Wind Energy Basics

Outreach Program Lesson Plan

WAAW foundation

Working To Advance STEM Education for African Girls

WAAW Foundation is non-profit organization dedicated to bringing hands-on STEM education to girls all over Africa.

Our Mission: To increase the pipeline of African women in Science, Technology, Engineering and Math (STEM) disciplines and to ensure this talent is engaged in African innovation.

Our Vision: To eradicate poverty in African through female education and science and technology innovation.

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Wind Energy Basics

Class Description-

In this class, students will explore how the sun generates wind energy, and how engineers have succeeded in transferring this energy into mechanical work. Students will participate in the design process and build their own wind turbines out of scrap materials.

Total class time: 90 minutes

Class Outcomes-

-Students will understand the basic components of a wind turbine and how they work together to transfer energy from the wind into usable mechanical energy.
-Students will construct a basic wind turbine of their own design out of basic craft materials and use it to lift weights.

Materials List-

The kit to teach this class should include:
-large standing or box fans (1 per every 6-8 students)
-scale
-paper cups, string, wooden spools, and washers

random collection of stuff for creating (not limited to...)
-popsicle sticks
-toothpicks
-paper
-boxes
-cardboard
-old plastic containers and lids
-dowels
-skewers
-straws
-plastic water bottles
-string
-thread spools
-corks
-tape (scotch, duct, masking)
-glue (tacky, hot glue)
-scissors

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Pre-Class Preparation and Set-Up

Before teaching this class, take time to try building your own wind turbine. This will give you an idea of the problems your students might face, and will allow you to get a sense of the materials that might be the most useful.

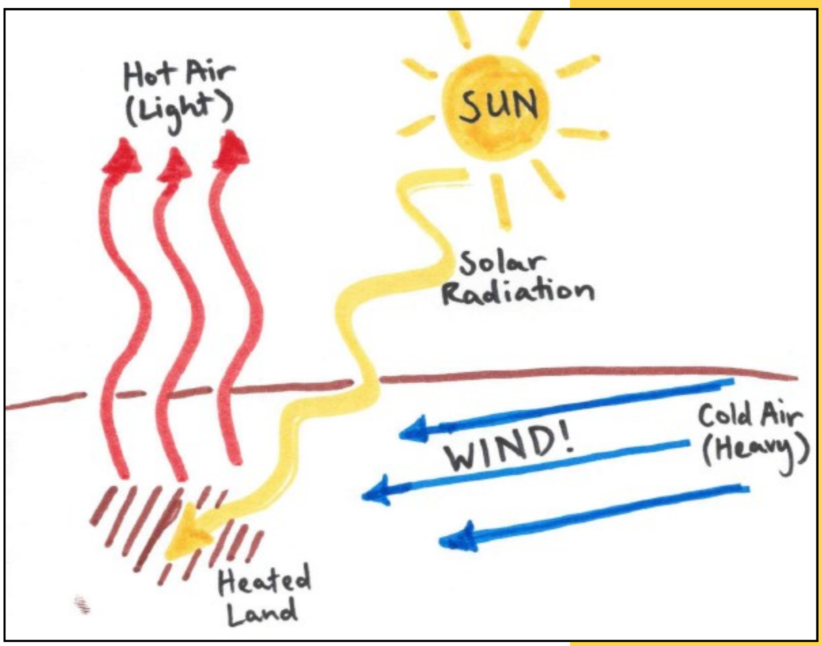
Lay out turbine materials in a neutral place where all students will be able to access them. Arrange chairs and tables to allow for groups of 3-4 students to work together. If you have a chalkboard, draw out wind diagram (below.)

As students enter, start to get to know their names, and ask questions to get acquainted with them.

Amounts and types of materials to collect can be tricky! Allow plenty of time to gather what the students will need.

Introduction (10 minutes)

First, review with your students: All of our energy ultimately comes from the sun. But how does the sun create WIND? Ask the students: Have you ever seen wavy lines the distort your vision just above the ground on a really hot day? As the sun shines on the ground it heats up, and that heat transfers to the air above it. Hotter air rises, and colder air sinks. This happens on a large scale all over the planet. Hot air forms over land masses near the equator and rises, and cold air from the poles and the oceans rushes in to take its place. The rotation of the earth causes these rising and falling air masses to move in certain ways. So even wind energy comes ultimately from the sun!



So how do we take that energy from the wind and transfer into energy we can use?

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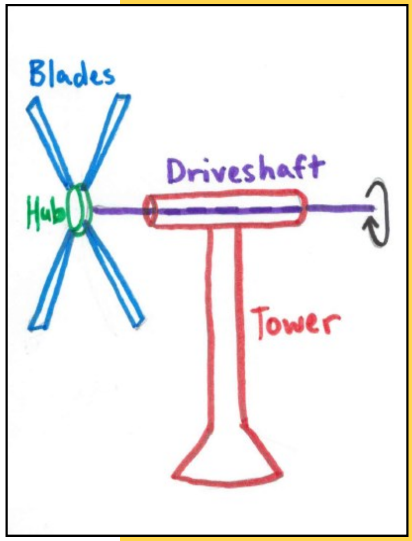
Parts of a Turbine (10 minutes)

Who can draw us a wind turbine? Have one student draw one on the board. Now, let's go through and identify the different parts and what purpose they serve (label each on the drawing):



- Blades- When the wind hits the blades, the force pushes on the blades, causing them to move. Blades can be made from many different materials and designed in many different ways to provide the best results.
- Hub- The blades are all connected to the hub, which holds them in place.
- Driveshaft- The driveshaft connects to the hub, so that when it spins, the driveshaft spins with it.
- Tower- The tower holds all these elements up where the wind will reach them. For our designs today, anything can be used to hold these elements up to the fan.

Now, what good is this? What can we do with a spinning driveshaft? In the next activity, students will be building their own simple wind turbines. Our goal will be to get some mechanical work out of our wind turbines: We'll attach a spool, string, and cup to the end of the driveshaft to see if we can lift weights (a few washers.)

Build a Turbine (60 minutes)

*Adapted from KidWind- Windwise Education Lesson 8: "How does a windmill work?"

Time to get to work! Organize the students into groups of 3-4 and allow them some time to plan their design. Provide a table full of random objects to play around with. Encourage groups to plan for at least 5 minutes before they start putting things together. They should record their plan in their notebooks. Remind them that they will need to find things to create the needed elements; they should be looking for materials to make blades, a hub, a driveshaft, and a tower. Also provide each group with the spool to attach to the driveshaft, but hold back on the string, cup and washers at first. Once a group gets their turbine spinning, they can think about lifting weights.

Encourage students to try out their own design ideas, even if they don't think they will work. Try to get groups to develop their own creative ideas. It is sometimes very easy for an entire class to get caught up in one design!

Build a Turbine (continued...)

Allow about 20 minutes for students to work on an initial design. Encourage them to just get all the components together and functioning, even if they are not functioning very well.

After the initial build time, have the groups take a break. It's important for engineers to stop every once in awhile to evaluate their work and see if they are headed in the right direction. Facilitate a discussion (about 10 minutes) to help the students evaluate and critique their own designs, and the designs of other students. Some questions to ask:

- Was it tough to get started?
- What components did your group focus on at the beginning?
- What problems did you run into as you began to work?
- Did you and your teammates have different ideas about how to design things? If so, how did you decide between different options?
- Where could your design improve? Are there any elements from other designs that seem to be working well? There is no shame in using another's ideas as a springboard for your own, as long as you ask and give credit where it is due. We're all learning together.
- As you make changes to your design, how are you judging if the change was an improvement? Did anyone find themselves making too many changes at once? Usually, a design process of trial, change one variable, then conduct another trial works best.

After the conversation, it's time for the challenge: How much weight can your turbine lift? Give students the rest of the remaining time to experiment with and improve their designs to lift the maximum amount of weight in the shortest amount of time.

If you see that students are really struggling, it can be helpful for them to see an example of working turbine, so consider bringing one that you made. However, do not show it right away, or you just might end up with a room full of just one turbine!

Two common problems that students can encounter in this activity are too much friction between the driveshaft and the tower, and not having pitched (angled) blades. Be ready to address these things!

Build a Turbine (continued...)

If there is extra time or the students need a new challenge-

Have students calculate the energy and power for their turbine. Students can measure the weight of their cup and washer combination and measure the distance that they are lifting their weights. Guide students through the following calculations:

$$\text{Energy(J)} = \text{Force(N)} * \text{Distance(m)} = \text{Mass(kg)} * \text{Acceleration of Gravity}(9.8\ m/s^2) * \text{Height(m)}$$

This calculation tells us how much energy is required to do the desired work (in this case, lifting the weights.)

$$\text{Power(W)} = \text{Energy(J)} / \text{Time(s)}$$

Power is a measure of how fast energy is converted. How much power does your wind turbine have?

It can be easy to run out of time with this class! Consider breaking it up between two class sessions, or allowing students to take their wind turbines and some materials home so they can continue to improve their designs.

Conclusion (10 minutes)

Wrap up should be a final discussion about the student's turbines and what they encountered while going through the design process. Some questions from the first discussion can be repeated; have answers changed? Have students record the highlights of the conversation in their notebooks. Some additional questions:

- How did your design change as you began to lift weights?
- Which factors seemed to be the most important (blade pitch, length, driveshaft friction, etc.)?
- What energy transfers took place in your turbine?
- How did you and your teammates work together? Were there ever any disputes about your design or the process you used?
- What are some similarities between the process we used to day and the process you would use for a large scale project?

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References-

- KidWind Project– WindWise Education Lesson 8: “How Does a Windmill Work?” www.windwiseeducation.org