4 Wind energy conversion systems

During its transition from the earlier day’s wind ‘mills’ to the modern wind electric generators, the wind energy conversion systems (WECS) have transformed to various sizes, shapes and designs, to suit the applications for which they are intended for. For example, at the inceptive stage of the technology, wind machines were used for grinding grains. Hence these ancient machines had vertical axis with wind catching surfaces made of canvas or bundles of reeds. The mechanical power available at the shaft was utilized for grain milling. With the advent of technology, so-called ‘American wind mills’ were introduced in the 19th century. These systems were designed with multi bladed rotor, mechanically coupled with reciprocating piston pumps, which was appropriate for water pumping application. The era of wind electric generators started in 1890 with the construction of the turbine in Denmark for meeting the rural electricity demand.

The modern wind turbine is a sophisticated piece of machinery with aerodynamically designed rotor and efficient power generation, transmission and regulation components. Size of these turbines ranges from a few Watts to several Mega Watts. Modern trend in the wind industry is to go for bigger units of several MW capacities, as the system scaling up can reduce the unit cost of wind generated electricity. Most of today’s commercial machines are horizontal axis wind turbines (HAWT) with three bladed rotors. Though research and development activities on vertical axis wind turbines (VAWT) were intense during the end of the last century, VAWT could not evolve as a reliable alternative to the horizontal axis machines.

The turbines may be grouped into arrays, feeding power to a utility, with its own transformers, transmission lines and substations. Stand-alone systems catering the needs of smaller communities are also common. As wind is an intermittent source of energy, hybrid systems with back up from diesel generators or photovoltaic panels are also popular in remote areas.

For the efficient and reliable performance of a WECS, all its components are to be carefully designed, crafted and integrated. In this chapter, we will discuss the constructional features of WECS giving emphasis to various components, systems and sub-systems. As off shore installations are getting prominence in the recent years, details of such turbines are also included. Wind powered water pumps, which are still relevant in remote rural areas, are also featured in this chapter.
4.1 Wind electric generators

Electricity generation is the most important application of wind energy today. The major components of a commercial wind turbine are:
1. Tower
2. Rotor
3. High speed and low speed shafts
4. Gear box
5. Generator
6. Sensors and yaw drive
7. Power regulation and controlling units
8. Safety systems

The major components of the turbine are shown in Fig. 4.1.