2.5 Siting of Wind Power Plants:

The power available in wind increases rapidly with wind speed. Therefore main consideration for locating a wind power generation plant is the availability of strong and persistent wind. A suitable site should preferably have some of the following features:

1. No tall obstructions for some distance (about 3 km) in the upwind direction (i.e. the direction of incoming wind) and also as low a roughness as possible in the same direction
2. A wide and open view, i.e. open plain, open shoreline or offshore locations
3. Top of smooth well-rounded hill with gentle slopes (about 1:3 or less) on a flat plain
4. An island in a lake or the sea
5. A narrow, mountain gap through which wind is channeled
6. The site should be reasonably close to power grid
7. The soil conditions must be such that building of foundations of the turbines and transport of road construction material loaded on heavy trucks must be feasible
8. If there are already wind turbines in the area, their production results are an excellent guide to local wind conditions.

2.5.1 WIND TURBINE SITE SELECTION:

- ➔ The selection of a wind farm site is complex and time consuming, and also it involves multiple disciplines working on parallel paths.
- ➔ It is imperative in all of the above-referenced steps that construction expertise be involved and consulted to achieve maximum use of the approved site.
- ➔ Wind is the energy resource that drives a wind turbine.
- ➔ A windmill needs to be placed on a high tower located in wind area. Not just any wind will do, a wind turbine needs air that moves uniformly in the same direction.
- ➔ The rotor cannot extract energy from turbulent wind, and the constantly changing wind direction due to turbulence causes excessive wear and premature failure of turbine.
- ➔ This means that turbine must be placed high enough to catch strong winds, and above turbulent air.
- ➔ Since the tower price goes up quickly with height, there is a limit to what is practical and affordable.

2.5.2 TURBINE HEIGHT:

- In general, wind turbines should be sited well above trees, buildings, and other obstacles. When the wind flows over an obstacle like a building or a tree, the wind is slowed down and turbulent air is created, and if a wind turbine is located in this zone of turbulence, the result will be poor energy production and increased wear and tear on the turbine. One way to get above the zone of turbulence is to put the wind turbine on a tall tower.

- Figure.2.18 (Installation of wind turbine) is an illustration of a simple rule of thumb that is often used to specify a minimum tower height for a residential-sized wind turbine. The rule of thumb is to make sure that the tower is tall enough so that the entire turbine rotor is at least 10 m above the tallest obstacle within 150 m of the tower. Because trees grow and towers do not, the growth of trees over the lifetime of the wind turbine (typically 20-30 years between major rebuilds) should be considered in installation.

- This should really be regarded as an absolute minimum for a wind turbine; at 10 m above an obstacle, there will still be some amount of turbulence and additional clearance is highly desirable. Changes in height of obstacles should be kept in mind as well. For example, if the obstacle like trees that are expected to grow up to 20 m high, it is advisable to use a 33m tower.

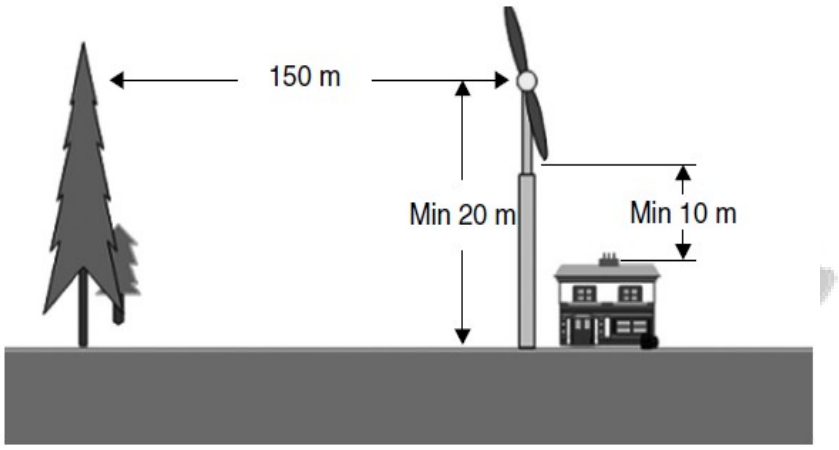

Figure: 2.5.1

[Source: "Solar Photovoltaics: Fundamentals,Technologies andApplications" by ChetanSingh Solanki, Page: 122]

- Likewise, a 20-m tower should only be used when the terrain is very flat with no obstacles in a wide area around; for example, at the edge of the sea, or on top of a cliff with a clear area around it, or in the tundra
- For most situations, a 20-m tower will only save a little money up front, while short selling energy production in the long run
- To go beyond the rule of thumb, the airflow over any blunt obstruction, including a tree, tends to create a _bubble' of turbulent air of twice the height of the obstacle, extending 20 times the height of the obstacle behind it. Therefore, your 10-m high house disturbs the air up to 200 m away.

2.5.3 Considerations and Guidelines for Site Selection:

When looking for a place for a wind turbine, engineers consider factors such as wind hazards, characteristics of the land that affect wind speed, and the effects of one turbine on nearby turbines in wind farms.

The following important factors need careful considerations

Hill effect:

When it approaches a hill, wind encounters high pressure because of the wind that has already built up against the hill. This compressed air rises and gains speed as it approaches the crest, or top of the hill. The installation of wind turbines on hilltops takes advantage of this increase in speed

Roughness or the amount of friction that earth's surface exerts on wind:

Oceans have very little roughness. A city or a forest has a great deal of roughness, which slows the wind

Tunnel effect:

The increase in air pressure undergoes when it encounters a solid obstacle. The increased air pressure causes the wind to gain speed as it passes between, for example, rows of buildings in a city or between two mountains. Placing a wind turbine in a mountain pass can be a good way to take advantage of wind speeds that are higher than those of the surrounding air.

Turbulence:

Rapid changes in the speed and direction of the wind,often caused by the wind blowing over natural or artificial barriers are called turbulence. Turbulence causes not only fluctuations in the speed of the wind but also wear and tear on the turbine. Turbines are mounted on tall towers to avoid turbulence caused by ground obstacles.

Variations in wind speed:

During the day, winds usually blow faster than they do at the night because the sun heats the air, setting air currents in motion. In addition, wind speed can differ depending on the season of the year. This difference is a function of the sun, which heats different air masses around earth at different rates, depending on the tilt of the earth towards or away from the sun

Wake:

Energy can neither be created nor destroyed. As wind passes over the blades of a turbine, the turbine seizes much of the energy and converts it into mechanical energy. The air coming out of the blade sweep has less energy because it has been slowed. The abrupt change in the speed makes the wind turbulent, a phenomenon called wake. Because of wake, wind turbines in a wind farm are generally placed about three rotor diameters away from one another in the direction of the wind, so that the wake from one turbine does not interfere with the operation of the one behind it.

Wind obstacles:

Trees, buildings, and rock formations are the main obstacles in the installation of wind turbines. Any of these obstacles can reduce wind speed considerably and increase turbulence. Wind obstacles like tall buildings cause wind shade, which can considerably reduce the speed of the wind, and therefore, the power output of a turbine.

Wind shear:

It is the differences in wind speeds at different heights. When a turbine blade is pointed straight upward, the speed of the wind hitting its tip can be, for example, 9 miles (14 km) per hour, but when the blade is pointing straight downward, the speed of the wind hitting its tip can be 7 miles (11 km) per hour. This difference places stress on the blades. Further, too much wind shear can cause the turbine to fail. Choosing the right site for wind turbine is the

most important decision. Further, the location plays a vital part in the performance and efficiency of a wind turbine.