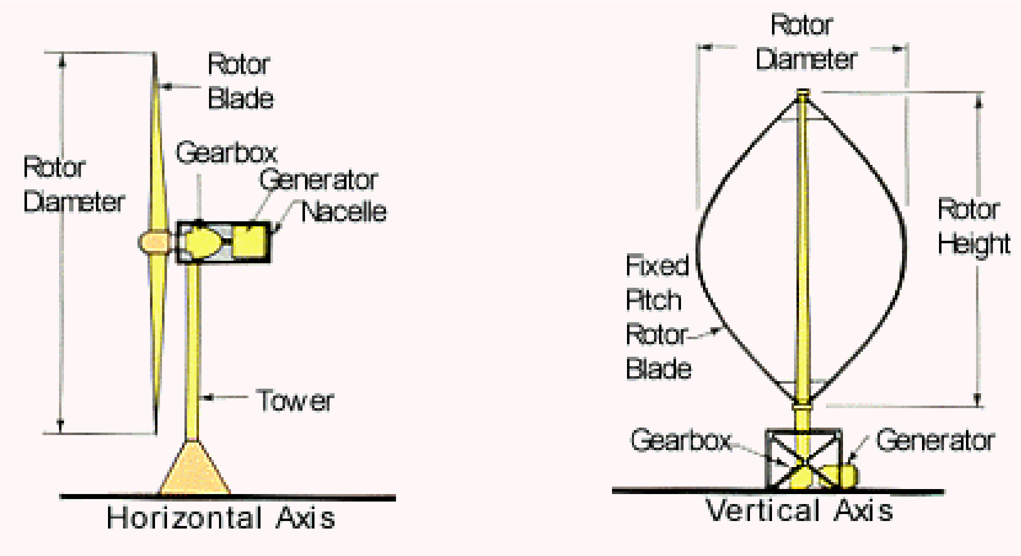
A wind mill is a machine for wind energy conversion. A wind turbine converts the kinetic energy of the wind's motion to mechanical energy transmitted by the shaft. A generator further converts it to electrical energy, thereby generating electricity.

Wind mills are generally classified as

--Horizontal axis type, and

--Vertical axis type,

depending on their axis of rotation, these are shown in the figure below.



Wind Turbine Configurations

Some authors refer to them also as wind axis rotors and cross – wind axis rotors respectively. In the former types, the rotors are oriented normal to the direction of wind, while in the latter types, the effective surface of the rotor moves in the same direction as the wind. Horizontal axis and mills further sub-classified as single bladed, double bladed, multiblade and bycycle multibladed type. Sail, wing, multibladed are example of horizontal axis wind mills. Savonius and Darrius rotors are example of vertical axis rotors.

The vertical axis wind mill is again sub-divided into two major types:

(i) Savonius or 'S' type rotor mill (low velocity wind),

(ii) Darrius type rotor mill (high velocity wind), based on the working speed of the machine and the velocity ranges required by the machine for operation.

Vertical axis machines are of simple design as compared to the horizontal axis.