Small Scale Wind Turbines

RESOURCE
RENEWABLE ENERGY

How much power can I generate?

It all depends on...

$$P = \frac{1}{2}\rho A v^2 \eta_g C_p$$

...which looks far more complicated than it is.

Power available (P) Watts

Calculated in Watts, kinetic energy in the wind per second.
(Joules per second)

Air density (ρ) kg/m^3

The density of air measured in kilograms per cubic metre. Air density is lower at higher elevations in mountainous regions; but average densities in cold climates may be up to 10% higher than in tropical regions. In the UK we use 1.23kg/m^3.

Swept Area $(A = \pi r^2)$ squared metres

Using the blade length as the swept area radius, work out with the area of a circle equation shown above.

Velocity OR wind speed (v) metres per second

This should be the average wind speed at the height of your tower. You can find out UK mean wind speeds on NOABL database.
(http://www.bwea.com/noabl/index.html)

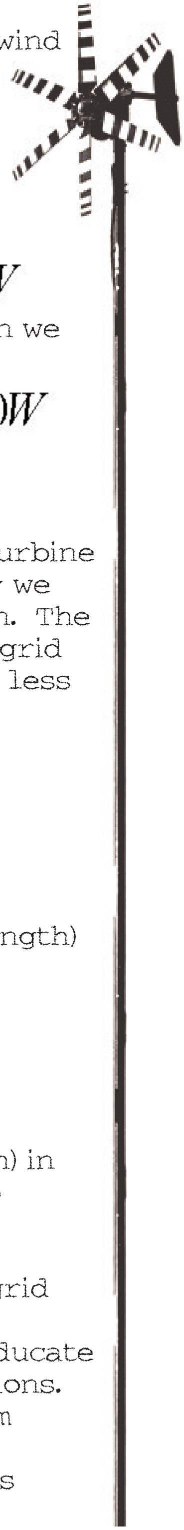
Generator (η_g) factor

There will always be losses within any motor or generator caused by friction, drag from the blades, gearbox, electrical conversion, etc... A good figure to use is 30% so use 0.3 in calculation.

Power co-efficient (C_p) factor

The Betz limit is a proved theory that the maximum energy a wind turbine is able to extract from the wind is 59.3%, for most wind turbines you're looking at 35% so use 0.35 in calculation.

This calculation will give you the instantaneous power and so you could think of it as the rated power of that wind turbine at your site.



Example calculation with a 2m blade length and a mean wind speed of 5m/s.

$$0.5 \times 1.23 \times (\pi \times 2^2) \times 5^2 \times 0.3 \times 0.35 = 20W$$

Not much you might say but a realistic value. Let's say we increase the height of the tower and therefore the average wind speed to 7m/s...

$$0.5 \times 1.23 \times (\pi \times 2^2) \times 7^2 \times 0.3 \times 0.35 = 39W$$

We almost double the output, lets see what happens when we double the blade length...

$$0.5 \times 1.23 \times (\pi \times 4^2) \times 7^2 \times 0.3 \times 0.35 = 160W$$

WOW! ...we quadruple the power output with double blade length.

Often we are interested in how much energy the turbine will produce over a period of time, like a year. This way we can compare the annual yield to our annual consumption. The average household consumption of people living on the grid is 3,300kWh/yr. However people who live off grid use far less than this as we don't have kettles, toasters, etc...

A helpful rule of thumb is the following equation. There are two versions in old and new measurements.

For the oldies $$\frac{kWh}{yr} = 0.1328 \times (D^2) \times (V^3)$$

Where **D** is the swept area diameter (double the blade length) in feet and **V** is the mean wind speed at the planned hub height in miles per hour.

For the youth $$\frac{kWh}{yr} = \frac{((D^2) \times (V^3))}{9072.402}$$

Where **D** is swept area diameter (double the blade length) in metres and **V** is the mean wind speed at the planned hub height in metres per second.

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