WindPitch Wind Turbine Experiment- Adjusting Blade Pitch

EXPERIMENT OVERVIEW

Adjusting the blade pitch for a given wind speed and load is critical to the wind turbine's power output. In this experiment students adjust a group of three blades in triangular pattern at three different blade angles (pitch) to measure the wind turbine's electrical output power at each pitch setting.

EXPERIMENT OBJECTIVES

- Students will use the Scientific Process to perform the experiment.
- Students will learn about how blade pitch alone produces different power outputs from the wind turbine.
- Students will come to understand that increasing blade pitch using only one fan speed and one resistive load may decrease the wind turbine's power output.

SAFETY

Caution must be exercised when using the wind turbine and table fan. Spinning blades can pose a hazard and can cause injury if not careful. DO NOT PLACE YOUR FINGERS, HANDS, ARMS, FACE OR ANY OTHER PART OF YOUR BODY IN THE SPINNING WIND TURBINE OR FAN BLADES!

Wear safety glasses for all experiments

PREREQUISITES

- Read and understand the WindPitch Education Kit instructions including:
  - Component Parts
  - Assembly
  - Blade Installation
  - Blade Pitch Adjustment
  - Electrical Connections

EQUIPMENT

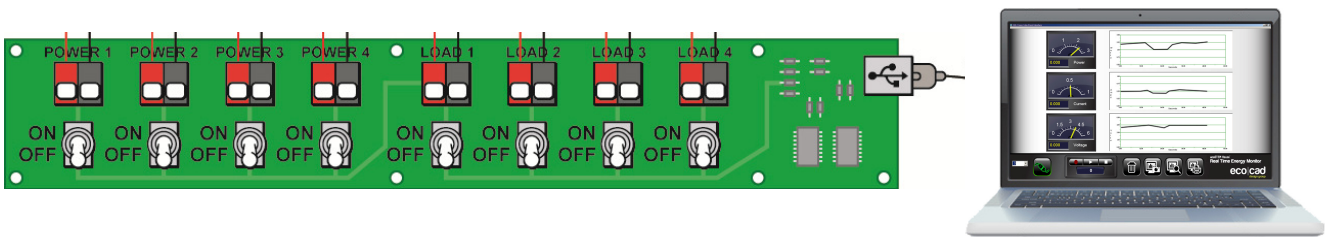
- Control Panel
- Computer running the ecoCAD Real Time Energy Monitoring software
- WindPitch wind turbine with 3 BP-28 profile blades
- Student built flat or profiled blades where available
- Large Table or Floor Fan (at least 16" in diameter with 3 speeds)
- Two (2) 100 ohm fixed resistors
- Printer

EXPERIMENT SETUP

1. The Control Panel should be connected to the computer with the graphic software running to perform the experiment. All the switches should be OFF.

2. Insert a 100 ohm fixed resistor into each **Load 1** and **Load 2** terminals. Polarity does not matter, so the resistor wires can be inserted in any orientation.

3. Attach the WindPitch electrical output terminals to the **Power 1** terminals on the Control Panel. You will need to acquire a length of 2 conductor wire to make the connection between the WindPitch and the Control Panel. Wire the Red terminal on the WindPitch to the Gray or Red terminal on **Power 1** and the Black terminal on the WindPitch to the Black terminal on **Power 1**.



DOING THE EXPERIMENT

15°

1. Setup the WindPitch wind turbine with two (3) BP-28 blades.
2. Adjust the blade pitch angle to 15°.
3. Set the table or floor fan as close to the wind turbine blades as possible. **MAKE SURE THAT THE WIND TURBINE BASE IS SECURE AND CAN'T MOVE. USE A BOOK OR OTHER OBJECT TO HOLD IT IN PLACE BEFORE TURNING THE FAN** ON.
4. Switch ON the wind turbine (**Power 1**) and both 100 ohm resistors (**Load 1 and Load 2**). Since the resistors are in parallel this makes a 50 ohm load.
5. Set the fan to its highest speed setting.
6. Clear the computer screen by clicking on the Trash can icon.
7. Click the Screen Capture icon to record the voltage, current and power being consumed by the variable resistor.
8. Stop the fan.

30°

9. Adjust the blade pitch angle to 30°.
10. Switch ON the wind turbine (**Power 1**) and both 100 ohm resistors (**Load 1 and Load 2**). Since the resistors are in parallel this makes a 50 ohm load.
11. Set the fan to its highest speed setting.
12. Clear the computer screen by clicking on the Trash can icon.
13. Click the Screen Capture icon to record the voltage, current and power being consumed by the variable resistor.
14. Readjust the variable resistor to full resistance (full clockwise).
15. Stop the fan.

45°

16. Adjust the blade pitch angle to $45^{0.}$

17. Switch ON the wind turbine (**Power 1**) and both 100 ohm resistors (**Load 1 and Load 2**). Since the resistors are in parallel this makes a 50 ohm load.

18. Set the fan to its highest speed setting.

19. Clear the computer screen by clicking on the Trash can icon.

20. Click the Screen Capture icon to record the voltage, current and power being consumed by the variable resistor.

21. Readjust the variable resistor to full resistance (full clockwise).

22. Stop the fan.

Repeat the entire experiment with custom blades of your own.

STUDENT EXERCISES

1. Which blade pitch angle produced the most power?

   15^0
   30^0
   45^0

2. Which blade pitch angle produced the least power?

   15^0
   30^0
   45^0

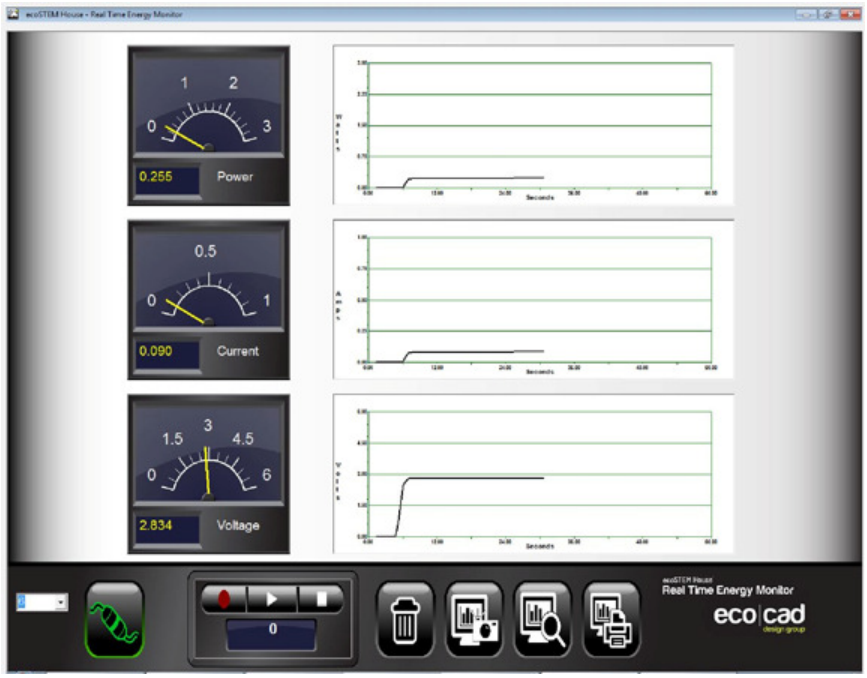
3. At what blade pitch setting did you expect to see the most power produced? Explain your answer.

4. At what blade pitch setting did you expect to see the least power produced? Explain your answer.

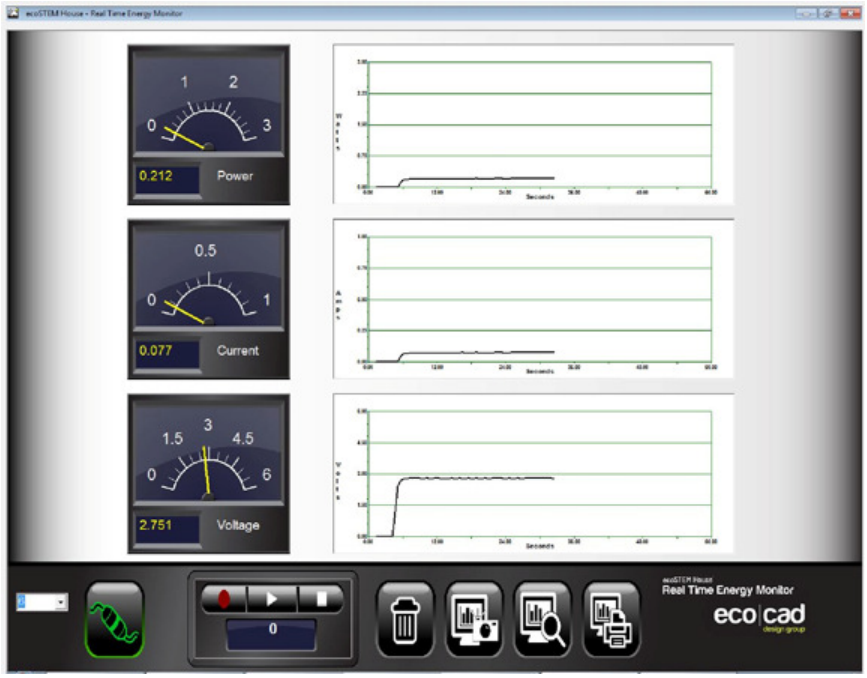
5. Would changing the fan wind speed affect the results differently? Explain why you think it would or would not.

TEACHER NOTES - ANALYZING THE RESULTS

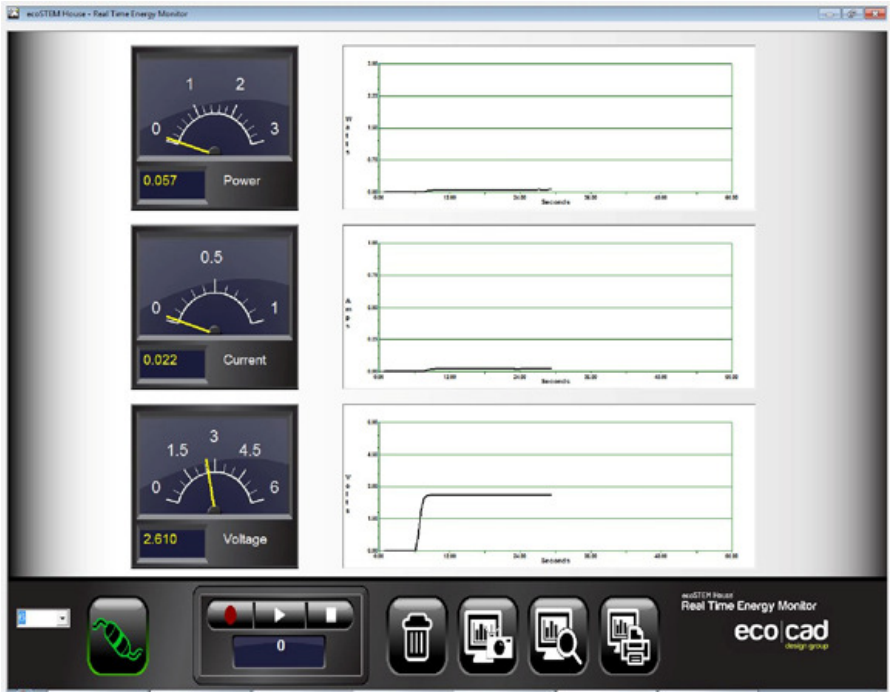
1. First, have the students print out the three (3) screen captures they did in steps 7, 13 and 20. Here are our results – your exact results will vary.



Step 7 Blade Pitch = 15° Power = 0.255 watts



Step 13 Blade Pitch = 30° Power = 0.212 watts



Step 20 Blade Pitch = 45° Power = 0.057 watts

- Explain to the students that increasing the blade pitch angle is really like trying to "grab" more air.

- When the fan speed is set to its highest setting, increasing the pitch angle only creates more resistance for the blades to turn. This is because the wider blade pitch is churning up the fast moving air creating more turbulence at greater pitch angles, which causes the blades to loose lift and slow down.

- This is why the power drops off as the blade angle is increased, because more turbulence is created. If the students don't understand the concept of turbulence or lift, have them look it up on the Internet. Look for the Bernoulli Principle that describes both.

- A larger blade pitch works better (produces more power) when the wind is slower. This allows the blades to capture more air without as much turbulence.

- Suggest doing the experiment over again, but this time with the fan speed set at medium and low speeds. The results may change significantly.