BrainStorm STEM EDUCATION

STEM KIT

EDUCATOR GUIDE

WIND TURBINE

CREATED FOR BOTH HOME AND SCHOOL

PERFECT FOR THE CLASSROOM

DESIGNED BY TEACHERS FOR TEACHERS

TABLE OF CONTENTS

LESSON OVERVIEW

Class Information

This lesson plan provides materials on the science and engineering behind wind turbines. Students will learn about the basics of renewable and nonrenewable energy and the importance of using these energies to create a better future. Once students have a solid understanding of these energy types, they will learn about wind and how it forms. Finally, students will be able to discover the history, types, pros and cons, and future of wind turbines.

CONCEPTS

- **Nonrenewable and Renewable Energy**
- **History of Wind Energy**
- **What is Wind?**
- **Wind Turbines**
- **Pros and Cons of Wind Energy**

LESSON OBJECTIVES

- Define what renewable energy and nonrenewable energy is.
- Describe what causes wind.
- Explain the difference between types of wind turbines.
- Understand the importance of renewable energy and its effects on the environment.

EDUCATIONAL STANDARDS

NGSS - Next Generation Science Standards

- **K-PS3-1.** Make observations to determine the effect of sunlight on Earth's surface.

- **K-2-ETS1-1.** Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

- **3-LS4-4.** Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.

- **3-5-ETS1-1.** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

- **5-ESS2-1.** Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.

- **MS-ESS2-6.** Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.

- **MS-ESS3-3.** Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

- **MS-ETS1-1.** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

INTRODUCTION

Today we will discuss wind turbines, so get ready to be blown away! We will learn about renewable and nonrenewable energies before we dive into wind turbines. Once we understand the importance of renewable energies, we'll introduce the science behind wind. Finally, we'll be learning about wind turbines, such as the different types, history, pros and cons, and the future of wind turbines.

VOCABULARY

Renewable energy - energy produced through the use of natural resources that will be replenished faster than they will be consumed.

Nonrenewable energy - often referred to as "dirty" energy, this type of energy comes from a source that will eventually be depleted.

Emissions - greenhouse gases that are released into the atmosphere, or a specific area, over a period of time.

Climate change - the change to a region's expected weather and temperature over a period of time.

Wind - the movement of air.

Atmosphere - an envelope of gases that surrounds the Earth.

Atmospheric pressure - the pressure caused by the weight of the atmosphere.

Wind energy - energy produced through harnessing wind power.

Wind turbine - previously referred to as a windmill, these machines use large blades to collect kinetic energy from wind to be converted into electricity.

Sustainability - the ability to meet current society's needs without causing future generations to be unable to meet their needs.

Vertical-axis turbines - turbines that usually consist of two large blade-like pieces, that are connected at the top and bottom of a rotor. These turbines look like a large egg beater.

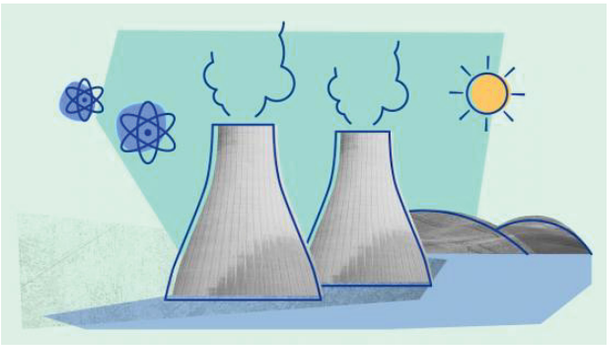
Horizontal-axis turbines - turbines that usually consist of three blades and look like airplane propellers.

Kilowatt-hour - unit of measuring electricity.

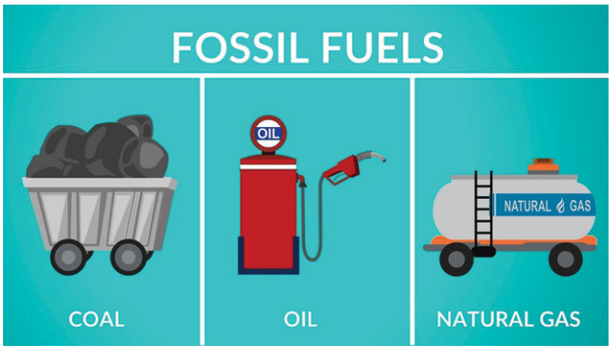
WHAT IS NONRENEWABLE ENERGY?

Nonrenewable energy often referred to as "dirty energy", is any energy derived from a source that will eventually deplete. This form of energy also tends to release more emissions into the atmosphere, ultimately affecting the climate in a negative way.

Nuclear energy is all energy derived from radioactive elements. The most common radioactive element is uranium, which is mined from ore and refined into fuel. There are a variety of issues with using nuclear energy including cost, time, mining lung cancer risk, the possibility of meltdown, emissions, and air pollution.



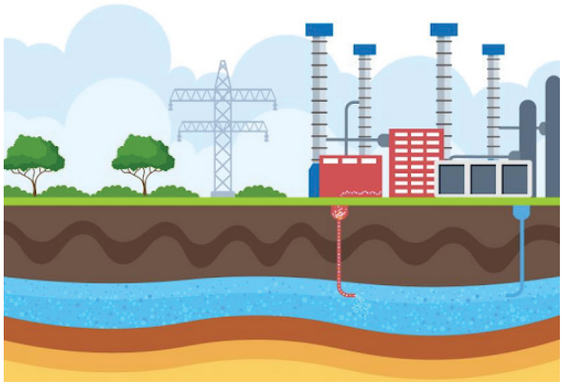
Fossil fuels are formed by dead plants and animals that, with the help of heat and pressure, have fermented for millions of years below the Earth's surface. Fossil fuels include oil, natural gas, and coal. These energy sources originally received their energy from the Sun through photosynthesis and were stored in the tissues of plant life. These plants were consumed by animals, which transferred the plant's energy into their bodies. When these types of energy are burned, they release the energy stored from dead plants and animals. Of the fossil fuels, both oil and natural gas can be pumped up from wells below the Earth's surface. Coal is a solid fossil fuel, buried beneath layers of sediment from fossilized swamps. Oil, sometimes referred to as crude oil, is used in gasoline and diesel fuel production. Natural gas, composed of mostly methane, is used for cooking and heating homes. Coal is often used for heating homes and generating power plants.



WHAT IS RENEWABLE ENERGY?

Renewable energy, often referred to as clean energy, is all energy that comes from a source that replenishes faster than it can be used. Renewable energy has lower emissions than nonrenewable energy. Emissions are released greenhouse gases that go into the atmosphere, or specific area, over a period of time.

Geothermal energy, is energy harnessed by pumping hot water and steam from below Earth's surface. Hydrothermal reservoirs are wells that are naturally hot and permeable. Enhanced geothermal systems are hot, but can be improved through the use of hydraulic action. Once these energy sources are pumped to the surface they can generate electricity through the **fluid being held at varying temperatures.**



Biomass energy, or bioenergy, is energy that harnesses a variety of organic materials. These biomass materials can include wood, charcoal, a variety of manure, and biofuels produced through crops. The majority of bioenergy is produced for use in more rural areas and can be used for cooking, lighting, and heating. These forms of energy are more common among developing countries. While biomass energy creates emissions, they are much lower than burning fossil fuels. Despite bioenergy being a type of renewable energy, it should be used sparingly, as it can contribute to deforestation and land-use change.

TYPES OF RENEWABLE ENERGY

Solar energy, which harnesses the power of the Sun, is the most abundant form of renewable energy available. Despite some thinking that solar energy can only be harvested on bright, sunny days, it can be harvested on cloudy days as well. Solar energy is most often gathered using solar panels, also referred to as solar photovoltaic panels (PV). Solar panels harvest solar energy through the photovoltaic effect, which uses a semiconductive material to free electrons and send them into an electrical current. Solar energy can be used for heating, cooling, natural light, and electricity. Solar panel costs have lowered in recent years, making them the cheapest form of renewable energy. As well as solar panels may last up to 30 years.

SOLAR

Hydroelectric energy, or water energy, is energy created through harnessing the natural flow of water from high to low points. Hydroelectric energy can come from either reservoir hydropower plants or run-of-river hydropower plants. Reservoir hydropower plants use water stored in reservoirs, while run-of-river hydropower plants use the energy produced through the flow of a river. Hydroelectric energy does more than produce electricity, it can also provide drinking water, provide water for irrigation, flood and drought control, and navigation services. While hydroelectric energy is the largest source of renewable energy, infrastructure to create large-scale plants can affect ecosystems negatively. Because of how ecosystems can be affected, small-scale plants are considered more environmentally sound.

HYDRO

TYPES OF RENEWABLE ENERGY

Wind energy is energy generated by harnessing the kinetic energy of wind. Although it is considered a separate energy type, wind energy is a product of the Sun. One of the reasons wind occurs is due to the uneven heating of the Earth's surface by the Sun. Wind energy is clean, uses little to no water, and produces no emissions of air pollution. Wind energy is harnessed through the use of wind turbines. As the blades of a turbine spin, they are attached to a generator, producing electricity. A large group of wind turbines is known as a wind farm. Wind farms can be placed onshore, offshore, or floating.

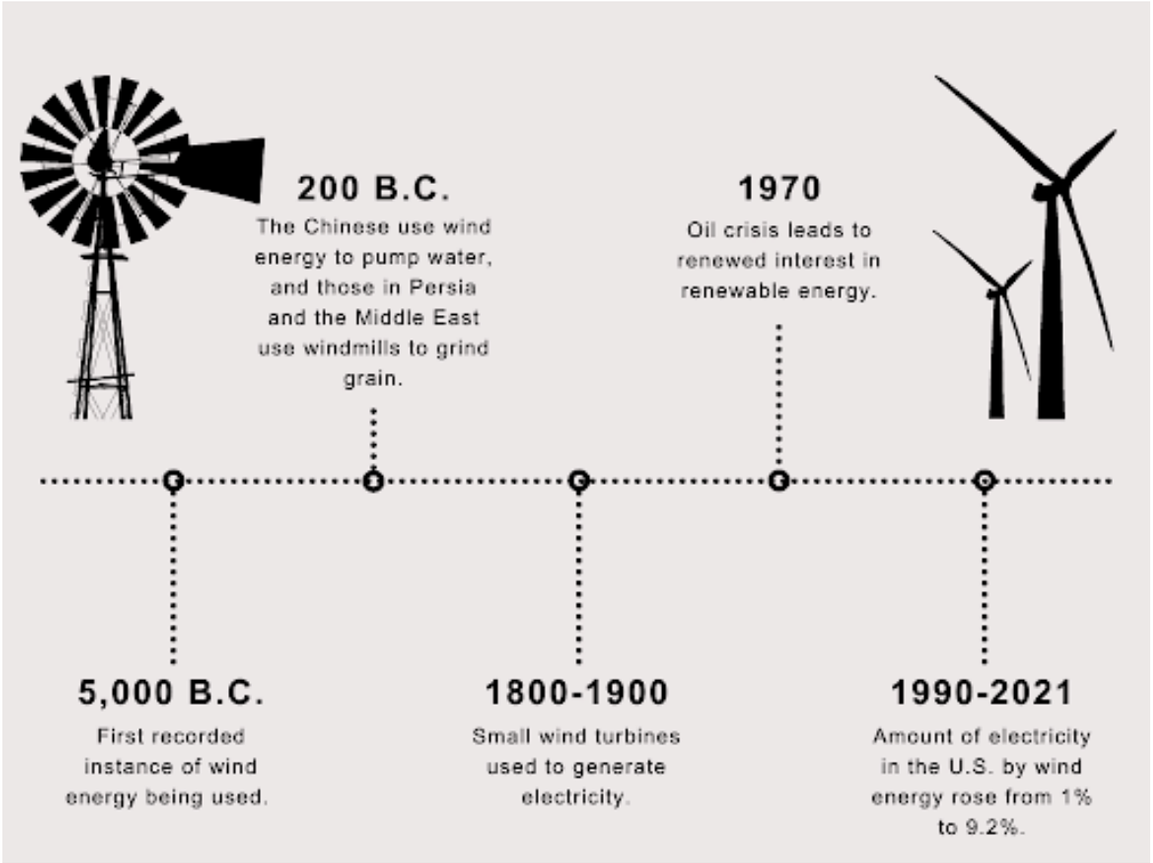
WIND

Tidal energy, or ocean energy, is energy generated through the natural rise and fall of tides. Tidal energy is similar to hydroelectric energy. Just as hydroelectric energy uses the kinetic energy of the natural flow of water, tidal energy uses the kinetic energy of the natural rise and fall of the tides. The most common and effective way of harnessing tidal energy is by placing turbines in the path of a tidal stream. Tidal stream areas are areas in which there is a fast movement of the tides going in and out. This form of energy is considered quite efficient, due to the density of water.

TIDAL

THE HISTORY OF WIND TURBINES

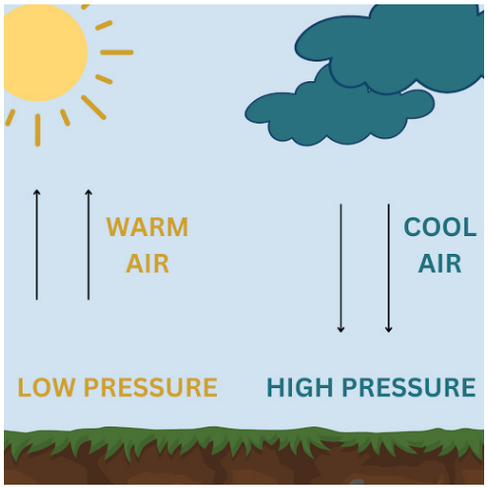
Wind energy has existed for thousands of years. By the 11th century, it was used widely by those in the Middle East for food production. As trade between nations grew, wind energy technologies were brought to Europe and eventually to the Western Hemisphere. As the U.S. wilderness became more populated, individuals dealing with the land built thousands of wind pumps across the West. By the 1930s much of the U.S. was electrified, causing a decline in the use of wind energy. With the oil crisis of the 1970s came a renewed interest in renewable energy. This led the U.S. government to fund research and development of these types of energy. By the 1980s, thousands of wind turbines were built along the length of California. In the 1990s and 2000s, incentives were established for renewable energy source production. Countries across Europe have invested in wind energy, also creating incentives for its use. China has also invested in wind energy, becoming the largest generator of wind energy electricity.



WHAT CAUSES WIND?

Before identifying the types of wind turbines, let's go over what causes wind. Despite solar energy and wind energy being considered separate renewable energies, wind energy is a form of solar energy. There are a few factors that contribute to what causes wind:

- Uneven heating of the Earth's surface by the Sun
- Differences along the surface of the Earth
- The Earth's rotation



Air contains an enormous amount of particles, such as nitrogen and oxygen, that have weight. The weight of these particles pushing down on Earth's surface causes atmospheric pressure. These particles react to how hot or cold the air becomes. When heated, particles will move away from the Earth's surface and spread out, causing lower pressure. When cooled, they will fall closer to Earth's surface and compress, creating higher pressure. The movement of these particles in the atmosphere causes wind.

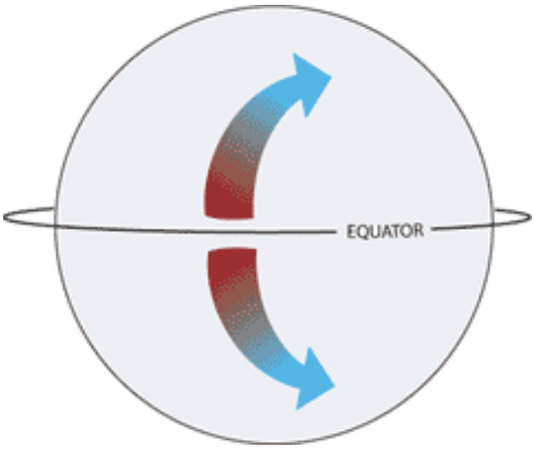
Wind transports heat, dust, moisture, and pollutants over considerable distances. Wind is specified by its speed and direction. Wind speed is determined by differences in air pressure:

Slow Wind = High Air Pressure

Fast Wind = Low Air Pressure

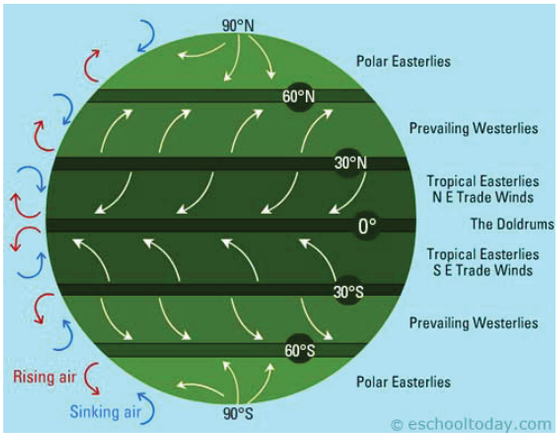
WIND PATTERNS

There are four major wind zones on Earth. These zones are the polar easterlies, westerlies, trade winds, and doldrums. Each of these areas deals with hot and cold air rising and falling. Each wind zone is named for the direction in which the winds originate, not the direction in which they are traveling. These winds are often affected by the Coriolis Effect, which is when circulating air moves towards the right in the Northern Hemisphere and the left in the Southern Hemisphere, due to Earth's rotation on its axis.



Polar easterlies are winds that begin in the east and are 60° latitude in both hemispheres. These winds join the westerlies to reduce upward motion and form when the air over the poles cools. This cool air can spread and sink, then turn west due to the Coriolis Effect.

Westerlies are winds between 30° and 60° latitudes and move toward the poles, ultimately turning toward the east. These winds are responsible for the majority of the weather in the United States and Canada.



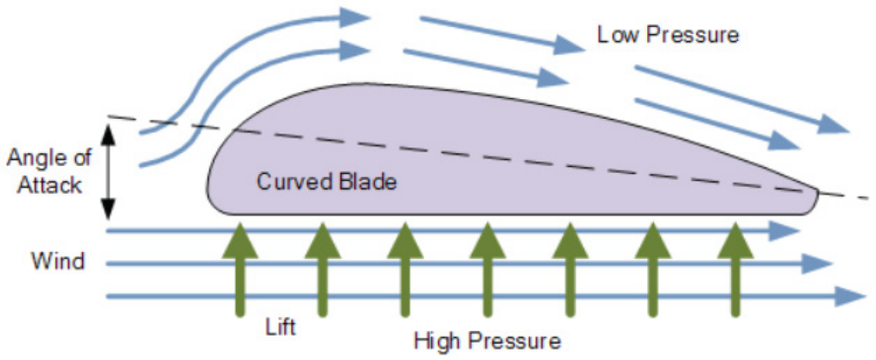
Trade winds are winds caused by air moving toward the equator. These winds, classified as warm, steady breezes, are almost always blowing. Because of the Coriolis Effect, these winds appear to be curving to the west, despite traveling to the equator from the south to the north.

Doldrums are winds caused by converging trade winds, creating an area of calm weather.

WIND TURBINES

Kinetic energy is energy that an object has because of its movement. Scientists and engineers are able to use the kinetic energy of the wind to generate electricity through the use of a wind turbines. The use of this wind flow is also referred to as motion energy. Wind turbines generate electricity through the turning of their blades. The process of generating electricity uses the aerodynamic concepts of lift and drag. As wind flows across the blades, air pressure decreases on one side, creating lift and drag. The lift is greater than the drag, which causes the rotor to spin. As the rotor spins, it is connected to a generator, and that produces the electricity.

Because the movement of the blades is key to the wind turbine's functioning, it is important that they are designed properly. Engineers have three choices for blade shapes: curved, bent, or flat; all of which depends on the type of wind turbine. The blades must rotate at the ideal speed. If the blades move too slowly, too much wind will pass through them. If the blades move too quickly, too much drag is created. The best overall blade design would allow for the maximum amount of wind power to be harnessed but with a minimum construction cost. Engineers must also take into account humidity when designing blades. Humidity has a huge impact on wind turbine function. When the air has a higher humidity level, it is less dense, leading to less wind power.



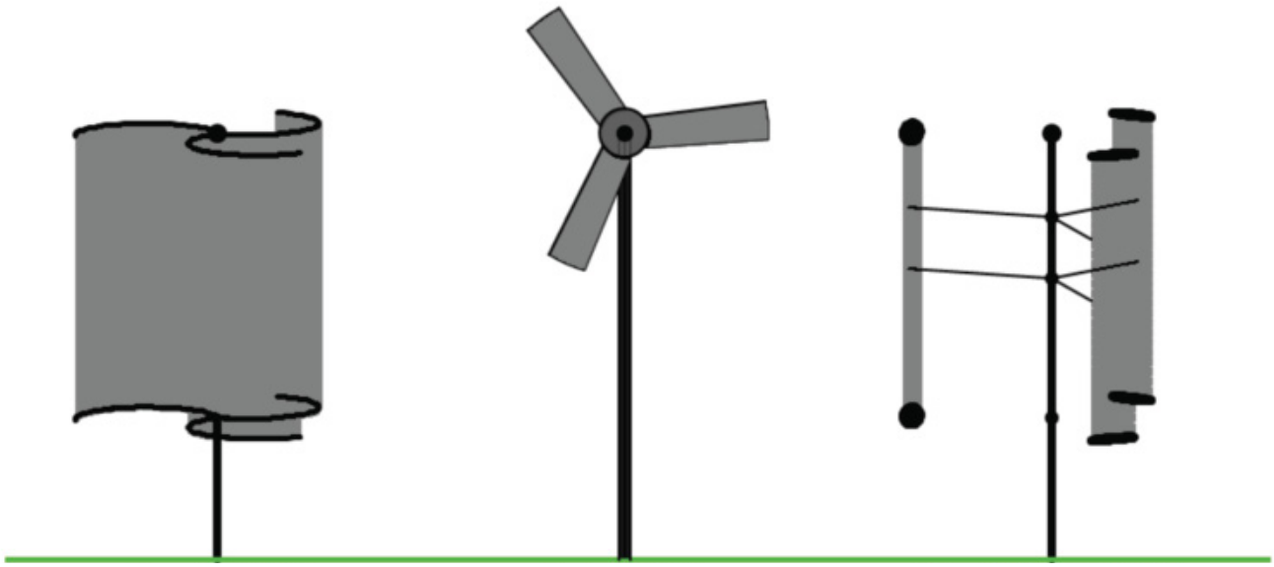
TYPES OF WIND TURBINES

HORIZONTAL-AXIS WIND TURBINE

Horizontal-axis wind turbines (HAWTs) are the most common type of wind turbine. HAWTs have the most commercial designs available. These types of turbines feature two to three long, thin, airplane propeller-like blades, facing parallel to the wind flow. The taller the HAWT and the longer its blades, the more electricity it is capable of creating.

VERTICAL-AXIS WIND TURBINE

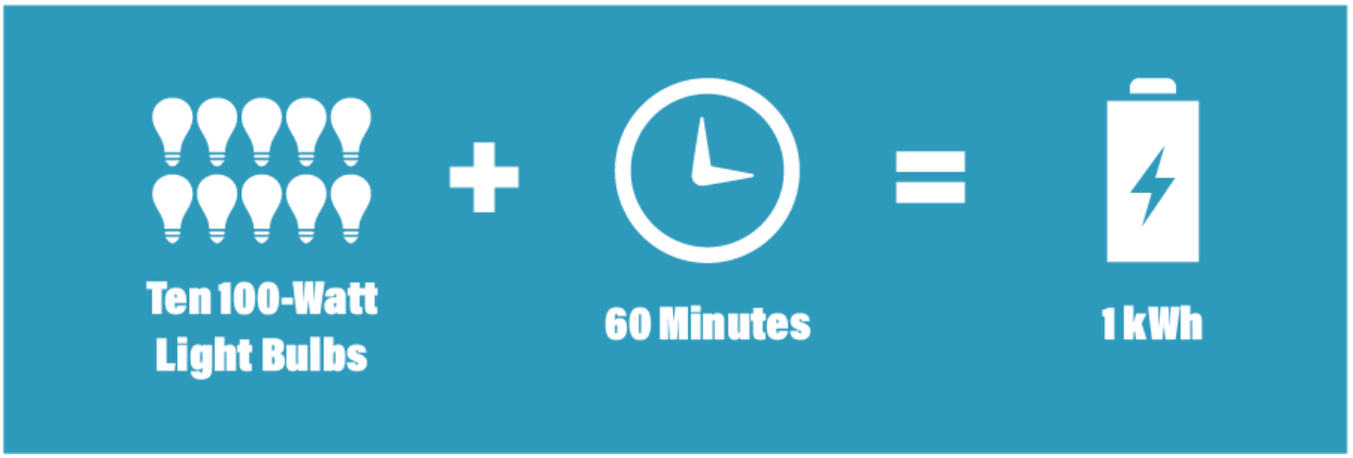
Vertical-axis wind turbines (VAWTs) are turbines that have short, wide, curved blades, and often have blades that look like beaters on an electric mixer. These blades are attached to the top and bottom of a vertical rotor. VAWTs, because of the position of their blades, are able to capture wind at all angles, without needing to be repositioned.



ELECTRICAL POWER UNITS

Electrical power is usually spoken of in watts. However, watts are quite small, so watts are commonly expressed in kilowatts (1000 watts), megawatts (1 million watts), and gigawatts (1 billion watts). Typically when calculating the cost of electricity the modern home uses, kilowatt-hours are used, and are measured over one month.

The power that will be supplied to the LED (light emitting diode) for this project can be measured in kilowatts (kW), specifically kilowatt-hours. Kilowatt-hours (kWh or kW h) is a unit of energy equal to one kilowatt used over one hour. This is the most common unit used to measure electricity, outside of the International System of Unit's (SI) joules (J). One kWh is equal to 3600 kilojoules. What is considered a small LED, which produces a brightness of 450 lumens, requires 1 kW-h to run per month. The LED being used in today's project is smaller than a small LED, and will use less power to produce light, but still requires a power source.



PROS OF WIND ENERGY

The use of wind energy has many pros, from positive effects on the economy and job market to its advantages in an array of communities and areas. Currently, in the U.S., there are over 120,000 jobs in wind energy. By the year 2050, it is projected that there will be hundreds of thousands of more wind energy jobs. Besides growing at a rapid rate, wind energy offers a variety of job types, from blade fabricators to asset managers. Because of the growing rate of wind energy generating electricity - it accounted for 9% of total energy production in the U.S. - over $20 billion was added to the U.S. economy due to investments in wind energy. Just as wind energy has assisted the U.S. economy, wind energy projects add an estimated $1.9 billion to state and local taxes and land leases each year. Areas that develop wind energy can use this additional money to apply towards schools, reducing taxes on homeowners, and addressing local infrastructure issues. With all the influx of finances into the U.S. economy, large-scale wind turbines, used for generating utility-level electricity, are the lowest-costing form of renewable energy currently available. As wind energy science and technologies advance, cost competition improves.

As previously discussed, wind energy is a renewable energy. Because wind is an abundant resource, and doesn't burn any fuel to produce electricity, or produce any air pollution, it is considered clean energy. Wind energy is the largest source of energy in the U.S. and helps society avoid 329 million metric tons of carbon dioxide emissions every year, which is equivalent to the emissions from 71 million cars. With the abundance of wind energy available, it works well in agricultural and multi-use areas. These areas include rural areas, such as farms and ranches, or island and coastal areas, where high-quality wind energy is often found.

CONS OF WIND ENERGY

There are a variety of cons to the use of wind energy, despite it being renewable. Some of these cons have to do with location and the surrounding area, while others have to do with cost competition. Whatever the case, both sides of the debate make good points. While wind energy is relatively low-cost, it is competing with solar energy, as well as forms of nonrenewable energy. While wind energy is available everywhere, it is not ideal in all areas, especially those not very windy. As scientists develop new technologies, a better understanding of wind, and manufacturing improvements are made, these areas may eventually benefit from wind energy as much as windier areas.

Engineers face issues with installing wind turbines and getting the electricity generated to more populated areas where it is needed. The U.S. would need to upgrade its transmission "power grid" network to get this wind power where it is needed. While not there yet, improvements to the transmission network and grid interconnections are being made. Similar to conventional power plants, wind farms contribute to noise pollution. Like all renewable energies, scientists and engineers need to look at the environmental impact. While wind farms have a considerably low impact on wildlife habitats, they still do interact with the environment. Scientists are performing research to better understand the interactions between wind energy and wildlife to best keep habitats intact.

FUTURE OF WIND ENERGY

Renewable energy technologies are constantly changing thanks to advancements in the industry and an interest in fighting the effects of climate change. Scientists and engineers are constantly looking for ways to make wind turbines more efficient and powerful. Ways wind turbines can be improved include improved blade design, general maintenance, and overall evaluation of the wind turbine performance. While wind energy has grown 55% between 2020 and 2021, it would need to grow even faster to reach the goal set by the Net Zero Scenario. The Net Zero Scenario refers to a balance reachable, by 2050, between the amount of greenhouse gases produced and the amount removed from the atmosphere.

Although a majority of wind energy is produced by onshore technologies, offshore technologies are projected to rise in the coming years. Despite the onshore wind technology being fully developed, offshore wind technology is still in the early stages. As wind energy technology continues to advance, and there are changes in design, scientists and engineers are always looking to increase productivity and lower the cost of producing wind energy.

The desire for wind energy, while positive, is not the primary driving force for its production. All across the world, the driving force behind wind energy is policy change. Employment of things such as auctions, feed-off tariffs, and contracts for different and renewable energy portfolio standards, are all driving for higher wind energy production. Since 1974, over 450 energy policies regarding wind energy development and research have been put into effect across the world.

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PROJECT OVERVIEW

This project will focus on wind energy. Wind energy is renewable energy, meaning its supply can be replenished faster than it is used. Students will build their own wind turbine and power a small LED light. Wind power uses kinetic energy from the wind's motion to generate electricity. Wind turbines, previously known as windmills, are used to harness wind power. As the blades of the wind turbine spin, the rotor is attached to a generator that creates electricity.

SAFETY WARNINGS:

Please read all saftey warnings before use:

Choking Hazard: Small parts not for children under 6 years or any individual who have a tendency to place inedible objects in their mouths.

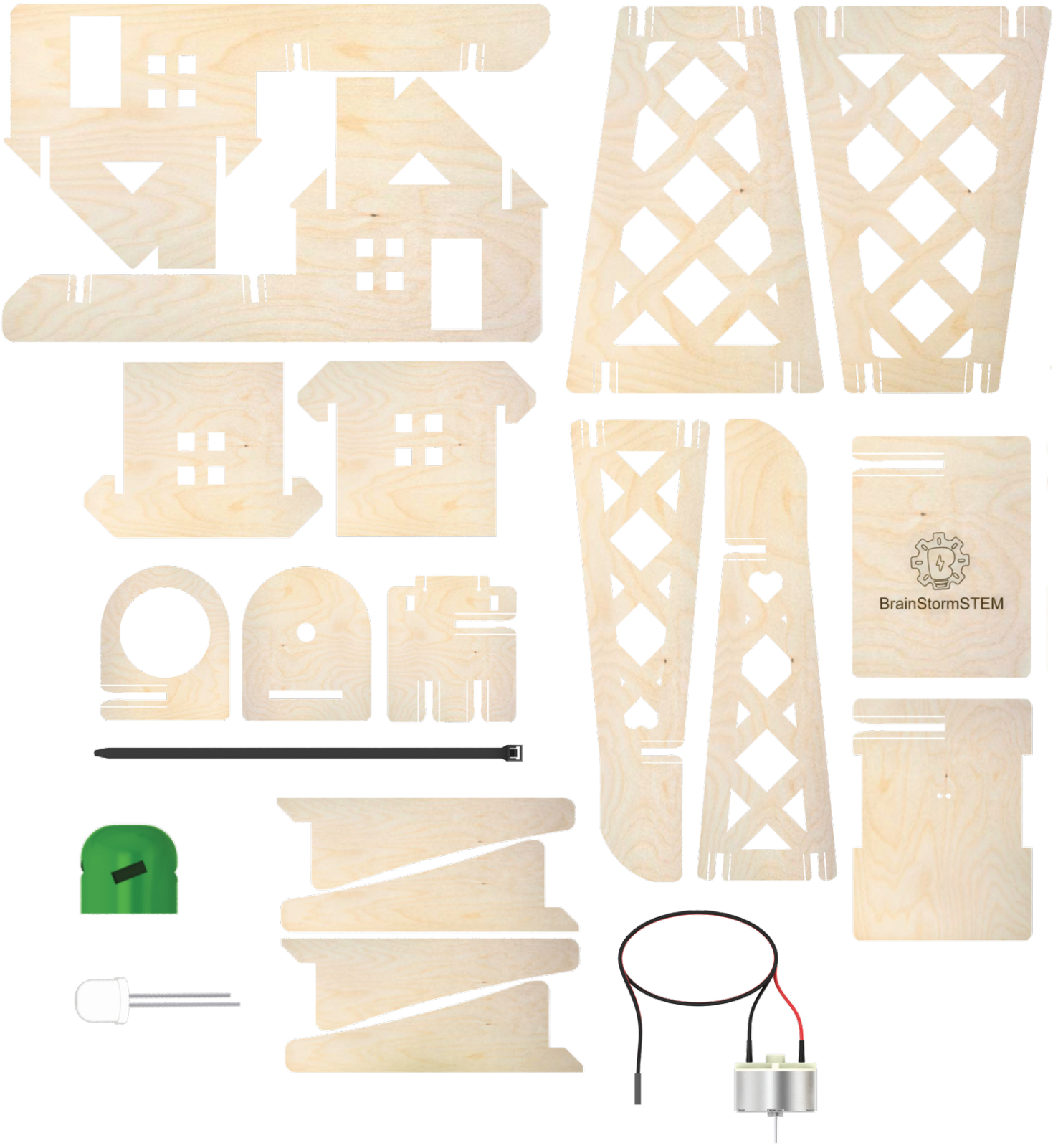
Keep hands and fingers away from spinning turbine.

Adult supervision required.

MATERIALS

Durable wooden construction pieces
Turbine Hub
Generator Motor
LED
Zipties

PARTS



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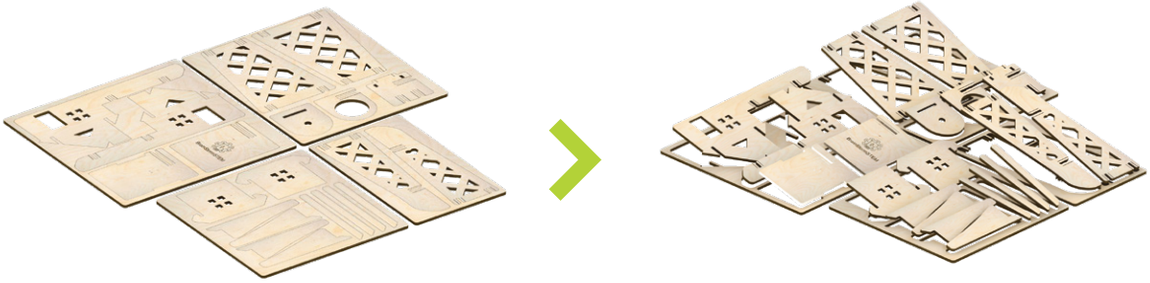

NOTE: If you can not break out the pieces by hand, use a blunt tool or a small knife to cut or punch them out. If you have no experience with tools or use a knife, get help from an adult. If there are any burrs, points or rough spots do to breaking or cutting, smooth them with a piece of sand paper.

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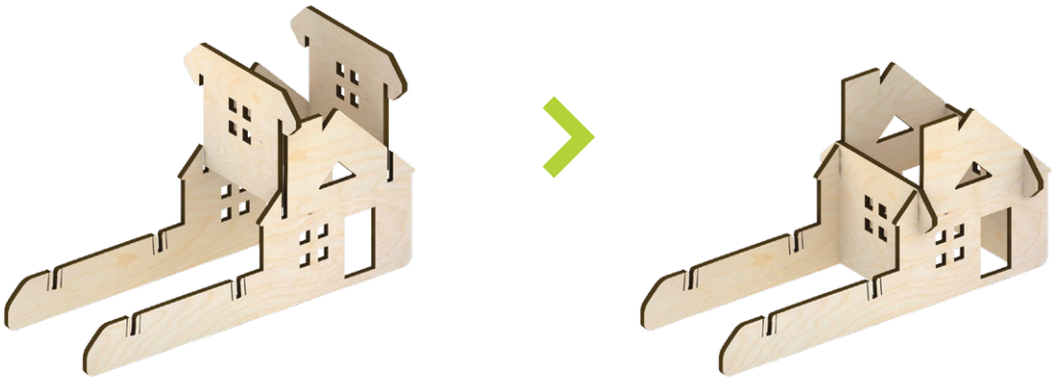

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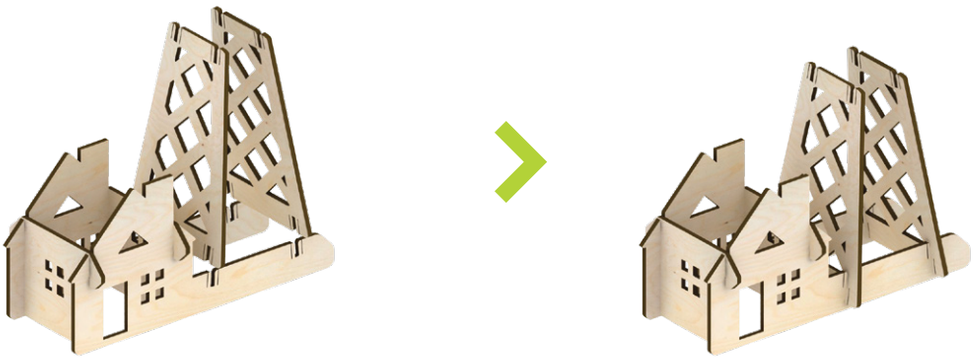

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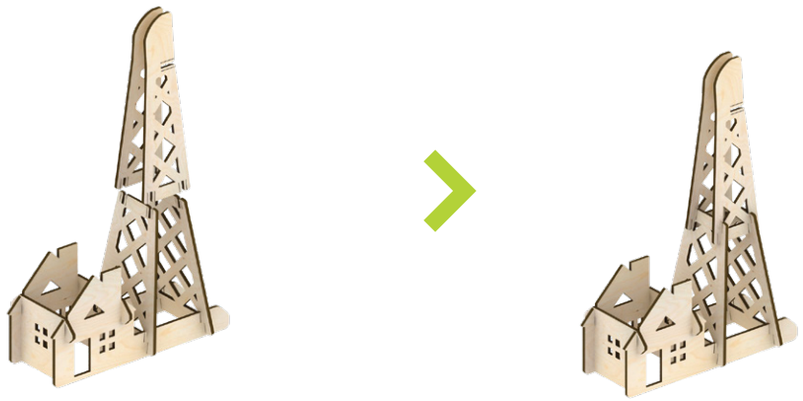

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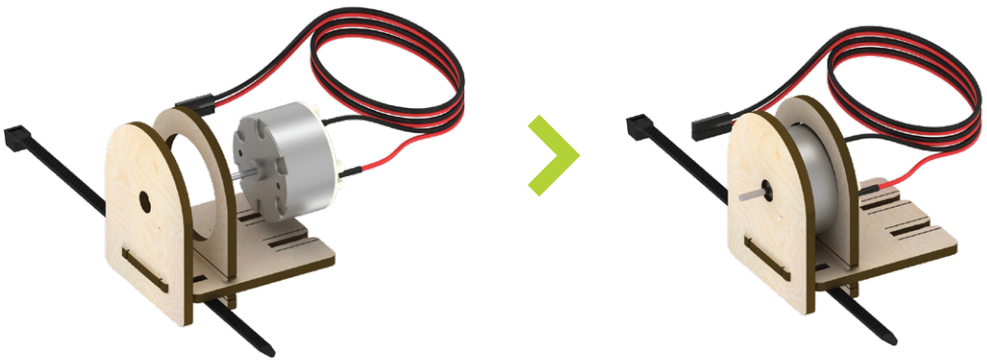

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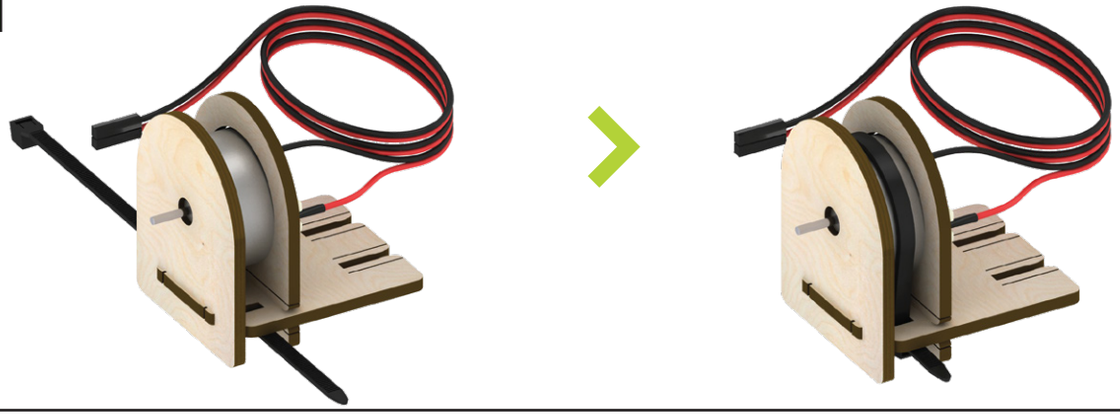

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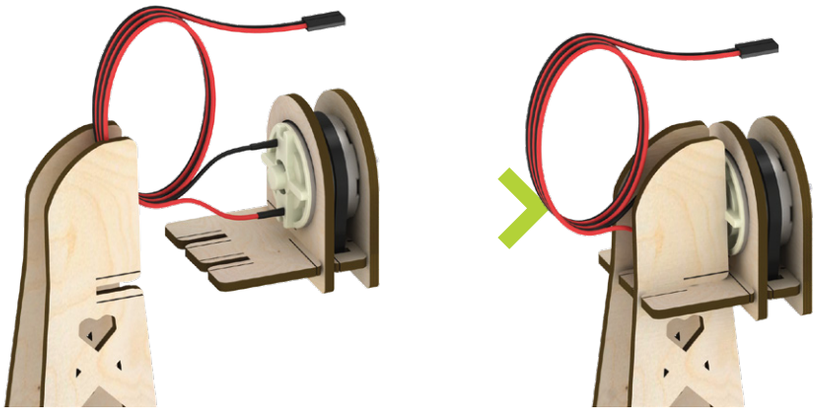

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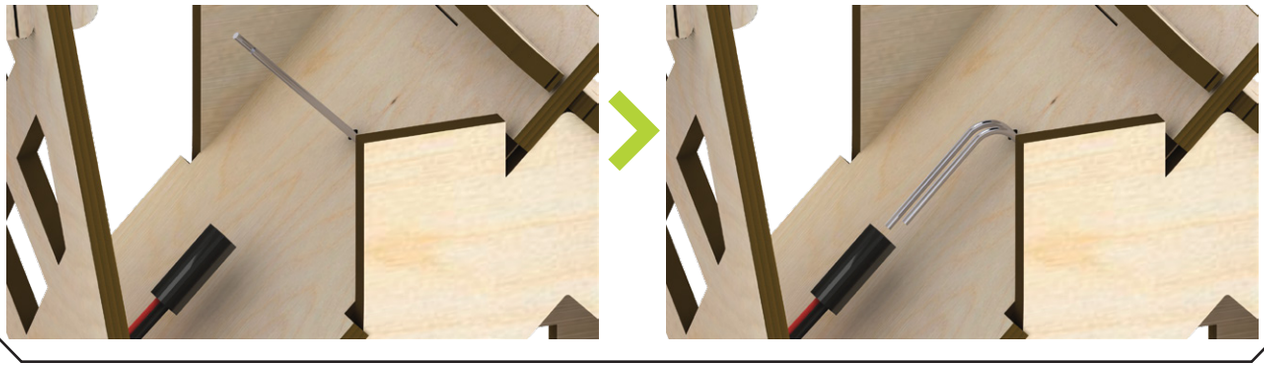

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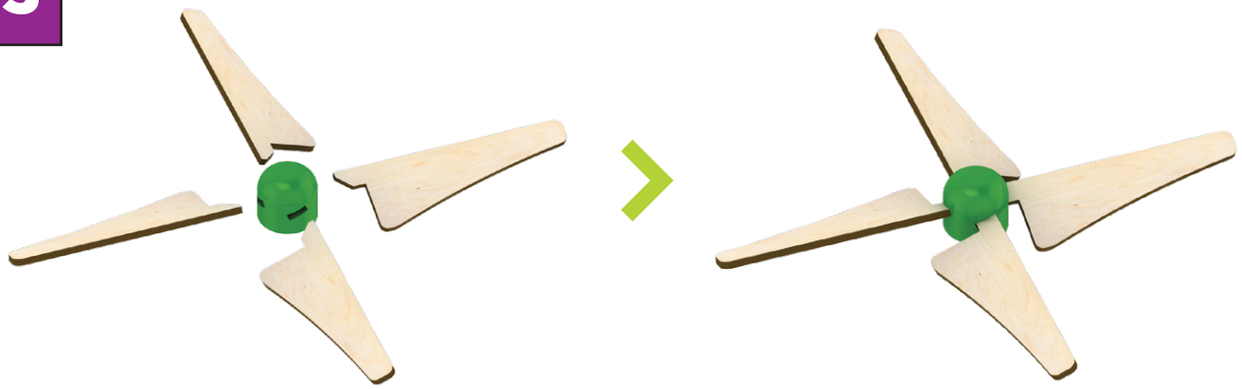
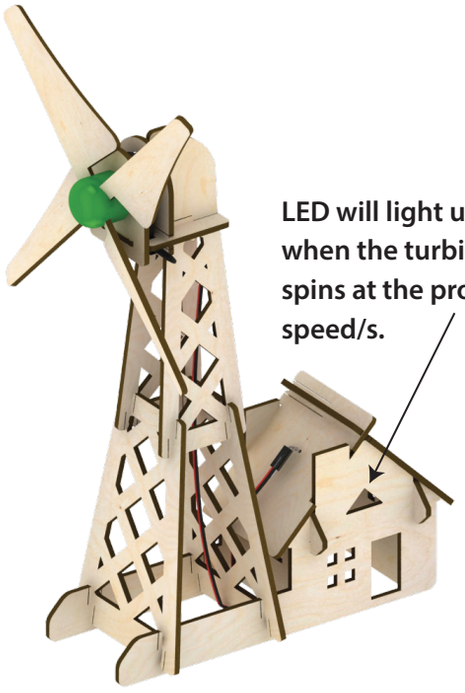


HOW TO USE

USE FAN*

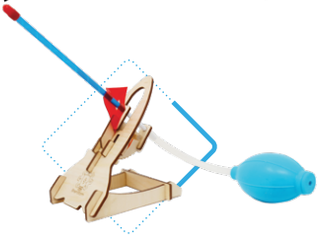
*Fan not included with STEM Kit



LED will light up when the turbine spins at the proper speed/s.

If you enjoyed this STEM Kit, check out some of our other Kits!

CIRCUIT SWORD



AIR-POWERED ROCKET

SOLAR OVEN

AND MORE!

ACTIVITY FOR PROJECT

The Brainstorm wind turbine can be used to power a small LED light. If a more engaging classroom activity is desired, the build can be paired with the following worksheets. There is both a beginner and advanced worksheet to adjust to your students' understanding.

Each worksheet is geared towards having the students recognize the importance of renewable energy, and identifying what a wind turbine consists of. On the beginner worksheet, students will build their wind turbine and draw out what it looks like, and label the major parts. On the advanced worksheet, students will identify renewable and nonrenewable energies, describe what wind is and what causes it, and express why renewable energy is important and what they can do to fight climate change.

Students will be able to see how the construction and design of a wind turbine can affect how much electricity is generated.

ACTIVITY WORKSHEET

Name(s): _____

Date: _____

INSTRUCTIONS:
Once you have built your wind turbine, and tested it, draw out how it looks.

Circle three renewable energies

Nuclear Hydroelectric Geothermal

Solar Wind Natural Gas Oil

Biomass Coal Tidal

What is something you can do to help the environment?

_____

_____

_____

WORKSHEET (Advanced)

Name(s): _____

Date: _____

Answer the following questions about renewable and non-renewable energy.

1. What is renewable energy? List three types.

2. What is nonrenewable energy? List three examples.

3. What is wind?

4. What are the three things that cause wind?

Draw out and label what happens to cool air and warm air. Label which area would have low atmospheric pressure and which would have high atmospheric pressure.