Windwise Education
Which Blades Are Best?

The blades of a wind turbine have the most important job of any wind turbine component; they must capture the wind and convert it into usable mechanical energy. Over time, engineers have experimented with many different shapes, designs, materials, and numbers of blades to find which work best. This lesson explores how engineers determine the optimal blade design.

OBJECTIVES

At the end of the lesson, students will:

- Understand how wind energy is converted into electricity
- Comprehend that there are multiple solutions to this design challenge
- Understand the engineering design process
- Know the process of scientific inquiry to test blade design variables

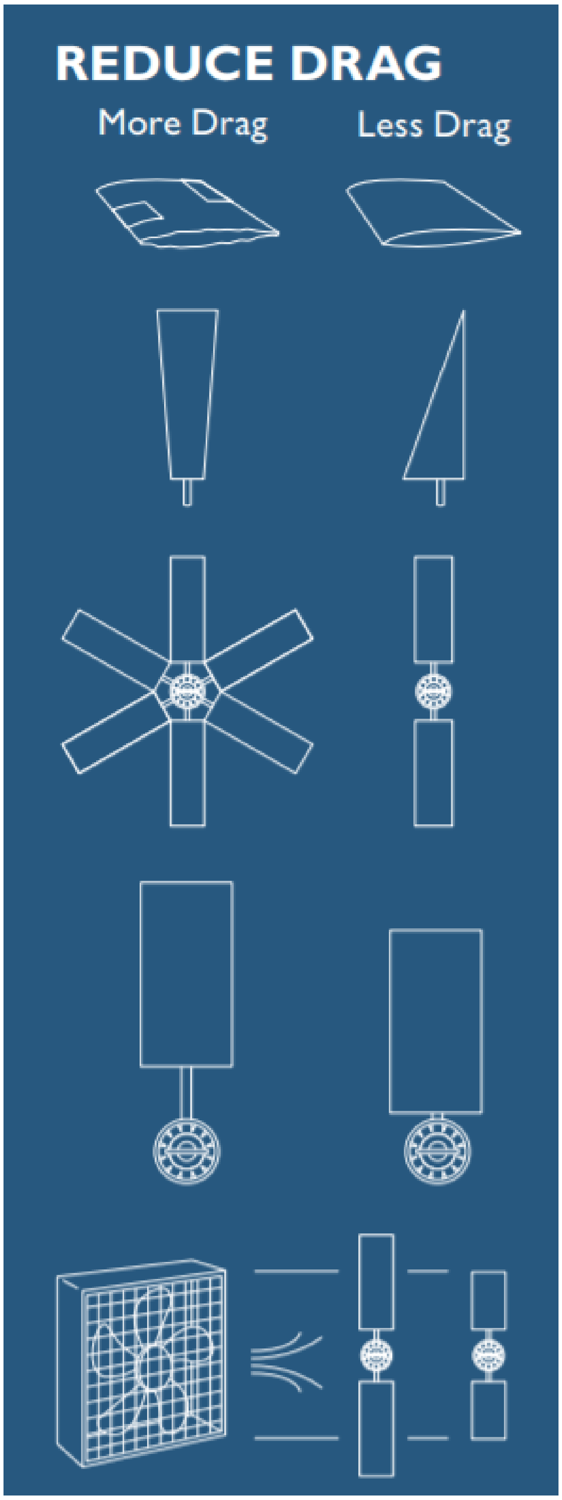
METHOD

Students will use wind turbine kits to test different variables in blade design and measure output of each. Each group of students will test their designs and then redesign based on testing. Groups will summarize and present their conclusions to the class.

MATERIALS

- ❑ Model turbines on which blades can be interchanged
- ❑ Box fans for each turbine
- ❑ Multimeters for each group
- ❑ Pictures of wind turbine blades
- ❑ Sample blades
- ❑ Balsa wood, cardstock, paper plates, Vernier blade materials, etc.
- ❑ Duct tape
- ❑ Scissors
- ❑ Protractors/rulers

KidWind PROJECT



GETTING READY

- Set up safe testing areas. Clear this are of debris. Make sure the center of the fan is aligned with the center of the wind turbine. Make sure each testing station will not be standing in the plane of rotation of a nearby turbine.
- Lay out sample blade sets that display different variables such as length, material, and number of blades.

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ACTIVITY

Step 1: Description of challenge and beginning questions for students (10 min)

- What do you think makes one blade design work better than another?
- What variables affect the amount of power a wind turbine can generate?
- Do some variables matter more than others? (For example, is length more important than number of blades?
- What do modern wind turbine blades look like?

Step 2: Brain storm blade variables (5 min)

Ask students to individually brainstorm about design variables that affect how much energy the blades can capture.

Variables may include:

- Blade length
- Number of blades
- Weight/distribution of weight on blades
- Blade pitch/angle
- Blade material
- Blade twist

Step 3: Building blades (30 min)
Divide students into groups and ask them to designate a record keeper. Groups should then collect their blade materials and work together to construct blades.

Step 4: Testing blades
Each group should have tested their design during their building period – give a warning at 20 min to remind them to do so.

Students will use wind turbine kits to test different variables in blade design and measure output of each.

Each group will attach a set of blades to the turbine and test it at both high and low speeds. The group can change wind speed by turning the fan higher or lower.

Students will measure the voltage with a multimeter and have their record keeper document their data.

Ongoing Improvement:
Ask students to analyze ways to improve their designs.

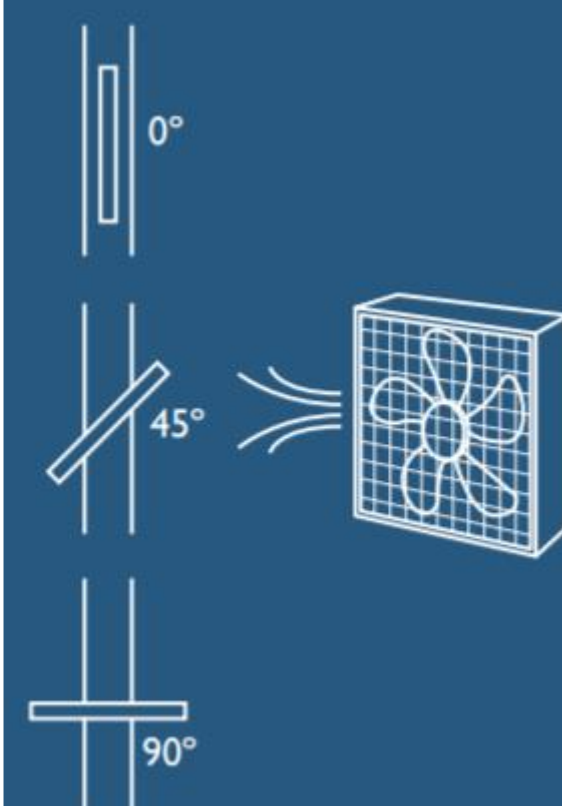
Students can alter their designs to increase their output, retrieving more materials as necessary.

Step 6: Presentation (15 min)
Each group will have 3 min to present their conclusions to the class. Students should discuss how they designed their blades and their results after redesigning.

Step 7: Wrap Up (15 min)
Volunteers share more information about their education, careers, and what excites them about engineering.

BLADE PITCH

Blade pitch is the angle of the blades with respect to the plane of rotation. The pitch of the blades dramatically affects the amount of drag experienced by the blades. Efficient blades will provide maximum torque with minimum drag. Measure pitch with a protractor.



Redesign: Suggestions for Students

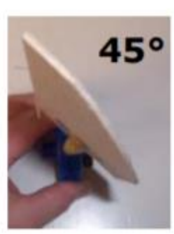
Experiments with blades can be simple or very complicated, it depends on how deep you want to explore. Some variables you can test with blades include:

- *Blade Length*
- *Blade Number*
- *Blade Pitch*
- *Blade Shape*
- *Blade Materials*
- *Blade Weight*

An important concept to keep in mind when making turbine blades is drag. Ask yourself, **"Are my blades creating too much DRAG?"**. Your blades are probably catching the wind and helping to spin the hub and motor drive shaft, but consider the ways that their shape or design might be slowing the blades down as well. If they are adding **DRAG** to your system it will slow down and in most cases low RPM means less power output.

Some tips on improving blades:

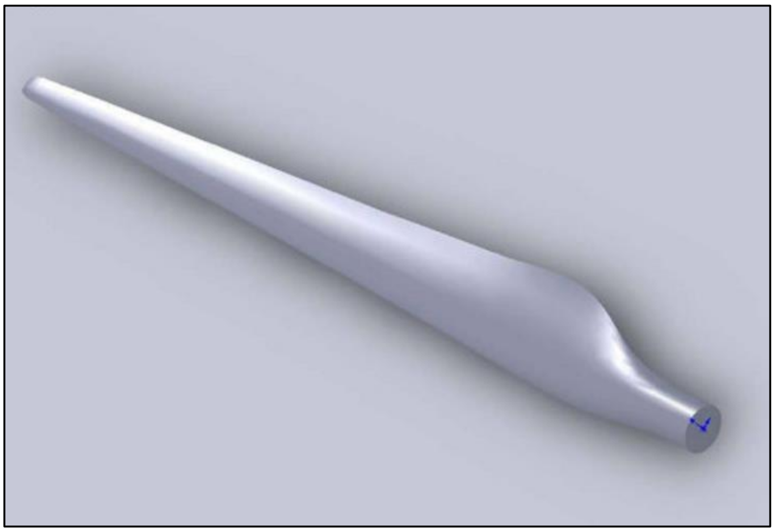
- **SHORTEN THE BLADES** - Wind turbines with longer blades do make more power. While this is also true on our small turbines it is often difficult for students (and teachers) to make large, long blades that don't add lots of drag and inefficiency. See what happens when you shorten them a few centimeters.
- **CHANGE THE PITCH** - Students commonly set the angle of the blades to around 45° the first time they try to use the turbine. Try making the blades flatter towards the fan (0° - 5°) . Pitch dramatically affects power output, so play with it a bit and see what happens. Finding a way to **TWIST** the blades (0° near the tips and around 10° - 20° near the root) can really improve performance.

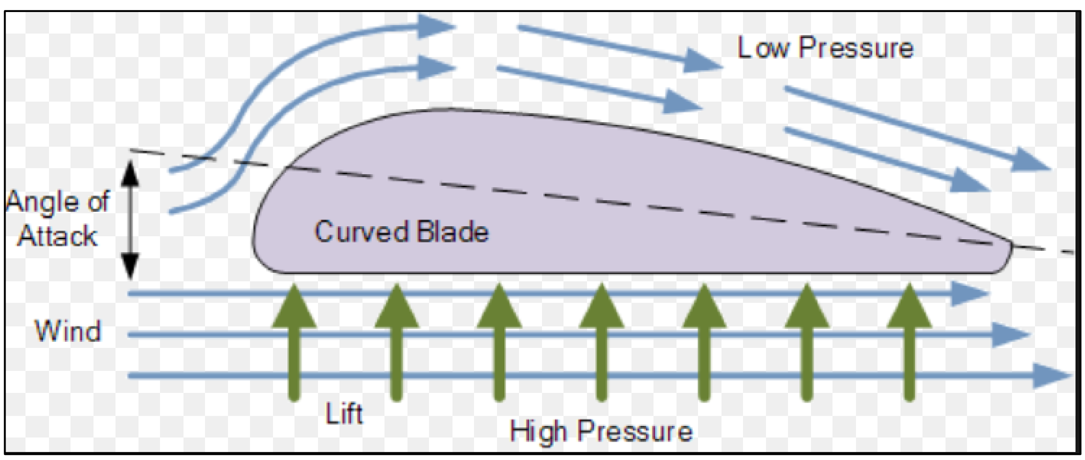


- **USE FEWER BLADES** - To reduce drag try using 2, 3 or 4 blades.
- **USE LIGHTER MATERIAL** - To reduce the weight of the blades use less material or lighter material.
- **SMOOTH SURFACES** - Smooth blade surfaces create less drag. Try removing excess tape or smoothing rough edges to reduce drag.
- **BLADES VS. FAN** - Are your blades bigger than your fan? If the tips of your blades are wider than the fan you're using, then they're not catching any wind– they are just adding drag!
- **BLADE SHAPE** - Are the tips of your blade thin and narrow or wide and heavy? The tips travel much faster than the root and can travel faster if they are light and small, which means that if you have wide or heavy tips you may be adding lots of drag.


MISSOURI
WIND AND SOLAR


TWISTED
BLADE




Low Pressure
Angle of
Attack
Curved Blade
Wind
Lift
High Pressure

Encouraging Phrases

You're on the right track.

That turned out really well.

You stayed so calm during that problem

That's it!

Looking good.

Now you've figured it out.

Keep working on it, you're almost there.

Great idea!

Terrific teamwork!

That's a really creative idea!

You're on fire!

Nice job persevering.

Way to learn from your mistake.

Fantastic problem solving!

You did it!

You're really working hard on this.

I like how you think!

Clever!

Cool!

I love it!

Thought Provoking Questions

How did you do that?

That's an interesting question. What makes you ask that?

Why do you think that?

Can you explain how you came up with that idea?

Which of these things makes the biggest difference in your design?

What happens if you make it bigger or smaller?

What do *you* think?

How do you know that?

Can you tell me more?

Are there any other explanations for…?

Why do you think this works?

Does this always work? Why?

How might you prove that?

Can you predict any results based on your work so far?

How does this relate to current events?

What did you decide were the most important factors in your design?