

## Homework Assignment: Due Monday October 31, 2005

*Wind Power (adapted from Appropriate Technology by B. Hazeltime and C. Bull, 1999)*

### Background

Wind power results from the kinetic energy of the wind as it moves. All wind-power generators use a rotating propeller that captures the kinetic energy as the wind pushes against the propeller blades. The power P can be expressed as follows:

$$P = 5.3 \cdot 10^{-6} A e V^3 \quad (1)$$

Where P is in kW, V is the wind velocity in mph, A is the area swept out by the propeller blades in ft<sup>2</sup> and e is the propeller efficiency (<1).

Equation (1) shows that a 25% increase in wind speed doubles the power output. Due to the increase in power associated with possible wind gusts, the power calculated by Eq. (1) needs to be multiplied by 2.5 if V is taken as the average wind speed.

Note that propeller type rotors generate high rpm. They have high efficiency (40%) at high speed and low efficiency at lower speed. Rotors should be at least 10ft above wind obstacles and within 100 yards in order to be effective.

Note that wind speed increases with the height, h, above ground as follows

$$\frac{V_1}{V_2} = \left[ \frac{h_1}{h_2} \right]^{0.2} \quad (2)$$

**Q1:** Increasing a wind tower height from 5 to 30 ft, results in increasing the velocity by how much? How will the power output be affected?

### Design

Consider the simple transmission system of a propeller type rotor, a DC generator, batteries, and a Household 12 V DC system (appliances). Consider the following demand: being able to charge batteries in 24 hours to supply a family in the case wind does not blow for the next three days. The family uses 960W for a period of 5 hours per day, and the demand is for a total of 4 days. An average wind velocity of 10 mph is assumed and the system has an efficiency e=15%.

**Q2:** determine the propeller blade length.

**Q3:** what would be the blade length if two (instead of one) propeller type rotors were used?

**Q4:** Assume that the 12V batteries used in the transmission system can only last 10 hours before needing recharging. A 9Amperes (A) current is drawn from the batteries to drive the appliances. How many batteries are needed to meet the demand of 960W for 5 hours/day and for 4 days?