2.4 Working of Wind Power Plants:

- Wind is a form of kinetic energy created in part by the sun. About two percent of the sun's energy that reaches the earth is converted to wind energy.
- The atmosphere is heated during the day by the sun and at night it cools by losing its heat to space. Wind is the reaction of the atmosphere to the heating and cooling cycles, as well as the rotation of the earth.
- Heat causes low pressure areas, and the cool of the night results in high pressure areas. This process creates wind when air flows from high pressure areas into low pressure areas. Wind energy has been used for hundreds of years.
- The windmills of Europe and Asia converted the kinetic energy of the wind into mechanical energy, turning wheels to grind grain. Today wind-driven generators are used to convert the kinetic energy of wind into electrical energy.
- Wind-driven systems consist of a tower to support the wind generator, devices regulating generator voltage, propeller and hub system, tail vane, a storage system to store electricity for use during windless days, and a converter which converts the stored direct current (DC) into alternating current (AC).
- Wind energy accounts for 6 percent of renewable electricity generation. The U.S. wind energy industry achieved unprecedented success in the first year of the new century, installing nearly 1700 megawatts or $1.7 billion worth of new generating capacity.
- Due to continuing research and better placement of turbines, wind power has become much more reliable. Virtually all regions of Canada have areas with good wind resources. Oceans and large lakes, open prairie, and certain hill or mountain areas often have good winds, and these areas are where Canada_s current wind generation facilities are located.
- There are commercial wind turbines in five provinces and the Yukon, with plans for further installations in almost all the rest of the provinces. Natural Resources Canada estimates that Canada has almost 30,000 megawatts of developable wind resource.
- This compares to the current installed base of 200 megawatts, and would be enough to supply 15 percent of Canada's electricity supply. The wind energy future looks bright and there is a growing interest in wind power within the North American electric industry.

- Wind power is a clean and renewable energy source, it produces no pollution and it doesn_t harm our earth. Also important is the fact that the price of wind power is not affected by fuel price increases or supply disruptions—it is a domestic, renewable energy source. The land used for wind turbines can still be used for other purposes such as grazing and farmland.

WORKING PRINCIPLE OF WIND TURBINE:

- There is an air turbine of large blades attached on the top of a supporting tower of sufficient height. When wind strikes on the turbine blades, the turbine rotates due to the design and alignment of rotor blades. The shaft of the turbine is coupled with an electrical generator. The output of the generator is collected through electric power cables.

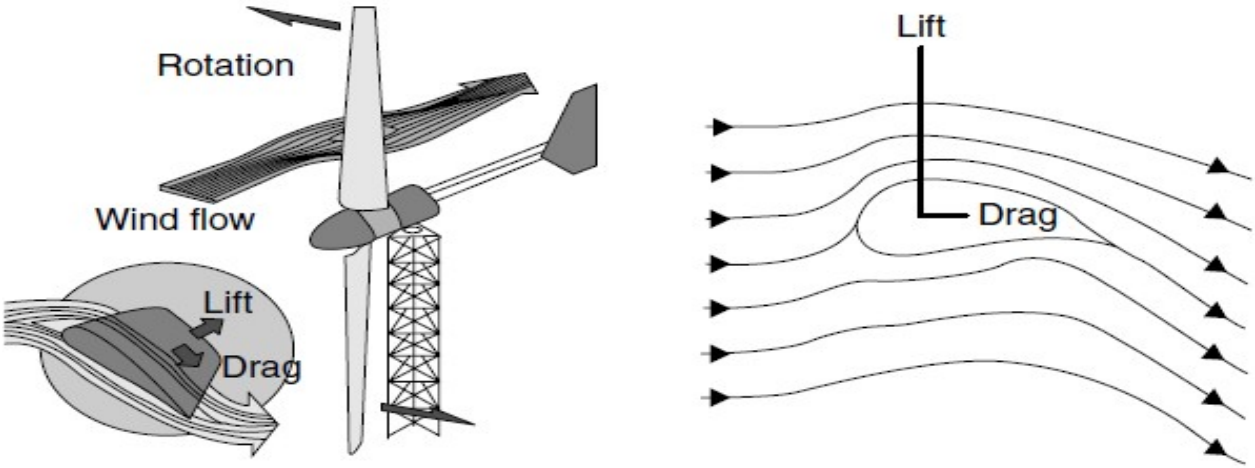

Figure 2.4.1. Principles of Wind turbine aerodynamics

[Source: "Solar Photovoltaics: Fundamentals,Technologies andApplications" by ChetanSingh Solanki, Page: 072]

- When the wind strikes the rotor blades, blades start rotating. The turbine rotor is connected to a high-speed gearbox.
- Gearbox transforms the rotor rotation from low speed to high speed. The high- speed shaft from the gearbox is coupled with the rotor of the generator and hence the electrical generator runs at a higher speed.
- An exciter is needed to give the required excitation to the magnetic coil of the generator field system so that it can generate the required electricity. The generated voltage at

output terminals of the alternator is proportional to both the speed and field flux of the alternator.

- The speed is governed by wind power which is out of control. Hence to maintain uniformity of the output power from the alternator, excitation must be controlled according to the availability of natural wind power.
- The exciter current is controlled by a turbine controller which senses the wind speed. Then output voltage of electrical generator(alternator) is given to a rectifier where the alternator output gets rectified to DC.
- Then this rectified DC output is given to line converter unit to convert it into stabilized AC output which is ultimately fed to either electrical transmission network or transmission grid with the help of step up transformer
- An extra units is used to give the power to internal auxiliaries of wind turbine (like motor, battery etc.), this is called Internal Supply Unit. There are other two control mechanisms attached to a modern big wind turbine.
    (i) Controlling the orientation of the turbine blade.
    (ii) Controlling the orientation of the turbine face.
- The orientation of turbine blades is governed from the base hub of the blades. The blades are attached to the central hub with the help of a rotating arrangement through gears and small electric motor or hydraulic rotary system.
- The system can be electrically or mechanically controlled depending on its design. The blades are swiveled depending upon the speed of the wind. The technique is called pitch control. It provides the best possible orientation of the turbine blades along the direction of the wind to obtain optimized wind power.
- The orientation of the nacelle or the entire body of the turbine can follow the direction of changing wind direction to maximize mechanical energy harvesting from the wind.
- The direction of the wind along with its speed is sensed by an anemometer (automatic speed measuring devices) with wind vanes attached to the back top of the nacelle.

- The signal is fed back to an electronic microprocessor-based controlling system which governs the yaw motor which rotates the entire nacelle with gearing arrangement to face the air turbine along the direction of the wind.