MacGyver Wind Lift Design Challenge

Teacher Lesson Plan

Background Information

Energy is the ability to cause a change in an object. That change can be moving it, crushing it, burning it, and changing its state, to name a few. We use many different sources of energy to do work. Energy sources can be grouped into two types:

RENEWABLE ENERGY SOURCES	NONRENEWABLE ENERGY SOURCES
This type of energy does not run out. It can be replenished in a short time or will always be there.	This type of energy has a limited supply. Once it is used, it cannot be replaced. It takes millions of years to form.
Renewable Sources: Biomass Geothermal Hydropower Solar Wind	Nonrenewable Sources: Coal Natural Gas Petroleum or Oil Propane Nuclear or Uranium

Each of these sources are obtained or collected in different ways. They are found in different places in Ohio, the United States and around the world. Many are used to make electricity.

Energy does not disappear. There is the same amount of energy today as there was when the world began. When we use energy, we do not use it up completely; we change it into other forms of energy. When we burn wood, we change its energy into heat and light. When we drive a car, we change the energy in the gasoline into heat and motion. The total energy in the world always remains constant. We call this concept the law of conservation of energy. While there will always be the same amount of energy in the world, more and more of it is changed into heat and will go into the air. It is still there, but it will be hard to use.

Energy is categorized into two types: kinetic energy or potential energy. Kinetic energy describes the amount of energy an object possesses when it is in *motion*, such as the energy in a moving bowling ball. Potential energy describes the amount of *stored* energy that an object possesses, such as the stored energy due to gravity in an apple hanging on a tree. When the apple begins to fall towards the ground, its potential energy is transformed into kinetic energy. A good understanding of kinetic energy is important to understanding many concepts in this activity.

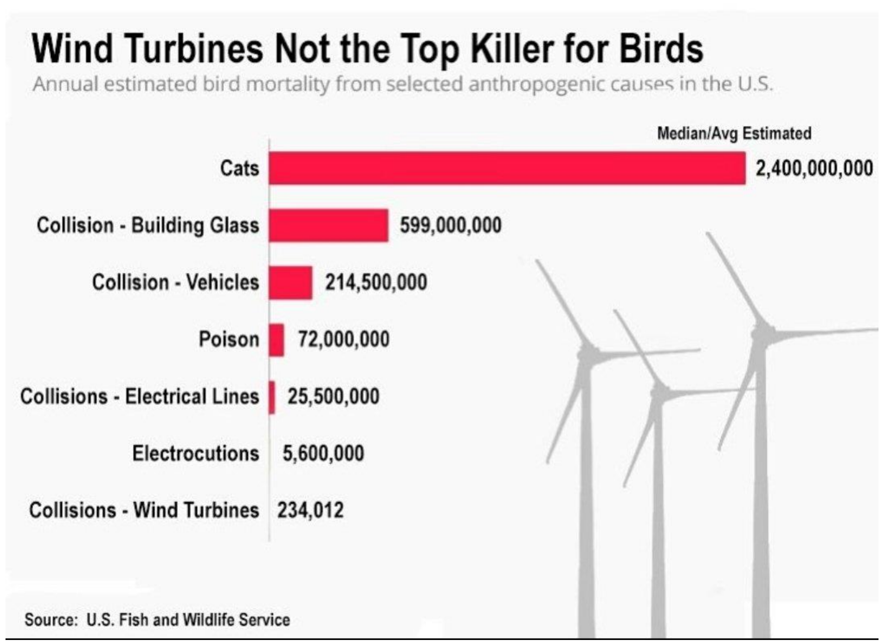
Wind Energy

Wind is simply air in motion. It is produced by the uneven heating of the Earth's surface by energy from the sun. Since the Earth's surface is made of very different types of land and water, it absorbs the sun's radiant energy at different rates. The direction and strength of the wind are changed by the Earth's terrain, bodies of water and vegetative cover. Some locations consistently have strong winds from a particular direction, while other locations have erratic or little wind. Much of this energy is transformed into heat as it is absorbed by land areas, bodies of water, and the air over these formations. We can harness the energy from the wind using a wind turbine to generate electricity and power our homes and businesses.

For more information about wind, refer to NEED's **Wind-at-a-Glance Graphic**.

Wind Advantages and Challenges

Why should we use wind energy?



It is a clean source of renewable energy and cost effective. Land based wind is one of the lowest priced energy sources available. There are zero emissions which can help prevent climate change and improve air and water quality. Using clean wind energy can also help reduce our fossil fuel dependence.

Challenges of wind power include impacting local wildlife (see chart) and building transmission lines from remote wind turbine locations to cities where electricity is needed.

Learn more about wind turbine's impact on wildlife from **Let's Talk Science**.

Wind Turbine Design:

Pitch: Blade pitch is the angle of the blades with respect to the plane of rotation. The pitch of the blades dramatically affects the torque of the rotor. (Torque refers to rotational force or how hard you can push something in a circle, like a wrench.) Pitch also affects the amount of drag encountered by the blades. Efficient blades will provide maximum torque with minimum drag.

Drag: This is also known as resistance. Friction on the blades against the air molecules as they rotate can slow down the turbine.

To experience pitch and drag, act out the movements with students by copying the images below. Have students pretend they are sticking their hand out of a car window. Pretend the wind is coming over their hands. Have them act out with you how an airplane works. With their arms out, demonstrate how when they tilt their hands up, their arms go up, when they tilt down, they go down. This tilt angle makes a big difference when using the wind to push something up or down. The blades tilt in the wind.

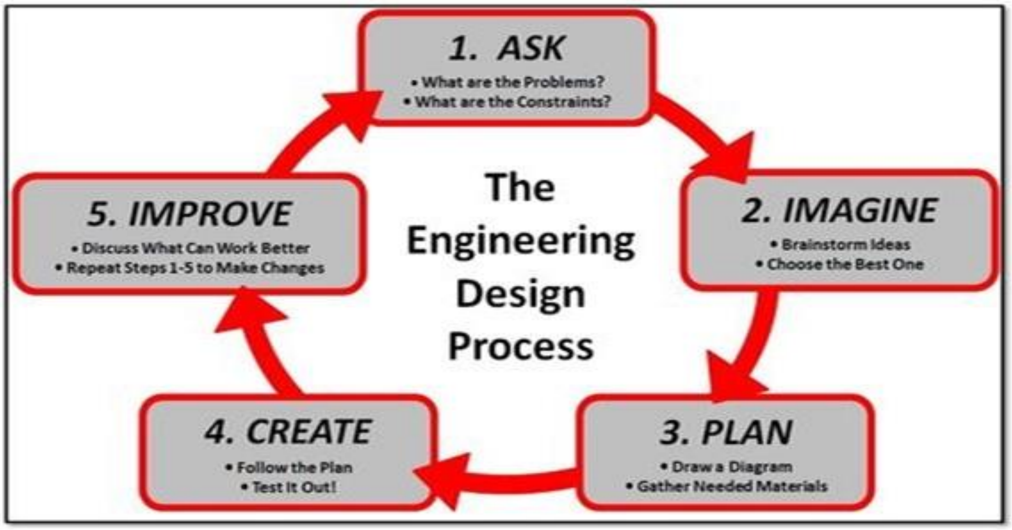
Turn on a fan and place your hand in front of it about 5 feet away.

- Extend your arm toward the fan with your palm facing the floor. What happens to your hand?
- Move your hand so your palm is facing the fan. What happens to your hand?
- Now, place your hand in front of the fan at a 45^{o} angle with your thumb facing up and your palm facing the fan. What happens you your hand?
- Finally, place your hand in front of the fan at a 45^{o} angle with your thumb facing down and your palm facing away from the fan. What happens you your hand?
- Experiment with different angles to determine which angle has the best lift.

Learn more about generating electricity from wind at the [US Energy Information Association](#).

MacGyver Wind Lift Design Challenge

In this challenge, students will implement the engineering design process to design, build, test and improve a MacGyver Wind Lift. They will test and calculate the power of their project by measuring how many pennies their turbine can lift. They will also calculate which turbine is most powerful, using the data collected from their experiment. Students will follow the Engineering Design Process.



Suggested Engagement Activities:

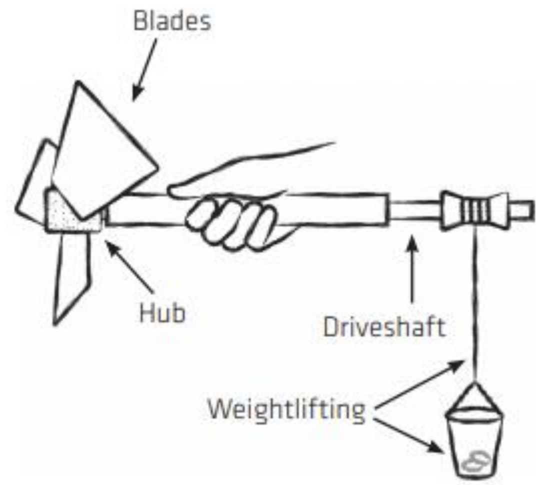
Before beginning the design challenge, introduce students to the concept of wind. Ask them what they know about wind, how it forms and how we can use it for energy. Students may have seen a wind turbine near where they live. Allow time for discussion to help build background knowledge and spark interest in the challenge.

In addition, consider some of the following activities to spark engagement and curiosity about wind:

- Learn about wind and take a tour of a wind farm with **Caitie's Classroom**. (*best for 3rd grade*)
- In this video, One Energy explains turbine construction to students through a read aloud of their book, ***How to Build a Wind Turbine*.**
- Read 'The Boy Who Harnessed the Wind', by William Kamkwamba and Bryan Mealer, a story about a 13-year-old boy in Malawi who can no longer go to school he loves when his family cannot afford the fees. At a library, William learns how to build a windmill to pump water on his family's farm. Against all the odds, he invents an unconventional way to save his family and village using the power of wind.
    - ***The Boy Who Harnessed the Wind*** picture book read aloud
    - ***Blowing in the Wind***-video bio of William Kamkwamba (3:22 minutes)
- Take a **tour of a wind turbine at One Energy in Findlay, Ohio**. (34:32 minutes; interior of turbine tour starts at 23:03 and 360-view from the top starts at 32:45)

Exploration:

After building background knowledge and engagement, it is now time to construct student's wind turbine.



Materials in your MacGyver Wind Lift Supplies:
Supplies will allow at least 50 students to build their own wind lift.

Materials Supplied:

- Hub: Pool Noodle, Glue Gun
- Blades: Bamboo Skewers *(100 of 3 lengths: 6", 8" and 10". Skewers can be cut with a good pair of scissors.)*
- Driveshaft: Dowel Rod, Plastic Straw
- Lift: String, Cup, Wooden Spool

Materials Not Supplied:

- Box Fan
- Materials for blades-index cards, plastic bottles, manilla folder, cardboard etc.
- Pennies (consistent weight for lift so balance is not needed)
- Meter stick for measuring string
- Tape, scissors, hole punch

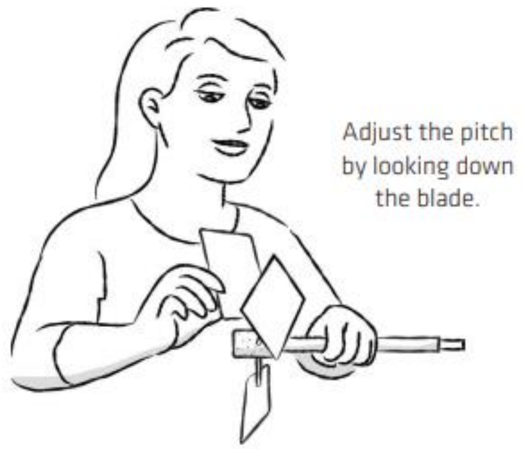
Watch the following video demonstrating **how to build the MacGyver Wind Lift**. You may choose to show this to students or watch to support your own class demonstration:

Students should follow the MacGyver Wind Lift Engineering Design Student Worksheet to explore wind energy and create their own wind turbine. They will follow the engineering design process to see which design is most powerful.

Pointers and Tips for Building:

- Pre-cut the pool noodle into 1" sections (one for each student.) A serrated or bread knife will easily cut the noodle.
- Pre-cut students string at .6 meters (60 centimeters) for ease of time. (The challenge is for the wind lift to raise the cup .5 meters. By pre-cutting lengths of .6 meters, you allow enough string to attach to the cup and spool.)
- If it is slipping, hot glue the driveshaft into the pool noodle.
- Do not glue the blades into the pool noodle, students will be adding and removing these as they test their lift.

- Do not make the blade bigger than the fan you have. Students make very long blades thinking bigger is better. This can also add drag so consider the blade size before constructing.
- Keep the fan setting the same for all testing to remove this variable and keep data reliable. May want to test your own turbine first to see which setting is best.
- Test all the wind lifts at the same distance from the fan. A piece of tape on the floor or table can ensure students are in the correct spot.
- Help students think about changing pitch using the diagram.



Testing, Data Collection, & Additional Trials:

Students should answer improvement and conclusion questions on the MacGyver Wind Lift Engineering Student Worksheet to make improvements before retesting and to reflect on their design process overall.

Note: When entering your student's data on the KidWind portal, the form will ask for the weight of the lift. If you used pennies as your weight, every penny is 2 grams. To get the lift weight, students will multiply the number of pennies x 2 grams.

Extension Activity: Penny Power

Students will collect and calculate the power of their turbine.

Additional Materials: Timer, calculator

Note: If completing the extension activity, pennies must be the item put in the lift and students will need to time how long it takes for the cup to be lifted .5 meters.

Calculating the power of a wind lift is easy, but the formulas and units are probably not familiar to students:

FORCE = Mass x Gravity	The unit for force is **NEWTONS**.
WORK = Force x Distance	The unit for work is **JOULES**.
POWER = Work ÷ Time	The unit for power is **WATTS**.

Since energy is the ability to do work, you are calculating how much energy is needed to lift the weight. To figure out the power, you need to know how long it takes. If you do the same work (energy) faster, then you have more power. Power is measured in watts.

Force = mass (kilograms) X the force of gravity (9.8 m/s^2).

- To make finding the force less complicated, students should use the chart to calculate their FORCE. *NOTE: Pennies were measured in grams and the force was rounded for ease in multiplication.*
- Notice the pattern in the chart. With that pattern in mind, students should be able to calculate the force if their wind machine lifted 21 pennies. How about if it lifted 30 pennies?

Number of Pennies	Force (Newtons)
4	0.1
6	0.15
8	0.2
10	0.25
12	0.3
14	0.35
16	0.4
18	0.45
20	0.5

Work= Force (newtons) X Distance (meters)

- Work is a measure of the energy expended in applying a force to move an object.
- Work = Force (from the chart above) X .5 meters

Power = Work (joules) ÷ Time (seconds)

- Power is how fast you do work. If you dig a hole that is 2 meters wide and 2 meters deep and it takes you one hour to do it, you are not as powerful as a steam shovel that can dig the same size hole in 5 minutes.
- Power = Work (calculated above) divided the time it took to raise the lift.

Example: Let's try a sample calculation.

Sally's design lifted 16 pennies in 8 seconds. Let's calculate her wind lift's power.

Force	.4 newtons (from chart)
Work	.4 newtons X .5 meters = .2 joules
Power	.2 joules ÷ 7 seconds = .025 watts

On the datasheet, students record three trials. Calculations from sample data might look like this:

Trial	# of pennies	Force (newtons) Copied from chart	X	Length of string (meters)	=	Work (joules)	÷	Time (seconds)	=	Power (watts)
Design #1	**16**	**.4**		**.5**		**.2**		**8**		**.025**
Design #2	**10**	**.25**		**.5**		**.125**		**12**		**.010**
Design #3	**25**	**.625**		**.5**		**.313**		**9**		**.035**

Remember, when you enter the data on the KidWind portal, you will enter the weight lifted, not the force. If using pennies as your weight, each penny is 2 grams.