MacGyver Wind Lift Design Challenge

Introduction to Wind Energy, Forces & Motion, Turbine Blades and the Engineering Design Process

Background Information

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

RENEWABLE ENERGY SOURCES	NONRENEWABLE ENERGY SOURCES
Renewable Energy does not run out. It can be replenished in a short time or will always be there.	Nonrenewable 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 energy sources 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 environment. It is still there, but it would be hard to use.

Energy is categorized into two forms: 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.

Forces & Motion

Movement is a change in position. If the forces acting on an object are balanced, there is no motion. However, if the forces are unbalanced, an object will move in the direction of the greater force. In this activity, the force of gravity is acting on the weight (cup of pennies). The greater the number of pennies, the more weight and the greater the force of gravity acting on the cup. The force from the wind caused by the moving blades of the fan will cause the turbine blades to turn and lift the cup.

Wind, moving air, is a force. It has direction and speed. Speed is a measurement of how fast or slow a change in position takes place. Using any weather app, you can find the current wind speed and direction for any location. Check the current wind speed in your area. Compare it to another area that has a wind farm. Van Wert County, Ohio would be a good example of a region in Ohio with a wind farm. Wind speed is greater at altitude than the wind speed at ground level. The typical wind turbine height is 280 feet or 80 meters tall. The greater the speed of the wind, the greater the force it can apply. View the Beaufort Wind Scale on the NOAA website, to see the relationship between wind speed and wind effects.

The wind from the fan causes the blades on the MacGyver Wind Lift to turn which lifts the cup of pennies. Students can calculate the speed that the cup moves using the formula:

$$\text{Speed} = \frac{\text{Distance (meters)}}{\text{Time (seconds)}}$$

The mass of the object effects its speed. Students will calculate the speed of two trials with different weights. The greater the mass, the slower the speed when the same force applied from the wind from the fan.

Wind Energy

Wind is 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 to power our homes and businesses.

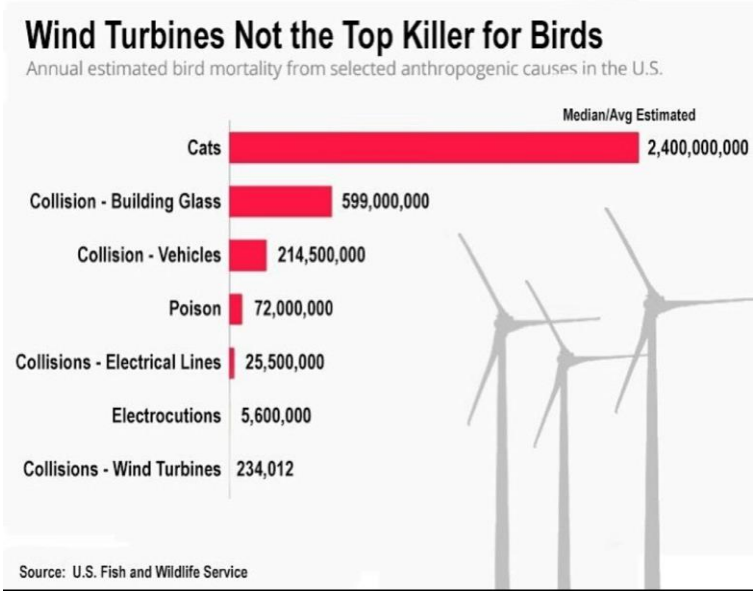
For more information about wind, refer to NEED's **Wind-at-a-Glance Graphic**, the video, **How Wind Turbines Work** (5:02 minutes), or the website **US Energy Information Association**.

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**.

Angles and Wind Turbine Blade Design:

Depending on your grade level, it may be helpful to review angles before starting the design challenge. Display a protractor on a white board so student can see they will need to angle their blades in the hub less than 90^{o}.

Video-**Introduction to Angles, Their Names & Using a Protractor** by Happy Learning (4:17 minutes)

Pitch: Blade pitch is the angle of the blades with respect to the plane of rotation. The pitch of the blades dramatically effects 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 effects 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 imitating the images below in front of a fan. Have students pretend they are sticking their hand out of a car window. Pretend the wind is coming over their hands. 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 (or hair dryer on cool setting) and place your hand in front of it about several 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° 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° 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.

What if we move our hand flat, like it's cutting through the wind?

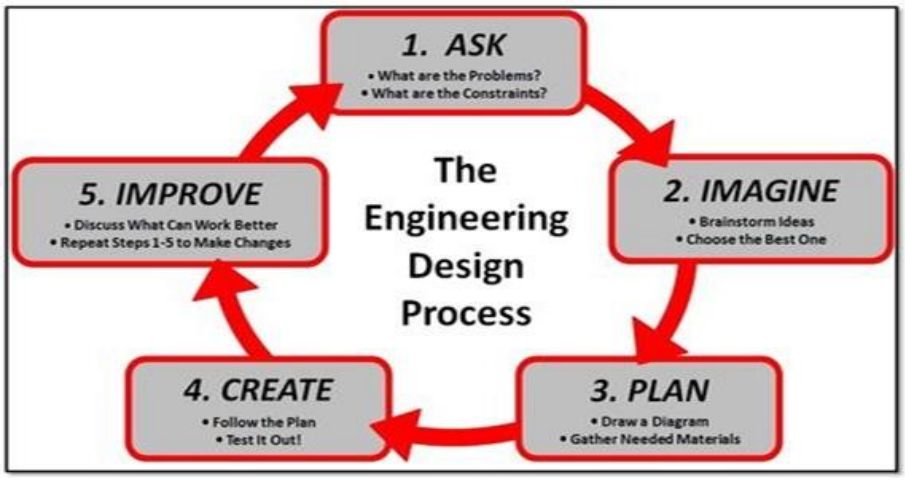
Now our hand is out, fingers together like we're making a wall. What happens to our hand?

What happens if we tilt our hand, thumb pointing upward?

What happens if we tilt our hand, thumb pointing downward?

Introducing the Engineering Design Process:

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. Students will follow the Engineering Design Process.



1. Ask: Engineers ask critical questions about what they want to create, whether it be a skyscraper, amusement park ride, bicycle or smartphone. These questions include: What is the problem to solve? What do we want to design? Who is it for? What do we want to accomplish? What are the project requirements? What are the limitations? What is our goal?
2. Imagine: You work with a team to brainstorm ideas and develop as many solutions as possible. This is the time to encourage wild ideas and defer judgment. Build on the ideas of others. Stay focused on topic and have one conversation at a time. Remember: good design is all about teamwork. Try this **group brainstorming activity**.
3. Plan: For many teams this is the hardest step! Revisit the needs, constraints and research from the earlier steps, compare your best ideas, select one solution and make a plan to move forward with it.
4. Create: Building a prototype makes your ideas real! These early versions of the design solution help your team verify whether the design meets the original challenge objectives. Push yourself for creativity, imagination and excellence in design.
5. Improve: Discuss how you could improve your solution. Make revisions. Draw new designs. Iterate your design to make your product the best it can be.
   And now, REPEAT!

Source: **TeachEngineering.org** Visit their website for more information on the Engineering Design Process.

Print: 8 ½ x 11 page of the **Engineering Design Process** diagram