Wind energy is the kinetic energy that is present in moving air. The amount of potential energy depends mainly on wind speed, but is also affected slightly by the density of the air, which is determined by the air temperature, barometric pressure and altitude.

For any wind turbine, the power and energy output increases dramatically as the wind speed increases. Therefore, the most cost-effective wind turbines are located in the windiest areas. Wind speed is affected by the local terrain and increases with height above the ground, so wind turbines are usually mounted on tall towers.

Application of wind energy:

1- Mechanical application: mainly (water pumping) Multi-blade windmill used for water pumping shown below:

2- Electricity generation:

Wind turbines vary in size and type. They are commercially available for electricity generation.

Size of wind turbines (400 Watt-5 MW)

How do wind turbines make electricity?

The wind turns the blades, which spin a shaft, which connects to a generator and makes electricity.

Wind turbine types:

1- Vertical axis wind turbine (i.e. Darius wind turbine)

Advantages of vertical wind turbines

Vertical wind turbines are easier to maintain because most of their moving parts are located near the ground. This is due to the vertical wind turbine's shape. The airfoils or rotor blades are connected by arms to a shaft that sits on a bearing and drives a generator below, usually by first connecting to a gearbox. As the rotor blades are vertical, a yaw device is not needed, reducing the need for this bearing and its cost. Vertical wind turbines have a higher airfoil pitch angle, giving improved aerodynamics while decreasing drag at low and high pressures.

Disadvantages of vertical wind turbines

There may be a height limitation to how tall a vertical wind turbine can be built and how much swept area it can have. Most VAWTS need to be installed on a relatively flat piece of land and some sites could be too steep for them while available to HAWTs. VAWTs that use guy wires to hold it in place create serious problems for the bottom bearing as all the weight of the rotor is on it and the guy wires increase downward thrust in wind gusts. Solving this problem requires a superstructure to hold in place the top bearing that also can share the weight of the rotor.

2- Horizontal axis wind turbine (HAWT):

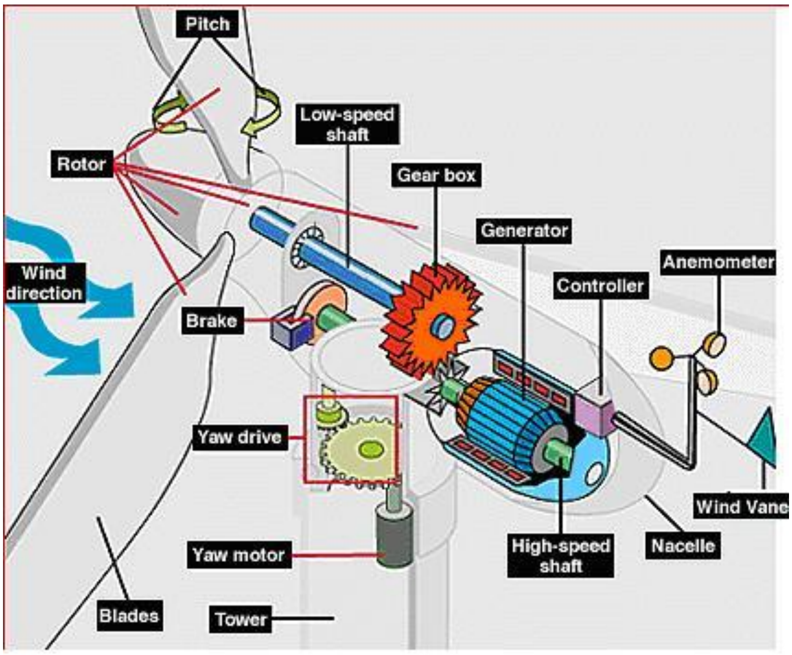
Advantages of horizontal wind turbines

In the horizontal wind turbine, the blades are to the side of the turbine's centre of gravity, helping stability. They have the ability to wing warp, which gives the turbine blades the best angle of attack. Allowing the angle of attack to be remotely adjusted gives greater control, so the turbine collects the maximum amount of wind energy for the time of day and season. The blades also have the ability to pitch the rotor blades in a storm, to minimize damage. Tall towers allow access to stronger wind in sites with wind sheer. In some wind sheer sites, every ten meters up, the wind speed can increase by 20% and the power output by 34%. Tall towers also allow placement on uneven land or in offshore locations. These can be placed in forests above the treeline. Most are self-starting. The horizontal wind turbines can be cheaper because of higher production volume, larger sizes and, in general, higher capacity factors and efficiencies.

Disadvantages of horizontal wind turbines

HAWTs have difficulty operating in near ground, turbulent winds because their yaw and blade bearings need smoother, more laminar wind flows. The tall towers and long blades (up to 180 feet long) are difficult to transport on sea and land. Transportation can now account for 20% of equipment costs. Tall HAWTs are difficult to install, needing very tall and expensive cranes and skilled operators. The supply of HAWTs is less than demand and between 2004 and 2006, turbine prices increased up to 60%. At the end of 2006, all major manufacturers were booked up with orders through 2008. The Federal Aviation Administration (USA) has raised concerns about tall HAWTs' effects on radar in proximity to air force bases. Height can be a safety hazard for low-altitude aircraft. Offshore towers can be a navigation problem. Downwind variants suffer from fatigue and structural failure caused by turbulence.

Inside Wind Turbine



Look at the Wind Turbine Close Up

Wind Turbine Glossary

Anemometer: Measures the wind speed and transmits wind speed data to the controller.

Blades: Most turbines have either two or three blades. Wind blowing over the blades causes the blades to "lift" and rotate.

Brake: A disc brake which can be applied mechanically, electrically, or hydraulically to stop the rotor in emergencies.

Controller: The controller starts up the machine at wind speeds of about 8 to 16 miles per hour (mph) and shuts off the machine at about 65 mph. Turbines cannot operate at wind speeds above about 65 mph because their generators could overheat.

Gear box: Gears connect the low-speed shaft to the high-speed shaft and increase the rotational speeds from about 30 to 60 rotations per minute (rpm) to about 1200 to 1500 rpm, the rotational speed required by most generators to produce electricity. The gear box is a costly (and heavy) part of the wind turbine and engineers are exploring "direct-drive" generators that operate at lower rotational speeds and don't need gear boxes.

Generator: Usually an off-the-shelf induction generator that produces 60-cycle AC electricity.

High-speed shaft: Drives the generator.

Low-speed shaft: The rotor turns the low-speed shaft at about 30 to 60 rotations per minute.

Nacelle: The rotor attaches to the nacelle, which sits atop the tower and includes the gear box, low- and high-speed shafts, generator, controller, and brake. A cover protects the components inside the nacelle. Some nacelles are large enough for a technician to stand inside while working.

Pitch: Blades are turned, or pitched, out of the wind to keep the rotor from turning in winds that are too high or too low to produce electricity.

Rotor: The blades and the hub together are called the rotor.

Tower: Towers are made from tubular steel (shown here) or steel lattice. Because wind speed increases with height, taller towers enable turbines to capture more energy and generate more electricity.

Wind direction: This is an "upwind" turbine, so-called because it operates facing into the wind. Other turbines are designed to run "downwind", facing away from the wind.

Wind vane: Measures wind direction and communicates with the yaw drive to orient the turbine properly with respect to the wind.

Yaw drive: Upwind turbines face into the wind; the yaw drive is used to keep the rotor facing into the wind as the wind direction changes. Downwind turbines don't require a yaw drive, the wind blows the rotor downwind.

Yaw motor: Powers the yaw drive.

The benefits of wind energy

Wind energy is an ideal renewable energy because:

- It is a pollution-free, infinitely sustainable form of energy.
- It doesn't require fuel.
- It doesn't create greenhouse gasses.
- It doesn't produce toxic or radioactive waste.

Wind Energy & the Environment

Wind is a clean fuel; wind power plants (also called wind farms) produce no air or water pollution because no fuel is burned to generate electricity.

Drawbacks of Wind Machines

The most serious environmental drawbacks to wind machines may be their negative effect on wild bird populations and the visual impact on the landscape. To some, the glistening blades of windmills on the horizon are an eyesore; to others, they're a beautiful alternative to conventional power plants.