Average Power

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Recap: Power in the Wind: $P_w = \frac{1}{2}\rho A v^3$

Average power in the wind: $P_{w,ave} = \frac{1}{2}\rho A (v^3)_{AVE} \neq \frac{1}{2}\rho A v_{AVE}^3$

Rayleigh distribution $f(v) = \frac{2v}{c} e^{\left(-\left(\frac{v}{c}\right)^2\right)}$

$c = \frac{2 v_{AVE}}{\sqrt{\pi}}$

w/ Rayleigh winds $P_{w,AVE} = \frac{1}{2}\rho A (v^3)_{AVE}$

$= \frac{6}{\pi} \frac{1}{2}\rho A v_{AVE}^3$

Ex 10 m high anemometer $\rightarrow$ $v_{AVE} = 6$ m/s

Friction coefficient $\alpha = \frac{1}{7}$

Air density $\rho = 1.225$ kg/m^3

a) Average power in the wind at 50 m?

$\frac{v_{AVE,50}}{v_{AVE,10}} = \left(\frac{50}{10}\right)^{\alpha} \rightarrow v_{AVE,50} = 6\left(\frac{50}{10}\right)^{1/7} = 7.55$ m/s

With Rayleigh statistics, $P_{AVE} = \frac{6}{\pi}\frac{1}{2}(1.225) v_{AVE,50}^3$

$= \frac{6}{\pi}\frac{1}{2}(1.225)(7.55)^3$

$= 504$ W/m^2 specific power, power density

b) Average power in wind at 80 m?

$\frac{P_{AVE,10}}{A} = \frac{6}{\pi}\frac{1}{2}(1.225)6^3 = 253$ W/m^2

$\frac{P_{AVE,80}}{P_{AVE,10}} = \left(\frac{H_{80}}{H_{10}}\right)^{3\alpha} \rightarrow \frac{P_{AVE,80}}{A} = 253\left(\frac{80}{10}\right)^{3/7} = 616$ W/m^2