

MORE ON THE SAVONIUS SUPER ROTOR

The kinetic energy (KE) of the wind is one-half the mass (m) times the velocity (v) squared.

$$KE = \frac{mv^2}{2} \quad \text{Equation 1}$$

The power (P) in the wind is the kinetic energy over a unit period of time.

$$P = \frac{KE}{t} = \frac{(1/2 mv^2)}{t} = \frac{mv^2}{2t} \quad \text{Equation 2}$$

The mass of the air with which one is dealing is the product of the volume (V) of air times the density (ρ).

$$m = \rho V \quad \text{Equation 3}$$

The volume of air per unit time in the area (A), intercepted by the windplant, is that area multiplied by the wind velocity (v).

$$\frac{V}{t} = Av \quad \text{Equation 4}$$

Thus the mass per unit time is as follows:

$$m = \rho V \quad (\text{Eq. 3})$$

$$\frac{m}{t} = \frac{\rho V}{t}$$

$$\text{Since } \frac{V}{t} = Av$$

$$\text{then } \frac{m}{t} = \rho Av \quad \text{Equation 5}$$

Substituting this last equation into Equation 2,

$$P = \frac{mv^2}{2t} = \frac{m}{t} \frac{(v^2)}{2} = \rho Av \frac{(v^2)}{2} = \frac{\rho Av^3}{2} \quad \text{Equation 6}$$

Thus the total power in the wind is the density of air ($\rho = 2.52 \times 10^{-3}$ slug-ft⁻³ at STP, standard temperature and pressure, 32° F and 29.92 inches of mercury) multiplied by the area of the windplant and by the cube of the wind velocity, and divided by two. If the wind velocity is expressed in ft per sec and the area in ft², the power will be in units of ft-lb per sec. Ft-lb per sec times 1.36 equals watts, and Equation 6 becomes:

$$P = \frac{\rho Av^3}{2} \quad \text{Equation 7}$$

$$P \text{ (watts)} = \frac{1.36 (2.52 \times 10^{-3}) Av^3}{2} \\ = 1.71 \times 10^{-3} Av^3 \text{ watts}$$

A 100% efficient windplant could extract only 59.3% of the total wind energy. Added to this, a Stuart (propeller-type) windplant itself is only 70% efficient, and an S-rotor 47%. Finally, consider 70% efficiency for the gearing and generator, and the power at the output shafts of these two types becomes:

$$P = 1.71 \times 10^{-3} Av^3 \text{ watts,}$$

$$A = \pi r^2 \text{ for the Stuart and } dh \text{ for the S-rotor.}$$

$$P_{\text{Stuart}} = .593 (.70) (.70) (1.71 \times 10^{-3}) (\pi r^2) v^3 \\ = 1.56 \times 10^{-3} r^2 v^3 \text{ watts}$$

$$P_{\text{S-rotor}} = .593 (.47) (.70) (1.71 \times 10^{-3}) (dh) v^3 \\ = 3.34 \times 10^{-4} dhv^3 \text{ watts}$$

The power from the Stuart is proportional to the square of the blade radius and to the cube of the wind velocity, while power from the S-rotor is proportional to the diameter, height and the cube of the wind velocity.

OK. For the three-barrel S-rotor, the height is approximately 9 feet and the diameter 3 feet (aspect ratio = 3). The power extractable with this device should then be:

$$P = 3.34 \times 10^{-4} (3) (9) v^3 \\ = 9.02 \times 10^{-3} v^3 \text{ watts}$$

The following should be a close approximation of watts output per wind velocity for Mike Hackleman's S-rotor. Actual values will depend upon the experimental design and the equipment used.

Wind speed, v (miles per hour)	v ³ (ft ³ /sec ³)	Watts output
5	3.99 × 10 ²	3.60
10	3.18 × 10 ³	28.7
15	1.06 × 10 ⁴	95.6
20	2.51 × 10 ⁴	226.
25	4.94 × 10 ⁴	446.
30	8.52 × 10 ⁴	769.
35	1.35 × 10 ⁵	1220.
40	2.02 × 10 ⁵	1820.

S-rotor design and operation is still an experimental field. But these power equations are as close as possible to the expected output . . . enough to act as a guide for design. For instance, if one desired a 1,000-watt output in a 15 mph wind (requiring a Stuart of 7.8-ft radius), the S-rotor dimensions would be:

$$P = 3.34 \times 10^{-4} dhv^3$$

$$dh = \frac{1.00 \times 10^3}{3.34 \times 10^{-4} (1.06 \times 10^4)} = 282$$

$$\text{Since the most common aspect ratio is } h = 3d,$$

$$3d^2 = 282$$

$$d = 9.70 \text{ feet}$$

$$h = 29.1 \text{ feet}$$