Wind Energy

Converts kinetic energy of wind into mechanical energy.

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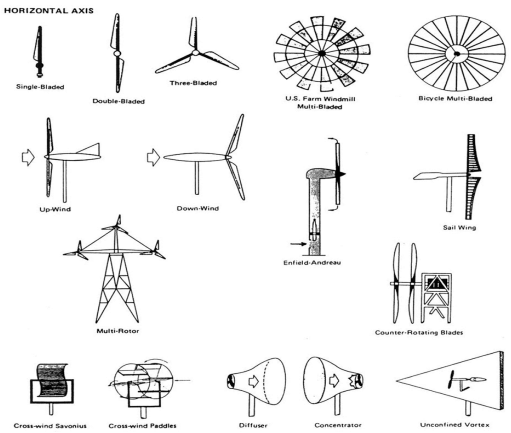
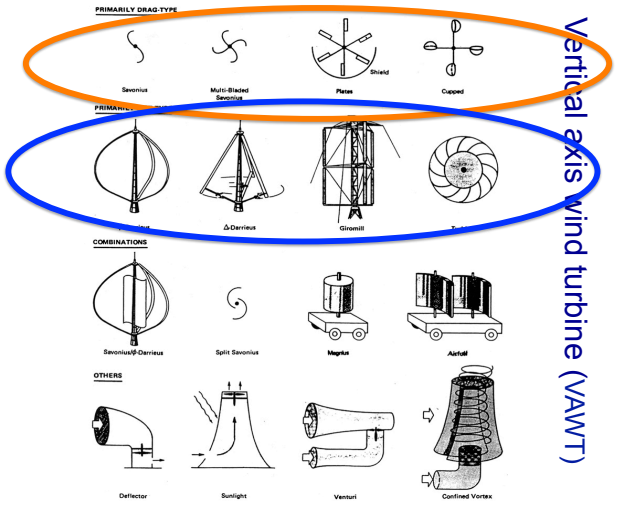
Unit -31

Ack: Alternative Energy Systems by B. K. Hodge,

Blades rotates either by drag or lift caused by flowing air through it



Horizontal axis wind turbine (HAWT)



Vertical axis wind turbine (VAWT)

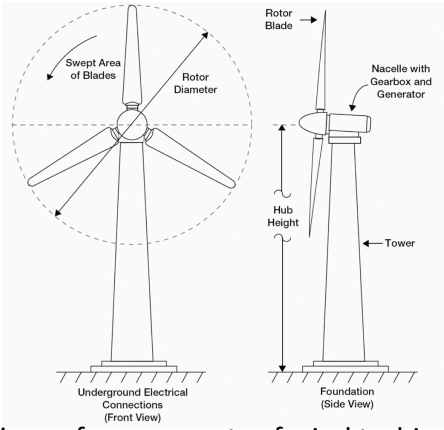
VAWT is independent of wind direction, but has low rotational speed with consequential higher torque and lower power coefficient.

But VAWT can be placed on ground level avoiding expensive tower

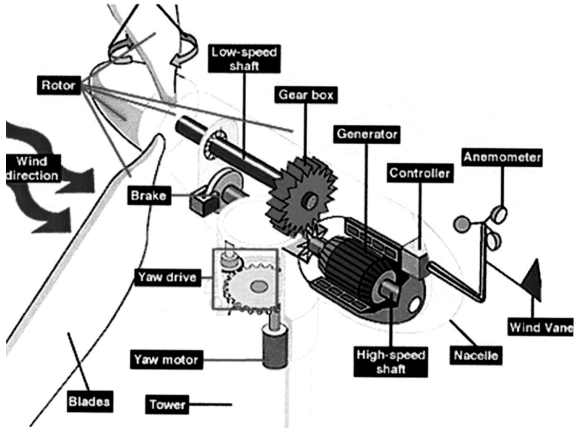
(a) HAWT (600-kW Mitsubishi)

(b) HAWT (1.5-kW Bergey)

(FloWind Corporation 17 EHD)



Definitions of components of wind turbine



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Coefficient of Power (CEP), C_p

$$C_p = \frac{\text{Power produced}}{\text{Energy available in wind}} = \frac{2P}{\rho A V^3}$$

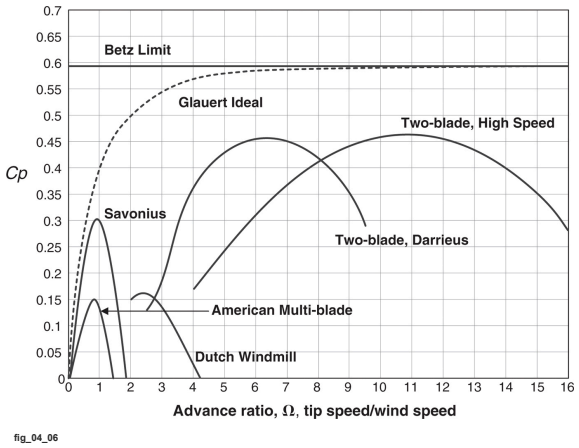
$$\text{Power produced} = \frac{1}{2} C_p (\rho A V^3)$$

Maximum value of power coefficient, C_p is 16/27 or 0.5926. No wind turbine can be more efficient than 59.26%. This limit is called **Betz limit.**

A 100% efficient turbine will require wind to stop behind the turbine preventing further air inflow

Tip speed ratio $TSR = \frac{r\omega}{V}$

- Tip speed ratio (TSR) is ratio of speed of turbine blade's tip and the wind speed.
- It influences how efficient the turbine is. If it rotates too slowly, air will pass undisturbed through gaps between blades. Again if it turns too quickly blades will act like a solid wall with little air passing through it.
- Fewer the number of blades faster the wind turbine rotor needs to turn to extract maximum power. Two bladed rotor has optimum TSR is 5, for four blade rotor it is 3.
- Multiblade turbine moves slowly resulting in higher torque, while twin blade rotates faster with less torque
- Aerodynamic efficiency increases with number of blades
- But noise emission is proportional to 5th power of blade speed



Speed range

- Start up speed is the speed at which the rotor assembly start to rotate
- Cut in speed is the minimum wind speed at which turbine will generate usable power It is generally between 7-10 mph
- Cut out speed in one at which turbine is stopped to generate power as a safety measure It is generally in the range of 45-80 mph
- Rates peed is the minimum speed at which wind turbine will generate its designated rated power. A 10 Kw rotor will not generate 10 kW until it reaches its rates speed of 25 mps. It is generatly in the 25-35 mpsh range

Practice problem

- A 12 m/s wind (1.2 kg/m3) enters a two bladed HAWT high speed turbine with a diameter of 11 m. Calculate
- a) power available from incoming wind
- B) Theoretical maximum power extractable
- C) Maximum actual power extractable for the turbine
- D) Rotor speed for the part (c)