Efficiency of new wind turbine

The efficiency of a wind turbine is maximum at its design wind velocity, and efficiency decreases with the fluctuations in wind. There are limits on both the minimum (2–5 m/s) and maximum (25–30 m/s) wind velocity for the efficient operation of wind turbines.

Conservation of mass requires that the amount of air entering and exiting a turbine must be equal. Accordingly, Betz's law gives the maximal achievable extraction of wind power by a wind turbine as 16/27 (59.3%) of the total kinetic energy of the air flowing through the turbine.

The maximum theoretical power output of a wind machine is thus 0.59 times the kinetic energy of the air passing through the effective disk area of the machine. If the effective area of the disk is A, and the wind velocity v, the maximum theoretical power output P is:

$$P = 0.59\frac{1}{2}\rho v^3 A$$

where ρ is air density of air.

Present wind turbines in practice produces much lower output such as 30% than the theoretically calculated power output. Let us consider wind streams at velocity 5m/s with a typical air density of 1.23kg/m^3:

In Comparison with HAWT (horizontal axis wind turbine) Let us assume radius of the wind turbine is 30 m. Then the covering area = Πr^2 =3.143x 30^2 =3.143x900 =2828.7m^2

The typical turbine blade area = 61.7928 m^2

Distance to the center of pressure from central axis = 12.8152m

Work done by moving the turbine blade full turn around the central axis = F.s

= Force x distance travel during one revolution

= F x 2 Πr =F x 2x 3.143x 12.8152 = Force x 80.556 m

Force = Blade area* air density * (wind speed)^3

Wind speed =v, Air density = ρ

Force on turbine blade = 61.7928 ρv^3

Work done by blade during one rotation= Fs =61.7928 ρv^3* 80.556

Work done by HAWT blade during one rotation = 4,977.802 **ρv^3 --------------(1)**

<u>Let us now consider the behavior of Wind turbine with Contour Tracer</u>

The blade can move a distance of 60 meters on horizontal direction during working stroke

Turbine blade area = 60m (length) x 30m (width) = 1,800 m^2

Therefore work done (F.s) is = 1,800 x 60 = 10,800 ρv^3

If the cross section covers 0.1 meter width for the blade height of 60meter, work done against resistance during return stroke = 60x60x 0.1 = 260 ρv^3

Therefore productive work done during one rotation = (10,800-260) ρv^3= **10,540 ρv^3--------(2)**

Let both turbines are having three blades. The ratio will be same

Power ratio = (2) /(1) = 10,540/4,977.802 = <u>2.117</u>

<u>Result</u> : The wind turbine with contour tracer can extract **<u>2.117</u>** times higher power than the typical horizontal axis wind turbine