berkeley engineers and mentors

Lesson plan for "Blade Design"

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Introduction/Background Info

There is a growing acceptance that traditional power sources must be systematically phased out and replaced by renewable ones. Thus, much research on renewable energy technologies is being done to make a complete switch feasible. In this lesson, we explore ways to improve the efficacy of wind turbines by improving blade design.

Student Objectives

The students should learn about blade design factors and experience the engineering design and review process.

Topics

Mechanics, Fluid Dynamics

Materials

Cardboard, Scissors, Duct tape

Lecture Material

There are some of the variables engineers might be looking to change: length, number, weight, pitch/angle, shape, material, curvature, twist etc.

1. Number
   Aerodynamic efficiency increases with the number of blades, but with diminishing returns. We've arrived at our modern 3-blade design because of efficiency-to-cost concerns.
2. Length
   The wind power extracted by a turbine is proportional to the square of the blade length. The maximum length attainable is dictated by the strength and stiffness of the material used to make the blades.
3. Pitch
   The angle the blade makes with the wind direction also affects the efficiency of the turbine. If more of the blade is exposed to wind (a larger angle of attack), the drag associated with lift decreases, while the ordinary drag increases. Altering this can be used to control blade speed in variable wind speeds and is known as stall.
4. Material
   The main characteristics sought after for turbine blades are light-weight and strength. Large blades are often made out of fiberglass with carbon fiber reinforcements. This produces light-weight blades that can support a long length and thus produce more energy. Since mass (and thus weight) scales with the cube of the length smaller blades can be made with heavier materials such as aluminum.

5. Shape, Curvature and Twist
   The geometry of the blades also plays a large role in the effectiveness of a wind turbine. This will likely be the easiest parameter for the kids to manipulate during the construction project. The optimum blade design depends on a balance of aerodynamic lift as well as drag associated with both the lift and the normal wind impact.
6. Placement and Orientation
   For horizontally oriented turbines, the blades should be pointed directly into the wind for maximum power to be obtained. Since vertically oriented turbines are symmetric about the vertical axis they function equally well in all wind directions. However other design issues limit the use of vertical turbines.

Procedures

1. Have the students design and build wind turbine blades.
2. Test and rank the different blade designs with respect to a suitable metric e.g. revolutions per second. Establish a visible leaderboard.
3. Consult with the students on their design choices, seize the opportunity to elucidate concepts and suggest improvements.
4. Continue testing and revising.
5. Reward the students who produced the top *x* designs.

Extra Questions

1. Why is renewable energy so important?