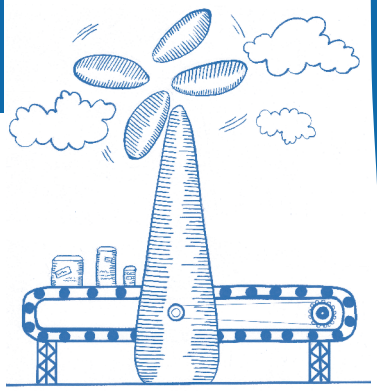
WIND POWER STATION

CHALLENGE SHEET



YOUR CHALLENGE

Design a machine that lifts heavy objects using only the wind!

DESIGN squad Global

PBS KIDS FOR MORE GREAT ACTIVITIES: PBSKIDS.ORG/DESIGNSQUAD

50 minutes / Ages 10 – 13

MATERIALS

- ☐ 1–2 wooden skewers
- ☐ plastic soda bottle with plastic cap
- ☐ scrap pieces of cardboard
- ☐ cardboard box
- ☐ straw
- ☐ scissors
- ☐ duct tape
- ☐ pencil/pen and scrap paper

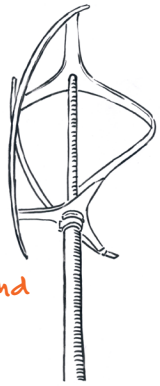
(For testing)

- ☐ portable electric fan, large piece of cardboard (to create wind), or access to the outdoors
- ☐ spool of thread
- ☐ 3 paperclips (to hold up the weights on the string)
- ☐ 3 small bags (to hold sand or weights)
- ☐ sand, metal washers, or other weights

DEFINE THE NEED

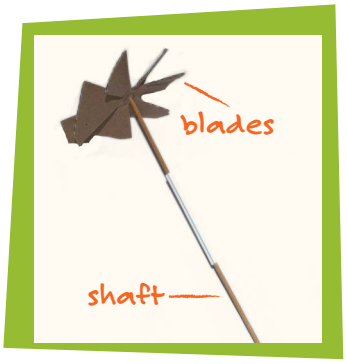
Engineers all over the world are working on building machines that generate power without burning fossil fuels like coal and oil. These fuels add to climate change and pollute the air. Wind turbines get energy from the wind to do all kinds of tasks, such as irrigating farm fields, grinding grain, sawing wood, or generating electricity by connecting to an electric generator.

3-BLADED TURBINE
good for strong, steady wind, high off the ground



MODERN VERTICAL AXIS TURBINE
good for gusty wind, low to the ground

BRAINSTORM & DESIGN



- **Design a wind turbine that can lift a weight.**
- The most important parts of a wind turbine are the **blades** and **shaft**.
- **All blades should be twisted in the same direction.** They spin in a circle when the wind blows. The blades turn the shaft to provide energy to do something useful.
- Many designs are possible, and **there are no right or wrong ways of building** a wind turbine. Engineers and inventors are still trying to figure out the best way to capture energy from the wind.
- **Sketch your design on a piece of paper.**

Video Link & QR Code
https://youtu.be/B75MYwICXzg

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BUILD

- **Look over all the materials before you begin.** Could you build a wind turbine out of cardboard or use plastic from the bottle? Could you use the straw to improve the function?
- How would you build a structure or tower that holds your blades and shaft?
- What size and shape of a blade would get the most wind?

TESTING CHECKLIST

- ☐ Shaft spins
- ☐ you feel the torque in your fingers
- ☐ lifts weight
  Describe the weight: how much, what kind?

  _____

TEST, EVALUATE, & REDESIGN

- If your wind turbine spins, try to stop the shaft with your fingers. If it is a little hard to stop, your wind turbine provides good **torque**. Torque is a twisting or turning force.
- Attach a small bag of sand or weights to see if your wind turbine can lift it. The more weight you can lift, the more torque your wind turbine provides.
- **Which tests does your power station pass?**
- **Redesign:** Change the size of the blades, number of blades, and other things.

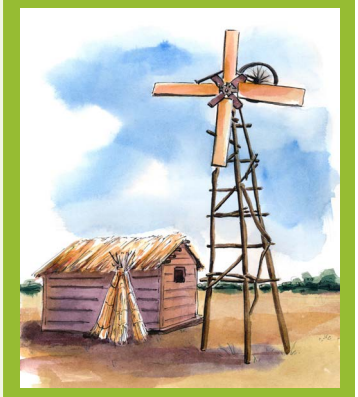
Problem-Solving Tips

- **Blades don't move?** Check the shape and size of your blades. Remember they all should be the same direction, and they need to be large enough to harness the wind!
- **Shaft doesn't spin?** Check how your shaft is connected to your blades. Make sure there isn't friction preventing the shaft from turning!
- **Whole thing falls over?** Maybe your base is too small. Make it wider and studier to sustain high wind!

ENGINEERING AND INVENTION IN ACTION

Photo: Nana Kofi Acquah

In Malawi, East Africa, a 14-year-old boy named William Kamkwamba solved a serious problem for his family. He and his 7 sisters could not get electricity unless they burned kerosene fuel in a generator. The generator created a lot of smoke and sometimes broke down. William built a wind turbine out of an old bicycle, some trees, and pieces of plastic pipe. He used bicycle gears to speed up his turbine's shaft to generate electricity. To get more power, William redesigned his wind turbine with more blades. Then, he built a much larger wind turbine that pumped water to the village's corn fields. "It was a simple machine that changed my life," he said. William's advice for other young inventors: "Trust yourself."



PBS KIDS
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WIND POWER STATION

LEADER NOTES

THE CHALLENGE

Design a machine that lifts heavy objects using only the wind!

DESIGN squad Global

PBS KIDS

FOR MORE GREAT ACTIVITIES:
PBSKIDS.ORG/DESIGNSQUAD

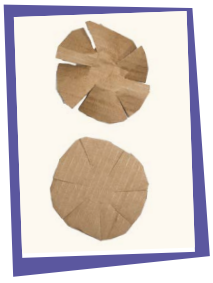
In this activity, kids think about:

- the need in their communities for an energy source that does not depend on fossil fuel
- how to design a machine that changes one kind of **force**—the simple pushing force of the wind—into the force of **torque** (a twisting or turning force)
- the **importance of testing** to see how redesigning can improve performance

I. PREPARE AHEAD OF TIME

- Read these leader notes and the challenge sheet.
- Try the activity yourself so you will know where kids may need help.
- Set up the demonstration and the testing.

For the demonstration



- Cut 2 cardboard circles about 5 inches (13 centimeters) across.
- Make 6 small cuts toward the center.
- On one of the circles, twist the cardboard flaps in the same direction, so that they look like blades of a fan.
- Press a skewer into the center of each cardboard circle so that they fit tightly and move with the circles.
- Place straws or pieces of rolled-up paper on each skewer so that the circles spin freely in your hand.

For the testing

- Fill the three small 3 bags with heavy material such as sand or metal washers to create 3 weights.

FOR SMALL GROUPS OR A LARGE EVENT

MATERIALS

- ☐ wooden skewers at least 6 inches (15 centimeters) long. Substitute any straight wooden stick, if necessary. (One per participant/team)
- ☐ plastic soda bottles with plastic caps (2 per participant/team). (Try to provide both 1-liter and 2-liter bottles. Wash the bottles and caps with a solution of water and a little vinegar to disinfect before the session.)
- ☐ scrap cardboard
- ☐ cardboard boxes. Try to find boxes with one short length (less than 6 inches/15 centimeters) and one taller length (greater than 10 inches/25 centimeters). Examples are a shoebox, shipping box, or shirt box.
- ☐ straws (one per participant/team)
- ☐ scissors (enough to share)
- ☐ duct tape (enough to share)
- ☐ pencil/pen and scrap paper

For testing (enough to share between several teams/participants):

- ☐ portable electric fan, large piece of cardboard (to create wind), or access to the outdoors
- ☐ spool of thread (or thin string)
- ☐ 3 paperclips (to hold up the weights on the string)
- ☐ 3 small bags (to hold sand or weights)
- ☐ sand, metal washers, or other weights

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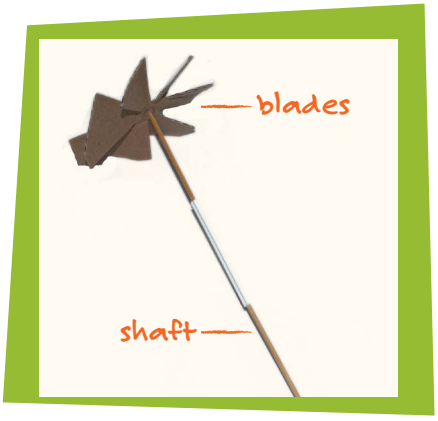
2. INTRODUCE THE CHALLENGE

- **Pass out the challenge sheets** and ask participants: *What do wind turbines do?*
  - A wind turbine gets energy from the wind and gives us the ability to do all kinds of tasks.
  - Some wind turbines generate electricity by connecting to an electric generator.
  - Other wind turbines provide power to do tasks, such as irrigating farm fields when connected to a water pump, grinding grain for food when connected to a stone wheel, or sawing wood to build houses when connected to a saw blade.
  - Wind turbines generate power without burning fossil fuels like coal and oil. Burning fossil fuels adds to climate change and can pollute the air.
- **Ask kids:** *What jobs could a wind turbine do in your community?*

3. LEAD PARTICIPANTS IN THE DEMONSTRATION

- Before the brainstorm, **lead kids in a short demonstration of the concepts** behind wind turbines. The demonstration will help them build their machines using principles they learn.
- **Show kids the two cardboard circles on skewers.** Tell them they are simple models of wind turbines and ask a volunteer to blow on the one with the twisted blades to make it go around. Then, ask the same volunteer to blow on the flat cardboard circle. Ask kids why the flat circle will not turn.

  Listen to what participants say and add:
  - *A wind turbine's **blades** are all at an angle.*
  - *Moving air has **force**, it can push an object.*
  - *The blades use the force of the wind to move in a circle.*
  - *The blades all need to be twisted at the same angle.*
- **Show participants the shaft of the wind turbine.** The shaft and blades spin together. The shaft sends the turbine's force where it needs to go to do a task.



4. BRAINSTORM AND DESIGN

- **Show kids the materials, including the cardboard and plastic bottles.**
- **Tell participants:**
  - *Draw a sketch of your design on scrap paper.* (Optional: To save time, activity leaders my opt to ask kids to talk about their plan instead of drawing it on paper.)
  - *Try to make blades spin in the wind and turn the shaft.*
  - *Your machine must be able to lift an object.*

5. BUILD

- **Decide if you would like to have kids work in teams or individually.** Pass out materials to participants and ask them to begin building.
- The work may seem challenging at first and kids may feel that they need a lot of help. Let them explore options on their own, but ask questions to help them reach their own solutions, such as:
  - *How could you build a structure or tower to hold up the wind turbine?*
  - *How could you keep the blades securely connected to the shaft?*
  - *How can you experiment with the size and shape of the blades to capture the most wind?*
  - *What could you do to make the tower hold the shaft but let the shaft turn easily?*
- More guiding questions are listed to the right.

6. TEST

Explain that testing is one of the most important parts of engineering—it is the way to find out what part of a design needs improvement. Ask kids to test their wind turbines using three tests:

- **First test:** *Do the blades and shaft spin?*
  - If not, refer to the guiding questions to the right.
  - If so, ask: *Why do they spin?*

  Listen to what kids say, and add:
  - *The wind is a type of* **force**, *a push or pull.*
  - *The wind's force turns the* **blades**.
  - *The blades provide a type of force that goes in a circle. This kind of force is called* **torque**.
  - *The blades send torque to the* **shaft**.
- **Second test:** *If your wind turbine spins, try to stop the shaft with your fingers. If it is a little hard to stop, your wind turbine provides good torque.*
- **Third test:** *Attach one of the small sand bags or weights to see if your wind turbine can lift it. The heavier the weight your turbine lifts, the more torque it provides.*

7. EVALUATE & REDESIGN

Ask kids: *How can you change your turbine to give it more torque? (Change the size of the blades or the number of blades, for example?)*

Guiding Questions for Leaders

- If the shaft comes loose, ask: *How could you make sure the shaft remains attached to the wind turbine hub* (the piece at the center of the blades)? Possible fixes could be to start again with another hub and make the hole smaller, pick a bigger wooden stick, or reinforce the connection with another material.
- If the blades get stuck when they turn, ask: *What could you do to help the blades spin smoothly?*
- If the wind turbine falls over when tested, ask: *What could you do to make your wind turbine stay upright?*

8. DISCUSS WHAT HAPPENED

Ask kids to talk about their designs and **how they solved problems** that came up:

- *What do you think I think is the best feature of your design? Why?*
- *What were some of the ways you were able to increase your turbine's torque?*
- *If you had more time, what design changes would you make to provide even more torque?*
- *Can you think of any uses for a wind turbine in your community?*

EXTENSION:

Add gears, as shown in the bonus session (The Gears Challenge) of the Design Squad Global Inventing Green Club Guide, found here: **bit.ly/green_activities**

Photo: Don Bernstein

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