# ON-SITE FIELD TRIP™
# Renewable Energy – Wind Power
# LESSON PLAN

## OVERVIEW

This On-Site Field Trip™ consists of a 60-minute session that combines lecture, discussion and activity.

Students discuss alternative energy sources, with a focus on wind energy and subsequent electricity production. New designs of wind turbines, especially the Vertical Axis Wind Turbine (VAWT) are explored. Students will create a model of a VAWT.

## SUGGESTED GRADE LEVEL:

This class is appropriate for grades 1-12. The same concepts are covered regardless of grade. It is up to the individual teacher to determine the appropriate subject matter and depth of discussion for their particular class.

## OBJECTIVES

Exploration of modern energy sources differentiating between renewable and non-renewable.
Discuss the origin of wind and the relationship between natural science and technology.
Understand the basic concepts of a modern wind turbine
Successful construction of a Vertical Axis Wind Turbine model.

## MATERIALS

**All About Learning** Wind Turbine Kit
Assorted Instructors' notes and learning aides

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www.allaboutlearning.co

## HOW TO USE THIS DOCUMENT

This class follows a natural flow from a general discussion of energy sources to the specific construction of a Vertical Axis Wind Turbine (VAWT) model. It is divided into four major sections. Each section has a stated overall objective.

The material in this class is suitable for K-12. Obviously, care must be taken to address the students at an appropriate intellectual and maturity level. In order to aide this wide disparity, certain discussion topics and facts have been presented at two levels. “Level 1” curriculum covers lower grades while “Level 2” curriculum covers higher grades. It is up to the Instructor to determine which level material is appropriate at any given point, and he/she should not feel compelled to stick with the same level throughout.

## ICON KEY

**Indicates words to be spoken to the class. Do not treat this as a “script”, but ensure that the keywords and spirit of the discussion is maintained.**

**Signifies an Instructor action or class activity. Usually, this occurs after a brief discussion.**

**Indicates supplemental facts or lecture based on the current topic of discussion. This material may be divided up into Levels 1 and 2. It is NOT necessary to include all these facts into the discussion. Rather, they are available to move discussion along, bring up interesting “sidebars”, or help answer specific questions students may raise.**

## SUPPLEMENTAL MATERIAL

Class materials include various handouts: facts sheets, illustrations and activities. Some of these handouts are referenced by title in this document, and should be used to help explain a concept.

## SECTION 1: ENERGY SOURCES - RENEWABLE vs. NON-RENEWABLE (10 minutes)

**Objective:** Discuss the major types of energy sources currently utilized around the world, differentiating between renewable and non-renewable.

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***Think about all the ways that you've used energy just to get this far in your day. Did an alarm clock wake you? Did gas or electricity heat your breakfast or the water for your shower? Did you travel by car or bus? What did it take to build this school?***

Compile a list on the board of energy TYPES, which will probably be limited to electricity, gas and nuclear. Discuss the SOURCES of these energies, using examples as cues. Emphasize the difference between energy type and energy source.

***Who knows how humans create these types of energy? What sources do we use? For example, we know electricity travels to our house from a "power plant", but how is the electricity produced? What different ways might the electricity be "made"?***

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| **LEVEL 1 AND 2** | **HOW IS OUR ENERGY PRODUCED?**<br><br>About 92% of the energy consumed in the United States comes from non-renewable energy sources, which include uranium ore and the fossil fuels — coal, natural gas, and petroleum.<br><br>• Oil/ petroleum<br>• Natural Gas<br>• Coal<br>• Uranium /nuclear<br><br>Renewable energy sources including biomass, hydropower, geothermal, wind, and |

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| | solar provide 8% of the energy used in the United States. Most renewable energy goes to producing electricity.<br><br>• Biomass<br>• Geothermal<br>• Hydropower<br>• Solar<br>• Wind |

Allow students to come up with as many sources as they can, then fill in any gaps. Write all nine sources on the board in any order
Raise the issue of renewable vs. non-renewable energy.

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***Which of these energy sources might "run out" one day? Will we always have oil or coal in the ground? What about water? Will rivers always flow? Will the sun always shine?***

Mark each energy source on the board as renewable or non-renewable. Explain that humans are currently trying to find ways of using renewable sources to create more energy before we run out of non-renewable sources.

***And now this class is going to concentrate on one of the renewable sources: wind.***

## SECTION 2: WIND AS AN ENERGY SOURCE (10 minutes)

**Objective:** Explore the origin of wind and the relationship between natural science and technology. As a renewable resource, wind power is one of the alternative forms of energy that's being explored. Historically, windmills and wind turbines are an effective way to produce clean electricity. No one alternative energy will satisfy the world's needs, and every form of energy creation has advantages and disadvantages.

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***Have you ever seen an old map that has pictures of men blowing ships across the ocean? The ancient Greeks thought that gods on Mt. Olympus were responsible for making the wind. Now we know better.***

**LEVEL 1**

**WHAT IS WIND?**

What exactly is wind? Have you ever been outside when it is really windy? Have you ever seen garbage cans or leaves blown around by the wind? Basically, it is just the movement of air. Wind can be strong and heavy or light little breezes. The wind can sometimes be our enemy — when it is so strong that it blows down buildings and causes billions of dollars worth of damage. On the other hand, the wind can also be our friend. It can produce energy and transport goods and humans. We can do fun things with wind, such as fly a kite, parasail and hang glide.

Air moves from areas of high to low pressure, creating winds. It can be the movement of air on a local scale such as your neighborhood (local winds) or the movement of air across the whole globe (global winds).

Winds are also created by local differences in air pressure and temperature, as well as surface disruptions, such as mountains, cliffs and trees. These are measured only on a local scale and last for a few hours or days. Wind blows against the surface of the Earth, and a force called friction slows the wind down. Other obstacles can also affect the wind, including buildings and vehicles.

**Use document; "How Wind is Formed"**

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| **LEVEL 2** | **WHAT IS WIND?**<br><br>Winds are caused by differences in air pressure and temperature. Meteorologists have made enough observations to define areas of high and low pressure across the Earth. For example, along the equator we normally find low air pressure. In addition, the sun heats the equator more than any other place on earth. These factors, combined with rotation of the Earth (or Coriolis Effect), create global winds. Air tends to move towards the equator because air generally moves from areas of high to low pressure, thus creating winds. The winds from the north and south converge at the equator because hot air rises and then cools. The Coriolis Effect diverts the air to the right in the northern hemisphere and to the left in the southern hemisphere. Without this diversion, air would just sink and return to the equator; but the Coriolis Effect moves the air back to the middle latitudes to start the process over again, creating a rotating effect. Similarly, some of the air from the middle latitudes moves to a low pressure area at the poles. |

***Wind has been used for over 2500 years to help us. In the Middle East, wind was used to turn a stone that ground grain into flour. Now we're using the same type of device to create electricity.***

***(*Level 2- see *"Quick History of Wind Energy Technology"* document for further discussion*)***

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| **LEVEL 1** | **WHAT IS WIND POWER AND HOW CAN IT BE USED?**<br><br>Wind can be used to do work.<br><br>When a boat lifts a sail, it is using wind energy to push it through the water. This is one form of work.<br><br>Farmers have been using wind energy for many years to pump water from wells using windmills. |

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| | In Holland, windmills have been used for centuries to pump water from low-lying areas.<br><br>Wind is also used to turn large grinding stones to grind wheat or corn, just like a water wheel is turned by water power.<br><br>Today, the wind is also used to make electricity. |

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| **LEVEL 2** | **WHAT IS WIND POWER AND HOW CAN IT BE USED?**<br><br>Whether powering sailboats across the surface of the water or pumping water from one location to another, the wind is a good source of power. Wind provided early explorers with the engine they needed to cross oceans and discover new lands. On land, the oldest and most widespread use of wind power is for pumping water. In virtually every country on Earth, humans are using wind power to either pump water from the ground or move it from one location to another.<br><br>Wind is moving air. The engine that drives this movement is the sun. Although modern wind turbines can produce some electricity in light winds, the stronger the breeze the better. The power available in the wind is proportional to the cube of its speed. For example, if the wind speed doubles, say from 10 to 20 miles per hour, the power available to a wind generator increases by a factor of eight, for instance, from 1,000 Watts to 8,000 Watts. One easy way to access higher wind speeds is simply to go higher above ground level.<br><br>Winds high above the ground are stronger than winds near the ground. On average a five-fold increase in elevation, raising the height of the wind machine from 10 feet to 50 feet, will result in twice as much available wind power. This is why wind turbines are perched on tall towers and are often located on mountains or hilltops. |

***We know now that Wind energy is a renewable energy source, but the world uses so much energy that no one source is enough.***

***Sometimes people can't or choose NOT to use wind energy. Why do you think wind energy would not work in some places? Why would some people not like the idea of wind energy?***

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| **LEVELS**<br><br>**1 AND 2** | **WHAT ARE THE ADVANTAGES AND DISADVANTAGES OF WIND POWER?**<br><br>**Advantages**<br><br>• Wind energy is free.<br>• It is a renewable energy resource.<br>• There are no dangerous emissions.<br>• Wind power can be used in remote areas.<br>• Wind power can be used in conjunction with other renewable energy resources such as solar energy.<br><br>**Disadvantages**<br><br>• Wind turbines are site dependent i.e. they need to be built in areas where there is a reliable source of wind.<br>• Wind speed can fluctuate. The wind speed can be too fast or slow which means that electricity is not produced.<br>• Blades can harm birds and disrupt other animals<br>• Wind farms can be a visual eyesore and may create excess noise.<br>• Energy storage devices, e.g. batteries, are sometimes necessary. |

## SECTION 3: HOW DOES A WIND TURBINE WORK? (10 Minutes)

**OBJECTIVE:** Understand the basic concepts of a modern wind turbine

A wind turbine creates electricity by converting the force of the wind into torque (turning force) acting on the rotor blades. The amount of energy which the wind transfers to the rotor depends on the density of the air, the rotor area, and the wind speed.

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***Has anyone ever seen a working windmill? The wind turns a blade, which is connected to a rod. And once you have that rod turning consistently, you can use it to do work for you.***

***Now, we use wind turbines to produce electricity. The spinning rod is connected to a device called a generator, and that generator produces electricity that moves along wires to a storage device. When we put many turbines together in one place, it becomes a wind farm.***

**LEVEL 1**

**HOW DOES A WINDMILL/TURBINE WORK?**

Electricity is the power we use to run our lights, video games, televisions— anything you plug into an outlet uses electricity. Electricity does not magically come out of the walls in your house.

Electricity is made in a generator, a system where magnets spin around coils of copper wire. Today, we use wind turbines to capture the energy in the wind to make electricity. A wind turbine sits on top of a tall tower. At the top of the tower is a box called a nacelle where the generator with magnets and copper wire is housed. On the front of the nacelle is a hub, which is where the blades are attached. It looks like the front of a propeller airplane. The wind pushes against the blades of the turbine. The blades spin and turn a long rod, or shaft, that goes from the hub into the nacelle. The turning shaft spins the generator. The generator changes the motion from the wind into electricity. The electricity then travels through wires to get from the wind turbine to your house.

LEVEL 2

**HOW DOES A WINDMILL/TURBINE WORK?**

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The blades on a wind turbine are similar to the propeller blades on an airplane. The rotor blades generate lift from the passing wind, causing them to rotate the hub of the turbine. The rotating action of the hub then turns a generator, which creates electricity. A gearbox is generally necessary to optimize the power output from the machine. That power is then either fed into the electric grid or stored in batteries for use on-site. While wind speed is important, so is the size of the rotor. On a turbine, the power available to the blades is proportional to the square of the diameter of the rotor. In other words, simply by making the turbine blades twice as long and beefing up the generator, you increase the power producing capability of the turbine by a factor of four.

Modern wind turbines come in two varieties: horizontal axis and vertical axis. Horizontal axis turbines have blades that spin on an axis that is parallel to the ground. These systems often look like the propeller on an airplane. Vertical axis systems have blades that spin on a vertical axis giving them an appearance somewhat like giant eggbeaters.

Although large utilities are getting the most attention for their move into wind power, rural residents in all 50 states and dozens of foreign countries have quietly been installing small-scale wind generation systems. These systems can be obtained for as little as $1,000 and are perfect compliments to solar photovoltaic systems. Several vendors sell ready-made towers and turbines that are easily installed

**LEVEL 2- USE DOCUMENTS:**

*How Wind Power Works – Turbine Aerodynamics*
and
*Energy Transfers and Conversions in a Turbine*

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**Horizontal-axis Turbines Look Like Windmills**

Most wind machines being used today are the horizontal-axis type. Horizontal-axis wind machines have blades like airplane propellers. A typical horizontal wind machine stands as tall as a 20-story building and has three blades that span 200 feet across. The largest wind machines in the world have blades longer than a football field. Wind machines stand tall and wide to capture more wind.

**Vertical-axis Turbines Look Like Egg Beaters**

Vertical-axis wind machines have blades that go from top to bottom. The most common type — the Darrieus wind turbine, named after the French engineer Georges Darrieus who patented the design in 1931 — looks like a giant, two-bladed egg beater. This type of vertical wind machine typically stands 100 feet tall and 50 feet wide. Vertical-axis wind machines make up a small share of the wind machines used today. It is the kind of model we're going to build today.

**SECTION 4: WIND TURBINE CONSTRUCTION** (20-30 minutes)

**OBJECTIVE:** Successful construction of a Vertical Axis Wind Turbine model.

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***Now we're going to put together a model of the Vertical Axis Wind Turbine.***

Using the contents of the kit and the included instructions, have students create their own Vertical Axis Wind Turbine. Allow time for personalization.

## TURBINE VOCABULARY

Blades:

Most turbines have either two or three blades. Wind blowing over the blades causes the blades to "lift" and rotate.

Gear box:

Gears connect the low-speed shaft to the high-speed shaft and increase the rotational speeds from about 30 to 60 rotations per minute (rpm) to about 1000 to 1800 rpm, the rotational speed required by most generators to produce electricity. The gear box is a costly (and heavy) part of the wind turbine and engineers are exploring "direct-drive" generators that operate at lower rotational speeds and don't need gear boxes.

Nacelle:

The nacelle sits atop the tower and contains the gear box, low- and high-speed shafts, generator, controller, and brake. Some nacelles are large enough for a helicopter to land on.

Pitch:

Blades are turned, or pitched, out of the wind to control the rotor speed and keep the rotor from turning in winds that are too high or too low to produce electricity.

Rotor:

The blades and the hub together are called the rotor.

Tower:

Towers are made from tubular steel, concrete, or steel lattice. Because wind speed increases with height, taller towers enable turbines to capture more energy and generate more electricity.

## RESOURCES

http://teachers.egfi-k12.org/lesson-harnessing-wind/

http://www.windpoweringamerica.gov/

http://www.pbs.org/now/classroom/wind.html